Rapid Assessment Program

RAP
Bulletin
of Biological
Assessment
47

A Rapid Biological Assessment of the Atewa Range Forest Reserve, Eastern Ghana

Jennifer McCullough, Leeanne E. Alonso,
Piotr Naskrecki, Heather E. Wright, and
Yaw Osei-Owusu (Editors)

Center for Applied Biodiversity Science (CABS)

Conservation International

Conservation International – Ghana

Alcoa World Alumina LLC (Alcoa)

Cover photos (Piotr Naskrecki)

Top: Sylvan katydid (*Mustius afzelli*)

Center: Frog (*Afrixalus vebekensis*)

Botton: Chameleon (*Chamaeleo gracilis*)

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The *RAP Bulletin of Biological Assessment* is published by
Conservation International
Center for Applied Biodiversity Science
2011 Crystal Drive, Suite 500
Arlington, VA USA 22202
Tel : 703-341-2400
www.conservation.org
www.biodiversityscience.org

Editors: Jennifer McCullough, Leeanne E. Alonso, Piotr Naskrecki, Heather E. Wright and Yaw Osei-Owusu
Design: Glenda Fabregas
Map: Mark Denil
Photography: Piotr Naskrecki

RAP Bulletin of Biological Assessment Series Editors:
Jennifer McCullough and Leeanne E. Alonso

ISBN #978-1-934151-09-9

Library of Congress Card Catalog Number 2007940630

RAP Bulletin of Biological Assessment was formerly *RAP Working Papers*. Numbers 1-13 of this series were published under the previous series title.

Suggested citation:
McCullough, J., L.E. Alonso, P. Naskrecki, H.E. Wright and Y. Osei-Owusu (eds.). 2007. A Rapid Biological Assessment of the Atewa Range Forest Reserve, Eastern Ghana. RAP Bulletin of Biological Assessment 47. Conservation International, Arlington, VA.

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Organizational Profiles

CONSERVATION INTERNATIONAL

Conservation International (CI) is an international, nonprofit organization based in Washington, DC. CI believes that the Earth's natural heritage must be maintained if future generations are to thrive spiritually, culturally and economically. Our mission is to conserve the Earth's living heritage, our global biodiversity, and to demonstrate that human societies are able to live harmoniously with nature.

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CONSERVATION INTERNATIONAL – GHANA

Conservation International Ghana's work started in 1990 with the Kakum National Park, where the habitat of globally threatened species was secured against further degradation and species extinction through innovative ecotourism development. To further secure Kakum National Park, CI-Ghana implemented the Cocoa Agro-forestry Programme in partnership with Kuapa Kokoo, assisting cocoa farmers within the Kakum Conservation Area to adopt ecologically sustainable agronomic practices for increased production. This agroforestry initiative has provided a buffer zone and additional wildlife habitat for the threatened species within the Park. As a result of CI-Ghana's interventions, Kakum National Park currently receives about 80,000 visitors annually, contributing significantly to the socio-economic development of Ghana.

From the project site at Kakum National Park, CI-Ghana has expanded its focus to the national level. CI-Ghana's work focuses on preventing species extinction, increasing protection and improving management of the remaining forest fragments, and the development of biodiversity corridors. To curb the threat of species extinction in Ghana, as a result of the bushmeat trade, CI-Ghana carried out a two-year nation-wide bushmeat campaign. This was done in partnership with the Wildlife Division, Atomic Energy Commission, Ghana Standards Board and Food and Drugs Board. Others included the Ministry of Food and Agriculture and the Environmental Protection Agency of Ghana. In partnership with the Ministry of Environment and Science, CI-Ghana provided technical support, secretariat and funding for the completion of the *National Biodiversity Strategy for Ghana.* To ensure the effective implementation of the Strategy, CI-Ghana also provided technical support for the formulation of the Action Plan. Currently, CI-Ghana is represented on the National Biodiversity Committee in Ghana. In December 1999, CI-Ghana facilitated a conservation priority-setting workshop that built a broad-based consensus on priorities for biodiversity conservation of the Upper Guinea forest

ecosystem through active participation of 146 individuals from 90 institutions. Government, NGOs and private sector participants developed a common platform to guide and coordinate new investment and conservation at various scales throughout the region.

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CENTER FOR APPLIED BIODIVERSITY SCIENCE (CABS)

The mission of the Center for Applied Biodiversity Science (CABS) is to strengthen the ability of Conservation International and other institutions to identify and respond to elements that threaten the earth's biological diversity. CABS collaborates with universities, research centers, multilateral government and non-governmental organizations to address the urgent global-scale concerns of conservation science. CABS researchers are using state-of-the-art technology to collect data, consult with other experts around the world, and disseminate results. In this way, CABS research is an early warning system that identifies the most threatened regions before they are destroyed. In addition, CABS provides tools and resources to scientists and decisions-makers that help them make informed choices about how best to protect the hotspots.

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ALCOA WORLD ALUMINA LLC (ALCOA)

As one of the world's leading aluminium producers with operations in a number of countries throughout the world Alcoa has given priority to addressing environmental concerns in its operations and developments. Alcoa has implemented a sustainability strategy that it applies in its processing operations and the development of new projects such as the proposed refinery in Guinea. The strategy is based on the goal of simultaneously achieving financial success, environmental excellence, and social responsibility through partnerships in order to deliver net long-term benefits to shareholders, employees, customers, suppliers, and the communities in which Alcoa operates.

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Acknowledgements

The success of this RAP survey would not have been possible without the collective effort of many dedicated individuals and organizations. The RAP team would like to thank the following people and groups for helping to make this RAP survey a success. First of all, we thank the Forestry Commission of Ghana for permitting access to the forest reserves and we are especially grateful for the collaboration from Okyehene, Osagyefo Amoatia Ofori Panin and chiefs and elders of the fringe communities surrounding Atewa.

We appreciate the strong commitment shown by ALCOA's Eric Black, Anita Roper, Kevin Lowery, John Gardner, Augustus Amegashie, Oumar Toguyeni, and Ibrahima Danso to incorporate biodiversity conservation into their project plans in Ghana. We are furthermore grateful for ALCOA's financial support to conduct this survey in such a biologically unique area.

We thank the staff of CI-Ghana, especially the Country Director, Okyeame Ampadu-Agyei, Emmanuel Owusu, Philip Badger for assistance with permits, logistics and equipment, Nana Abena-Somaa for logistical support and help in the field, and Yaw Osei-Owusu for his leadership and dedication in the field.

Local assistants and field guides were of invaluable help during field work, including Joshua Akyeaner, Daniel Koranteng, Agyare Duodu, Kwabena Frempong, Alex Boapeah and Eric Boadi. Their hard work, dedication and their inspiring companionship helped make this expedition a success. Special thanks to our cooks, Ohenewaa Boadu Portia and Teye Maccarthy, who kept us nourished and well fed. Their good nature and cooking gave us the energy to carry out our long days of fieldwork. We also owe a debt of gratitude to our drivers, Collins Nuamah, Kwesi Amissah and Eric Mensah, and our videographer Isaac Amissah and his assistant Jacob Zong.

The RAP participants thank Leeanne Alonso, Piotr Naskrecki, Heather Wright and Peter Hoke of Conservation International for the invitation to participate to this RAP survey. The editors thank Mark Denil of CI's Conservation Mapping Program and both Glenda Fabregas and Kim Meek for their attention to detail and patience in designing RAP publications.

This project was made possible through Conservation International's Center for Environmental Leadership in Business (CELB) and West Africa programs, and we particularly thank Marielle Canter and Jessica Donovan for their input and support throughout this RAP survey.

The primate group wishes to thank Vincent for field assistance, as well as the many local workers, especially Joshua Akyeanor (our guide from Tete), as well as all the RAP participants. Thanks also to the local villagers for participating in interviews.

The butterfly team wishes to thank Yaw Osei-Owusu of CI- Ghana for the opportunity to take part in the expedition. They are indebted to Dr. Torben B. Larsen for his valuable comments on the manuscript and continual assistance on butterfly species identification. They also thank all the team members for the fun and good time at the muddy camp sites.

The amphibian team thanks Nana Abena, Leeanne E. Alonso, Piotr Naskrecki, Yaw Osei-Owusu, and Heather Wright, as well as all other RAP participants, for their support.

The small mammal team thanks Kwame Botchway and Nana Abena Somaa for their dedicated assistance in the field. The identification of shrews and murids by Rainer Hutterer (ZFMK) is highly appreciated. Jan Decher, University of Vermont, provided helpful information and comments on the manuscript. Laurent Granjon, IRD Montpellier, and Mark-Oliver Rödel, University of Würzburg, offered suggestions on the manuscript. Analysis and publication of the data is part of the BIOLOG-program of the German Ministry of Education and Science (BMBF; project W09 BIOTA-West, 01 LC 0411).

Report at a Glance

Expedition Dates
6 – 24 June 2006

Area Description
The Atewa Range Forest Reserve (Atewa) was established as a national forest reserve in 1926 and has since been designated as a Globally Significant Biodiversity Area (GSBA) and an Important Bird Area (IBA) (Abu-Juam et al. 2003). The Atewa mountain range, located in south-eastern Ghana, runs roughly from north to south and is characterized by a series of plateaus. One of only two reserves in Ghana with Upland Evergreen forest (Hall and Swaine 1981, Abu-Juam et al. 2003), Atewa represents about 33.5% of the remaining closed forest in Ghana's Eastern Region. Atewa is home to many endemic and rare species, including black star plant species and several endemic butterfly species (Hawthorne 1998, Larsen 2006). Seasonal marshy grasslands, swamps and thickets on the Atewa plateaus are nationally unique (Hall and Swaine 1981).

Atewa has long been recognized as a nationally important reserve because its mountains contain the headwaters of three river systems, the Ayensu, Densu and Birim rivers. These three rivers are the most important sources of domestic, agricultural and industrial water for local communities as well as for many of Ghana's major population centers, including Accra.

The RAP survey was conducted around three sites within Atewa: Atiwiredu (6°12'24.7"N, 0°34'37.2"W, 795 m); Asiakwa South (6°15'44.3"N, 0°33'18.8"W, 690 m); and Asiakwa North (6°16'16.4"N, 0°33'52.8"W, 769 m). The RAP sites were chosen to coincide with areas of potentially high biodiversity and concentrated bauxite deposits that had been earmarked for exploitation activities by ALCOA. The fish and dragonfly teams also sampled streams, rivers and other freshwater sites outside the reserve that are part of the watershed originating within Atewa.

EXPEDITION OBJECTIVES

In addition to high biodiversity, Atewa is known to harbor mineralogical wealth including both gold and bauxite deposits. The Government of Ghana granted an exploration license to ALCOA to prospect within Atewa for bauxite deposits. Due to Atewa's classification as a GSBA, ALCOA initiated an agreement with Conservation International (CI) to assist them in better understanding the area's biodiversity context. The aim of the agreement was to provide significant gains for biodiversity conservation, industry, government, and the people of Ghana.

Specifically, the RAP survey aimed to derive a brief but thorough overview of species diversity in Atewa, to evaluate the area's relative conservation importance, to provide management and research recommendations, and to increase awareness of the Atewa ecosystems in order to promote their conservation.

OVERALL RAP RESULTS

The results of the RAP survey show that Atewa is an exceptionally important site for national and global biodiversity conservation. All taxonomic groups surveyed were comprised almost

exclusively of forest species, indicating an intact forest ecosystem, which is a highly unusual and (from a conservation perspective) highly significant finding for West Africa, where most forests are highly fragmented and disturbed.

Atewa harbors a high diversity of species especially of butterflies (Atewa has the highest butterfly diversity of any site in Ghana), dragonflies, katydids, birds, and plants. Included among the many rare and threatened species at Atewa are six black star plant species, six bird species of global conservation concern, two primates and 10 other large mammals, and a high proportion of threatened amphibian species such as the Critically Endangered frog *Conraua derooi*, for which the Atewa Range is likely to hold the largest remaining populations.

The unique and diverse species assemblages documented during the RAP survey, especially of amphibians, Odonata (dragonflies and damselflies) and fishes, all depend on the clean and abundant water that originates in Atewa for their survival. Ghanaians around Atewa and as far as Accra also depend on this water source, which is provided by the plateau formations which soak up rain and mist and then hold, clean and discharge fresh water.

CONSERVATION CONCLUSIONS AND RECOMMENDATIONS

This RAP survey confirms that Atewa is a site of extremely high importance for global biodiversity conservation and should be protected in its entirety. Atewa is one of the largest remaining forest blocks in Ghana and contains Ghana's last intact stand of Upland Evergreen forest. The only other forest of this type in Ghana, in the Tano Ofin Forest Reserve, is smaller and significantly more disturbed. Atewa is also an extremely important watershed – holding, cleaning and discharging freshwater that supports a rich biodiversity and provides clean water to millions of Ghanaians. There is no other place like Atewa in Ghana.

Based on the results of the RAP survey and previous studies, we offer the following two principal conservation recommendations. See the Executive Summary section for more details and for management recommendations.

- Within the Atewa Range Forest Reserve, the Government of Ghana should delimit and establish an integrally protected area with high protection status, such as a National Park, that includes all remaining intact Upland Evergreen forest, especially on the plateaus. A buffer zone covering the more disturbed slopes and valleys of the reserve should be established surrounding the core protected area.
- To ensure the sustainable protection of Atewa, alternative incomes for the local communities, particularly in Kibi, should be developed to reduce existing or potential dependence on extractive industries and forest products from Atewa. This should be done as a collaborative effort between government, private, NGO, scientific, development, and community groups.

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SPECIES RECORDED AT THE THREE RAP SITES

	All RAP sites in this survey	Atiwiredu	Asiakwa South	Asiakwa North
Number of species recorded	839	295*	435*	307*
Species of conservation concern**	36	20	13	14
New species discovered	9***	4	6	4
New records for Ghana	46	16	28	24

*excludes birds, fishes and dragonflies which were not sampled by site

**species of global conservation concern as listed by IUCN (2007) and of national conservation concern (Schedule I of the Ghana Wildlife Conservation Regulation and black star species)

***includes a new species of spider tick (see 'other invertebrates' in Executive Summary)

RESULTS BY TAXONOMIC GROUP

	Total species recorded	Species new to science	New records for Ghana	Species of conservation concern*	Species endemic to Upper Guinea
Plants	314			6 (Black Star)	n.r.
Odonata	72		8	1	n.r.
Butterflies	143				16
Orthoptera (katydids)	61	8	36		n.r.
Fishes	19		1		n.r.
Amphibians	32			9	16
Birds	155		1	6	11 from Upper Guinea Endemic Bird Area
Small mammals	15		2	2	3
Large mammals	22			10	n.r.
Primates	6			2	1

*see Executive Summary for list of species
n.r. = not reported by RAP scientists

Executive Summary

INTRODUCTION

Across West Africa, forest cover has been reduced to less than 30% of its potential extent (Bakarr 2001). The highly fragmented forest patches that remain continue to be degraded or completely lost at an alarming rate. Based on high levels of species endemism, coupled with intense and ongoing threats to their survival, the remaining West African forests have been designated as one of 34 global hotspots of biodiversity (Mittermeier et al. 2004).

Montane habitats are extremely restricted in extent within this region. Long-term geological erosion has turned West Africa into a mostly flat landscape with significant tracts of montane forest limited to the Upper Guinea Highlands. These montane forest areas constitute unique ecosystems with exceptional species richness and high levels of endemism (Bakarr et al. 2001, 2004). Between the Upper Guinea and Cameroon Highlands, only the Atewa Range in Ghana, the Volta Highlands between Ghana and Togo, and the Jos Plateau in Nigeria harbor significant upland forest patches. Among these three, Upland Evergreen Forest is found only in the Atewa Range. The Atewa Range Forest Reserve (hereafter referred to as 'Atewa') is one of only two forest reserves in Ghana where Upland Evergreen Forest occurs (Hall and Swaine 1981, Abu-Juam et al. 2003), the other being the Tano Ofin Forest Reserve, which is already highly degraded.

Ghana has lost roughly 80% of its forest habitat since the 1920s (Cleaver 1992) and Atewa represents one-third of the remaining closed forest in the Eastern Region of Ghana (Mayaux et al. 2004, Chapter 11). Atewa is known to hold numerous endemic and rare species, in part due to the unique floristic composition of its Upland Evergreen forest generated by the misty conditions on top of the plateaus (Swaine and Hall 1977). In addition, several butterfly species are strictly endemic to the Atewa Range (Larsen 2006). Seasonal marshy grasslands, swamps and thickets on the tops of Atewa's plateaus are also thought to be nationally unique (Hall and Swaine 1981).

Atewa has been officially classified in various ways over the past 90 years, with changes due mainly to new programs and designations assigned by the Government of Ghana and not to any changes in Atewa's biodiversity or ecological values. Atewa was declared a national forest reserve in 1925, then was classified as a Special Biological Protection Area in 1994, as a Hill Sanctuary in 1995 and, finally in 1999, as one of Ghana's 30 Globally Significant Biodiversity Areas (GSBAs) (Abu-Juam et al. 2003) based on its high botanical diversity. Designation as a GSBA is equivalent to IUCN's Category IV designation: a protected area designated mainly for conservation through management intervention (IUCN 1994). In 2001, Atewa was listed as an Important Bird Area (IBA) by BirdLife International, one of 36 such areas in Ghana (Ntiamoa-Baidu et al. 2001).

Historically, Atewa has been recognized as a nationally important reserve because the Atewa Range provides the headwaters of three river systems, the Ayensu River, the Densu River and the Birim River. These three rivers are the most important source of domestic and industrial water for local communities as well as for many of Ghana's major population centers, including Accra. Thus, the Atewa forests protect and provide a clean water source for much of Ghana's human population and for key elements of the country's biodiversity.

SCOPE OF PROJECT

In addition to high biodiversity, Atewa is known to harbor mineralogical wealth including both gold and bauxite deposits. The Government of Ghana opened several forest reserves for mining in 2001, but Atewa was not included. However, the Government granted an exploration license to ALCOA to prospect for bauxite deposits in Atewa.

Due to the fact that Atewa had been classified as a Globally Significant Biodiversity Area (GSBA), ALCOA entered into an agreement with Conservation International (CI) to assist them in better understanding the biodiversity context of Atewa in order to incorporate biodiversity into the company's risk assessment and Environmental Impact Assessment of the project, should it proceed. This partnership involved applying CI's Initial Biodiversity Assessment and Planning (IBAP) methodology to increase understanding of an area's ecosystems and socio-economic dynamics and to provide recommendations for incorporating biodiversity considerations in the earliest stages of decision-making. This partnership was formed in the spirit of providing significant gains for biodiversity conservation and industry, as well as for the government and people of Ghana.

Previously, ALCOA and CI had partnered successfully to utilize the IBAP methodology and conduct biodiversity surveys in Guinea (West Africa) and Suriname (South America). For Atewa, CI first worked with partners to conduct desktop and preliminary field research on Atewa's biodiversity in 2005, followed by a Rapid Assessment Program (RAP) survey in June 2006 to assess a wide range of taxa, as well as potential threats to and opportunities for conservation in Atewa. Following the RAP survey, a consultative workshop was held at the Palace of Paramount Chief Okyehene in Kibi on June 26, 2006 with participation from local community members and Chiefs, representatives from ALCOA and several NGOs, and several of the RAP scientists (see Appendix 11 for complete list of participants).

RAP EXPEDITION OVERVIEW AND OBJECTIVES

Conservation International's Rapid Assessment Program (RAP), a department within the Center for Applied Biodiversity Science (CABS), was founded in 1990 in response to the increasing loss of biodiversity in tropical ecosystems. RAP is an innovative biological inventory program designed to generate scientific information to catalyze conservation action in tropical areas that are under imminent threat of habitat conversion.

Together with CI's Ghana program and Center for Environmental Leadership in Business (CELB), RAP organized a rapid biological survey of Atewa in June 2006. Prior to the RAP survey, most biological research had focused on plants and butterflies, with little data available for other taxonomic groups. The primary objective of the RAP survey was to collect scientific data on the diversity and status of species within Atewa in order to make recommendations regarding their conservation and management. The specific aims of the expedition were to:

- Derive a brief but thorough overview of species diversity within Atewa and evaluate the area's relative conservation importance;
- Undertake an evaluation of threats to this biodiversity;
- Provide management and research recommendations for this area together with conservation priorities; and
- Make RAP data publicly available for decision-makers as well as members of the general public in Ghana and elsewhere, with a view to increasing awareness of this ecosystem and promoting its conservation.

RAP CRITERIA

Criteria generally considered during RAP surveys in order to identify priority areas for conservation across taxonomic groups include species richness, species endemism, rare, new to science, and/or threatened species, and critical habitats. Measurements of species richness can be used to compare the number of species per area among areas within a given region. Measurements of species endemism indicate the number of species endemic to some defined area and give an indication of both the uniqueness of the area and the species that will be threatened by degradation or loss of that area's habitats (or conversely, the species that will likely be conserved through protected areas). Describing the number of critical habitats or sub-habitats within an area identifies sparse or poorly known habitats within a region that contribute to habitat variety and, therefore, to species diversity.

RAP scientists use the IUCN Red List of Threatened Species (IUCN 2007) to determine if species are globally threatened. Categories, from most to least threatened include: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC). Assessment of rare and/or threatened species that are known or suspected to occur within a given area provides an indicator of the importance of the area for the conservation of biodiversity. The presence or absence of such species also aids assessment of their conservation status. Many species on the IUCN Red List carry increased legal protection, thus giving greater importance and weight to conservation decisions.

RAP TEAM AND FOCAL TAXONOMIC GROUPS

The RAP survey's 20-member, multi-disciplinary team included representatives from the Wildlife Division of the Forestry Commission, Water Research Institute, the Faculty of Renewable Natural Resources, the University of Ghana, the Kwame Nkrumah University of Science and Technology, the Forestry Research Institute of Ghana, l'Université d'Abobo-Adjamé (Côte d'Ivoire), University of Liège (Bel-

gium), University of Ulm (Germany), Natuurhistorisch Museum Naturalis (Leiden, The Netherlands), and Harvard University (USA).

The RAP team, comprising experts specializing in West Africa's ecosystems and biodiversity, examined selected taxonomic groups to determine the area's biological diversity, its degree of endemism, and the uniqueness of the ecosystem. RAP expeditions survey focal taxonomic groups as well as indicator species, with the aim of choosing taxa whose presence can help identify a habitat type and its condition.

At Atewa, the RAP team surveyed plants, Odonata (dragonflies and damselflies), Orthoptera (katydids), butterflies, fish, amphibians, birds, and mammals (including three mammal survey teams: small mammals, large mammals and primates).

STUDY AREA

Surveys of the 23,665 ha Atewa Range Forest Reserve were conducted over 19 days (6 - 24 June 2006) at the beginning of the rainy season. Each RAP site ranged from lowland and some gallery forest down in the valleys to highland forest in the upper elevation as a result of the plateau formations. The mountain range, which peaks at 842 m a.s.l. (SRTM90 data), runs roughly from north to south and is characterized by plateaus, which are remnants of a Tertiary peneplain. In addition to the three sites described below, the fish and dragonfly teams sampled streams and rivers (namely the Birim, Densu and Ayensu) and associated standing water habitats, with headwaters located within the reserve, as well as freshwater sites outside the reserve.

Atewa lies within two climatic zones: the dry and the wet semi-equatorial transition zone. The larger, northern portion of Atewa lies in the wet semi-equatorial climatic zone, which is characterized by high temperatures and a double maxima rainfall regime. It has a mean monthly temperature of between 24 and 29°C, and experiences a mean annual rainfall of between 120 and 1600 mm. The first rainfall peak occurs in May-July with the second one occurring in September-November.

The area also lies in two vegetation zones. The transitional climatic zone and the thicket vegetation is the result of human activities in the form of land cultivation, logging, and extraction of fuel wood. The vegetation cover also includes elephant grass, and the invasive "Siam weed" or "Acheampong weed" (*Chromolaena odorata*). North of this zone, and covering about 80% of the Akyem Abuakwa area is a moist deciduous forest. Unlike the evergreen forest, some of the trees in the moist deciduous zone shed their leaves during various periods of the year. However, trees of the lower layer of the zone remain evergreen throughout the year. About 17,400 ha of the reserve is Upland Evergreen forest. Atewa is one of only two forest reserves in the country in which this forest-type occurs, the second one being Tano Ofin, and these two reserves together hold approximately 95% of the Upland Evergreen forest in the country. The diverse flora of Atewa contains submontane elements, with characteristic herbaceous species, and abundant and diverse epiphytic and terrestrial ferns; a number of plant species found here are not known to occur elsewhere in Ghana. The bowals (seasonal marshy grasslands on bauxite outcrops), swamps and thickets that occur here are also thought to be nationally unique.

Overall, Atewa is considered to have a forest condition score of 3 (on a scale of 1-6), which indicates that it is slightly degraded but has predominantly good forest with healthy and abundant regeneration of timber trees and other forest plants (Hawthorne and Abu-Juam 1995).

RAP camps were established at three sites within Atewa. The RAP sites were chosen to coincide with areas of high biodiversity and concentrated bauxite deposits (Atiwiredu, Asiakwa South and Asiakwa North) that had been earmarked for exploitation activities by ALCOA. The most southern part of Atewa was not surveyed because it is fairly degraded and was not a focus of ALCOA's activities at the time of the RAP survey.

Site 1 (Atiwiredu) was located at 6°12'24.7"N, 0°34'37.2"W, at an elevation 795 m, and sampling was conducted here from 6 – 10 June, 2006. This site had an extensive network of roads, and was subject to prospecting activity by ALCOA. Despite this activity, the forest condition was rated as 2 by the botanical team, indicating a low level of disturbance. Two plant species endemic to Upper Guinea, *Neolemonniera clitandrifolia* and *Aframomum atewae*, were present at the site, and the dominant trees were *Cola boxiana* and *Chidlowia sanguinea.* This site showed evidence of previous logging of economically important tree species. There were also indications of hunting (spent cartridges, snares, and hunting trails.)

Site 2 (Asiakwa South) was situated at 6°15'44.3"N, 0°33'18.8"W, at an elevation of 690 m, and sampling was conducted here from 11 – 16 June, 2006. This site, while not currently subject to prospecting activity, still contained an extensive network of roads from previous exploration activity, some overgrown with tall grasses. These roads appear to act as passages allowing the penetration of invasive elements, such as grasses or species of insects normally associated with open habitats, deep into the forest. The condition of the forest at this site was rated as 3, and the dominant tree species were *Rinorea oblogifolia* and *Hymenostegia afzelii*. This site showed evidence of hunting (spent cartridges, wire snares) and harvesting of chewing stick, sponge and cane. However, there were no signs of previous farming activities.

Site 3 (Asiakwa North) was located at 6°16'16.4"N, 0°33'52.8"W, elevation 769 m, and was sampled from 16 – 24 June, 2006. Most of the site was covered with tall, closed-canopy forest, with little underbrush and no open roads. Its condition was rated as 2, and the dominant tree species was *Rinorea oblongifolia*. There were few gaps in the forest, which

accounts for the low number of species associated with such habitats. The only gaps present were overgrown with tall, broad-leaved plants of the family Marantaceae. Of the three sites sampled, this site showed the most extensive evidence of hunting, with hundreds of spent cartridges, wire snares, and an extensive network of hunting trails.

RAP RESULTS

The results of this RAP survey confirm that Atewa is a site of extremely high importance for global biodiversity conservation and should be protected in its entirety. This forest reserve represents the last intact piece of Upland Evergreen forest in Ghana and is a critical source of clean water for the local people and many of Ghana's human population cen-

Table 1. Species of conservation concern recorded in the Atewa Range Forest Reserve during the RAP survey.

Taxon	Species name	Common name	Threat status*	Sites		
				Atiwiredu	Asiakwa S	Asiakwa N
Amphibian	*Conraua derooi*		CR		x	x
Amphibian	*Hyperolius bobirensis*		EN	x	x	
Amphibian	*Phrynobatrachus ghanensis*		EN	x		
Plant	*Neolemonniera clitandrifolia*		EN / Black star			x
Amphibian	*Kassina arboricola*		VU	x	x	
Bird	*Bleda eximius*	Green-tailed Bristlebill	VU			
Bird	*Criniger olivaceus*	Yellow-bearded Greenbul	VU			
Bird	*Melaenornis annamarulae*	Nimba Flycatcher	VU			
Primate	*Colobus vellerosus*	Geoffroy's pied colobus	VU	x	x	x
Plant	*Sapium aubrevillei*		VU / Black star			x
Amphibian	*Amietophrynus togoensis*		NT	x		
Amphibian	*Acanthixalus sonjae*		NT	x		
Amphibian	*Afrixalus nigeriensis*		NT	x	x	
Amphibian	*Afrixalus vibekensis*		NT		x	
Amphibian	*Phrynobatrachus alleni*		NT	x		
Bird	*Bycanistes cylindricus*	Brown-cheeked Hornbill	NT			
Bird	*Illadopsis rufescens*	Rufous-winged Illadopsis	NT			
Bird	*Lamprotornis cupreocauda*	Copper-tailed Glossy Starling	NT			
L. Mammal	*Anomalurus pelii*	Pel's flying squirrel	NT	x		
Sm. Mammal	*Crocidura grandiceps*	Large-headed shrew	NT	x		
Sm. Mammal	*Scotonycteris zenkeri*	Zenker's Fruit Bat	NT	x	x	
L. Mammal	*Cephalophus dorsalis*	Bay Duiker	LR/nt	x	x	x
L. Mammal	*Cephalophus maxwelli*	Maxwell's Duiker	LR/nt	x	x	x
L. Mammal	*Cephalophus niger*	Black Duiker	LR/nt			x
L. Mammal	*Cephalophus silvicultor*	Yellow-backed Duiker	LR/nt / Sch. I			x
L. Mammal	*Neotragus pygmaeus*	Royal Antelope	LR/nt	x	x	x
Primate	*Procolobus verus*	Olive colobus	LR/nt		x	
L. Mammal	*Epixerus ebii*	Western palm squirrel	DD	x		x
Odonate	*Atoconeura luxata*		VU in WA			
L. Mammal	*Civettictis civetta*	African Civet	Sch. I	x	x	
L. Mammal	*Nandinia binotata*	African Palm Civet	Sch. I	x		x
L. Mammal	*Uromanis tetradactyla*	Long-tailed Pangolin	Sch. I			x
Plant	*Gilbertiodendron splendidum*		Black star	x		x
Plant	*Ixoria tenuis*		Black star		x	x
Plant	*Psychotria longituba*		Black star	x		
Plant	*Psychotria subglabra*		Black star	x		
Sm. Mammal	*Hypsugo [crassulus] bellieri*	Bellier's Broad-headed Pipistrelle	n.a.	x		x
Sm. Mammal	*Pipistrellus* aff. *grandidieri*	Grandidier's Pipistrelle	n.a.			x

* **Threat status**:
IUCN Red List categories: Critically Endangered (**CR**), Endangered (**EN**), Vulnerable (**VU**), Near Threatened (**NT**), Lower Risk/near threatened (**LR/nt**), Data Deficient (**DD**) (IUCN 2007)
Sch. I Species wholly protected in Ghana and listed on Schedule I of the Ghana Wildlife Conservation Regulation
Black star Species ranked as internationally rare and uncommon in Ghana (Hawthorne and Abu-Juam 1995)
n.a. Not assessed by the last IUCN revision due to recent taxonomic results, but when assessed it will be added to IUCN Red List
VU in WA Listed by IUCN as regionally vulnerable for western Africa

ters, including Accra. Our results show that Atewa is still a uniquely important site that continues to harbor a number of rare and threatened species within an intact and unique habitat type (Table 1).

The results of the RAP survey not only corroborate previous designations of Atewa as an important site for biodiversity conservation (see below), but strongly suggest that the biological community present at Atewa represents a very rare example of a relatively intact West African forest, a highly unusual and (from a conservation perspective) highly significant finding. All taxonomic groups surveyed were found to include unique species assemblages that are representative of Upper Guinean rainforest fauna. Atewa harbors a high and unique diversity of dragonflies and butterflies, as well as primates that are highly threatened throughout West Africa (Table 2).

The RAP results add to previous biological data in several ways, most notably by showing that Atewa is an important site for amphibians. An extremely high proportion of threatened amphibian species were recorded (almost one-third of recorded species are Red-Listed), including the Critically Endangered *Conraua derooi*, for which the Atewa Range is likely to hold the largest remaining populations. While this species is historically known from a number of sites close to the Togolese border, recent surveys have recorded it only from some of its previously known localities, where it is under extreme pressure from habitat destruction and consumption. Hence, Atewa could hold the last

Table 2. Number of species documented during the 2006 RAP survey in the Atewa Range Forest Reserve, Ghana and comparison of sites.

	Site 1: Atiwiredu	Site 2: Asiakwa South	Site 3: Asiakwa North	Total
Dates (June 2006)	6 – 11	12-17	18-23	
Elevation (m a.s.l.)	817	783	814	
Habitat	Roads have left habitats fragmented and there is evidence of previous logging	Forest canopy is open in places, especially along hauling roads. Human activities include small-scale harvesting of non-timber forest products and trapping and hunting wild game, particularly along the footpath leading to nearby communities.		
Plants	145 spp.; 3 black star	247 spp.; 1 black star	189 spp.; 4 black star (2 of these recorded only from this site)	314
Dragonflies				72
Butterflies	74 spp.	89 spp. This site appeared to be most disturbed with respect to this taxon.	57 spp.	143*
Katydids	26 spp.	50 spp. Highest species richness for Orthoptera, likely due to a strong edge effect created by dense network of roads	28 spp.	61
Fish				19
Amphibians	26 spp. While results indicate this area has already suffered some habitat degradation, it still harbors the only records for a number of forest specialists	23 spp. Fast-flowing forest streams here hold the Critically Endangered *Conraua derooi*.	6 spp. After rainfall, the Critically Endangered *Conraua derooi* was found here.	32
Birds				155
Small mammals	9 spp.	8 spp.	8 spp.	15
Large mammals	12 spp. Large mammals signs 1.41 times/hour Index of illegal activity: 1.07/hour	14 spp. Large mammal signs 2.9 times/hour Index of illegal activity 1.05/hour Clear evidence of excessive hunting including many spent cartridges and wire snares. High levels of non-timber forest product harvesting.	15 spp. Large mammal signs 2.67 times/hour Index of illegal activity 1.87/ hour Likely to be the best refuge for large mammals in Atewa though shows evidence of excessive hunting.	22
Primates	3 spp.	4 spp. Includes the only records of the Olive colobus (*Procolobus verus*) from the survey.	4 spp.	6

* Includes 13 species recorded outside of RAP survey sites

remaining viable population of this Critically Endangered species and we urgently recommend additional surveys to determine if this is the case (see Conservation Recommendations). In addition, the Atewa population proved to be genetically distinct from the Volta populations and may hence be also biologically unique.

The unique and diverse species assemblages documented during the RAP survey, especially of amphibians, Odonata (dragonflies and damselflies) and fishes, all depend on the clean and abundant water that originates in Atewa for their survival. Millions of Ghanaians also depend on this water source, which is provided by the plateau formations that soak up rain and mist and then hold, clean and discharge the water for all to utilize.

The three sites surveyed during the RAP survey all contain significant biodiversity and important species (Table 2). The RAP team found Asiakwa North to be the most intact and undisturbed. This site may thus serve as a refuge for wildlife displaced from other areas, despite heavy hunting levels recorded here. Asiakwa South contains large populations of the Critically Endangered frog, *Conraua derooi*, as well as the only record of the Olive colobus primate during the RAP survey. Despite being the most impacted site with active mineral prospecting taking place during the RAP survey, Atiwiredu still harbors high biodiversity, including two black star plant species and a high diversity of amphibians.

The RAP results confirm the importance of Atewa for biodiversity conservation, which had already been recognized by many organizations including the Government of Ghana:

- Based on botanical diversity, the reserve was declared a Globally Significant Biodiversity Area (GSBA) in 1999 by the Government of Ghana,
- Based on avian diversity it was designated a globally significant Important Bird Area (IBA) by Birdlife International in 2001,
- As far back as 1926, when it was designated as a national forest reserve by the Government of Ghana, Atewa was recognized as critically important in maintaining important watersheds upon which many Ghanaians (and Ghanaian biodiversity) depend,
- Atewa has previously been recognized as the single most important site in Ghana for butterflies (Larsen 2006),
- The 1999 West Africa Priority Setting Workshop organized by Conservation International identified Atewa as an area of Very High priority for biodiversity conservation (Bakarr et al. 2001),
- Conservation International and partners have been designating Key Biodiversity Areas (KBA), which are sites of global significance for biodiversity conservation that are large enough or sufficiently interconnected to support viable populations of the species for which they are important. KBAs represent discrete sites that are globally vulnerable and irreplaceable and are defined by the presence of threatened species (Eken et al. 2004). While KBAs have yet to be formally designated in Ghana, Atewa will undoubtedly qualify as a KBA when they are determined.

RESULTS BY TAXONOMIC GROUP

Plants A total of 71 plant families comprising 314 plant species were recorded during the RAP survey. An additional 30 leaf specimens were pressed for correct identification. At Atiwiredu, 145 plant species in 43 families were recorded, including three black star species *Gilbertiodendron splendidum, Psychotria longituba* and *P. subglabra*. At Asiakwa South, 247 species in 65 families were confirmed, including one black star species *Ixora tenuis*. A total of 189 species in 53 families were recorded from Asiakwa North, and among these were four black star species. Of these, two were recorded only from this site and are also listed on the IUCN Red List, *Neolemonniera clitandrifolia* (EN) and *Sapium aubrevillei* (VU).

Odonates (Dragonflies and Damselflies) A total of 72 species were found in the streams and rivers that have their headwaters within the reserve (and associated standing water habitats), although only 31 (43%) were found strictly within the reserve's boundaries. Eight species were recorded in Ghana for the first time, of which six (75%) were recorded inside the reserve. Of these, *Atoconeura luxata* is the most significant discovery because: 1) it had not been described at the time and material taken during the RAP was included in its recently published description; 2) it is the only regionally threatened dragonfly in western Africa that is found in Atewa (VU); and 3) it confirms the nationally unique 'montane' character of the site.

Butterflies Overall, 143 species belonging to 55 genera in five families were recorded during the Atewa RAP survey. The composition of butterfly species is plainly indicative of a good forest habitat. The suspected presence of *Tetrarhanis baralingam, Neaveia lamborni* and *Bicyclus auricruda* in Atewa were confirmed during this survey. At present, *N. lamborni* and *B. auricruda* have not been recorded from any protected area in Ghana. Almost half of the 17 rare species recorded during the RAP survey are known either exclusively from Atewa or from just one other protected area in Ghana. Four of these rare species (*Mimeresia cellularis*, *Heteropsis peitho, Vanessula milca* and *Euphaedra splendens*) have been recorded exclusively from Atewa.

Interesting *Catuna* forms were noted, perhaps an indication that new (sub)species of the genus may be residing on the reserve. The RAP survey documented 16 endemic species of which two (*Euphaedra mariaechristinae* and *Ceratrichia maesseni*) are endemic to Ghana. The remaining are endemic

to the West Africa sub-region. Atewa provides a haven for many West African endemics. Ten such endemic species are so far known in Ghana only from the Atewa Range and might well be limited in Ghana to this reserve. The very high index of biodiversity, the presence of many endemic species, and several other species known from nowhere else in Ghana, and the pan-African rarity status of many of those species present in Atewa combine to indicate that its conservation importance is of the highest priority.

Orthoptera (Katydids) A total of 61 species of Tettigoniidae were collected, the highest number of katydids known from a single location anywhere in Africa. Of these, at least 8 are new to science, and 36 are new to Ghana. Site 2 (Asiakwa South) showed the highest species richness (50 spp.), likely due to a high edge effect created by a dense network of roads. The high diversity of sylvan katydids (Pseudophyllinae) and the mecopodines (Mecopodinae) (21 species total) indicate a low level of disturbance of the forest habitats within Atewa. However, the extensive network of roads in the reserve is already allowing for penetration of savanna species (*Ruspolia* sp.) into the reserve.

Other Invertebrates A new species of spider tick (order Ricinulei, Arachnida) was discovered within Atewa. This new species represents only the 58th known species of this ancient, relict group of organisms, known only from a few sites in the northern part of the Neotropics and West Africa. This is also the largest known species in this group. Its presence at Atewa indicates that this site may play a role of a refuge to organisms that have vanished from surrounding areas due to habitat loss and/or climate change. In addition, 68 ant species were documented during the RAP survey (Appendix 5).

Fishes The freshwater ecosystem studied during this RAP survey included the streams of Atewa, an area protecting the headwaters of the Ayensu, Birim and the Densu river basins, and from which these basins originate. A total of 15 streams within the Atewa forest and at sites just emerging out of the forest were surveyed and their fish fauna documented. Nineteen species of freshwater fish were recorded during the RAP survey, belonging to nine genera of five fish families: Mormyridae, Characidae, Cyprinidae, Cyprinidontidae and Cichlidae. All species encountered in the present study have been recorded in river basins in West Africa, but *Epiplatys chaperi spillamanni*, which we recorded in the Ayensu system, was previously known only from Côte d'Ivoire.

Amphibians We recorded a total of 32 species, but predict that overall species richness of the area can be expected to reach 40-50 species. The amphibian community of the Atewa Range is exceptional in comprising a) almost exclusively forest species, indicating an intact forest ecosystem, b) a very high percentage of species that are endemic to the Upper Guinea forests or even much smaller parts of these forests, and c) an extremely high proportion of threatened species (almost one-third are ranked as threatened on the IUCN Red List). For one Critically Endangered species (*Conraua derooi*) the Atewa Range is likely to harbor the largest remaining population in the world. The occurrence of other rare, endangered, or undescribed species at Atewa is likely.

Birds During 16 days of field work in Atewa, 155 bird species were recorded. Of these, six are of conservation concern, amongst which three are classified as Vulnerable and three as Near Threatened. Six of the 11 species restricted to the Upper Guinea Forests Endemic Bird Area and 115 (or 64 %) of the 180 Guinea-Congo Forests biome species now known from Ghana were observed during the study. A song, heard and partly tape-recorded, was thought to be from the Nimba Flycatcher *Melaenornis annamarulae*, a Vulnerable species not previously found in Ghana; this record has since been confirmed and constitutes a major eastward range extension. The site, listed in 2001 as an Important Bird Area, was found to have a remarkably rich avifauna, with relatively large mixed-species flocks being a particularly conspicuous feature. Some species, such as Green-tailed Bristlebill *Bleda eximius* and Yellow-bearded Greenbul *Criniger olivaceus*, are at the eastern limit of their known range here. Several species that are rare in Ghana and uncommon to rare in their global range also occur in the reserve.

Small Mammals A total of 12 bat species were recorded. Composition of bat species clearly reflects a forest assemblage, with no savanna species being observed. Two rarely recorded bat species (*Hypsugo crassulus bellieri* and *Pipistrellus* aff. *grandidieri*) are reported for the first time for Ghana, raising the total number of species for this country to 86. Together with specimens from five localities in West Africa, *Pipistrellus* aff. *grandidieri* from Atewa might represent a species new to science. *Hypsugo* [*crassulus] bellieri* is endemic to the Upper Guinean forests. Zenker's fruit bat *Scotonycteris zenkeri* is ranked by the IUCN Red List as Near Threatened (IUCN 2007). The three terrestrial small mammal species recorded during the survey are likewise forest-dependent and include two West African endemics: Edward's swamp rat *Malacomys edwardsi* and the shrew *Crocidura grandiceps*. The latter is ranked as Near Threatened by the IUCN Red List and had not been recorded from Ghana since its description. The overall species composition of small mammals indicates high habitat integrity of Atewa, which constitutes the most significant block of Upland Evergreen forest in Ghana.

Large Mammals Altogether, 22 species were found at the three RAP sites with 12, 14 and 15 species recorded from Atiwiredu, Asiakwa South and Asiakwa North respectively. Of the species recorded, Pel's flying squirrel (*Anomalurus pelii*) is ranked as Near Threatened, Yellow-backed duiker (*Cephalophus silvicultor*), Black duiker (*Cephalophus niger*), Bay duiker (*Cephalophus dorsalis),* Maxwell's duiker (*Cephalophus maxwellii*) and Royal antelope (*Neotragus pygmaeus)* are classified as Lower Risk/Near Threatened, and West palm squirrel (*Epixerus ebii*) is listed as Data Deficient on the IUCN Red List. In addition to these

Table 3. Numbers of Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) amphibians, birds and mammals recorded during RAP surveys of 16 West African sites. # IUCN refers to species listed under the above categories plus Near Threatened (NT) and Data Deficient (DD). *preliminary results

	Côte d'Ivoire		Guinea					Liberia			Ghana					
	Haute Dodo	**Cavally**	**Pic de Fon**	**Déré**	**Diécké**	**Mt. Béro**	**Boke**	**North Lorma**	**Gola**	**Grebo**	**Draw River**	**Boi-Tano**	**Krokosua**	**Atewa**	**Ajenjua Bepo***	**Mamang River***
Area (ha)			25,600	8,920	59,143	26,850	N/A	71,226	202,000	260,326	23,540 (GSBA 12,800)	12,850 (GSBA 3,300)	48,170	23,663	569	5,300
# sites	1	1	2	1	2	1	3	1	1	1	1	1	1	3	1	1
# survey days	8	8	11	3	8	6	18	6	7	5	5	5	5	16	7	5
# IUCN	30	42	24	14	33	25	8	27	22	39	22	17	14	26	2	4
# CR	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
# EN	3	4	2	0	4	0	2	5	2	3	4	3	1	2	0	0
# VU	7	8	4	3	5	6	0	4	5	10	5	5	2	5	0	1

species of international conservation concern, the African civet (*Civettictis civetta*), African palm civet (*Nandinia binotata*), Long-tailed pangolin (*Uromanis tetradactyla*) and Yellow-backed duiker (*Cephalophus silvicultor*) are nationally protected in Ghana. Interviews in fringe communities indicated that four additional mammal species are possibly present in the reserve, while five others could now be locally extinct. Many illegal activities, especially related to hunting, were recorded during the assessment. It was also noted that deforestation along trail lines and occasional illegal farms could be a significant factor affecting the conservation of large mammals in Atewa.

Primates Overall, six primate species belonging to four families were identified in Atewa, including two families of nocturnal prosimians represented by the potto, *Perodicticus potto* and Demidoff's galago, *Galagoides demidovii.* Four diurnal simians belonging to two families were also identified, including two Red-Listed colobus monkeys: Geoffroy's pied colobus, *Colobus vellerosus* (VU) and Olive colobus, *Procolobus verus* (LR/nt) and as well as two cercopithecine monkeys: the lesser spot-nosed monkey, *Cercopithecus petaurista buettikoferi* and Lowe's monkey, *Cercopithecus campbelli loweï*. The RAP results suggest that Sites 2 and 3 appear to be the most important for primates in Atewa and particularly slopes and plateaus within these sites, at least during this season of the year. The least evidence of primates per environmental category was recorded in valleys. Nevertheless, observations of fruit remains suggest that, in terms of primate diet, the gallery forest found in valleys constitutes an important habitat. The primate populations of Atewa require the integrity of this mountainous biotope (including plateaus, slopes and valleys) to survive.

RESULTS FROM THE CONSULTATIVE WORKSHOP

Following the RAP biodiversity survey, a workshop was organized to discuss the findings of the survey with chiefs, elders and community members of Akyem Abuakwa Traditional area. The workshop was chaired by the Chief of Asiakwa and was attended by 70 participants including politicians, government agencies and local NGOs.

The objectives of the consultative workshop were to 1) Review the results of the Atewa RAP survey, 2) Identify current uses of Atewa's biodiversity and how these uses are perceived to impact the forest's biodiversity, and 3) Identify actions that can be undertaken to mitigate biodiversity impacts to conserve Atewa's biodiversity and benefit surrounding communities. Appendix 10 provides a summary of the biodiversity uses, users/stakeholders, impacts of use, and suggested actions for conserving Atewa's biodiversity assets as discussed by three working groups during the workshop.

The workshop concluded that there is need for consultation involving all government agencies and companies involved in making decisions about the future uses and protection of Atewa. The workshop participants acknowledged the initiatives taken by ALCOA and encouraged ALCOA

and others to continue to:

a) Deepen the level of commitment to consultation, as the communities would like to see more direct interactions between themselves and others and to be better informed,

b) Take traditional practices into consideration in every interaction with communities and the forest,

c) Demonstrate social responsibility in hiring practices, hiring from local communities whenever possible,

d) Relate and interact with all community chiefs during all project stages, and

e) Strengthen monitoring of the forest and its exploitation.

Representatives from the Ministry of Lands, Forestry, and Mines and the Forestry Commission expressed their support for conducting community consultations and keeping communication open with local communities about the future of Atewa. The participants in the workshop are listed in Appendix 11.

REGIONAL COMPARISONS OF BIODIVERSITY

To evaluate relative conservation significance, the Atewa RAP survey results were compared with results from seven other West African RAP surveys, covering 16 West African forest reserves (McCullough 2004; Alonso et al. 2005; McCullough et al. 2005, in prep; Wright et al. 2006a, b; Hoke et al. 2007). Direct comparison between the 16 sites is difficult due to wide variation in sampling effort and habitat types. However a number of observations as to the relative conservation value of Atewa can be made.

Appendix 12 lists IUCN Red-listed amphibian, bird and mammal species recorded from the 16 reserves studied during West African RAP surveys (excluding Schulenberg et al. 1999) and Table 3 presents summary statistics on the numbers of threatened species within these taxa recorded from each site. Of all 16 sites, only Atewa was found to hold any species of these taxa listed by the IUCN as Critically Endangered, the highest threat level possible. The frog *Conraua derooi* was recorded in Atewa and it is thought that this area may harbor the most important remaining populations of this species. *Conraua derooi* was originally described from western Togo (Hulselmans 1971) and apart from there is only known from a few Ghanaian sites, close to the Togolese border (Schiøtz 1964 as *C. alleni*). Until very recently it had never been found again, although numerous suitable habitats were searched (Rödel and Agyei 2003, Leaché et al. 2006). Sites at which this species has previously been recorded are all close to human settlements and hence the persistence of the species in these areas is uncertain (A. Hillers et al. unpubl. data). Hence, this is an extremely important finding.

Table 4 shows the number of bird species recorded during each survey, followed by the number of species of birds

Table 4. Number of bird species recorded during West African RAP surveys, including the number of species restricted to the Upper Guinea Endemic Bird Area (EBA) and Guinea-Congo Forest biome.

	Côte d'Ivoire		Guinea				Liberia			Ghana					
	Haute Dodo	Cavally	Pic de Fon[1]	Déré	Diécké	Mt. Béro	Boke	North Lorma	Gola	Grebo	Draw River	Boi-Tano	Krokosua	Atewa	Ajenjua Bepo	Maman River
# bird species	147	153	233	140	150	189	239	143	145	156	126	109	138	155	121	115
Upper Guinea EBA	8	7	6	4	7	6	n/a	7	6	9	4	3	5	6	1	2
% Guinea-Congo forests biome	61%	63%	68%	56%	67%	51%	n/a	53%	49%	62%	53%	46%	54%	64%	44%	43%

making up the Upper Guinea Forests Endemic Bird Area and number of Guinea-Congo Forest biome species recorded from each site. While the total number of bird species recorded at Atewa is not exceptionally high when compared to several other reserves in other parts of West Africa (in Pic de Fon, Guinea, 233 species were recorded in 11 survey days), Atewa shows the highest number of bird species recorded from any of the reserves surveyed during other Ghana RAP surveys, and a higher proportion of Upper Guinea Endemic Bird Area species and Guinea-Congo Forest biome species as well. Longer survey time at Atewa can partially account for these higher numbers, but the 2005 RAP survey of Draw River, Boi-Tano and Krokosua Hills covered the same number of survey days and recorded 170 species from all three sites. These sites covered a number of different habitat types with the first two sites located in Ghana's Wet Evergreen forest and the third site (Krokosua Hills) over 100 km to the north and in the Moist Semi-deciduous forest, north-west subtype. Additionally, survey methods in the 2005 survey included mist-netting which was not employed during the Atewa survey; this can be expected to increase the species list as well.

In 1999, the Government of Ghana implemented the legal establishment of Globally Significant Biodiversity Areas (GSBAs), designated based on the Genetic Heat Index (GHI) of a reserve's botanical species. For the purpose of prioritizing plant conservation in Ghana, each plant species has been assigned to a star category, based on rarity. Black star species are internationally rare and uncommon in Ghana and urgent attention to the conservation of these species is called for. A high GHI signifies that an area is relatively rich in rare, black star species such that loss or degradation of the area would represent a highly significant erosion of genetic resources from the world, and from Ghana in particular (Hawthorne and Abu-Juam 1995). Atewa has been designated as a GSBA, but Atewa's GHI is lower than that of both Draw River and Boi-Tano (though higher than Krokosua Hills). However, Atewa is considered to be of high conservation importance primarily because of its Upland Evergreen Forest vegetation (Hall and Swaine 1976, 1981) rather than due to the presence of a large number of endemic species. As far as is known, there are no endemic plant species found in the Atewa Range. However, several species from Atewa (like *Aframomum atewae, Epistemma assianum, Hymenocoleus multinervis,* and *Ixora tenuis*) are known from only a few other places and most of these other locations are threatened or already degraded.

Atewa is also extremely important for insects, which are key to healthy ecosystem functioning. The RAP survey revealed that Atewa harbors the highest number of katydids known from a single location anywhere in Africa. Of these, at least eight species are new to science, and 36 species are new to Ghana. In addition, Atewa has long been known as a center of butterfly diversity for Ghana and West Africa and is now known to harbor the highest diversity of butterflies in all of West Africa (Larsen 2006, Chapter 5). This is not due to higher levels of collecting effort at Atewa since Larsen has done intensive butterfly research throughout Ghana and West Africa. Larsen has recorded a total of 575 butterfly species in Atewa and estimates that there are at least 700 species there (Chapter 5). This high diversity includes at least two species endemic to Atewa, many rare species that are not elsewhere in Ghana, and the magnificent *Papilio antimachus*, which has the widest wingspan of any butterfly in the world. Larsen has recently proposed ranking the Atewa endemic, *Mylothis atewa,* as Critically Endangered, the highest threat level on the IUCN Red List of Threatened Species.

CONSERVATION CONSIDERATIONS

Between 1990 and 2005, the deforestation rate in Ghana was very high (2.0%) compared to most other countries in West Africa, resulting in the loss of 25.9% (1,931,000 ha) of Ghana's forest cover over 15 years (FAO 2006). Degradation and depletion of forests through logging, bushmeat hunting, encroaching agriculture and mining activities has severely reduced and fragmented the country's forest cover. Only designated forest reserves still contain significant forest blocks that serve as source areas for a broad variety of animal and plant species, protect watersheds and maintain Ghana's climate, thereby providing essential goods and services for the human population of the country (Agyarko 2001). Atewa constitutes the largest and most intact patch of Upland Evergreen forest in Ghana, representing at least 75% of this habitat type countrywide. This forest reserve is distinguished by one of the highest levels of biodiversity in Ghana, for butterflies the highest in the country and in all of West Africa (Larsen 2006, Chapter 5).

Recent studies have stressed the importance of maintaining larger intact forest blocks like Atewa to protect the last strongholds of forest-dependent species in Ghana. A study of the effects of habitat fragmentation on birds in Ghana revealed dramatic influence of patch size on species composition with only the largest fragments harboring area-sensitive species (Beier et al. 2002). Negative effects of climatic alterations as a result of fragmentation were demonstrated by Hill and Curran (2003). Montane areas are a particular case: as a result of orthographic precipitation (mist and rainfall on mountain slopes and plateaus) these areas have offered long-term environmental stability and acted as refuges during drier times in the past. In line with this argument, Ricketts et al. (2005) predicted that future extinctions will be mainly found in species that are restricted to mountains. Atewa is the only significant Upland Evergreen Forest that remains between the Upper Guinea Highlands in the West and the Cameroon Mountain Range in the East.

Struhsaker and Oates (1995) have long warned of the critical situation of Ghana's forest fauna and the potentially tragic consequences for primate diversity of continued forest exploitation. Amongst the ten forest species of monkeys occurring in Ghana, three species, all endemic to southwestern Ghana and eastern Côte d'Ivoire, are highly threatened by extinction (Oates et al. 1997). Given the particular context and history of Ghana, each forest fragment presently populated by primates, regardless of size, should be actively pro-

tected from further destruction and fragmentation. The rich and original upland ecosystem of Atewa is a relatively large and isolated forest fragment, which constitutes an irreplaceable refuge for six primate species including two threatened species of colobus monkeys (IUCN 2007).

CONSERVATION RECOMMENDATIONS

With an area of 23,663 ha, Atewa represents one of the largest remaining forest blocks in Ghana and one of the largest GSBAs. In Ghana there is no other place like Atewa. The only other Upland Evergreen forest, in the Tano Ofin Forest Reserve, is smaller and significantly more disturbed, and the mountains near the border with Togo have a much drier climate. Outside Ghana there are no upland forests with a similar combination of species.

It is clear from the results of the RAP survey and previous studies that the Atewa Range Forest Reserve is an extremely important site for global biodiversity conservation and should be protected to the fullest extent possible. However, at the same time, the livelihood of the communities around Atewa must be considered in order to ensure long-term protection of the forest.

In order to protect the integrity of Atewa and its biodiversity, we propose two principal recommendations:

I. Within Atewa, the Government of Ghana should delimit and establish an integrally protected area with high protection status, such as a National Park, that includes all remaining intact Upland Evergreen forest, especially on the plateaus. A buffer zone covering the more disturbed slopes and valleys of the reserve should be established surrounding the core protected area.

II. To ensure the sustainable protection of Atewa, alternative incomes for the local communities, particularly in Kibi, must be developed to reduce or eliminate their dependence on extractive industries and forest products from Atewa.

To elaborate:

I. We recommend that the entire Atewa Range Forest Reserve be protected to the fullest extent possible due to its: 1) High levels of biodiversity (documented during this RAP survey and previous studies), 2) Significant tract of rare Upland Evergreen forest, and 3) Importance as a clean water source for local communities and many of Ghana's metropolitan areas. We recommend that the legal status of the reserve be upgraded to prohibit all exploitative activities, including mining, logging, and agriculture in the reserve**.**

The entire extent of Atewa's Upland Evergreen forest must be protected because focusing conservation effort on only a part of the range (such as only the northern part) would lead to greater fragmentation of this unique forest habitat, loss of its function as a biodiversity corridor, and, ultimately, the likely loss of many of its species due to microclimatic changes caused by diminishing forest coverage and invasion of savanna elements into the reserve. The value of Atewa lies not only in the presence of rare or threatened species within its borders and the multiple ecosystem services provided by this biotic community (including, but not limited to, being a significant source of water to surrounding areas), but also in being a unique and a very complex ecosystem, one with a combination of species found nowhere else on the planet.

Any alterations to its present, largely undisturbed state will likely lead to a more depauperate and homogenous biological community with a lesser value to global biodiversity and, on a local scale, the area will become a less effective provider of ecosystem services such as pollination of surrounding agricultures or provision of freshwater. Even selective clearing of the plateaus would undeniably affect headwaters of major rivers and could have long-term destructive consequences on the environment, principally by increasing soil erosion on surrounding slopes and disturbing the hydrographical net of the entire sub-region. Habitat loss would put a number of species under serious threat of local extinction.

Specific recommendations:

1. **Delimit and establish an integrally protected area with high protection status, such as a National Park, that includes all the remaining intact Upland Evergreen forest within Atewa, especially on the plateaus**. We agree with previous recommendations for Atewa (Hawthorne 1998) that many parts of the lower slopes are heavily over-used and degraded and that priority areas for protection should be the forests on the higher altitude plateaus, slopes, and ravines as well as the forest remaining on the steep slopes. All forests on the plateaus merit strict protection, including the 17,400 ha covered with Upland Evergreen forest.

   Critical areas that must be included in the core area are: a) The entire northern part of the Atewa Range, which is most intact, including the Asiakwa South and North RAP sites, which have high levels of biodiversity, a critically endangered frog species, and the Olive colobus primate (see Table 4), b) The central plateau area, including Atiwiredu, which has two black star tree species and a high diversity of amphibians and butterflies, c) Any Upland Evergreen forest areas remaining in the reserve, and d) All plateau swamps and wetlands, which soak up the rainwater and provide the source of the Ayensu, Birim, and Densu rivers.

2. **Establish a buffer zone covering the more disturbed slopes and valleys of the reserve, particularly in the southern areas of the reserve, for use by local com-**

munities within the Akyem Abuakwa Traditional Area. We concur with recommendations by Hawthorne (1998) that there is great pressure on the lower slopes that will most likely result in continued land use. The lower slopes should be incorporated into a buffer zone surrounding the protected area, within which sustainable land use practices should be developed that will restore and reforest degraded land.

3. **Re-evaluate then Implement and Enforce the Atewa Management Plan created by the Forestry Commission of Ghana.** Much thought and research has already gone into evaluating the importance of Atewa's biodiversity and watershed values, and in developing a management plan for its sustainable use (Abu-Juam et al. 2003). Based on the additional information from the RAP survey and other recent research, we recommend that Atewa be fully protected. If this recommendation is accepted and implemented, the Atewa management plan will likely need to be revised to incorporate management of a protected area and a buffer zone. A management plan should include the sustainable use of forest products (chewing sticks, fuel wood, etc.) in the buffer zone to ensure that they are not depleted. The new management plan should then be put into practice and enforced by the Government of Ghana in order to ensure that the area is protected.

4. **Implement a collaborative approach between public and private institutions**, including local communities, the Government of Ghana, international funding and aid agencies, the mining industry and environmental and social non-governmental organizations (NGOs) to address and halt the threats currently and potentially facing the reserve. Include scientific organizations and universities to improve our scientific knowledge of the area and to use these data for management of the protected area. The delineation and mechanism for protecting Atewa must take into consideration the high human population around Atewa, their relatively high level of poverty, as well as their dependence on the forests of Atewa for much of their livelihood.

II. Explore alternative income opportunities in and round Atewa for local communities to reduce their dependence on extractive industries and bushmeat hunting. The people living around Atewa understand the need to conserve this treasured site. They have maintained this area, preserving its biodiversity for all these years. The government has also promulgated all the necessary legislation to the extent that Atewa is designated as a GSBA and the RAP survey and other studies have demonstrated its biological and ecological importance. The issue now at hand is the fact that there is bauxite available for exploitation whilst the people are impoverished. Cocoa, formerly the main economic base of the area, has now disappeared. The main road from Accra to Kumasi, which used to pass through the commercial capital of the Atewa area, has been diverted to save time and short circuit the journey from Accra to Kumasi. The economy of the Atewa area is now in very poor condition. The employment opportunities offered by mining and other development of Atewa are very attractive to people who are in dire need of jobs. Even if the current development plans are abandoned, other development plans and groups will surface in the future. The key to preserving Atewa lies in building an economic base for the local communities that will be an alternative to the exploitation of the bauxite deposits and timber of Atewa.

Specific recommendations:

1. **Ecotourism** is likely the best option for bringing income to the region, particularly to Kibi, by transforming Atewa forest into world class ecotourism center, which will focus on the rare and beautiful species identified during the RAP survey and other studies. Atewa is located just a few hours drive from Accra and Kumasi, which makes it an ideal tourist destination for both local Ghanaian and international visitors. The attractions of Atewa could include birds, butterflies, insects, amphibians, primates, bats, the headwaters of the three rivers, the unique floral species, forest hiking, camp sites, swimming, and a retreat center. Tours could be run through a visitor center or Multi-Use Center (see below) and also through independent tour agents/ NGOs operating out of Kibi and other local villages. Local hotels, restaurants, souvenir stands, and other shops will be needed to support a tourist industry.

   To achieve this, a group of tourism and biodiversity experts should first develop a strategic plan with innovative experiential tourism design for the attractions, something unique comparable to the Kakum canopy walkway, which will attract people in great numbers to the site. The local community must be involved in approving and developing the plans, and eventually take over implementation of ecotourism activities. Alliances with international tour operators will bring additional international adventure and nature travelers to the area. Partnerships with NGOs, companies, and other organizations interested in ecotourism and the conservation of Atewa should be formed. Already, Butterfly Conservation Ghana has been promoting ecotourism visits to Atewa with an international partner, EcoTours (see http://www.ecotours.hu/butterflies/butterflies00/ghana00). Projects such as these should be supported and integrated into the Ecotourism plan for Atewa.

2. **To facilitate Ecotourism, establish a Multi-use Biodiversity Center near to Atewa.** The center should be based at the edge of Atewa so that visitors have easy access to the forest and can enjoy the cooler climate provided by the forest. It should also be located near to Kibi or other villages so they also benefit from tourist visits. The center could contain lodging, kitchen and

dining facilities, an educational center, classrooms, meeting rooms, laboratories, and a library. This center could also provide facilities for Christian or other religious communities to use as a spiritual retreat for prayer and meetings. Support for the center could come from the Christian community (both national and international), national government, international NGOs, private companies, and national and international universities. Most importantly, the center can be built, maintained, and staffed by local community members, thus providing long-term employment opportunities. This center could serve many functions including those listed below:

a) **Research station** to facilitate research of Atewa and surroundings by Ghanaian and international scientists, promote collaborations, and train biology and natural resource management students;

b) **Tourist/visitor center** to bring ecotourism to Atewa and provide information about its biodiversity to visitors and residents;

c) **Education center** to raise awareness of the uniqueness and importance of Atewa: provide classes and training for local communities, jobs for local residents as interpreters and teachers, and opportunities for local and national school children to spend a night in the rainforest, Integration of a research and education center would provide opportunities for Ghanaian scientists and students to share their knowledge and research with tourists and local students;

d) **Spiritual retreat** for the Christian community and/or other local religions to have a place to get away to meet together; both Ghanaian and international Christian groups could use the center as a quiet and spiritual meeting place;

e) **Sustainable employment opportunity** for local community members as builders, managers, maintenance and housekeeping, tour guides, researchers, and research assistants.

3. **Investigate the possibility of a Payment for Ecosystem Services (PES)** scheme through which the users of the water provided by the watershed (e.g. Accra and other cities) pay the local communities around Atewa for protection of the forest and watershed. This would provide income to the surrounding communities in return for keeping the surrounding watershed and forest biodiversity intact. This type of PES scheme has been successfully implemented in many countries, most notably Costa Rica, by governments, NGOs, and private organizations. See McNeely (2007) for more information.

4. **Investigate the current status and investments of international development/aid projects that are reported to be working in the Atewa area**, including the GEF/World Bank/Government of Ghana Community Investment Fund Project, the GEF/World Bank-sponsored Promoting Partnership with Traditional Authorities Project (PPTAP) and the Government of Ghana sponsored Presidential Initiative on Tree Plantations Project on the communities around Atewa to support development of alternative incomes. Small grants can also be applied for through Conservation International's Verde Ventures program (www.verdeventures.org). There are many examples of successful ventures in all of the areas listed below that can be studied and consulted as models for developing such projects in the Atewa area.

5. **Other potential alternative-income industries**:
   a) **Butterfly farming** - for sale of live butterfly pupae to the global market,
   b) **Beekeeping** - producing honey for local consumption and for sale,
   c) **Farming of native ornamental fishes** for aquarium trade,
   d) **Producing products for the tourist trade** such as baskets, Kente cloth weavings, wood carvings, etc.,
   e) **Alternatives to bushmeat hunting**, such as raising other types of animals for meat, including grasscutters and snails,
   f) **Orchards** of fruit trees and nitrogen-fixing crops (e.g. beans) on degraded land to provide food and also stabilize erosion and renew the soil.

RECOMMENDATIONS FOR MANAGEMENT OF ATEWA

I. Control hunting as it poses a significant threat to the large mammals and larger birds within the entire reserve. Hunting pressure is strong throughout Atewa, even in the northern areas where there are no roads. Evidence of hunting, including spent cartridges, snares and hunting trails was found at all three RAP sites (see Table 4). Healthy mammal and bird communities, as well as their associated invertebrate communities, are especially important for maintaining primary and secondary seed dispersal that are essential for plant regeneration and forest dynamics. Although hunting in the reserve currently mainly targets mammals, certain large bird species, such as Crested Guineafowl, Great Blue Turaco and large hornbills, are also illegally hunted.

1) **Prevent access to hunters along roads and trails**. Asiakwa North showed the most hunting evidence even though there are no roads there. There is access to the reserve through an extensive trail system used by local communities. Existing roads at Asiakwa South and Atiwiredu also provide easy access throughout the southern part of the reserve. Most of these trails and existing

roads need to be allowed to grow over and should be patrolled to prevent illegal access to the reserveRegular use of trails by tourists and researchers will also deter illegal access and activities.

2) **Engage local people from communities in the area**, particularly the community of Kibi, in protecting the reserve and reducing hunting. Increase awareness of and pride in the biodiversity and watershed importance of Atewa among the local people through training. Involve local people in research (see below) and enforcement and provide education on the importance of conserving, rather than hunting, large mammals and on alternatives to bushmeat. Work with community Chiefs to establish hunting guidelines and to develop strategies based on their animal totems.

3) **Empower and fund the Wildlife Department and the Forestry Commission** of the Government of Ghana to protect the biodiversity of Atewa through increased monitoring and patrols, especially for illegal hunting (and logging). Enforce penalties for any illegal activities or trespassing.

4) **Make an alliance against hunting with all who have access to Atewa**, including local communities, government agencies, development agencies, and NGOs. This would help to control the distribution and sale of bushmeat from Atewa and educate local people on the importance of protecting globally threatened species that live in their forests.

5) **Conduct research to determine which larger mammal and bird species are targeted and most heavily impacted.** The population sizes of key species that are most heavily hunted and most highly threatened in this area can then be determined and used to inform more specific recommendations on conserving key species threatened by hunting.

II. **Protect the headwaters of the Ayensu, Densu, and Birim rivers that originate within the Atewa Range.** The steady flow of clean water off the Atewa Range is determined by the capacity of the soil, swamps and forest on the plateaus and in the valleys to store and filter rainwater, and to buffer for spates and droughts. Both human and wildlife populations around Atewa depend on this healthy and reliable resource for their survival. The threatened frog species found on the range and the high diversity of dragonflies and damselflies rely on the watershed.

The RAP results indicate a healthy watershed in Atewa and the surrounding area, with limited pollution and streambed erosion. This is confirmed by the presence of forest species even in more disturbed landscapes. However, activities entailing the removal of vegetation or mineral deposits from the range could seriously compromise its capacity to store, buffer and filter rainwater, jeopardizing the reliable discharge of freshwater into the region's rivers, an essential resource for millions of Ghanaians and a rich biodiversity.

1) **Protect the plateau forests in the upper catchment of the Ayensu,** Densu and Birim rivers. Control and restrict access to the forests and swamps, especially with regard to small-scale miners, loggers and shifting cultivation plots. Create a strict protected area on the plateaus as discussed above.

2) **Leave buffer zones of vegetation of at least 100 m around water bodies** (e.g., rivers, swamps and other inundation zones) if any activities are to take place in the reserve (including the Multi-use Station). Any removal of forest cover from stream banks must be rigorously controlled and monitored.

3) **Prevent sedimentation and runoff from mining, roads, and clearings**, which all have negative impacts on the water quality in the streams. Especially in the southern part of Atewa, human activities including logging, agriculture, hunting, and roads currently threaten the integrity of the aquatic ecosystems. These impacts are particularly high in the foothills.

4) **Initiate a water-quality monitoring program of the status of several key aquatic taxa** (including fishes, amphibians, plants, and selected invertebrate groups) as well as water quality and sedimentation to create a baseline and identify negative impacts to aquatic resources before they become irreversible. Monitoring specific responses to certain indicators is essential. We recommend following standard aquatic monitoring protocols at regular intervals (at least twice a year).

5) **Educate local communities on the benefits of preserving riparian flora and fauna** so that they understand the role that riparian vegetation plays in preserving the quality and quantity of their water, as well as preventing soil erosion.

III. **Maintain corridors and large tracts of forest to ensure survival of larger species and to maintain ecosystem processes.** Linking patches of forest by corridors is important to addressing the increasing problem of habitat fragmentation, both within and outside of Atewa. Larger mammal species, such as the threatened primates, and many bird species need large tracts of forest for feeding and nesting. Threatened species have a much higher chance of going extinct in smaller forest patches that have no connection to additional habitat or that lack a large enough elevation range to allow species to adapt to changing conditions and human pressures.

1) **Maintain Corridors along the length of the Atewa Range** to allow for species migrations and adaptations to changes in habitat and human pressures. Keep the northern part of the reserve as intact as possible to maintain a large tract of forest and keep connections to the southern parts of the reserve.

2) **Reforest roads, trails and clearings** that are no longer in use to reduce habitat fragmentation and human access to the forest and to discourage illegal logging, hunting of large mammals, and agricultural production. Trails and other access routes in all three areas should be minimized and regulated and roads should be blocked and reforested to prevent large-scale encroachment into the reserve. The few roads and trails necessary to to provide access for ecotourism and research should be carefully maintained and patrolled to ensure the least possible impact.

3) **Link Atewa to other forest reserves and patches of forest.** Outside of Atewa, the Kwahu plateau forested zone, about 15 km north from Atewa contains similar upland habitat and is consequently a good candidate to connect to Atewa. A feasibility study including assessment of diversity in Kwahu and landscape description should be carried out prior to such an action.

4) **Promote and utilize biodiversity friendly land-use practices** in agricultural areas between forest reserves to maximize biodiversity in the areas surrounding Atewa and to provide a connection between Atewa and nearby forest reserves. This could include minimizing the use of pesticides and herbicides and other chemicals in agriculture, promoting crop rotation and natural pest control, and planting native tree species among crops to harbor wildlife.

5) **Prohibit logging** in the core protected area on the plateaus and upper slopes and strictly control logging in the buffer zone on the lower slopes. Logging accelerates habitat fragmentation and habitat degradation.

6) **Monitor several key species or groups that depend on intact forest** to ensure healthy populations and to detect changes as early as possible to prevent serious declines. Target groups should include large and small mammals, amphibians, and several insect groups. Since small mammals are highly dependent on forest structure for their survival and constitute a key component of the diet of large animals, monitoring small mammal diversity and abundance is a good way to track the integrity of the forest ecosystem.

IV. Conduct in-depth studies focusing on threatened, rare and endemic species, and during other seasons, and expand basic species surveys to include additional groups of organisms.

1) **Conduct studies of the Critically Endangered *Conraua derooi*** in Atewa and other areas where it is known to occur. While this species is historically known from a number of sites, recent surveys have failed to record it from some of its previously known localities. At other sites, it is under sever pressure from habitat degradation and consumption. Hence, Atewa could hold the last remaining viable population of this Critically Endangered species and we urgently recommend additional surveys to determine if this is the case. Areas holding 95% of the remaining population of a Critically Endangered species are eligible for consideration as Alliance for Zero Extinction (AZE) sites, a designation which would increase the significance of Atewa as a conservation target and could potentially increase available funding for conservation activities.

2) **Survey during the dry season.** This RAP survey was conducted during the rainy season when the plants *Mapania bakdwinii* and *Leptapisi cochleata* form a carpet covering much of the forest floor making footprints, dung and other signs of animals difficult to see. Undertaking a similar survey during the dry season and sampling additional areas towards the periphery of the reserve would most likely increase the number of mammal species directly or indirectly encountered, thus adding to the confirmed species list for the reserve.

3) **Conduct additional surveys for groups of organisms not included in previous surveys**, but having a high probability of including rare and/or new species, such as dung beetles, preying mantids, arachnids, or mollusks (both freshwater and terrestrial).

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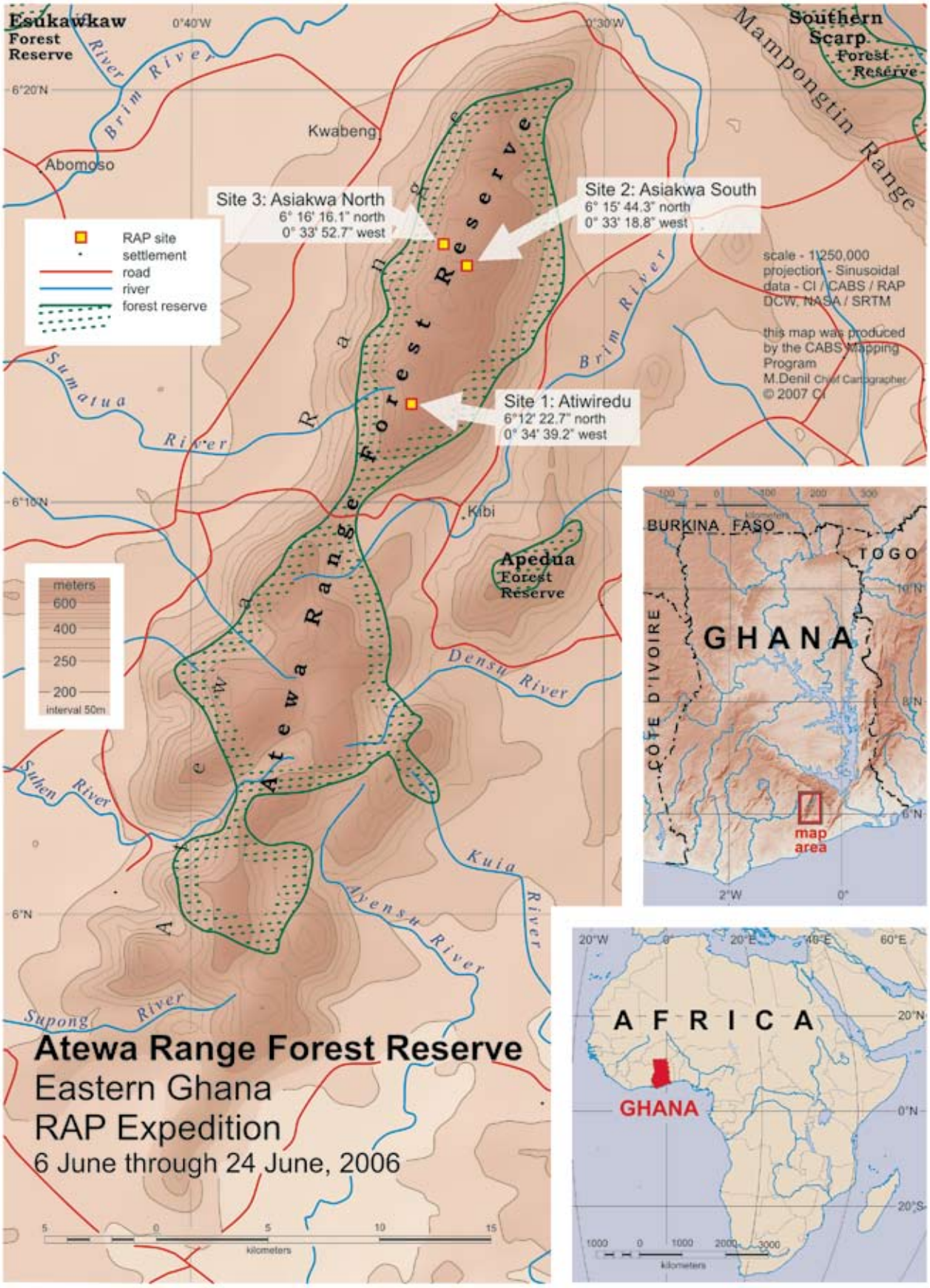
Map


Esukawkaw Forest Reserve
Southern Scarp Forest Reserve
Mampongtin Range
Kwabeng
Abomoso
Site 3: Asiakwa North
6° 16' 16.1" north
0° 33' 52.7" west
Site 2: Asiakwa South
6° 15' 44.3" north
0° 33' 18.8" west
Site 1: Atiwiredu
6°12' 22.7" north
0° 34' 39.2" west
RAP site
settlement
road
river
forest reserve
scale - 1:250,000
projection - Sinusoidal
data - CI / CABS / RAP
DCW, NASA / SRTM
this map was produced by the CABS Mapping Program
M.Denil Chief Cartographer
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Brim River
Sumatua River
Ramsar Site
Forest Reserve
Atewa Range
Kibi
Apedua Forest Reserve
Densu River
Suhen River
Kuia River
Ayensu River
Supong River
meters
600
400
250
200
interval 50m
BURKINA FASO
TOGO
GHANA
COTE D'IVOIRE
map area
AFRICA
GHANA
Atewa Range Forest Reserve
Eastern Ghana
RAP Expedition
6 June through 24 June, 2006
kilometers

Photos from the Atewa RAP Survey

All photos taken by Piotr Naskrecki (except where noted)

Butterfly (*Kallimoides rumia*)

A new species of tick spider (*Ricinoides* sp. n.)

Tadpoles of the clawed frog (*Siluarana tropicalis*)

A female of *Orthetrum julia* (the Julia Skimmer), one of Africa's most common dragonfly species

Green tree viper (*Atheris chlorechis*)

Atewa tree fern (*Cyathea manniana*)

Rhinoceros viper (*Bitis nasicornis*)

A new species of katydid (*Tetraconcha* sp. n.)

Szabolcs Sáfián

Mudpuddling male of the Atewa Dotted Border, *Mylothris atewa*, a narrowly endemic species that occurs only in the upland rainforest of the Atewa Range

A driver ant (*Dorylus* sp.) attacking a termite

A stream of driver ants (*Dorylus* sp.)

Hyperolius bobirensis is known only from two other Ghanaian sites. Characteristics are its large size and the granular back skin.

RAP scientist Natalie Weber with a bat (*Hipposidesos gigas*)

Tree frogs in amplexus (*Chiromantis rufescens*)

Decayed leaf katydid (*Weissenbornia praestantissima*)

Leaf katydid (*Poreuomena lamottei*)

The Atewa RAP team

The aquatic *Conraua derooi* is Critically Endangered and may have its largest populations in the Atewa Range Forest Reserve

Chapter 1

An ecological, socio-economic and conservation overview of the Atewa Range Forest Reserve, Ghana

As one of the world's 34 Biodiversity Hotspots (Mittermeier et al. 2004), the Guinean Forests of West Africa hotspot encompasses the lowland forests of West Africa, stretching from Guinea and Sierra Leone in the west to the Sanaga River in Cameroon in the East and incorporating areas of Liberia, Côte d'Ivoire, Ghana, Togo, Benin, and Nigeria, as well as four islands in the Gulf of Guinea. Two distinct sub-regions make up the hotspot. The first sub-region, the Upper Guinea Forest, stretches from southern Guinea into eastern Sierra Leone and through Liberia, Côte d'Ivoire and Ghana into western Togo. The second sub-region, Nigeria-Cameroon, extends along the coast from western Nigeria to southwestern Cameroon. The Guinean Forests hotspot represents a range of distinct vegetation zones varying from moist forests along the coast, freshwater swamp forests, and semi-deciduous forests inland with prolonged dry seasons. The hotspot also supports important montane regions, including the Cameroon and Nimba Highlands.

THE UPPER GUINEA FOREST

At its greatest extent following the peak of the last glaciation (approximately 18,000 years B.P.), the Upper Guinea Forest is estimated to have covered as much as 420,000 km^2. Centuries of human activity however have resulted in the loss of at least 70% of the original forest cover (Bakarr et al. 2001). Current biodiversity patterns and high levels of plant and animal endemism in the Upper Guinea Forest are most likely the result of repeated climatic changes during the Pleistocene epoch (10,000-1.9 million years B.P.) when dry conditions in the tropics created isolated forest refugia. Today however, the Upper Guinea Forest is restricted to a number of more or less disconnected forest reserves and a few national parks acting as man-made refuges for the region's biodiversity. Nevertheless, these remaining forests still contain exceptionally diverse ecological communities, distinctive flora and fauna, and several forest types harboring a substantial number of endemic and restricted-range species.

Ghana

Ghana lies along the Gulf of Guinea in West Africa and covers an area of about 239,000 km^2. Along with the rest of West Africa, Ghana belongs geologically to the ancient (570 to 4,600 million years) Precambrian Guinean Shield of the former supercontinent Gondwana and can be divided into several broad natural regions: the coastal or *low plains*, comprising a broad belt along the Gulf of Guinea; the *Ashanti highlands* to the northwest; the *Akwapim-Togo Mountains* in the East; and the Volta basin and terraces of the *high plains* in the north of the country. Ghana can also be divided into several biogeographical zones: the Guineo-Congolian, including the wet evergreen and moist semi-deciduous forests of the southwest; the Guineo-Congolian-Sudanian transitional zone in the middle and the south-east; the Sudanian in the north; and the Sub-Sahelian in the north-eastern corner (Ministry of Environment and Science 2002). About 35% of southwestern Ghana, corresponding to the Guineo-Congolian zone, is located within the Upper Guinea Forest sub-region.

Two rainy seasons occur in Ghana, the first from April to June and the second from September to November, separated by a short dry season of about six weeks during July and August. This pattern corresponds to the movement of the Intertropical Convergence Zone (ITC) over the African landmass (Ojo 1977). Annual rainfall ranges from about 750 mm in the northern forests to over 1,750 mm in the southwestern forests (Hall and Swaine 1981).
In economic terms, Ghana has roughly twice the per capita output of the poorest countries in West Africa but remains heavily dependent on international financial and technical assistance. Major sources of foreign exchange include gold, timber, and cocoa, while the domestic economy is heavily reliant on subsistence agriculture, which accounts for 37% of GDP and employs 60% of the work force, mainly small landholders. GDP is estimated to be $2,700 USD (2006 est.) per capita (purchasing power parity) with 31.4% (1992 est.) of the population living below the poverty level (CIA World Factbook 2007).

Conservation in Ghana

Significant deforestation across Ghana was first noted as early as 1908 (Thompson 1910). Shifting agriculture has undoubtedly occurred for centuries, but the rate of deforestation accelerated early in the last century, as a result of the growing demand for timber required for gold mining, the development of communications infrastructure, and an increase in the land area converted to agricultural production, including cash-crops such as cocoa (Hawthorne and Abu Juam 1995). As a result, Ghana has lost roughly 80% of its forested habitat since the 1920s (Cleaver 1992), with about one-third of its forests disappearing in just 17 years between 1955 and 1972 (Hall 1987). Between 1990 and 2005, the deforestation rate in Ghana remained high (2.0%) compared to other countries in West Africa, resulting in the further loss of 25.9% (19,310 km^2) of forest cover (FAO 2006, see Table 1.1).

Virtually all forests remaining in reasonable condition in Ghana today were designated as forest reserves over the course of the past century by the Forest Services Division of the Forestry Commission. Many of these forests have retained much of their integrity, in the sense that the boundary lines laid down decades ago are still respected, regularly cleared and quite prominent. A forest ordinance was first established in 1927 granting powers to a newly formed Forestry department to reserve areas for management by the state, in some cases by agreement with chiefs to whom the forests belonged (Hawthorne and Abu-Juam 1995). At this time, reserves were defined in all major hills and watersheds, with barrier and shelterbelt reserves established to reduce damage from fires and to maintain local rainfall and humidity levels. Today, there are over 280 forest reserves in Ghana covering about 11% of Ghana's land surface. Many of these reserves are production forests and most are exploited for timber and non-timber forest products including fuel wood, herbal medicines, cane and rattan.

Table 1.1. Area of forested and other wooded land in a number of African countries with annual change rate calculated for the periods 1990-2000 and 2000-2005 (FAO 2006).

Country/area	Forest							Other wooded land		
	Area (1 000 ha)			Annual change rate				Area (1 000 ha)		
	1990	2000	2005	1990–2000		2000–2005		1990	2000	2005
				1 000 ha/year	%[a]	1 000 ha/year	%[a]			
Côte d'Ivoire	10 222	10 328	10 405	11	0.1	15	0.1	2 675	2 662	2 626
Democratic Republic of the Congo	140 531	135 207	133 610	-532	-0.4	-319	-0.2	83 277	83 277	83 277
Equatorial Guinea	1 860	1 708	1 632	-15	-0.8	-15	-0.9	5	22	31
Gabon	21 927	21 826	21 775	-10	n.s.	-10	n.s.	-	-	-
Gambia	442	461	471	2	0.4	2	0.4	170	140	125
Ghana	7 448	6 094	5 517	-135	-2.0	-115	-2.0	0	0	0
Guinea	7 408	6 904	6 724	-50	-0.7	-36	-0.5	5 850	5 850	5 850
Guinea-Bissau	2 216	2 120	2 072	-10	-0.4	-10	-0.5	293	241	236
Liberia	4 058	3 455	3 154	-60	-1.6	-60	-1.8	0	0	0
Nigeria	17 234	13 137	11 089	-410	-2.7	-410	-3.3	9 717	6 902	5 495
Rwanda	318	344	480	3	0.8	27	6.9	175	61	61
Saint Helena	2	2	2	0	0	0	0	0	0	0
Sao Tome and Principe	27	27	27	0	0	0	0	29	29	29
Senegal	9 348	8 898	8 673	-45	-0.5	-45	-0.5	5 301	5 101	5 001
Sierra Leone	3 044	2 851	2 754	-19	-0.7	-19	-0.7	765	511	384
Togo	685	486	386	-20	-3.4	-20	-4.5	1 246	1 246	1 246
Total Western and Central Africa	**300 914**	**284 608**	**277 829**	**-1 631**	**-0.6**	**-1 356**	**-0.5**			
Total Africa	**699 361**	**655 613**	**635 412**	**-4 375**	**-0.64**	**-4 040**	**-0.62**			

The criteria used to designate protected areas and forest reserves in Ghana have changed over time. Some of the more recent designations have included Special Biological Protection Areas (designated in 1994) and Hill Sanctuaries (1995). Most recently, in 1999, the Government of Ghana obtained the assistance of the Global Environment Facility (GEF) to implement the legal establishment of Globally Significant Biodiversity Areas (GSBAs) – reserves harboring a high concentration of biological resources of global conservation importance. Based on the results of a two-year extensive botanical survey across the high forest zone, the Forestry Department has designated GSBAs using an index of the concentration of rare plants within the forest community – the Genetic Heat Index (GHI). To calculate GHI, each plant species has been assigned to a star category, based on rarity. Black star species are internationally rare and uncommon in Ghana and therefore require urgent conservation attention. Thus a high GHI signifies that an area is relatively rich in rare, black star species such that loss or degradation of that area would represent a highly significant erosion of genetic resources from the world, and Ghana in particular (Hawthorne and Abu-Juam 1995). Thirty forest reserves have now been designated as GSBAs, where, in principle, no logging or hunting should take place.

In 1961 Ghana adopted the Wild Animals Preservation Act (Act 43) that regulated export and hunting of "wild animals, birds and fish" in Ghana, later strengthened by the Wildlife Conservation and Wildlife Reserves Regulations introduced in 1971. In 1965, the Game and Wildlife Department was established primarily to manage areas in order to promote animal diversity (Hawthorne and Abu-Juam 1995). Ghana then became a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1976. Finally, in 1999 and 2000, wildlife management in Ghana changed slightly as the Wildlife Department, at that time part of the civil service, was re-classified as an autonomous division of the Forestry Commission, alongside the Forest Services Division. Resulting changes to date include closer collaboration between the Forest Services Division and the Wildlife Division. Forest reserves controlled by the Forestry Division however often have so few staff that they have trouble maintaining boundary lines let alone maintaining adequate patrols to prevent poaching activities. Forest areas controlled by the Wildlife Division enjoy slightly more protection but often are not adequately patrolled either, with only minimal impact on illegal hunting activities. Patrol efforts are also poorly standardized and/or regulated and are often inefficient due to the use of wide patrol trails that are easily recognized (and subsequently avoided) by hunters (Kormos et al. 2003). It has been noted that hunting pressure in forest areas often increases dramatically within a few meters of a standard patrol trail (Magnuson 2002).

The Atewa Range

The Atewa Range is located in the Eastern Region of Ghana and consists of a range of hills aligned approximately north-south with steep-sided slopes and flat summits. The Range represents the remains of the Tertiary peneplain that once covered southern Ghana and is largely characterized by very ancient soils reputed to be bauxite laden.

The topography of the area is dominated by a dissected forest plateau. In the eastern region (i.e. within the Fanteakwa District) the plateau averages an elevation of about 350 m a.s.l. However, the northern region dips into the Voltarian Basin and the topography is much gentler. The central portion meanwhile is dominated by the Atewa-Atiwiredu ridge, with a general elevation of about 300 m a.s.l., but also containing the Atewa, Atiwiredu and Koto hills, with heights of 800, 723 and 711 m a.s.l., respectively. As the ridge stretches westwards into the Kwaebibirem District, average elevation declines to about 200 m a.s.l. However, from Apinaman towards the Eastern border of East Akyem District, the land rises sharply to about 500 m a.s.l. and culminates in the Atiwiredu hills at a height of about 800 m a.s.l. Geologically, the area is underlain by Birimian formations, and Voltarian metamorphosed sediments, rich in minerals such as gold, diamond, bauxite and kaolin.

The Atewa Range represents some of the highest forest-covered hills in Ghana (along with the hills of the Southern Scarp and the Nyinahin Range (Swaine and Hall 1977)). Hence altitude, with its significant impacts on individual species' ecologies, plays an important role in making Atewa a rare and special place. Daytime air temperature declines consistently with increasing altitude, at a rate of 1° C to 160-170m on mountains in West Africa (Hall 1973), though cold air drainage may cause temperature inversions on clear nights. Reduction in atmospheric temperature and pressure with increasing altitude also leads to a corresponding increase in precipitation, even when the altitudinal increase is small (Schnell 1971). Increased cloudiness on mountains results in a general increase in humidity to the upper limit of the mist zone, which, together with the resulting fog-drip, represent the main causes of the greater luxuriance of epiphytes in upland areas (Swaine and Hall 1977). Langdale-Brown et al. (1964) for example have shown in Uganda that a decrease in annual evapotranspiration of up to 25% can occur with the increase in altitude from sea-level to 600 m.

The botanical uniqueness of Upland Forests in Ghana has been made clear through an extensive survey and ordination analysis of Ghana's forest vegetation (Hall and Swaine 1976). This analysis showed that forests occurring at higher elevations had a significantly different botanical composition to all other Ghanaian forests, rather than simply containing transitional elements of different vegetation zones as previously thought. In particular, these forests contain about 50 species of plant that are unknown elsewhere in Ghana (Hall et al. 1973) including many rare epiphytes with montane distributions in other regions of tropical Africa. The Upland

forests differ from surrounding lowland forests most obviously in possessing a lower proportion of deciduous canopy trees, lower canopy height, greater profusion of ephiphytes, and poorer stocking of commercial timber species (Swaine and Hall 1977). Atewa is particularly unique in harboring one of only two remaining areas in Ghana with significant Upland Evergreen forest cover (the other being Tano Ofin).

The Atewa Range lies within the dry and wet semi-equatorial transition zones. The larger northern portion of the Atewa Range lies in the wet transition zone, which is characterized by high temperatures and a double maxima rainfall regime. It exhibits a mean monthly temperature of between 24° and 29°C, and experiences a mean annual rainfall of between 1200 and 1600 mm. Atewa also lies within two vegetation zones: i) the transitional climatic zone and thicket vegetation resulting from human activities such as land cultivation, lumbering, and fuel wood extraction; ii) the moist deciduous forest zone that lies to the north of the transitional zone and covers about 80% of the Akyem Abuakwa area. Precipitation records taken from Atewa between April 1966 and May 1967 show higher precipitation, more rain days and a shorter dry season than in nearby lowland forest. Daytime observations in September 1974 showed temperatures on the Atewa plateau (at 750 m) to be approximately 4-5° C lower than those at neighboring Kibi (at 300 m) (Swaine and Hall 1977).
Historically, the Atewa Range has been recognized as nationally important for providing the headwaters of three river systems in Ghana: the Ayensu, Densu and Birim rivers. These three rivers are the most important source of domestic and industrial water for local communities as well as for many of Ghana's major population centers, including Accra. The intact Atewa Range ecosystem acts to protect and provide a clean water source for much of Ghana's human population as well as the country's biodiversity.
The population of the Atewa area is growing at a relatively slow rate, possibly as a result of emigration by farmers and youth. With a decline in the cocoa industry around the Atewa Range, farmers have migrated to areas like Brong Ahafo where the cocoa industry is thriving, while many of the region's youth have migrated to urban areas. More than 40 settlements with an estimated population of about 75,180 are located within the vicinity of the Atewa Range, according to the 2000 National Population and Housing Census Report. The major economic activities of these communities include agriculture, small-scale collection of non-timber forest products (NTFPs), mining, logging and bushmeat hunting.

Conservation of Atewa

The Atewa Range Forest Reserve (Atewa) was originally established in 1926 under the Akyem Abuakwa State Native Authority by-laws. It was later reconstituted under Forest Ordinance Cap 157 of 1935. Ownership of the reserve is vested in the President of Ghana and held in trust for the Akyem Abuakwa Stool (Gazettment Supplement 1935, pg 1105). The entire reserve falls within the jurisdiction of the Akyem Abuakwa Traditional Area. The Atewa reserve includes 232 km^2 of forest – moist semi-deciduous at lower levels and Upland Evergreen at higher elevations.
Even though the Atewa forest was declared a protected area as far back as 1926, communal rights were granted to natives of the Akyem Abuakwa Traditional Area and individual owners of lands purchased prior to the establishment of the reserve. Included within these rights were: farming within the reserve (admitted farms); collecting forest products (including building materials, canes, vines, ropes, pestles, palm trees, snails, mushrooms, chewing sticks, medicinal plants, game and wildlife); receiving a share in timber royalties resulting from forestry on privately owned land; accessing sacred places; establishing hunting camps; and washing for gold.

The culture of the forest fringe communities is inextricably linked with the existence of the Atewa reserve. The forest is regarded as the home of the ancestral spirits, who provide protection, success and progress for the Akyem Abuakwa people. Some animals are regarded as totems by certain clans. Taboos such as avoidance of farming activities along river banks are all indications of the socio-cultural significance of forest resources. Forest fringe communities also depend on the forest for non-timber forest products, some of which are extracted in large quantities for sale. Several streams and headwaters of major rivers like the Densu, Ayensu and Birim serve as important sources of drinking water to a large number of people within and outside the traditional area, including Accra and other urban areas. Many individuals, institutions and communities hold a stake in the continued existence of the reserve.

The reserve has been managed under the Protection Working Circle system of the then Forestry Department (now Forest Services Division) where an area is managed with the intention of protecting the watershed and no logging is allowed. Atewa was designated as a Special Biological Protection Area in 1994. In 1995 it was reclassified as a Hill Sanctuary under the Forest Protection Strategy proposals. In 1999, Atewa was again re-designated as one of the 30 Globally Significant Biodiversity Areas (GSBAs). It is also among the 36 Important Bird Areas (IBAs) in Ghana as designated by BirdLife International (Ntiamoa-Baidu et al. 2001). In 2003 the first management plan was prepared for the Atewa forest reserve with the main objectives of: protecting the headwaters of major rivers, namely the Birim, Densu and Ayensu and their tributaries; maintaining forest cover on the slopes of hills to prevent excessive erosion; and preventing the encroachment or conversion of the reserve to agriculture.

THREATS TO BIODIVERSITY IN THE ATEWA RANGE FOREST RESERVE

Cropping practices which encourage intensive use of the same piece of land over a prolonged period of time have led to leaching and loss of soil fertility in parts of Atewa. In local villages, deep channels have been created by surface water running over ground lacking plant cover. Within some of the villages, erosion has eaten away the foundation cover of houses, and in some cases washed away whole streets, bridges and other services. Illegal logging has been prevalent in Atewa, especially during the 1990s, leading to further problems with erosion throughout the area. Indeed in 2001, logging escalated so much that the Ghanaian army was called in to help protect the reserve from loggers (Hawthorne 2002). Unsustainable exploitation of forested areas, coupled with the relatively high prevalence of bush fires, has resulted in the depletion of important timber species. Trees such as mahogany, Odum, Obeche, and Emire, which were abundant before the 1960s are now locally rare. At least 954 ha (4.1%) of Atewa was converted to plantation through the taungya program between 1954 and 1975 (Hawthorne 2002). Most of these plantations have since been abandoned and remain as severely degraded areas covering most of the lower slopes of the reserve.

Mining activities by unlicensed individuals and groups are increasing and causing serious problems for communities. Major pollution occurs downstream from water bodies along whose banks mining takes place, as a result of improper mining practices. Most affected is the Birim River which suffers from pervasive sediment loading.

A 2001 bushmeat market survey targeting the major bushmeat markets in both Accra and Kumasi indicated that about 15 % of the bushmeat found in these markets comes from the Atewa forest (Conservation International-Ghana 2001, 2002). Most of the species sold are wholly protected in Ghana (i.e. Black-and-white colobus, Spotted palm civet, Giant and Long-tailed pangolins). In addition, the survey revealed that some traditional sacred animals (totems) such as Crested porcupine (totem of the Ashantis*)* are being hunted and sold. A number of bushmeat markets are in existence in close proximity to Atewa. The largest roadside bushmeat market in Ghana is at Anyinam, at the fringe of the Atewa, where bushmeat is sold throughout the year. Hunters illegally entering Atewa are known to use automatic rifles, poisonous chemicals, traps and fires.

Atewa is dissected by many rivers and their tributaries. However, human activities in the form of farming, deforestation, and to some extent mining have now polluted and silted up many of these waterways. The effluents of the many small-medium scale oil palm-processing factories in the area are also a major cause of water pollution. In order to secure adequate amounts of water for their operations, many of these factories are located on the banks of streams where water can be more easily obtained. Oily waste matter from the factories is then washed into the streams, especially at Kade, Boadua, Wenkyi and Mepom. Furthermore, the forests that shelter these waterways have been cleared, with many rivers and streams experiencing greater rates of evaporation for longer periods of the year. Hence, they are now increasingly unable to satisfy the water requirements of the communities they are supposed to serve.

Prior Research in the Atewa Range Forest Reserve

Due to the biological interest in Atewa as an Upland Evergreen forest and because of its proximity to Accra, more is known about Atewa than any forest reserve in Ghana (except perhaps Bobiri; Hawthorne 2002). Past botanical research has included Temporary Sample Plots (TSP) conducted during the National Forest Inventory between 1986-1992 (56 samples with 7235 plant records), and Rapid Botanic Survey plots (RBS) carried out in the early 1990s by Hawthorne and Abu Juam (16 samples with 1239 plant records; 1995). The butterflies of Atewa have also been extensively collected over the past 70 years (see Chapter 5 of this report). The institutions which have carried out research or are mandated to carry out research in Atewa include:

The Forest Services Division

The Forest Services Division (FSD) is responsible for the conservation, protection, management and utilization of forest resources in Ghana. In the past they maintained a research unit that was responsible for research and monitoring work in all forest reserves. Permanent Sampling Plots (PSPs), one-hectare sampling units, were established in almost all the forest reserves to monitor ecological trends. Eighteen PSPs were established in Atewa and 72,474 plant records from the monitoring program are stored at the Resource Management and Support Centre of FSD in Kumasi (Hawthorne 2002).

Forestry Research Institute of Ghana (FORIG)

The main mandate of FORIG is to conduct research and generate scientific information to support the management of forest reserves in Ghana. FORIG took over management of the 18 PSPs in Atewa but has since been unable to carry out any research or monitoring work in the area.

The Botany Department of the University of Ghana

The department is entrusted with the responsibility of training undergraduate and post-graduate level personnel in plant science and has used Atewa as a field laboratory to facilitate undergraduate and graduate research work. The Department has no formal research focus for the area. In the past, research scientists of the Botany Department of the University of Ghana established temporary research plots to conduct botanical surveys but these were abandoned after their objectives were accomplished.

ONGOING PROJECTS

A number of projects are being implemented at Atewa and within its vicinity. These include:

- Community Investment Fund Project: supports income-generating ventures aimed at improving livelihoods of forest fringe communities. This is being implemented as part of the GEF/World Bank/Government of Ghana program for all 30 GSBAs in Ghana.
- High Forest Biodiversity Project: part of the World Bank/Government of Ghana Natural Resource Management Program.
- GEF/World Bank-sponsored Promoting Partnership with Traditional Authorities Project (PPTAP)**:** aimed at unearthing the cultural, historical and ecological heritage and assets of the Akyem Abuakwa Traditional area.
- Ghana government-sponsored Presidential Initiative on Tree Plantations Project: seeks to rehabilitate degraded forest areas.

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Chapter 2

The botanical diversity of the Atewa Range

Carel C.H. Jongkind

INTRODUCTION

In the early nineties, when I visited Atewa for the first time, we walked "the old geological survey road", at that time a heavily eroded and overgrown road starting from the main road between Kibi and Asiakwa and going up to the top of the range. Later, after the road was brought back into use for timber extraction, even taxis were seen driving people up the ridge to collect whatever they needed from the forest. When walking west along a footpath located in the north (near Asiakwa), it was impossible at that time to avoid hearing the chainsaws from illegal timber extraction. One had to jump off of the path from time to time, when people carrying large planks of freshly sawn wood on their heads were almost running downhill. During this same period, the already narrow connection between the southern and northern parts of Atewa was mostly cut away by large scale illegal farming. Remembering this it is almost surprising that rich forest remains on the Atewa Range that is worth preserving.

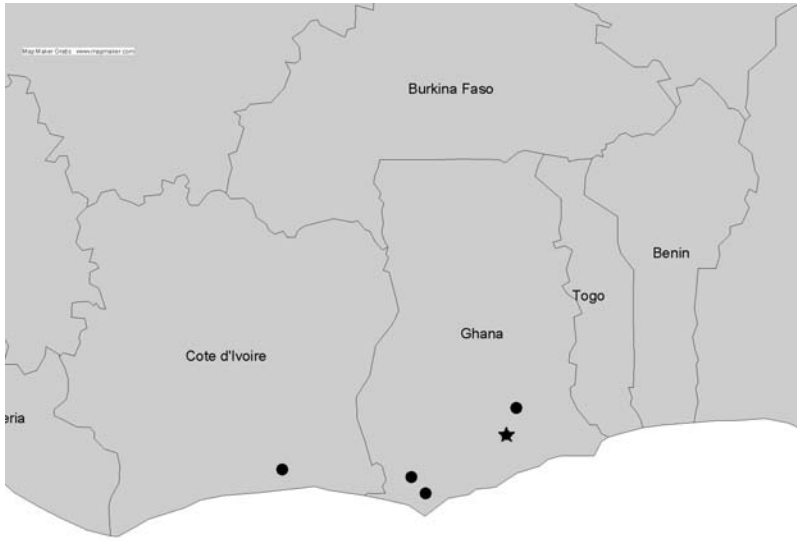
Several foresters and botanists had already studied the forest on the Atewa Range many years before my first visit. The work of J.B. Hall and M.D. Swaine is especially well known. They were the first to recognize the forest of the Atewa Range, and of the less important Tano Ofin reserve, as a rare and special kind of vegetation for Ghana, a vegetation they called Upland Evergreen forest. With what is known today, it is clear that the Atewa Range was, and still is, a stepping stone for many forest species. During the driest periods of the Ice Ages, Atewa was at least partly covered with forest while data from sediments in Lake Bosumtwi (a lake which today is situated in the middle of the closed forest area of Ghana) have shown that forest cover disappeared from most of southern Ghana during the past ten thousand years (Maley 1991, Talbot and Johannessen 1992). Furthermore, several rare but widespread species are, in Ghana, only found on Atewa and many Upper Guinea endemics have their easternmost foothold within this range (see Figure 2.1 for examples).

METHODS

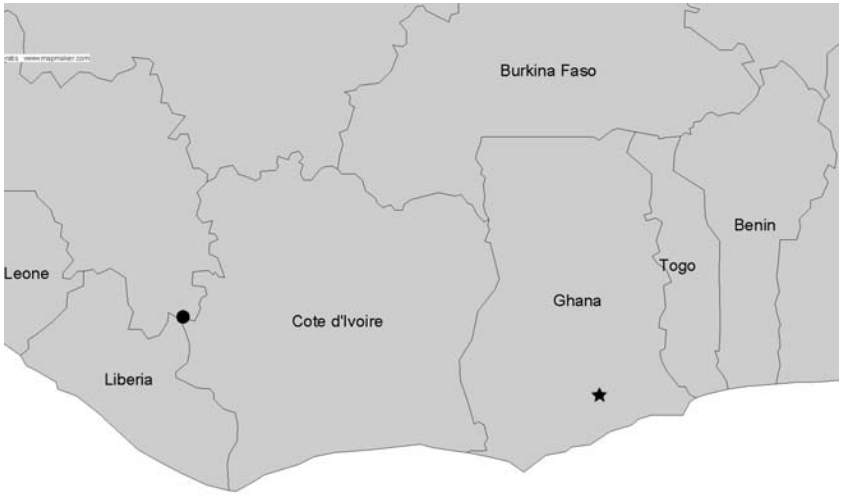
This report is based on earlier research and reports, no new field work has been carried out. Most important were the report prepared by W.D. Hawthorne (1998), who studied the forests of Ghana for many years, and the data available in the herbarium database at Wageningen. An important part of the Upper Guinea data in the database at Wageningen was digitized and updated for the ECOSYN project (1996-2005) at the Wageningen University, a research project on plant biodiversity and management of West African forests. This database currently includes data from about 67,000 herbarium specimens from Upper Guinea. The maps presented in this report are extracts from that database.

Botanical Samples in Atewa

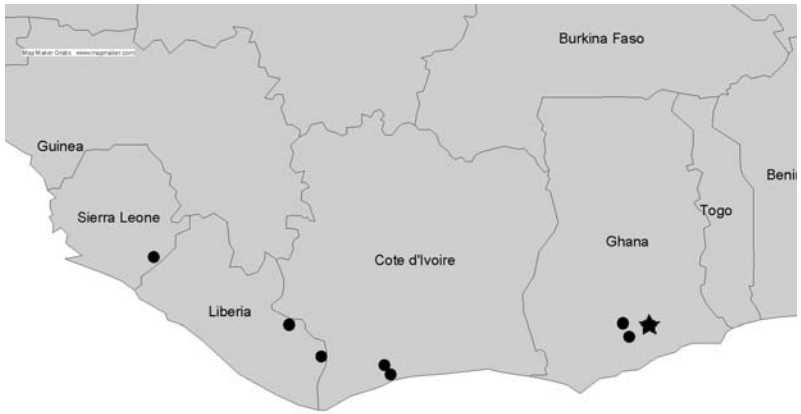
Through the years many foresters and botanists have collected botanical samples in Atewa. To visit Atewa you do not need to plan an extensive expedition since it is in walking distance from the main Accra-Kumasi road – from Accra a visit is an easy one-day trip. As a result of this relatively easy access, several new plant species have been found for the first time on Atewa (e.g. *Aframomum atewae*). Most of the preserved samples from the area are stored in a small number of herbaria, in Ghana these are the herbaria in Legon and Kumasi, in Europe they can be found mainly in the herbaria in Oxford, Wageningen and Kew. These herbaria are in the process of digitizing their collections, and a Checklist for Atewa will be much easier to compile and much more complete when all these herbarium collections are online.



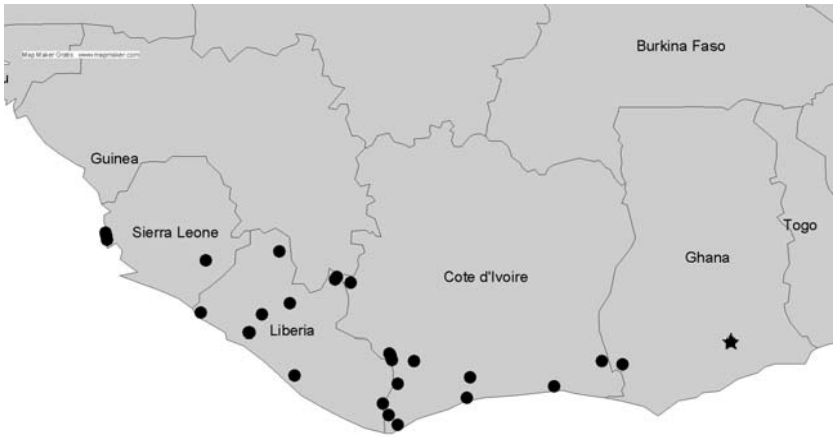
Aframomum atewae



Asplenium schnellii



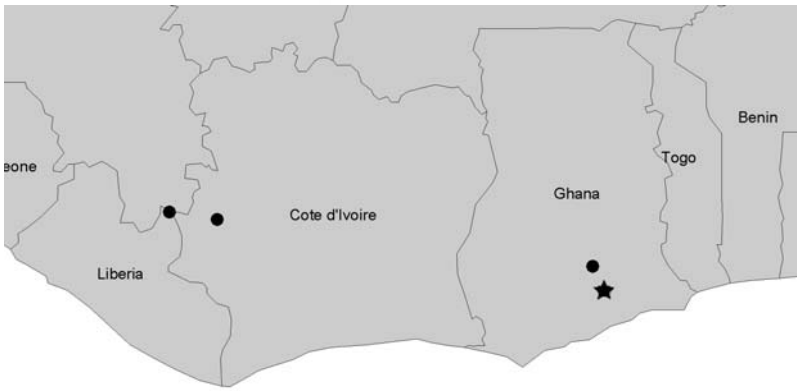
Cola boxiana



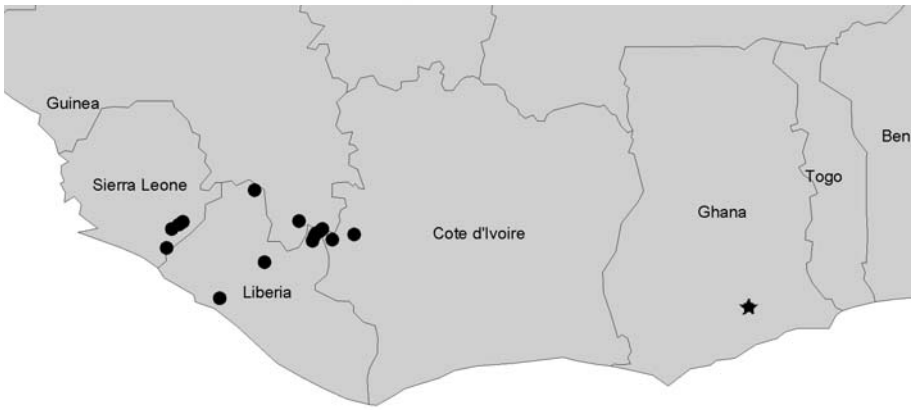
Costus deistelii

Figure 2.1. Species distribution maps of several rare plant species known from the Atewa Range. Data are extracted from the herbarium database at Wageningen University.

Epistemma assianum



Hymenocoleus multinervis



Justicia guineensis

Figure 2.1. cont.

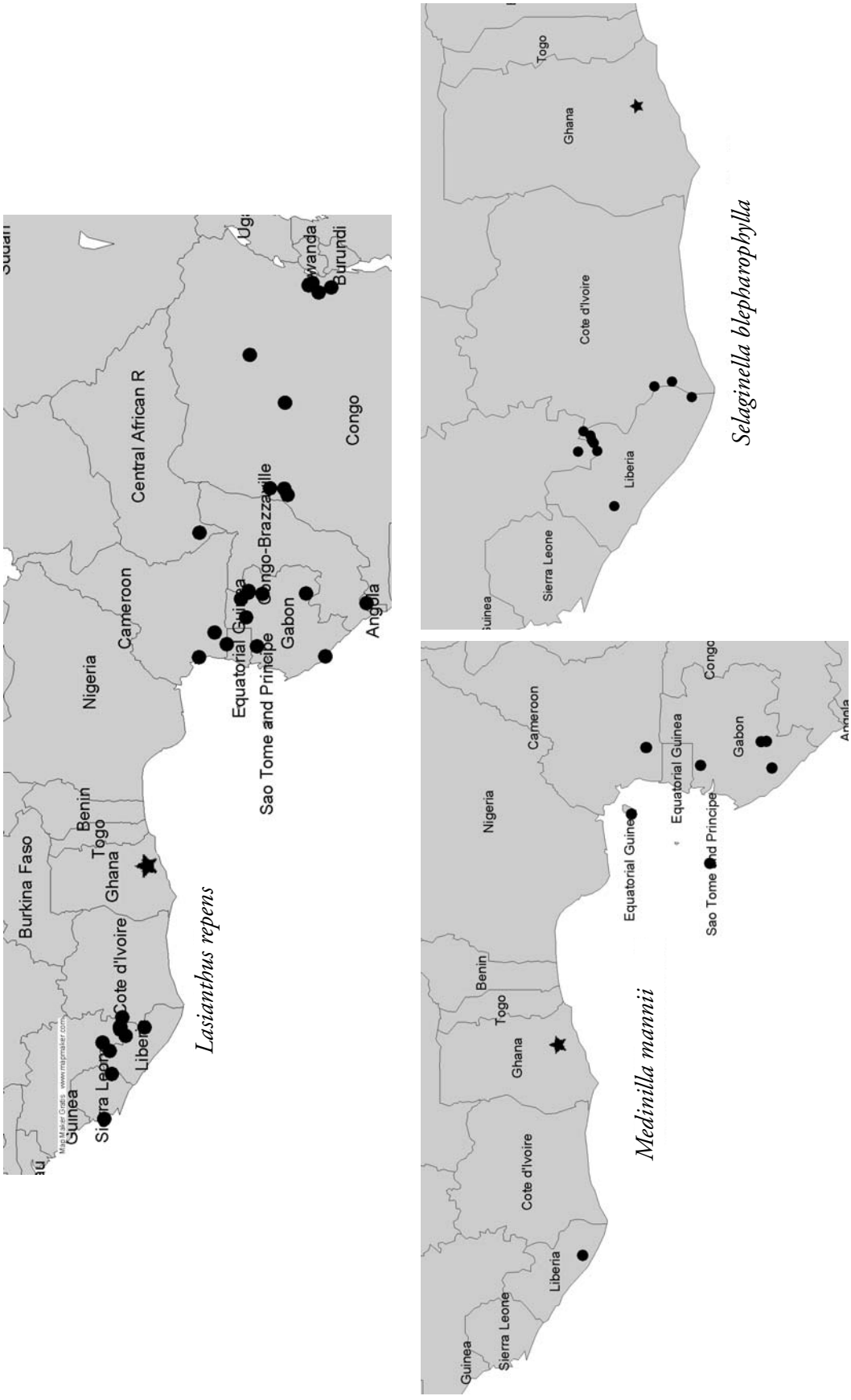
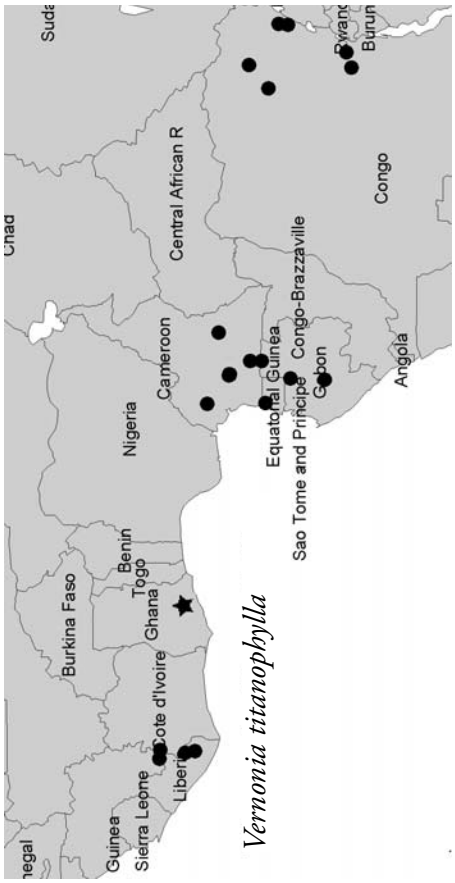


Figure 2.1. cont.



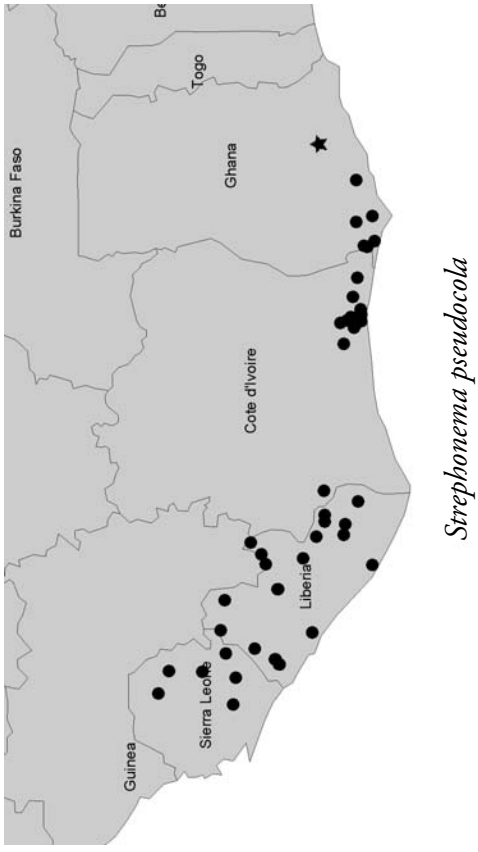


Figure 2.1. cont.

The Vegetation of Atewa

Atewa is special in the first place because of its Upland Evergreen forest vegetation (Hall and Swaine 1976, 1981) rather than due to the presence of a large number of endemic species. As far as is known, there are no endemic plant species found in the Atewa Range. However, several species from Atewa (like *Aframomum atewae, Epistemma assianum, Hymenocoleus multinervis,* and *Ixora tenuis*) are known from only a few other places and most of these other locations are threatened as well. In Ghana there is no other place like Atewa. The other Upland Evergreen forest, on Tano Ofin, is smaller and even less intact and the mountains near the border with Togo have a much drier climate. Outside Ghana there is no upland forest known with this combination of species. Atewa, and especially the northern part of the range, is covered with this vegetation because of the abundant rain and fog on and around the plateau which keeps the forest on top very humid for most of the year, resulting in abundant epiphytes and a species-rich forest undergrowth. The local climate at the top of the range is, on a smaller scale, intensified by rocky valleys like Pusu Pusu and by upland swamps. This condition makes possible the common presence of woody epiphytes like *Anthocleista microphylla*, *Epistemma assianum* and *Medinilla mannii*, a group of plants rarely seen in most tropical West African forests, and characteristic upland forest species like *Cyathea manniana* (Treefern), *Rubus pinnatus* var. *afrotropicus* and *Hymenocoleus multinervis*. Atewa is also home to an abundance of plants growing only in the shade of closed high forest like *Alsodeiopsis staudtii*, *Buforrestia obovata*, *Cola boxiana*, *Dicranolepis persei*, *Diospyros chevalieri*, *Drypetes pellegrini*, *Mapania baldwinii*, *M. coriandrum*, *Nephthytis afzelii*, *Pauridiantha sylvicola*, and large forest trees and lianas otherwise only found in wet lowland forest like *Combretum multinervium*, *Neolemonniera clitandrifolia*, *Newtonia duparquetiana*, *Strephonema pseudocola* and *Strychnos icaja*.

Appendix 1 lists 765 different species of vascular plants including 106 Upper Guinea endemics known from Atewa (Upper Guinea sensu White 1979) taken from different sources. The larger part is taken from an unpublished 1998 report by William Hawthorne that is itself already a combination of different sources. A smaller part is taken from the herbarium database at Wageningen University, which includes specimens taken from Atewa by several collectors and deposited in various herbaria. A few other species on the list are mentioned by Hall and Swaine (1981). The list is without doubt incomplete. Many additional species collected from Atewa are stored in herbaria around the world, most of which were neither seen for this report, nor cited in earlier reports or publications. In addition to this, I am sure more species in the range are still to be discovered, especially in the canopy.

For a number of species from Atewa that are rare in Ghana or are otherwise mentioned above, the geographical distribution is shown in Figure 2.1. Species distributions mapped include *Aframomum atewae* (Zingiberaceae), *Asple-*

nium schnellii (Aspleniaceae), *Cola boxiana* (Sterculiaceae), *Costus deistelii* (Costaceae), *Epistemma assianum* (Apocynaceae, Asclepioideae), *Hymenocoleus multinervis* (Rubiaceae), *Justicia guineensis* (Acanthaceae), *Lasianthus repens* (Rubiaceae), *Medinilla mannii* (Melastomataceae), *Selaginella blepharophylla* (Selaginellaceae), *Strephonema pseudocola* (Combretaceae) and *Vernonia titanophylla* (Compositae).

For a more extensive description of most species see the 1998 report by W.D. Hawthorne and Hawthorne and Jongkind 2006.

RECOMMENDATIONS

In preparing this report it became clear that little is published about the epiphytic flora of Atewa while this flora is without doubt very rich. I am sure more important data could be found on this subject in the abovementioned herbaria. I expect that one month's work would extend the species list considerably, especially the number of species in the Orchid family which is likely to double several times. On top of this, specialized canopy fieldwork would certainly increase our knowledge, as all data about epiphytes seem to come from plants that have fallen down accidentally. Thus, more systematic collection of data for this group of plants is especially needed.

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Chapter 3

A rapid botanical survey of the Atewa Range Forest Reserve, Ghana

D.E.K.A Siaw and Jonathan Dabo

SUMMARY

A total of 314 plant species belonging to 71 families were recorded during a rapid biological assessment of the Atewa Range Forest Reserve. An additional 30 leaf specimens were pressed for correct identification. At Atiwiredu, 145 plant species in 43 families were recorded, including three black star species *Gilbertiodendron splendidum*, *Psychotira longituba* and *P. subglabra*. At Asiakwa South, 247 species in 65 families were confirmed including one black star species *Ixora tenuis*. At Asiakwa North, 189 species in 53 families were recorded. Among these were four black star species including two recorded only from this site and also listed on the IUCN Red List, *Neolemonniera clitandrifolia* (EN) and *Sapium aubrevillei* (VU).

INTRODUCTION

The Upper Guinea Forest, which includes the forests of Ghana, ranks among the 34 most important biodiversity Hotspots worldwide (Bakarr et al. 2004). This region is highly threatened by exploitation, agriculture and an increasing human population (Bakarr et al. 2001) and remaining fragments of original forest are generally found in remote, inaccessible areas where forest reserves were established a long time ago (Oates 1999).

The Atewa Range is situated in the Moist Semi-Deciduous forest zone with hill vegetation classified by Hall and Swaine (1976) as Upland Evergreen (UE) Forest type. The Upland Evergreen forest in Ghana is known to be botanically very unique in terms of floral richness and diversity. Hall and Swaine (1981) compiled longer botanical species lists in Upland Evergreen forests than in surrounding lowland Moist Semi-Deciduous forests (MSSD). They also noted that Atewa represents an extreme type of provenance for endemic and highly distinct species (e.g. *Aframomum atewae*, *Medinilla enti, Anthocleista obanensis, Piper capensis, Cyathea manii* and *Rubus pinnatus* var. *afrotropicus*). The Atewa Range Forest Reserve (hereafter referred to as 'Atewa') is known to contain some plant species not found elsewhere in Ghana (e.g. *Piper capensis* (Hawthorne and Abu-Juam, 1995)).

The area of Atewa, designated as such in 1925, is 232 km^2. Seventy-five percent of the slopes within the range are at an angle greater than 15 degrees. Atewa, one of 214 forest reserves in Ghana, is the 43rd Forest Management Unit (FMU 43) and overall has a forest condition score of 3 indicating that it is considered a slightly degraded, ecologically tolerable forest mosaic with healthy and abundant regeneration of timber trees and other forest plants. Animals that like closed forest tend to thrive in this type of mosaic (Hawthorne and Abu-Juam 1993).

Records show that several botanical surveys (16) of Atewa have been conducted since 1971. In 1986, one survey inventoried trees of the DBH greater than 5 cm. Hawthorne and Abu-Juam (1995) reported 656 species of vascular plants at Atewa. These comprised 323 tree species, 83 shrub species, 155 liane and climber species, 68 herbaceous species, 22 epiphytes and 5 grasses. At least five black star species (species of the highest conservation priority in Ghana) and 33 Gold star species have been recorded in Atewa. The black star species include: *Sapium aubrevillei, Psychotria subglabra, Neolemonniera clitandrifolia, Lecaniodiscus punctatus* and *Ixora tenuis*.

Non-botanical forest characteristics, such as steepness of slopes, importance to watershed maintenance, and presence of sacred areas and animal habitats, have been stated as the reasons for the creation of forest reserves in Ghana. Protection of rare plant species and maintenance of biodiversity *per se* was never a stated objective in past designation of forest reserves. However, many of the abovementioned characteristics depend on plant regeneration and redevelopment of tree cover; these in turn influence the ability of animals to flourish in parts of the forest mosaic, as well as sustain the source of streams and rivers in the forest landscape. Flora is an important indicator of the climate, stage of ecological succession, soil type and mineral deposits of any particular area. For example, the occurrence of certain plant species such as *Draceaneae manii* is indicative of the presence of gold deposits (indigenous knowledge, personal comm. – Mr. Ossum).

METHODS

Forest tree and other vascular plant species of three hill summits on the Atewa Range were surveyed from 7 – 23 June, 2006. Temporary Sample Plots (TSP) of 50 m x 50 m and regeneration subplots of 10 m x 10 m were established at each site and vegetation occurring within each plot was identified. Flora of less than 5 cm diameter at breast height (DBH) at a height of 1.3 m was identified inside the subplot. Four TSPs were set up at each RAP survey site using the four cardinal geographic coordinates. A Garmin GPS 76 was used to record georeference positions and altitudes of sample plots.

Additionally, transect walks of at least 6 km were traversed. Existing timber hauling roads, footpaths and lines cut through forest were used as transects. Trees within 20 m on either side of each transect were identified. Leaf samples of plant species that could not be identified in the field were collected and pressed for proper identification at a herbarium in Kumasi.

The periods of June 7-11, 12-17, 18-23, 2006 were spent at Atiwiredu (Site 1), Asiakwa South (Site 2), and Asiakwa North (Site 3), respectively. GPS coordinates for the three sites are given in the Gazetteer of this report.

RESULTS AND DISCUSSION

Appendix 2 shows a summary of the plant species recorded in Atewa during the RAP survey, including species' Star ratings. A total of 71 plant families comprising 314 plant species were recorded during the current biological assessment. An additional 30 leaf specimens were pressed for correct identification. At Site 1, 145 plant species in 43 families were recorded, 247 species in 65 families were confirmed at Site 2, and 189 species were recorded within 53 families were recorded at Site 3. We noted a number of footpaths traversing the forest reserve, many animal traps and signs of illegal chainsaw activity.

The pattern of vegetation and forest quality revealed that the forest reserve at Site 1, Atiwiredu, was in relatively healthy condition with an average score of 2 (Hawthorne and Abu- Juam 1995), despite the fact that the area was logged in 1991 and there were obvious signs of ongoing illegal logging activities.

Asiakwa South, Site 2, was dominated by the shade-bearing tree *Cola boxiana*. Pioneer species like *Macaranga, Trema orientalis, Musanga* and *Harungana madagascariensis* occurred in places where the forest canopy was open, especially along hauling roads. Based on our findings, the plant team awarded this site a forest of condition score of 3 (Hawthorne and Abu-Juam 1995). Signs of human activities, like small-scale harvesting of non-timber forest products (NTFPs) such as canes, chewing sticks, and chewing sponge (*Acacia pentagona)*, and hunting and trapping game were noticeable in some areas, particularly along the footpath leading to surrounding communities.

Asiakwa North, Site 3, was the least disturbed of the three sites but showed signs of illegal chainsaw operations and hunting. At the sources of three streams within this site, tree ferns *Cyathea manniana* were abundant. *Sapium aubrevillei*, a black star species, was also recorded at this site.

Four black star species known from Atewa (Hawthorne 2002): *Sapium aubrevillei, Ixoria tenuis, Psychotria subglabra,* and *Neolemonniera clitandrifolia* were observed during this survey. The star rating system adopted by Ghana defines the conservation significance of each forest species in Ghana (Hawthorne and Abu-Juam 1995). The star rating of a species defines its weight for the calculation of weighted average referred to as Genetic Heat Index (GHI) which provides a framework for defining the conservation merit of a tract or sample of forest of any size.

CONSERVATION RECOMMENDATIONS

The biology and ecology of the Atewa black star and endemic species need to be studied further. The sustainable cultivation of non-timber forest product (NTFP) should be encouraged in the surrounding communities. Exploitation that directly affects the main structural elements of the forest, i.e. canopy trees, soils and watercourses, should be limited. However exploitation of non-canopy forest products, for example non-timber forest products (NTFPs), affect only populations of the species being exploited and thus can be managed sustainably.

Rattans are part of the forest ecosystem and depend on forest trees for support. To date no framework for conservation has been devised. This is a major course for concern. Out of four rattan genera found in Ghana, three occur at Atewa and only Site 2 had the genus *Calamus.* A framework for conservation and the sustainable use of bamboo and rattans should be devised.

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Chapter 4

Dragonflies and Damselflies (Odonata) of the Atewa Range, Ghana

Klaas-Douwe B. Dijkstra

SUMMARY

Odonata were surveyed during a Rapid Assessment Program (RAP) survey of the Atewa Range Forest Reserve in Ghana. A total of 72 species were found in the streams and rivers that have their headwaters within the reserve (and associated standing water habitats), although only 31 (43%) were found strictly within the reserve's boundaries. Eight species were recorded in Ghana for the first time, of which six (75%) were recorded inside the reserve. Of these, *Atoconeura luxata* is the most significant discovery because: (1) it had not been described at the time and material taken during the RAP was included in its recently published description; (2) it is the only regionally threatened odonate found, being Red-listed as Vulnerable in western Africa; and (3) it confirms the nationally unique 'montane' character of the site. The results indicate a healthy watershed in the forest reserve and the surrounding area, with limited pollution and streambed erosion. This is confirmed by the presence of forest species even in more disturbed landscapes. If forest cover and natural stream morphology are retained, the present dragonfly fauna is expected to persist. However, if development activities were to entail the removal of vegetation or mineral deposits from the range, its capacity to store, buffer and filter rainwater would be seriously compromised, jeopardizing the reliable discharge of freshwater into the region's rivers; an essential resource for millions of Ghanaians and a rich biodiversity.

INTRODUCTION

Odonata (dragonflies and damselflies) are receiving increasing attention from scientists and the public. These graceful, colorful creatures are the quintessence of freshwater health. Due to their attractive appearance, dragonflies and damselflies can function as guardians of the watershed. They can be flagships for conservation, not only of water-rich habitats such as wetlands and rainforests, but also for habitats where water is scarce and, therefore, especially vital to the survival of life. Their sensitivity to structural habitat quality (e.g., forest cover, water clarity) and amphibious habits make Odonata well suited for evaluating environmental change in the long term (biogeography, climatology) and in the short term (conservation biology), both above and below the water surface (Corbet 1999).

Odonata larvae are excellent indicators of the structure and quality of aquatic habitats (e.g., water, vegetation, substrate), while adult Odonata exhibit high sensitivity with regards to the structure of their terrestrial habitats (e.g., degree of shading). As a consequence, Odonata show strong responses to habitat changes, such as those related to deforestation and erosion. Ubiquitous species prevail in disturbed or temporary waters, while habitats like pristine streams and swamp forests harbor a wealth of the more vulnerable and localized species. Different ecological requirements are linked to different dispersal capacities. Species with narrow niches disperse poorly, while pioneers of temporary habitats (often created by disturbance) are excellent colonizers. For this reason, Odonata have a potential use in the evaluation of habitat connectivity (Clausnitzer 2003, Dijkstra and Lempert 2003).

Odonata possess characteristics distinct from those of relatively well-studied taxonomic groups like plants, birds, mammals and butterflies. Therefore, their study supplements knowl-

edge obtained from these better-known groups. There are also practical advantages to Odonata as environmental monitors. Aquatic habitats, the focal point of their life histories, are easy to locate, and their diurnal activity and high densities make Odonata easy to study. The number of dragonfly species occurring in Africa is manageable, their taxonomy is fairly well resolved, and identification is relatively straightforward. Considering the ever-changing nature of the African landscape, be it under human, geological or climatic influence, the study of African Odonata constitutes an exciting challenge, as knowledge of their geography, ecology and phylogeny helps us understand the past and future of a rapidly changing continent.

This was the third African RAP survey to include Odonata. The previous ones, at Lokutu in Democratic Republic of Congo (Dijkstra 2007a) and at several forests in Liberia (Dijkstra 2007b) showed that it is possible to obtain a fair picture of the local diversity within a short period of time: a rich Odonata fauna probably represents high overall aquatic biodiversity. The results of odonate surveys may contrast sharply with the impoverished and imperiled fauna and flora indicated for the other taxonomic groups studied on any particular RAP survey. Because of their 'information rich' potential, Odonata might be placed more at the forefront of RAP surveys and conservation policy. The group is very 'RAPable' and is complementary to traditional RAP taxa, such as large mammals. Particularly in forest and freshwater ecosystems, an emphasis on odonate research seems beneficial as a baseline for biodiversity and watershed conservation. Sampling these charismatic insects can demonstrate whether present and future conservation actions are protecting freshwater biodiversity. Moreover, the interpretation of survey results has recently been facilitated by the inclusion of Odonata in IUCN's assessment of freshwater biodiversity in western Africa, which summarizes the distribution, habitat, threats and taxonomy of all species.

The Odonata of the Upper Guinean forest have been fairly well studied. Landmark papers appeared on Sierra Leone (Carfì and D'Andrea 1994), Ghana (O'Neill and Paulson 2001), the Guinean side of Mt. Nimba (Legrand 2003), Taï Forest in Côte d'Ivoire (Legrand and Couturier 1985) and Liberia (Lempert 1988). The earliest mention in the odonatological literature of material from present-day Ghana is the holotype of *Phyllomacromia sophia* from Cape Coast Castle in 1871. Karsch (1893) treated material from the area Adeli around Bismarckburg, in what was then German Togo. This area now lies partly within the borders of Ghana's Kyabobo National Park, as well as in present-day Togo. Lacroix (1921) described *Tetrathemis godiardi* from Koforidua and later (1924) listed *Cyanothemis simpsoni* and *Orthetrum microstigma* from there. Neville (1960) produced a list of 34 species, collected principally in the Bobiri Forest Reserve. His paper also includes the first behavioral information on Ghanaian Odonata. Pinhey (1962) reported on a small collection from the Prah-Annam Forest Reserve. Marshall and Gambles (1977) recorded 46 species from Mole National Park. D'Andrea and Carfì (1994) added a few scattered records. The most substantial contribution to the odonatology of Ghana was by O'Neill and Paulson (2001), who recorded 71 species, 24 of them new national records, based on material collected in 1997 from widespread localities. These authors were also the first to draw up a complete list of the Ghanaian Odonata, including 123 species. More Ghanaian records were obtained by H.A. Olsvik in February-April and October-November 1993 and by the present author in April-May 2000. This yielded many new records and also provided the necessity to reconsider some species previously listed for Ghana. Although the new national list is, as yet, unpublished, it includes 177 species (see Appendix 3). Judging by data from neighboring countries, about another 50 species may be discovered in Ghana (Dijkstra and Clausnitzer 2006). Lempert's (1988) Liberian data were analyzed combined with the author's data from Ghana (Dijkstra and Lempert 2003). This analysis describes the composition of odonate assemblages in running waters in the Upper Guinean rainforest. As running forest waters harbor the larger part of the region's odonate diversity, particularly of range-restricted species, this baseline is an important tool in the interpretation of the data from the present survey.

METHODS

Adult and larval Odonata were observed and caught with a hand net during daylight at freshwater habitats in the Atewa Range Forest Reserve (Atewa) and at habitats outside the reserve that receive their water from it (Table 4.1). Details of

Table 4.1. Odonata study sites in the Atewa area, Ghana.
ARFR: Atewa Range Forest Reserve

	Location	Coordinates	Altitude (m)
OnO	Obeng-ne-obeng stream in ARFR	6.23429°N 0.56755°W	640
Ade	Adensu stream in ARFR	not obtained	about 600
Swp	Two swamps in ARFR	6.24227°N 0.55684°W 6.22373°N 0.57911°W	800 750
For	Other sites (pools, roadsides) in ARFR	various	600-800
Wan	Wankobi stream and Asikam Gold Mine	6.20170°N 0.53658°W	290
Den	Densu River at Odumase-Okanta bridge	6.08699°N 0.53047°W	230
Bir	Birim River at Bunso waterworks	6.26594°N 0.47070°W	210
Aye	Ayensu River at Anum-Apapem	6.01225°N 0.60923°W	220

their ecology and behavior were noted. Identifications were made using Clausnitzer and Dijkstra (in prep.) and additional literature; taxonomy follows Dijkstra and Clausnitzer (in prep.). Collected specimens were deposited in the collection of the National Museum of Natural History (Leiden, The Netherlands).

RESULTS

A total of 72 species of Odonata were found, while the author had previously obtained records of six additional species from the area (Appendix 3). Thus 65% of the about 120 odonate species expected to occur in Atewa and its direct surroundings were found. Only 31 species were found strictly within the reserve's boundaries. However, the sampling of sites outside the reserve is relevant because those sites are part of the same freshwater system, depending on the situation upstream (i.e. within the reserve). Moreover, many habitat types are more accessible just outside the reserve's limits than within them. None of the recorded species are presently listed as globally threatened. Unlike the Odonata of northern, eastern and southern Africa, those of central and western Africa were not assessed for the 2006 Red List, as data were relatively limited and fragmented (Dijkstra and Vick 2004). However, the author has recently collated and assessed these data, and a preliminary Red-Listing has been made. One recorded species is regionally threatened (see below).

Eight species were recorded in Ghana for the first time, at least six of which are forest-dependent and at least six occur exclusively in running water. While only 43% of the recorded species were found strictly within the reserve's boundaries, three-quarters (six species) of the novelties originate from inside the reserve and five even from a single site, Obeng-ne-obeng stream:

1. *Africallagma vaginale* inhabits rainforest swamps. Previously known from Uganda south to northern Zambia, the present record thus represents a remarkable range extension.

2. A single female pertains to the genus *Onychogomphus*, which was previously unknown from Ghana. The specimen recalls *O. styx*, but the taxonomy of the genus is problematic and a definitive identification cannot be made at present.

3. *Paragomphus serrulatus* (also known by the synonyms *P. bredoi* and *P. xanthus*) inhabits open rivers from northeastern Democratic Republic of Congo to western Africa, having been reported from Sierra Leone, Liberia, Côte d'Ivoire, Togo, Benin and Nigeria.

4. A single female probably pertains to *Phyllogomphus moundi*. A male collected by the author in the Volta Region shortly after the RAP survey confirmed the presence of this species in Ghana. It was already known from Togo, Nigeria and Guinea.

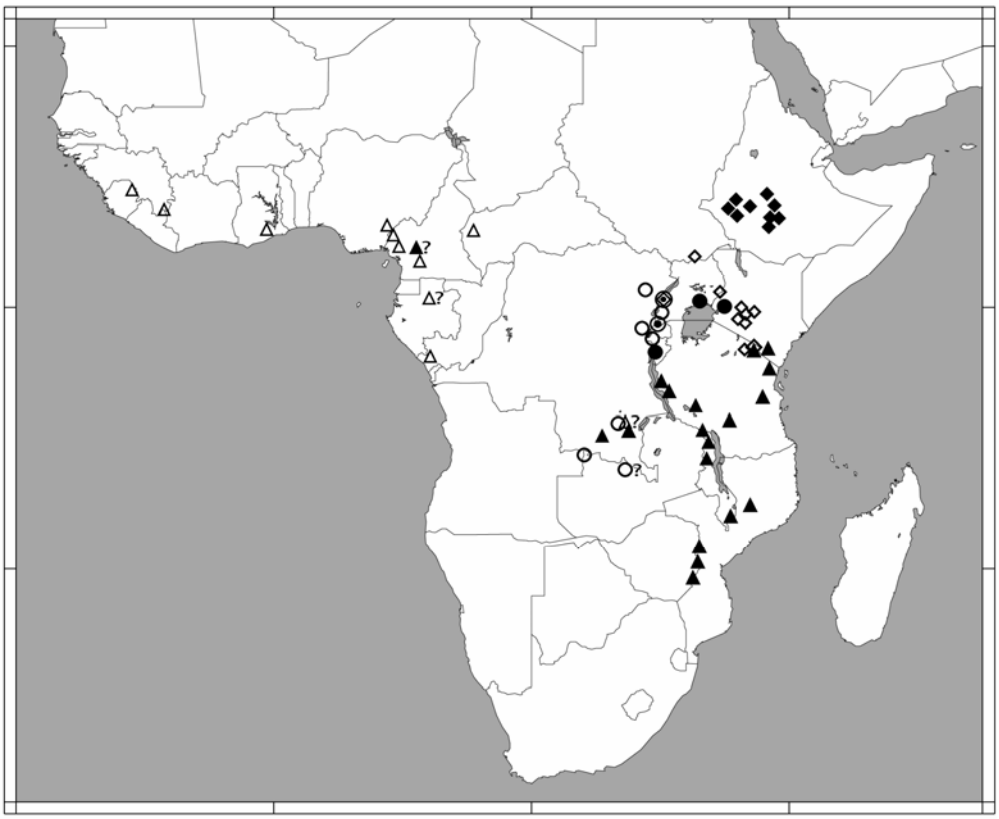

Figure 4.1. Distribution of the genus *Atoconeura*, demonstrating its montane character. Records of *A. luxata* (including that in Atewa) are marked by open triangles, other symbols represent five other *Atoconeura* species. Combined symbols indicate the sympatric presence of species, question marks doubtful or unconfirmed localities.
From: Dijkstra (2006).

5. A single female pertains to the genus *Tragogomphus*, which was previously unknown from Ghana. The taxonomy of the genus is problematic and a definitive identification cannot be made at present.

6. Two collected males are conspecific with *Phyllomacromia legrandi*, known only from the type locality Kpimé in Togo. However, a third male is morphologically identical but much darker, suggesting synonymy with *P. melania*. That species is also new for Ghana, but probably occurs (records require confirmation) both further west (Liberia, Guinea) and east (Nigeria), occurring in rainforest streams as far east as Uganda.

7. *Atoconeura luxata* occurs at fast sections of forest streams flowing off highlands. It had previously been found to the east in Nigeria, Cameroon, Congo-Brazzaville and the Central African Republic, but also in Guinea and Sierra Leone to the west.

8. *Orthetrum saegeri* inhabits streamside forest swamps and had not previously been found reliably west of Cameroon.

The discovery of *Atoconeura luxata* in Atewa is the most significant odonatological find of the RAP survey for a number of reasons. Not only was it first described only recently, with the inclusion of material and photographs taken during the RAP survey (see Dijkstra 2006), but it is also the only regionally threatened species found, being listed as Vulnerable on the IUCN Red List of West African Odonata (as evaluated in Accra shortly after the RAP survey). Unlike the five eastern African *Atoconeura* species, this one does not occur on top of highlands (above 1000 m), but at their base, including the Adamawa Massif and Mts. Nimba and Loma in western Africa (Figure 4.1). The discovery demonstrates Atewa's highland character despite its modest elevation. It is, for instance, also the only place in Ghana where brambles (*Rubus*) grow. The valley in Atewa where *A. luxata* occurs is notable for the presence of treeferns (*Cyathea*), a typical plant of Afro-montane forests. The unexpected discovery of *Africallagma vaginale*, which belongs to a genus of mostly upland species, may be another indication of Atewa's importance as a refuge for 'montane' species in a region presently dominated by lowland habitats.

CONSERVATION RECOMMENDATIONS

The Atewa forest harbors odonate assemblages that are representative of the Upper Guinean rainforest fauna. The forest stream assemblages found match those described by Dijkstra and Lempert (2003), suggesting healthy watersheds, with limited degrees of pollution and streambed erosion. As long as forest cover and natural stream morphology are retained, the existing dragonfly fauna is expected to persist. Considering the imperiled nature of the Upper Guinean rainforest, it is recommended that the forest and the watersheds it protects are conserved. Three major rivers in this densely populated region of Ghana have their headwaters in the Atewa Range, the Ayensu, Birim and Densu, the latter supplying one-third of the water used by Accra. Two observations are relevant in this light:

1. Several torrential downpours during the RAP did not alter the level of the streams and rivers, demonstrating the Atewa Range's capacity to absorb and gradually discharge water.

2. The site sampled on the Densu was heavily disturbed, with trees almost completely removed, but still harbored a diverse fauna, including typical forest dragonflies like *Umma cincta*, *Sapho ciliata*, *Chlorocypha luminosa*, *C. radix*, *Gomphidia gamblesi*, *Ictinogomphus fraseri*, *Cyanothemis simpsoni* and *Zygonyx chrysobaphes*. This suggests that the water quality was sufficient to support these species despite extensive damage to the surrounding landscape.

The steady flow of clean water off the range is determined by the capacity of the soil, swamps and forest on the plateaus and in the valleys to store and filter rainwater, and to buffer for spates and droughts. The populations of both dragonflies and humans around Atewa depend on this healthy and reliable resource for their survival. If the vegetation and deposits are stripped off the range, this would jeopardise the availability of freshwater for millions of Ghanaians and imperil a rich biodiversity with a nationally unique 'highland' character. While we recommend complete protection of Atewa, if any development activities were to take place within the Atewa Range it is of the utmost importance that minimal damage to the watershed be ensured by leaving broad zones around water bodies (e.g., rivers, inundation zones) untouched.

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Chapter 5

A rapid survey of butterflies in the Atewa Range Forest Reserve, Ghana

Kwaku Aduse-Poku and Ernestina Doku-Marfo

SUMMARY

Butterflies were used as one of the target species in a Rapid Assessment Program (RAP) survey to obtain quick, reliable and cost-effective biodiversity data from Atewa Range Forest Reserve. Overall, 143 species belonging to 55 genera in five families were recorded during the entire RAP expedition. The composition of butterfly species is plainly indicative of a good forest. The presence of *Tetrarhanis baralingam, Neaveia lamborni* and *Bicyclus auricruda* in Atewa were confirmed during our survey. *N. lamborni* and *B. auricruda,* prior to this survey, had not been seen in any protected area in Ghana. Almost half of the 17 rare species recorded are known either exclusively from Atewa or from just one other protected area in Ghana. The conservation of and further studies on these species is of ultimate importance in the quest to use butterflies as biological indicators. More than 700 different species of butterfly are now expected to occur on the Atewa Range. This is more than in any other single locality in Ghana, and for that matter anywhere in Africa west of the Dahomey Gap (and more than twice as many butterflies as in the whole of Europe!). As many as 50 rare species in Atewa may be recorded nowhere else in Ghana. The RAP expedition recorded 16 endemic species of which two (*Euphaedra mariae-christinae* and *Ceratrichia maesseni*) are endemic to the Ghana sub-region of West Africa. The remaining are endemic to the entire West Africa sub-region. The Atewa Range Forest Reserve provides a haven for many West African endemics. Ten of such endemic species are so far known only from the Range and might well in Ghana be limited to this reserve. Conservationists' understanding of the Afrotropical biological diversity has significant gaps and this hampers efforts to formulate sound biodiversity conservation measures. A few biologically rich, surviving forests like the Atewa forest remain the only hope for understanding some of the complexities and the functioning of ecosystem processes. The very high index of biodiversity, the presence of many endemic species, and several other species known from nowhere else in Ghana, and the pan-African rarity status of many of the species present in the Atewa Range Forest Reserve combine to indicate that its conservation importance is of the highest priority that the area should not be subject to development of any kind.

INTRODUCTION

Butterflies (Lepidoptera, Rhopalocera (Papilionoidea and Hesperioidea)) are a useful insect group in environmental monitoring and evaluation studies and have been used in several biodiversity monitoring programs around the globe with considerable success (Kremen 1992, 1994; Brown 1997; New 1997; Kerr et al. 2000; Larsen 2005a). They are by far the best known and most studied larger group of organisms apart from plants and vertebrates (Larsen 2006). Information such as habitat preference, habits, host plants, geographical distribution, endemism and/or rarity of most species is readily available for use in biodiversity data synthesis and interpretation. They can arguably be used as flagship taxa for terrestrial invertebrate biodiversity conservation.

The aesthetic beauty and charismatic nature of many butterflies have the ability to invoke

people's passion and interest, both of which are useful in butterfly conservation. Public interest in butterflies has grown enormously and has even become a political force in some countries. Major building developments have been rejected and proposed motorways have been relocated simply to protect scarce butterfly populations (New et al. 1995). By using butterflies as targets in biodiversity conservation, many co-existing and co-dependent organisms, like their food plants and natural enemies, may also be conserved.

Butterflies, by virtue of their high sensitivity, respond strongly to habitat disturbance (Brown, 1997) and most have special geographical distributions (Larsen 1994, 2006), reflecting past conditions, making them potentially useful biological indicator species. The use of butterflies as tools in rapid biodiversity assessment missions presents other advantages as well, such as their relatively stable and well known taxonomy, high sensitivity to changes in their habitats and microclimate heterogeneity and a high correlation with spatial, structural, and taxonomic diversity of vascular plants (Panzer and Schwartz 1998). Their high species richness (~20,000 in the world; ~4,000 in Afrotropics and ~925 species in Ghana), relative ease of capture, ubiquitous nature and explicit ecological preference, more or less, make them a useful taxon for use in a rapid biodiversity assessment.

Butterflies were therefore used as one of the target species in a RAP mission to obtain quick, reliable and cost-effective biodiversity data in the Atewa Range Forest Reserve (Atewa). The data resulting from this expedition are intended to inform conservationists and/or policy makers in formulating sound science-based conservation measures needed to conserve these charismatic species and the millions other species that co-exist with them or even depend on them.

STUDY SITES AND METHODS

Atewa covers a total landmass of 232 km^2. It is located within moist evergreen and semi-deciduous forest at lower levels and upland evergreen forest at higher levels (above 700 m). It is one of just two major areas of upland evergreen forest in Ghana, the other being at Tano Ofin. The RAP mission concentrated on three plateaux within the reserve that had been designated for bauxite exploration (and potential extraction) by ALCOA. The three plateaux were named Atiwiredu, Asiakwa South and Asiakwa North by the RAP team for consistency.

Atiwiredu was the first survey site for the research team. It is located at 06°12"22.7'N and 00°34"39.2'W with an altitude of 817 m a.s.l. There was evidence of very recent human disturbance of the vegetation. The plateau had numerous fresh (bauxite) exploratory transects constructed mainly with cutlasses and chainsaws. Investigation here was conducted over five field days from 7-11 June 2006.

Asiakwa South (06°15"44.3'N; 00°33"18.8'W; altitude 783 m a.s.l) was the second RAP camp. Again, the team stayed here for five field days (12-16 June 2006). The site generally had lots of old exploratory transects, indicating that mineral exploration had been carried out here not more than two years ago.

Asiakwa North (06°16"16.1'N; 00°33"52.7'W; altitude 814 m a.s.l) was the least disturbed habitat with most of its vegetation still intact. The team spent six field days, from 17-22 June 2006, sampling this plateau.

On the last sampling day (22 June), the butterfly team collected specimens along the main access road passing through the reserve. Portions of the road sampled were at least 10 km from the nearest plateau or camp site. This was done to build up the species checklist for the expedition. As a result, only species that had not been recorded earlier in the three study plateaux were noted.

Typical fruit-baited traps (see DeVries 1987 for details) and standard butterfly nets were used for specimen collection. Traps were baited mainly with rotten banana fruits, though pineapple fruits were used occasionally. Traps were set in suitable butterfly habitats along main roads used by vehicles within the reserve, exploratory transects, hunter trails and in the forest interior. A few traps were also set in the tree canopy. The trapping protocol was intended to yield most of the species in the Nymphalidae family (Satyrinae, Charaxinae, Nymphalidae) that are difficult to catch with butterfly nets. In all, 20 fruit-baited traps per site were used for the study, except for Atiwiredu where 14 traps were set. Traps were re-baited every 24 hours during the sampling periods. This protocol was repeated for each study/camp site.

Using mainly pre-existing hunting trails passing through suitable butterfly habitats, a standard butterfly net was also used to collect specimens. Species seen (and easy to identify in flight) during transect/trail walks were also recorded. Available taxonomy treatises (e.g. Larsen 2005) were used for properly identifying confusing/difficult specimens. The distance walked at each site depended very much on the prevailing weather conditions. Longer distances were walked at sites with more favorable butterfly weather conditions (i.e. reasonable amount of sunshine) and vice versa. To allow for effective comparison of butterfly composition between sites, the time spent during trail walk survey was standardized into "effective sampling hours". For this RAP survey, one effective sampling hour denotes one hour of good butterfly weather. This may not necessarily be one uninterrupted hour of good butterfly weather. High quality specimens were kept in glassine envelopes and taken to a laboratory in Kwame Nkrumah University of Science and Technology (KNUST), Kumasi for further processing. Specimens that were confusing or difficult to identify were sent to Dr. Torben B. Larsen for clarification. KNUST has recently built a museum and a space for a butterfly specimens collection has been applied for. The specimens together with others collected by the lead author (Kwaku Aduse-Poku) from other localities will form the first batch of butterfly voucher specimens for the university museum. Species rarity and endemism status were adopted from Larsen (2006).

RESULTS

Overall, 143 species belonging to 55 genera in five families were recorded during the RAP expedition (Appendix 4). This number represents about one-fourth of the species positively recorded from and accepted for the entire reserve. It is probable that more favorable butterfly weather (lots of sunshine) would have yielded many more species. It was raining on average almost every three out of four (75%) days throughout the expedition period. Overwhelmingly, two-thirds of the specimens collected belonged to the Nymphalidae family. This family contains species that are mostly fruit feeders and will normally come to fruit-baited traps. This indicates that the trapping protocol was a useful component of the RAP survey. The unfavorable weather (characterized by heavy mist and frequent rain showers) probably accounted for the conspicuous absence of Lycaenidae and Hesperiidae (skippers) from the list.

As a comparison of the butterfly biodiversity between sites, at Asiakwa South we recorded the highest number of species (89) and at Asiakwa North we recorded the lowest number of species (57) (Table 5.1). Thirteen additional species were recorded along the main road (about 20 km from the study site) after 2.5 'effective sampling hours'. It is worth mentioning that many species were seen along the main road but only those not recorded in the three RAP survey sites were noted. Over 90 percent of the species collected during the expedition were typical forest species (Appendix 4).

Considering the species composition at the various sites, our results indicate that Asiakwa South was the most disturbed. Here, we recorded a high incidence of 'sun-loving' species like *Bicyclus sandace* and *B. vulgaris*. There were also many activities and individuals of *Junonia terea terea* and *Precis pelarga* on this plateau. These species prefer (patchily) disturbed habitats within forest zones and are often justifiably used as indicator species for anthropogenic disturbance within forest zones. The Asiakwa South site is believed to have been explored last year for bauxite deposits. The exploration has created significant openings in the vegetation, much more than in the two other study sites, hence giving way for many species not strictly limited to forest. It was not surprising, therefore, that this area recorded the highest number of species since butterflies, like most insect groups conform well to the mild (intermediate) disturbance principle (Fermon et al. 2000, DeVries and Walla 2001). It must also be mentioned that the area still has a reasonable amount of good forest patches that are able to support viable population of forest butterfly species. In contrast, Asiakwa North held the lowest species richness, though this site was the best in terms of vegetation or habitat health conditions. There were generally low relative numbers of species collected on this plateau. Atiwiredu was intermediate to the two plateaux in terms of both species richness and habitat health.

DISCUSSION

Overall Biodiversity

More than 700 different species of butterfly are now estimated to occur on the Atewa Range, of which almost 600 are positively recorded. This is more than in any other single locality in Ghana, and for that matter anywhere in Africa west of the Dahomey Gap. The presence of *Tetrarhanis baralingam, Neaveia lamborni* and *Bicyclus auricruda* in Atewa was confirmed during the mission. *N. lamborni* and *B. auricruda* have so far not been recorded from any of the protected areas in Ghana. *T. baralingam* however has been recorded in three of the National Parks in Ghana; namely Kakum, Ankasa and Bia. Interestingly, each site recorded one of these confirmed species. *T. baralingam* was seen on the Atiwiredu plateau. *N. lamborni* and *B. auricruda* were collected on the north and south plateaux of Asiakwa respectively. The three confirmed species were among those suspected as possibly occurring on the Atewa Range (Larsen 2006). This will now raise the number of species that have been positively recorded and accepted in Atewa Forest Reserve to 575. This is nearly twice as many butterflies as in the whole of Europe.

Endemicity

The RAP expedition recorded 16 endemic species of which two are endemic to the Ghana sub-region (*Euphaedra mariaechristinae* and *Ceratrichia maesseni*). The remaining 14 species are endemic to the West Africa sub-region as a whole. Atewa provides a haven for at least 66 of the known 100 West African endemics. Ten of such endemic species are so far known in Ghana only from Atewa and might well be limited to this area. Some of these species are suspected to reside also in Tano Ofin, which is similar to Atewa in terms of both vegetation and topography. Unfortunately this reserve is highly degraded and earmarked for bauxite mining.

Table 5.1. Details of actual fields days and effective sampling hours spent per site during a RAP survey in the Atewa Range Forest Reserve in Ghana. The number of species observed per camp site is also presented.

Sites	Field days spent	Effective Sampling hours	No. of Species
Atiwiredu	5	12	74
Asiakwa South	5	9	89
Asiakwa North	5	8	57
Along main road	1	3	13 additional

Astictopterus anomoeus, recorded at Atiwiredu and Asiakwa South during the RAP survey, is one such species, recently known from nowhere else in Ghana but Atewa and just in Volta. Among other West African endemics (not seen during the RAP expedition but) known only from Atewa in Ghana are:

Mylothris atewa. Described from Atewa and almost certainly a narrow endemic to the Atewa Range, this species is found only above the 600 m contour. This distinctive species may be common, and is unlikely to have been overlooked elsewhere in West Africa. Larsen (2005b) comments that it has no obvious affinities to other members of the genus.

Anthene helpsi. Described from Atewa following its capture by Major T. Helps, this is the only white *Anthene* among almost a hundred others in Africa. Though a questionable record from near Abidjan in Côte d'Ivoire exists, Larsen (2005b) now discounts this record and considers the species to be an amazing Atewa endemic. What is fascinating is, at the very same spot where two individuals of this species were collected in 1993, two other species of conservation interest (*Mylothris atewa* and *Papilio antimachus)* were also seen. Unfortunately, bauxite exploratory transects have already been cut into this area.

Acraea kibi. Described from Atewa as a distinct species, Larsen (2005b) considers this to be a distinctive and valid subspecies of *A. kraka* which is otherwise known only from the mountains of the Nigeria/Cameroon border. The species is obviously a resident of the upland forest habitat and has also once been found in numbers at Tano Ofin.

The Atewa Range also supports most of the butterflies that are endemic to Africa west of the Dahomey Gap (for details see Larsen 2006).

Biogeography

Some species found at Atewa have biogeographical affinities with the fauna of eastern Nigeria and Cameroon. Two examples are:

Bicyclus sylvicolus. Widely distributed in the equatorial rainforest of central Africa and occurring in eastern Nigeria, it also occurs in the forests of the Ghana/Togo Mountains, widely separated from the main population. The species is found also on Atewa, but nowhere else in Ghana. Although there are old records of this species from Father Masseni Atewa collection in Allyn Museum, USA, Larsen (2005b) suspected possible mislabeling and needed this claim substantiated. Not long after the RAP survey in August 2006, the lead author (Aduse-Poku) caught both female and male of this species in baited traps. On Atewa it co-habits with *Bicyclus abnormis* which is an endemic of Africa west of the Dahomey Gap that is widely distributed from Ghana to Sierra Leone. ONLY on the Atewa Range do these two species occur in the same locality. It is very rare to find such two geographical vicariants inhabiting the same locality.

Acraea translucida is similar in its range, being found only in western Cameroun, Nigeria, the Volta Region Mountains and on Atewa. However, this species has no proper West African vicariant; so that Atewa is the westernmost point of its range.

Rare Species

The importance of Atewa is also underlined by the presence of a large numbers of very rare butterflies – species that are rare not just in Ghana but in Africa as a whole. Almost half (48%) of the 17 rare species recorded during the expedition (see Table 5.2) are positively recorded either exclusively from Atewa or from just one other protected area in Ghana. Some of the rare species recorded either are positively limited to the Atewa Range Forest Reserve or occur in just one of the protected areas in Ghana. *Vanessula milca* is one of the Atewa exclusives. *Bicyclus trilophus, Aslauga lamborni* and *Bebearia arcadius* occur in Atewa and just one of the protected areas in Ghana. The conservation and further studies on these species is of importance in the quest to use butterflies as biological indicators in overall biodiversity assessment. The host plant of *Vanessula milca* for instance, to date, remains unknown and finding it will provide an understanding of its irregular distribution in West Africa: though usually common on Atewa, it has not recently been found elsewhere in Ghana and its distribution in the rest of Africa is very patchy. Review of existing butterfly literature of the forest reserve shows that about as many as 50 rare species in Atewa are recorded nowhere else in Ghana (Larsen 2006). One good example of such species is the recently discovered *Charaxes fournierae jolybouyeri,* Vingerhoedt, 1998. This species is most unusual and some authors (Joly 2003) consider the presence of this species sufficient to justify conservation measures for Atewa. *C. fournierae jolybouyeri* is the western subspecies of an extremely rare butterfly from equatorial Africa; it was found on the Atewa Range and then – amazingly – also in the Guinea Mountains near Nzérékoré.

The extremely rich butterfly fauna of Atewa contains a number of rare species worthy of special mention, though they were not recorded during the RAP survey. First among these is the magnificent *Papilio antimachus* Drury, 1782 whose wing-span can be up to 25 cm, the widest of any butterfly in the world. The wings are very narrow and other butterflies surpass it in wing surface. The only other Ghana records traced are from Amedzofe in the Volta Region and most recently (2005) from Bobiri. The population in Volta now appears to be extinct and the rather extensive forests below Amedzofe have largely been destroyed. The species is, however, still present on Atewa and has been found on at least five occasions during the past five years - but it is rarely seen except when coming down to drink from the edge of streams since it stays in the canopy.

Other interesting and significant species include:

Graphium rileyi – a large species that is endemic to West Africa and in Ghana known only from Atewa; there are long series from Atewa in collections but no recent records from Ghana or Côte d'Ivoire.

Pentila petreoides – a very rare West African endemic species; the only Ghana records are from Atewa.

Ornipholidotos issia – is a West African endemic; its only known Ghana population is on the Atewa Range.

Table 5.2. Rare butterfly species recorded at each study/camp site during a RAP survey in the Atewa Range Forest Reserve, a forest fragment in Ghana. Rare species as adopted from Larsen (2006) are species usually found on less than 10-20% of visits to most suitable localities.

	Species	Atiwiredu	Asiakwa South	Asiakwa North
1	*Aslauga lamborni*		x	
2	*Ornipholidotos onitshae*		x	x
3	*Mimeresia cellularis*	x		x
4	*Iolaus aethria*	x		
5	*Hypolycaena clenchi*			x
6	*Bicyclus trilophus jacksoni*			x
7	*Bicyclus nobilis*		x	
8	*Heteropsis peitho*	x	x	x
9	*Vanessula milca milca*			x
10	*Precis sinuata*	x	x	
11	*Euriphene incerta incerta*		x	
12	*Bebearia arcadius*		x	x
13	*Euphaedra splendens*	x		
14	*Euphaedra eupalus*		x	
15	*Acraea orina*	x		
16	*Ceratrichia semilutea*	x	x	x
17	*Ceratrichia maesseni*	x		
TOTAL		**8**	**9**	**8**

Mimeresia moyambina – a very rare West African endemic, originally described from Sierra Leone, where it has not since been refound; a few were found in Côte d'Ivoire during the 1960s and a small series caught on Atewa a few years ago.

Liptena griveaudi – an almost unknown species described from Côte d'Ivoire; the only Ghana records are from Atewa. The status of Sierra Leone material is uncertain.

Stempfferia staudingeri – a rare butterfly found from Sierra Leone to western Nigeria, in Ghana only known from Atewa.

Iolaus mane – this species was recently described from the Fouta Djalon in Guinea; a specimen from Atewa was unexpectedly located in the Allyn Museum of Entomology in Florida and no other Ghana specimens are known

Anthene atewa – a recently described butterfly named after the Atewa Range that has been found also in other Ghana forests of good quality and rarely in Côte d'Ivoire; it seems a very scarce West African endemic.

Bicyclus dekeyseri – a rare endemic of the wettest forest in West Africa; very few are known from Ghana, mostly from Atewa.

Euphaedra ignota –a distinctive Ghana endemic that was described from Atewa but has been recorded also from Kakum and forests near Atewa.

Euphaedra eusemoides – a most distinctive and very rare butterfly, endemic to Africa west of the Dahomey Gap, only known from the Atewa Range in Ghana; none has been found in Ghana since the 1960s.

Celaenorrhinus sagamase – a very rare butterfly recently described from Atewa (named after the Sagyemase track to Atiwiredu), but one has also been found in Kakum; a spectacular West African endemic.

Celaenorrhinus ankasa – a rare West African endemic; one of the types was from Atewa; it has since been found also in Sierra Leone.

Many other species that are rare on a pan-African basis are found in the Atewa forests. Dr. T.B. Larsen (pers. comm.) was consulted on this section and commented that the list of rare species could be continued for more pages than this report can contain.

CONSERVATION RECOMMENDATIONS

The very high index of biodiversity, the presence of many endemic species and several other butterfly species known from nowhere else in Ghana, and the pan-African rarity status of many of those species present in Atewa combine to indicate that its conservation is of the highest priority – possibly the most important site in the country apart from the national parks (Ankasa, Bia, Kakum). It is therefore not surprising that the conservation status of this reserve has increased and elevated over the years from a Special Biological Protection Area (SBPA), to a Hill Sanctuary, and most recently a Globally Significant Biological Area (GSBA).

Conservationists' understanding of Afrotropical biological diversity has significant gaps and this paucity of information hampers their ability and efforts to formulate sound biodiversity conservation measures. The few biologically rich, surviving forests like the Atewa forest remain the only hopes for understanding some of these complexities and functioning in ecosystem processes. Forests in Ghana are fast disappearing and even considered one of the most imperiled ecosystems in the world (FAO 2006). Unfortunately what is unknown in this vulnerable ecosystem eclipses what is known, making it one of the least studied and ecologically understood forest zones in the world (Laurance 1997). We strongly recommend, based on the results of this survey and prior work in the Atewa area, that the Atewa Range Forest Reserve should be fully protected and not opened up for development activities that could harm this site of global conservation priority.

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Chapter 6

Additional comments on butterflies of the Upland Evergreen Forest of the Atewa Range Forest Reserve, Ghana

Torben B. Larsen

INTRODUCTION

Chapter 5 of this report presents a good summary of the Atewa butterfly fauna based on the RAP survey and existing data and appears to be the first major review of butterflies in Ghana that has been written by Ghanaian researchers, which is promising for the future. The most important facts are well highlighted within that chapter: i) the uniqueness of the Upland Evergreen forest in Ghana (the small and damaged area in Tano Ofin aside), ii) the presence of three species of butterflies endemic to the Atewa Range, iii) the presence at Atewa of a significant number of species not found elsewhere in Ghana, and iv) the fact that with 700 species of butterflies certain to occur there, Atewa it is the most biodiverse locality in Ghana for that group. Aduse-Poku and Doku-Marfo thus leave little more to be said.

Mylothris atewa

However, some further notes on the endemic species *Mylothris atewa* (Atewa Dotted Border) are called for. The species seems first to have been collected in the 1960s by Father Theodor Maessen, a Roman Catholic priest who collected butterflies in Ghana for 32 years between 1950 and 1982, recording a total of more than 800 of the 930 species currently known from Ghana. However, only in 1980 was the species described by Dr. Lucien Berger, then curator for insects at the Royal Museum for Central Africa (MARC) in Tervuren, Belgium.

The species is quite different in both sexes from any other member of its genus, of which there are at least 60 species throughout Africa. Both sexes can be recognized at a glance from any of the eight *Mylothris* that fly in Atewa. The species flies only in the higher level forests where the Upland Evergreen vegetation is found, probably because it feeds on a species of mistletoe (Loranthaceae) that is similarly restricted in range. The potential range of this butterfly is certainly less than 100 km^2, but it occurs patchily and the actual inhabited area within the forest is much less than that. We can be almost certain that the species occurs nowhere else (should an overlooked population exist in Tano Ofin, it will be even smaller).

The small area of occurrence, the small population size, the encroachment on the forest, and the threat to the forest by mining has led to almost certain ranking of this species on the World Conservation Union (IUCN) Red List in the most threatened category of Critically Endangered (CR).

UPLAND EVERGREEN FOREST – A FOSSIL HABITAT

Mylothris atewa obviously evolved in the Upland Evergreen forest, probably during cooler periods when the extent of this forest was larger than it is today, since it could survive at lower elevations. The Atewa Forest has had a complex history. During the many dry periods of the past 20 million years the West African rainforests have been pushed into tiny refuge areas (one of which was centered on Ankasa and southwestern Côte d'Ivoire, another on Liberia and eastern Sierra Leone). The rest of the forest zones were covered with savannah. During such periods the Atewa Forest must have survived as a forest island inside the savannah. Dur-

ing wetter periods the forests expanded far into Senegal and Burkina Faso – the savannahs of the Dahomey Gap in Togo and Bénin were also then covered with forest. But the upland forest type that had evolved during periods of isolation now survived as an island inside the type of lowland rainforest that we see today. The last major climatic perturbation took place as recently as the most recent ice-age. Pollen samples from Lake Bosumtwi show that between 19,000 and 15,000 years ago its surrounding was open savannah country: Atewa was too far to the south for the pollen of its forests to reach the lake. Samples from 10,000 years ago show a completely different picture. The forest had by then extended far to the north and east and no trace of savannah pollen was now present in the lake. Probably most of the Dahomey Gap was forested as well (Maley 1996). But the upland forest on Atewa still survived, and we still have it today.

The Upland Evergreen forest can actually be considered a fossil habitat that is very old, certainly measured in millions or tens of millions of years. Its flora and fauna will have changed over the vast periods of time, but evidence of its origins and affinities with the rest of Africa remain in the DNA of its present inhabitants. How old is *Mylothris atewa*? The relevant DNA analysis has not yet been undertaken. Judging from other butterflies where such studies have been made (e.g. the genus *Bicyclus* (Monteiro and Pierce 2000)), a species as distinct *M. atewa* probably diverged from the other West African *Mylothris* at least 5 million years ago. Ideally no organism should be allowed to go extinct, which will certainly happen to *M. atewa* if the upland forest is severely damaged or diminished in size. However, more important than a single butterfly is the Upland Evergreen forest as a habitat with its own unique and complex ecosystem. Inside the flora and fauna of the Upland Evergreen forest lie many secrets of evolutionary processes that have still not been unlocked. When these processes are unravelled, further light will be thrown on the effects of climatic perturbations on the distribution of organisms.

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Chapter 7

The katydids of the Atewa Range Forest Reserve, Ghana

Piotr Naskrecki

SUMMARY

Sixty-one species of Tettigoniidae were collected, the highest number of katydids known from a single location anywhere in Africa. Of these, at least 8 are new to science, and 36 are new to Ghana. Site 2 (Asiakwa South) showed the highest species richness (50 spp.), likely due to a high edge effect created by a dense network of roads. While we recommend this area be protected in its entirety, any future development that is allowed within the area should be restricted to the southern part of the range in order to reduce further fragmentation of the remaining forest. Furthermore, roads and clearings that are no longer in use should be reforested to reduce habitat fragmentation and to discourage illegal logging and hunting.

INTRODUCTION

Katydids (Orthoptera: Tettigonioidea) have long been recognized as organisms with a significant potential for their use in conservation practice. Many katydid species exhibit strong microhabitat fidelity, low dispersal abilities (Rentz 1993a), and high sensitivity to habitat fragmentation (Kindvall and Ahlen 1992) thus making them good indicators of habitat disturbance. These insects also play a major role in many terrestrial ecosystems as herbivores and predators (Rentz 1996). They are themselves a principal prey item for several groups of invertebrates and vertebrates, including birds, bats (Belwood 1990), and primates (Nickle and Heymann 1996). At the same time many species of katydids are threatened, and some appear to have already gone extinct (Rentz 1977).

The conservation value of katydids has been recognized in Australia (Rentz 1993b) and Europe, leading to the development of captive breeding programs (Pearce-Kelly et al. 1998), listings on individual country (Glowacinski and Nowacki 2006) and global Red Lists (IUCN 2006), and introduction of regulations aimed at their conservation. But their use as conservation tools or targets of conservation actions in tropical regions, where their importance and the level of endangerment are the highest, is hampered by the lack of baseline data on katydid distribution as well as the shortage of katydid expertise and identification tools, a phenomenon known as the taxonomic impediment. It is therefore critically important that more effort be directed towards basic faunal surveys of katydids across the tropics, thus creating the basis on which a successful conservation strategy for these animals can be built. Such surveys, if conducted in pristine or relatively undisturbed areas, also provide reference data, which can later be used in habitat monitoring or restoration efforts that should follow any industrial or agricultural activity. West African ecosystems are in particular need of extensive biotic surveys, as these are some of the least studied tropical habitats while also being subject to widespread, poorly regulated, and often illegal logging and mining activities, combined with persisting slash-and-burn agricultural practices. This results in a rapid decline of available, natural habitats, and thus an inevitable loss of biodiversity.

The following report presents the results of a survey of katydids conducted between June 6 – 24, 2006 at selected sites within the Atewa Range Forest Reserve (Atewa) in the Eastern

Region of Ghana. This is the first systematic survey of katydids in this country, and its results indicate the presence of a rich and unique fauna of this group of insects. To date, the only records of katydids in Ghana are those in the works of Beier (1965), Bolivar (1886, 1890, 1906), Karsch (1888, 1890), Ragge (1962, 1980), and Redtenbacher (1891) who collectively recorded only 13 species of katydids from this country.

From both floristic and faunistic points of view, the Atewa Range is a particularly interesting area. Located in the Akyem Abuakwa Traditional Area, the reserve comprises two blocks of the Upland Evergreen Forest, one of only two such forest ecosystems in Ghana. The reserve contains about 60% of the forest coverage within the entire Eastern Region, and thus most of the available habitats for its forest fauna. The area included within the confines of the reserve spans two floristic zones, with the larger, northern portion of the reserve covered with a moist deciduous forest. Most of the reserve is situated on two plateaus, ranging in elevation from 350 to 800 m above sea level. This topography contributes to climatic conditions that favor plant formations that require constant, high humidity, and somewhat lower temperatures than floras in the surrounding, lowland areas. Consequently, the insect faunas of the Atewa Range can be expected to differ from lower areas of Akyem Abukawa.

METHODS

During the survey three methods were employed for collecting katydids: (1) collecting at incandescent and ultraviolet (UV) lights at night, (2) visual search at night, and (3) net sweeping of the understory vegetation during the day and at night. Unfortunately, the UV light method was not available at all study sites, thus potentially reducing the chance to collect flying, nocturnal species, such as many members of the Phaneropteridae. However, the availability of other light sources (incandescent lights around the camp) allowed us to collect many of the nocturnal, flying species of katydids, including several inhabitants of the upper layers of the forest canopy.

Net sweeping was employed in the vegetation along the roads within the forest, the forest understory, and natural openings within the forest, such as edges of streams or forest ponds. This method was highly effective in locating seed-feeding katydids in tall grasses as well as a number of arboreal katydids that cling upside-down to the lower surface of leaves. Sweeping was standardized by performing five consecutive sweeps in a series before the contents of the net were inspected. By far the most effective method of collecting, both in terms of the number of species collected and number of collected specimens, was the visual search at night. Most of the collecting was conducted after dark, between the hours of 8 pm and 2 am when the activity of virtually all katydid species is the highest. Yet day collecting along the forest roads also yielded several interesting species, including one (*Ruspolia* sp. 1), the presence of which may indicate an encroachment of savanna elements into the reserve.

In addition to physical collection of specimens, stridulation of acoustic species was recorded using the Sony MZ-NHF 800 digital recorder and a Sennheiser shotgun microphone. These recordings are essential to establish the identity of potentially cryptic species, for which morphological characters alone are not sufficient for species identification. An ultrasound detector Pettersson D 200 was also used to locate species that produce calls in the ultrasonic range, undetectable to the human ear.

Representatives of all encountered species were collected and voucher specimens were preserved in 95% alcohol and as pinned, dry specimens. These specimens will be deposited in the collections of the Museum of Comparative Zoology, Harvard University and the Academy of Natural Sciences of Philadelphia (the latter will also become the official repository of the holotypes of several new species encountered during the present survey upon their formal description).

Katydids were surveyed at three sites within the reserve, Site 1 in the southern, and Sites 2 and 3 in the northern part of the range. Site 1 (Atiwiredu) was located at 6°12'24.7"N, 0°34'37.2"W, elevation 795 m, and sampling was conducted there from 6 – 10 June, 2006. This site had an extensive network of roads, and was subject to prospecting activity by ALCOA. Despite this activity, the forest condition was rated 2 by the botanical team, indicating a relatively low level of disturbance.

Site 2 (Asiakwa South) was situated at 6°15'44.3"N, 0°33'18.8"W, at the elevation of 690 m, and sampling was conducted there from 11 – 16 June, 2006. This site, while not currently subject to prospecting activity, still contained an extensive network of roads, some overgrown with tall grasses. These roads appear to act as passages allowing the penetration of invasive elements, such as grasses or species of insects normally associated with open habitats, deep into the forest. The condition of the forest at this site was rated as 3.

Site 3 (Asiakwa North) was located at 6°16'16.4"N, 0°33'52.8"W, elevation 769 m, and was sampled from 16 – 24 June, 2006. Most of the site was covered with tall, closed-canopy forest, with little underbrush, and no open roads. Its condition was rated as 2. There were few gaps in the forest, which accounts for the low number of species associated with such habitats. The only gaps present were overgrown with tall, broad-leaved plants of the family Marantaceae.

RESULTS

The survey resulted in the collection of 61 species of katydids, the highest number of katydids known from a single location anywhere in Africa. Most collected species represent new records for Ghana, and at least eight species are new to science (but it is quite likely that more species will be determined to be new once the process of their identification is completed.) Identities of several species require confirmation by comparing them to type specimens of species described from West Africa as in some cases the original descriptions are not detailed enough to make positive identification.

Many species listed here appear to have a wide, West African distribution, having been recorded from sites in Cameroon and Guinea. Their presence in eastern Ghana supports this notion, and fills a gap in our knowledge of West African biogeography. A full list of recorded taxa is given in Table 7.1, and below I comment only on new or particularly interesting species.

Family Phaneropteridae

This group of katydids includes most species restricted to thecanopy level of the forest. Many are excellent fliers, and can be collected at night using UV or incandescent lights. Some are diurnal and can be heard calling during the day from tall trees. All members of this family are exclusively herbivorous. Twenty-seven species of this family were found during this survey.

Ducetia fuscopunctata Chopard, 1954 – this species was originally described from Mt. Nimba, Guinea, and this is its first record from Ghana. It is associated with edge habitats, such as tall vegetation along the roads, but in can also be found in natural gaps within the forest. This species was particularly abundant at Site 2, but was conspicuously absent from Site 3.

Arantia spp. – Six species of this genus were recorded, at least two of which are possibly new to science. They were all associated with tall understory vegetation within the forest as well as tall, broad-leaved plants along the roads. *A. rectifolia* Br.-Watt, *A. retinervis* Chopard, and *A. angustipennis* Chopard are new to Ghana, having been previously recorded only from Fernando Po, Cameroon, and Guinea, respectively.

Preussia lobatipes Karsch, 1890 – This spectacular leaf mimic has been known so far only from a handful of specimens collected in Cameroon and Guinea, and its presence in Ghana is not surprising. A single female was collected at lights at Site 2.

Weissenbornia praestantissima Karsch, 1888 – Like the previous species, *W. praestantissima* has previously been known only from Cameroon and Guinea. Two individuals were collected at lights at Site 2.

Plangiopsis foraminata Karsch – Two individuals of this arboreal, lichen-mimicking katydids were collected at lights at night at Site 2. Previously this species has only been known from Cameroon (Karsch 1891).

Family Conocephalidae

The Conocephalidae, or the conehead katydids, include a wide range of species found in both open, grassy habitats, and high in the forest canopy. Many species are obligate graminivores (grass feeders), while others are strictly predaceaous. A number of species are diurnal, or exhibit both diurnal and nocturnal patterns of activity. Only three species of this family were recorded.

Conocephalus carbonarius Redtenbacher, 1891 – This species is one of the few true forest species of the genus. Individuals of *C. carbonarius* were common in the understory of forests at all visited sites, but were particularly abundant along roads and in herbaceous vegetation along the edges of bodies of water. Unlike most species of the genus *Conocephalus*, males of *C. carbonarius* are active both day and night, singing from vegetation very low to the ground. This species appears to be predominantly predaceous. It was originally described from Ghana (Redtenbacher 1891), and was subsequently found in Guinea (Chopard 1954).

Ruspolia sp. 1 – A single individual of this predominantly savanna genus was found at Site 2 in grasses along one of the roads. *Ruspolia* species are obligate graminivores, and can only survive in habitats rich in grasses, and where humidity is not very high. The presence of a *Ruspolia* species deep within the forest is a sign of potentially negative changes within this environment, and points to the important role roads play in allowing foreign elements to penetrate forested areas.

Thyridorhoptrum sp. 1 – A new species of this genus was found at Site 2. It appears to be related to *T. baileyi* Pitkin from forests of Uganda, but differs in a number of characters, including the call pattern of the males.

Family Meconematidae

This poorly studied family includes some of the smallest species of katydids, and many appear to be exclusively predaceous. Nearly all species of Meconematidae are arboreal, nocturnal, and extremely agile, making it very difficult to collect them (many are flightless, and thus rarely come to lights at night.) Ten species were recorded, including at least two representing a new genus and new species.

Amyttosa mutillata (Karsch, 1890) – A species known previously only from Cameroon (Karsch 1890). It was also erroneously recorded from Equatorial Guinea (Beier 1965), a mistake based on the false assumption that the original type specimens of *A. mutillata* possessed damaged female reproductive organs (hence the name), and that similar but "undamaged" individuals from other parts of Africa were conspecific. Yet numerous individuals collected at Sites 2 and 3 during the current survey prove conclusively that this species is unique in having a highly reduced, rudimentary ovipositor, a condition extremely rare within this group of katydids, and usually associated with egg laying on exposed surfaces, such as leaves or bark. Such a behavior is found in katydids living in highly humid environments.

Gen. nov. spp. – Two species of a new genus of flightless Meconematidae were found at Sites 2 and 3. They appear to be closely related to a yet undescribed genus of katydids from the Upper Guinean forest of Guinea, and may turn out to be congeneric. Because these new species appear to have poor dispersal abilities, typical of most flightless katydids, it is possible that they may be endemic to the Atewa Range.

Family Mecopodidae

Three species of this exclusively tropical group of katydids were found during this survey. Most of its species are associated with humid forests, and all species appear to be herbivorous. No members of this family have ever been recorded from Ghana, although their presence there is not surprising as they are known from most of the neighboring countries.

Afromecopoda spp. – Two species of this genus were

Table 7.1. A check list of species of katydids recorded from the Atewa Range Forest Reserve, Eastern Ghana.

	Species	Site 1 (Atiwiredu)	Site 2 (Asiakwa S)	Site 3 (Asiakwa N)	New to Ghana	New to science
	Conocephalidae (3 spp.)					
1	*Conocephalus carbonarius* Redtenbacher	x	x	x		
2	*Thyridorhoptrum* sp. nov. 1		x		x	x
3	*Ruspolia* sp. 1		x			
	Meconematidae (10 spp.)					
4	*Amytta* sp. 1		x			
5	*Amytta* sp. 2		x			
6	*Amyttosa mutillata* (Karsch)		x	x	x	
7	*Anepitacta lomana* Ragge		x	x	x	
8	*Anepitacta* sp. 2		x			
9	*Anepitacta* sp. 3	x				
10	*Anepitacta* sp. 4		x			
11	Gen. Nov. sp. 1		x	x	x	x
12	Gen. Nov. sp. 2		x	x	x	x
13	*Proamytta* sp. 1			x		
	Mecopodidae (3 spp.)					
14	*Afromecopoda frontalis* (Walker)	x	x	x	x	
15	*Afromecopoda* sp. nov.	x			x	x
16	*Corycoides abrubtus* (Krauss)		x	x	x	
	Phaneropteridae (27 spp.)					
17	*Ducetia fuscopunctata* Chopard	x	x		x	
18	*Tapiena minor* Bolivar	x	x			
19	*Arantia rectifolia* Br.-Watt.		x		x	
20	*Arantia retinervis* Karsch		x	x	x	
21	*Phaneroptera nana* Stal		x			
22	*Arantia* sp. 2	x	x	x		
23	*Arantia* sp. 3	x	x	x		
24	*Arantia angustipennis* Chopard	x	x	x	x	
25	*Arantia* sp. 4	x		x		
26	*Catoptropteryx capreola* Karsch	x	x	x		
27	*Catoptropteryx* sp. 2		x			
28	*Catoptropteryx* sp. 3		x			
29	*Catoptropteryx* sp. 4		x			
30	*Eurycorypha ornatipes* Karsch			x	x	
31	*Eurycorypha* sp. 2	x	x			
32	*Eurycorypha* sp. 3		x			
33	*Eurycorypha mutica* Karsch		x	x	x	
34	*Plangiopsis foraminata* Karsch		x		x	
35	Gen. Nov. 2 Phan sp. 1		x		x	x
36	Gen. Nov. 3 Phan sp. 1			x	x	
37	*Goetia galbana* Karsch	x			x	
38	*Preussia lobatipes* Karsch		x		x	
39	*Poreumena lamottei* Chopard		x	x	x	
40	*Tetraconcha* sp. 1	x	x			
41	*Tetraconcha* sp. 2		x			
42	*Weissenbornia praestantissima* Karsch		x		x	
43	*Zeuneria melanopeza* Karsch		x		x	
	Pseudophyllidae (18 spp.)					
44	*Stenampyx annulicornis* Karsch		x	x	x	
45	*Tomias hardus* (Karsch)	x	x		x	
46	*Adapantus bardus* Karsch	x	x	x	x	
47	*Adapantus nitens* Chopard	x	x	x	x	
48	*Adapantus* sp. nov. 3	x	x	x	x	x
49	*Adenes obesus* Karsch	x		x	x	
50	*Adenes* sp. 2	x	x			
51	*Adenes* sp. 3		x	x		
52	*Batodromeus richardi* Griffini			x	x	
53	*Habrocomes personatus* Sjöstedt	x			x	
54	*Lichenochrus congicus* Rehn	x	x	x	x	
55	*Polyglochin peculiaris* Karsch		x		x	
56	*Mormotus* sp. n. 1	x	x	x	x	x
57	*Mormotus* sp. n. 2	x			x	x
58	*Mormotus obtusatus* Br.-Watt.		x	x	x	
59	*Mormotus bardus* Karsch	x	x	x	x	
60	*Tympanocompus erectistylus* (Karsch)		x			
61	*Mustius superbus* Sjöstedt	x	x			
	Totals	**26**	**50**	**29**	**36**	**8**

collected, and one appears to represent a species new to science. *A. frontalis* (Walker) was found to be common at all three sites. Members of this genus are some of the few West African katydids associated with leaf litter and the bottom of evergreen and deciduous forests.

Corycoides abruptus (Krauss, 1890) – This interesting species is known only from the holotype from an unknown locality and a handful of specimens collected in Guinea (Chopard 1954). This is the first record from Ghana.

Family Pseudophyllidae

Virtually all members of tropical Pseudophyllidae can be found only in forested, undisturbed habitats, and thus have a potential as indicators of habitat changes. These katydids are mostly herbivorous, although opportunistic carnivory was observed in some species. Many are confined to the upper layers of the forest canopy, and never come to lights, making it difficult to collect them. Fortunately, many of such species have very loud, distinctive calls, and it is possible to document their presence based on their calls alone, a technique known well to ornithologists. At least 18 species of this family were collected during the present survey.

Adapantus nitens (Chopard, 1954) – Originally described from N'Zo (Mt. Nimba), this is only the third record of this species, and the first outside of Guinea. These katydids were common at all three sites.

Adenes spp. – Three species of this flightless genus were found during this survey, at least one of which appears to be new to science (a comparison with the type specimens of the already described species is required before the final decision of its new status can be made).

Lichenochrus and *Polyglochin* – Two species of these interesting, lichen-mimicking genera were found: *L. congicus* Rehn and *P. peculiaris* Karsch. Both are new to Ghana. Like most lichen-mimicking katydids, these insects may be restricted to small patches of humid, higher elevation forests that can support a wide variety of the lichens these katydids feed upon.

DISCUSSION

Despite a relatively very short period of time spent surveying katydids within the ARFR, this study increased the number of species known from Ghana by over 500%. This does not necessarily indicate the uniqueness or particular richness of the area's insect fauna, but clearly demonstrates the lack of baseline data on the distribution of katydids (and most likely other invertebrates) in this country. Such data are critically important as a reference for future habitat restoration projects, and may also help pinpoint populations of particularly endangered or threatened species where an immediate conservation action is required.

Within the ARFR we found a remarkable species richness of katydids, and a very high number of new and potentially endemic species. Despite ongoing bauxite prospecting activity, the forest of the reserve still appears fairly intact, and harbors the highest number of katydids known from any single location in Africa. Thus, every effort should be made to minimize the impact any future development may inflict on the forest reserve. Of the three sites within the reserve, the highest number of species was found at Site 2 (Asiakwa South). In comparison to Sites 1 and 3, which appeared to have fewer roads and less open, easily accessible habitat, Site 2 shows the most pronounced edge effect. Because Sites 2 and 3 are both located within the northern part of the range (the northern plateau), and this part constitutes a larger, continuous swath of the forest than the southern plateau, conservation of the northern portion of the reserve should receive a higher priority. If any development is planned within the reserve, it is strongly recommended that such activity be limited to the southern part of the range, thus reducing the fragmentation of the already severely restricted forest, and the loss of species that require large, continuous areas of a forest habitat. Landscape- or habitat-altering development within this robust and intact ecosystem will not only damage, perhaps irreparably, the original forested habitats, but will also open them to other destructive activities, such as illegal logging or hunting, by creating access points and inroads. The negative effects of a dense network of prospecting roads within the Atewa Range are already evident through the loss of virtually all tall, emergent trees, and the rampant bushmeat hunting activity. In addition, wide roads entering the forest allow invasive elements, such as grasses or savanna insects to penetrate into this environment. They also contribute to fragmentation, higher light penetration, and ultimately a decrease in forest humidity, which may lead to the loss of species requiring shady and humid conditions. Thus, in addition to restricting any potential exploration activities to the southern part of the range, it is strongly recommended that any roads or exploratory clearings within the forest that are no longer in use be reforested with the same tree species that were present prior to prospecting activities.

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Chapter 8

A Rapid Assessment of Fishes in the Atewa Range Forest Reserve, Ghana

E. K. Abban

SUMMARY

The freshwater ecosystem studied during this RAP survey included the streams of the Atewa Range Forest Reserve, Ghana, an area protecting the headwaters of the Ayensu, Birim and the Densu river basins, and from which these basins originate. A total of 15 streams within the Atewa forest and at sites just emerging out of the forest were surveyed and their fish fauna was documented during the month of June 2006. We recorded 19 species of freshwater fishes, belonging to nine genera of five fish families: Mormyridae, Characidae, Cyprinidae, Cyprinidontidae and Cichlidae. All species encountered in the present study have been recorded in river basins in West Africa, but *Epiplatys chaperi spillamanni*, encountered during our survey in the Ayensu system, was known previously only in the waters of Côte d'Ivoire. In reference to the number of species per stream, it was our observation that where the forest was least disturbed, the number of species recorded in a stream, even where the stream had been sampled at more than one locality, was rarely more than four and the species were predominantly only of aquarium importance. Thus the occurrence of up to ten species per stream, especially where species composition included fishes of food importance, indicated disturbance of stream forest cover. To conserve forest fishes, the waters in which they exist and their forest environment and necessary habitat characteristics must be largely conserved. Therefore, we recommend that removal of forest cover from streams up to a determined distance from stream banks must be seriously controlled and monitored. Additionally, we recommend the implementation of a rural campaign to educate communities on potential benefits of forest fish fauna as well as other flora and fauna.

INTRODUCTION

The Atewa Range Forest Reserve (Atewa) is located in Ghana, a tropical West African country which lies between Latitude 4°30' N and 11°00' N and straddles the Greenwich Meridian from Latitude 1°10' E to 3°15' W. The Atewa Range Forest Reserve is made up of the Atewa Forest Reserve, covering an area of 232 km² (or 23,663 ha) and the surrounding Atewa Range Extension, which, in combination with the Reserve covers a total area of 26,312 ha. Together they form a continuous block lying within latitude 5°58' to 6°20' N and longitudes 0°31' to 0°41' W (Figure 8.1). This forest block was designated as a reserve in 1925 (Abu-Juam et al. 2003), as a Special Biological Protection Area (SBPA) in 1994 (Hawthorne and Abu-Juam 1995), and one of 30 Globally Significant Biodiversity Areas (GSBAs) in 1999 (Forestry Commission 1999). In addition, the area is also one of Ghana's 36 Important Bird Areas (IBAs) as classified by BirdLife International (Ntiamoa-Baidu et al. 2001). All this points to the fact that the area has long been recognized for its high biodiversity values.

Since the pre-colonial years, the most compelling reason for holding the Atewa forests as a reserve has been that the range of highlands which the forests cover provides the headwaters of three river systems in the country: the Ayensu, Densu and Birim rivers. The forests protect important water sources, contributing to both domestic and industrial water requirements in three important watersheds in Ghana.

The streams within Atewa that are protected by the forest cover provide a unique habitat for a number of fishes, as well as other fauna. Fish are of concern to conservation for numerous reasons:

i) Fish constitute a major global food item;

ii) Fish are nutritionally significant as they comprise more than 50% of animal proteins in diets of most developing countries, including Ghana;

iii) Appreciable proportions of developing countries' populations rely on fish for their social and economic livelihoods, including: fishers, fish handlers and processors, fishing vessel engine mechanics, fish traders and also trading systems associated with importation and trading in fishing inputs.

In tropical countries, forest rivers, such as those assessed in the present RAP survey, harbor species of fish whose aesthetic qualities make them of importance to the aquarium trade. Combining the food, trade and livelihood value of fish, their potential to help achieve Africa's Millennium Development Goals has been recognized.

The above makes it imperative that any effort to conserve fish resources at all levels (ecosystem, community, population and species) must be appreciated globally. Efforts to generate information on fish resources and document them to contribute to their conservation everywhere should be supported by authorities and local communities that rely on such resources. This effort would contribute to and elaborate upon known information and reveal further benefits of fish to mankind. Thus a biological assessment of an aquatic ecosystem's fish fauna and diversity is justified and necessary to obtain important biological information. Such information can be made available and used as a developmental tool.

METHODS

The freshwater ecosystem studied during this RAP survey included the streams of Atewa in Ghana. As indicated earlier, the Atewa forest protects the headwaters of the Ayensu, Birim and the Densu river basins, which originate within the reserve. Figure 8.1 shows the study area and its location in Ghana and the three river basins originating within the Range. Table 8.1 provides data on the area encompassed by the basins.

A total of 15 streams within Atewa and at sites just emerging out of the forest were surveyed and their fish fauna was documented during the month of June 2006. This time fell within the major rainy season of this area in Ghana. The season usually lasts from May-June until September-October. Six of the streams surveyed were tributaries to the Ayensu system, five of them contribute to the Birim and four contribute to the Densu river systems (Table 8.2.)

A summary of stream characteristics is presented in Table 8.3. Generally, all surveyed streams were small, ranging from about 1.0 m to about 6.0 m wide, 0.005 to 0.6 m in depth. The nature of the bottom of the streams was mostly rocky with boulders, stones and gravel. In the majority of situations, branches and forest foliage along stream banks covered more than 80% of stream.

The fish team used two types of fishing gear to obtain specimens. First was a "mini-seine" net built with a 2 mm mesh size nylon netting material (not conventional gear). Second, the team used a battery of four gill-nets, each 6.0 m long and 1.0 m deep but with different mesh size netting material. The mesh sizes of the nets were 12.5, 15.0, 17.5 and 20.0 mm (lateral stretch). The mini seine net yielded the most abundant results.

RESULTS

Table 8.4 gives the checklist of fish species in Atewa's streams based on the current study. The list indicates 19 species, belonging to nine genera of five fish families. The families we documented included: Mormyridae, Characidae, Cyprinidae, Cyprinidontidae and Cichlidae.

Table 8.5 presents fish species recorded in each of the three river basins of which the Atewa Range provides the headwaters. The number of species per stream ranged from one, in Manmen stream, to ten, in Adensu stream, a tributary to the Ayensu River (Table 8.2).

DISCUSSION

To date, no records exist to suggest that the fish fauna of Atewa had been studied prior to the present work. However, all species encountered in the present study have been recorded in river basins in West Africa, including parts of Ghana (Leveque et al. 1990, 1992; Dankwa et al. 1999).

Table 8.1. Physical data on river basins associated with the Atewa Range Forest Reserve, Ghana.

BASIN	AREA			
	Acres	Square Miles	Hectares	Square Kilometers
Birim	969,240	1,514	392,251	3,922
Ayensu	305,983	478	123,831	1,238
Densu	463,054	723	187,398	1,873
Total Area	**1,738,277**	**2,716**	**703,481**	**7,034**

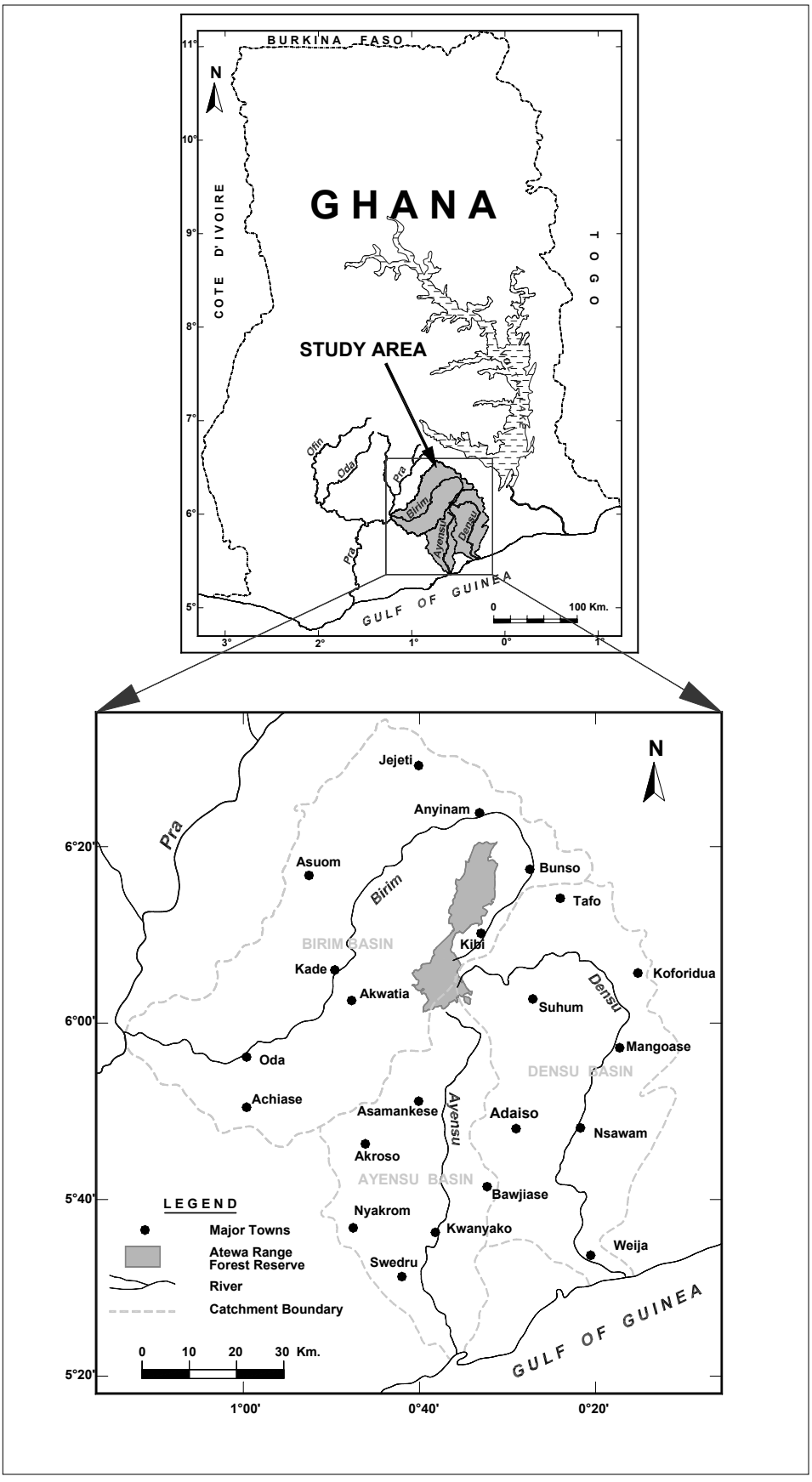

Figure 8.1. Map of Study Area: Birim, Ayensu and Densu river basins in Ghana.

Table 8.2. Fish species occurrence in streams of Atewa Range Forest Reserve, Ghana during the RAP survey in June 2006.

Species Name	STREAMS INTO BIRIM RIVER					STREAMS INTO DENSU RIVER				STREAMS INTO AYENSU RIVER					
	Wankobi 1 & 2	Birim	Obeng-ne Obeng	Supong	Adensu	Densu	Mamen	Anko	Ohunfon	Ayensu 1,2 &3	Adensu	Sukuntu	Ansom	Name unknown	Surum
Brienomyrus brachyistius											+				
Brycinus leuciscus				+											
Brycinus longipinnis						+		+	+						
Brycinus nurse	+	+	+	+						+	+		+		+
Micralestes elongatus	+	+	+	+	+					+	+		+		
Micralestes occidentalis		+	+							+	+		+		
Barbus trispilos						+	+	+	+		+	+			
Barbus macrops					+										
Barbus ablabes						+		+	+	+	+				+
Barbus walkeri	+	+	+						+	+				+	
Barbus macinensis		+				+		+			+	+			
Aplocheilichtys pfaffi	+	+	+	+	+										
Epiplatys dageti dageti								+	+					+	
Epiplatys chaperi schreiberi														+	
Epiplatys chaperi spillmanni														+	
Tilapia busumana								+			+		+		
Tilapia zillii						+					+				
Chromidotilapia geuntheri				+											
Hemichromis fasciatus					+	+					+				
No. of Species	**4**	**6**	**5**	**5**	**4**	**6**	**1**	**6**	**5**	**5**	**10**	**2**	**4**	**4**	**2**

Table 8.3. Habitat characteristics of Atewa Range Forest Reserve streams, June 2006.

Stream name		Location Surveyed	Stretch of Stream (m)	Av. Width (m)	Av. Depth (m)	Bottom cover	% Foliage Cover	% Forest Disturbance
B	Wankobi (2)	Adukrom-Kejebi Road	200	2.5	0.04	Stones, gravel	90	30
	Birim Oben-ne-oben	Akim Apapam	300	7.0	0.04	Boulders. Rocks Sand	90	20
	Supong	Atewa forest (flows→Wonkobi	250	2.5	0.3	Rocks, Stones, gravel, mud	90	< 3
	Adensu	– Birim)	100	3.5	0.4	Rocks, stones mud	80 – 90	30
		(joins Brim at Asiakwa) Sagyimase bridge						
D	Densu	Akim Odumasi Bridge	70	0.3	0.5	Rocks, stones mud		
	Mamen	Apeniapong (via Suhum)	10	0.003	0.005	Sandy	70	< 50
	Anko/Densu	Potroase	60	4.2	0.8	Stones, Sand	70	40
	Ohunfen	Between Ptroase & Odumase	100	0.70	0.03	Boulders, Stones Sand	90	Old 10
A	Ayensu	Bele (near Oboɔho)	250	8	0.5	Rocks, Boulders		2 – 5
	Ayensu	Anum-Apapam (Bridge)	100.0	7.0	0.6	Mud, Sand	20	80 – 90
	Adensu	Anum-Apapam (just prior to join	500.0	2.5	0.4	Mud, Sand, Boulders	30	80 – 90
	Ansom	Ayensu)				Mud		
	Unknown	Outskirt of Asamankese	80 – 100.0	3.6	0.4	Mud & Stones		
	Surum	Brekumanso (Owuram to Asamankese	300	2.0	0.5	Mud – Gravel	80	40
		(Join Ayensu at Oboɔho)					80 – 90	50
			20	0.3	0.03			

Table 8.4. Checklist of fish species of Atewa Range Forest Reserve, Eastern Ghana.

FAMILY (5)	GENUS (9)	SPECIES (19)
MORMYRIDAE	*Brienomyrus* (Tarverne 1971)	*brachyistius* (Gill, 1863)
CHARACIDAE	*Brycinus* (Valenciennes, 1849)	*leuciscus* (Gunther, 1967)
		longipinnis (Gunther,1864,Paugy 1986)
		nurse (Ruppel, 1832; Paugy 1986)
	Mircralestes (Boulenger, 1899)	*elongatus* (Daget, 1957)
		occidentalis (Gunther, 1899)
		trispilos (Bleeker, 1963)
CYRINIDAE	*Barbus* (Cuvier & Cloquet, 1816)	*macrops* (Boulenger, 1911, Hopson & Hopson 1965)
		ablabes (Bleeke, 1863)
		walkeri (Boulenger, 1904)
		macinensis (Dagct 1954, Hopson & Hopson1965)
	Aplocheilichthys (Bleeker, 1863)	*pfaffi* (Daget, 1954)
CYPRINIDONTIDAE	*Epiplatys* (Gill, 1863)	*dageti dageti*
		chaperi schreiberi
		chaperi spillmanni
CICHLIDAE	*Tilapia*	*busumana* (Gunther, 1903)
		zillii (Gervais, 1848)
	Chromidotilapia (Boulenger, 1898)	*guentherii* (Sauvage, 1882)
	Hemichromis (Peters, 1858)	*fasciatus* (Peters, 1852)

Leveque et al. (1990) and Dankwa et al. (1999) both indicate that species such as *Brycinus nurse. Mircrales occidentalis*, and the *Barbus*, *Tilapia*, *Chromidoliapia* and *Hemichromis* (listed in Table 8.4) had been recorded in river basins associated with forest streams.

Our current survey revealed additional information related to fish and their distribution. For example, *Brienomyrus brachyistius*, had previously not been recorded in the Ayensu river system but only in the Birim and Densu, most likely in lower parts of the river. *Micralestes elongates* had been previously recorded in river ecosystems in Ghana similar to the Ayensu, Birim and Densu rivers of Atewa. Finally, Leveque et al. (1992) noted that *Epiplatys chaperi spillamanni*, encountered during our survey in the Ayensu system, was known previously only in the waters of Côte d'Ivoire.
The species we encountered were mostly forest stream freshwater fishes, in terms of diversity and quantities, with the following major common characteristics:

- Generally, small species (e.g. the *Micralestes, Barbus, Aplocheilithys* and *Epiplatys* species) were recorded. This could be anticipated since the streams surveyed are themselves small with reference to width and depth (see Table 8.3)
- Diet of typical forest stream fishes typically consists of forest materials (e.g. seeds, fruits and insects from forest vegetation) as primary productivity in forest streams is minimal.
- In reference to the number of species per stream, Table 8.2 indicates between one and ten. It was our observation that where the forest was least disturbed, the number of species recorded in a stream, even where the stream had been sampled at more than one locality, was rarely more than four and the species were predominantly of aquarium importance. Thus the occurrence of up to ten species per stream, especially including fishes of food importance, indicated disturbance of forest cover of streams at study site(s).
- The occurrence of 'big' fish species recognized as food fishes, such as the *Tilapia* and *Hemichromis* species, indicated considerable removal of forest cover of streams to be able to sustain fauna which depend mostly on direct or indirect photosynthetic output.

In tropical countries, forest rivers, such as those assessed in the present RAP survey, harbor species of fish whose aesthetic qualities make them of importance to the aquarium trade. This situation could be harnessed and developed to the economic benefit of entrepreneurs and local young men and women.

CONSERVATION RECOMMENDATIONS

To conserve the fishes of the forest, the waters in which they exist and their forest environment and necessary habitat must be largely conserved. Therefore, the following are recommended:

- Control and monitor the removal of forest cover from streams up to a determined distance from stream banks.
- Plan and implement a rural campaign to educate communities on the potential benefits of forest fish fauna and other flora and fauna.

Table 8.5. Basin distribution of fishes of Atewa Range Forest Reserve streams, June 2006.

			RIVER BASINS			
FAMILY	**GENUS**	**SPECIES**	**Ayensu**	**Birim**	**Densu**	**EI**
Mormyridae	*Brienomyrus*	*brachyistius*	+	-	-	F
Characidae	*Brycinus*	*leucicus*	-	+	-	A
		longipinnis	-	+	-	A
		nurse	+	+	-	F&A
	Micralestes	*elongatus*	+	+	-	A
		occidentalis	+	+	-	A
Cyprinidae	*Barbus*	*trispilos*	+	-	+	A
		macrops	-	+		A
		ablabes	+	-	+	A
		walkari	+	+	+	A
		macinensis	+	+	+	A
Cyprinidontidae	*Aplocheilichthys*	*pfaffi*	-	+	-	A
	Epiplatys	*dageti dageti*	+	-	+	A
		schrecberi	+	-	+	A
		spllmanni	+	-	-	A
Cichlidae	*Tilapia*	*busumana*	+	-	+	F
		zillii	+	-	+	F
	Chromidotilapia	*guentheri*	-	+	-	A
	Hemichromis	*fasciatus*	+	+	+	

Legend:

+ = Present
- = Not encountered
EI = Economic Importance (major)
F = Food
A = Aquarium

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Chapter 9

A rapid survey of the amphibians from the Atewa Range Forest Reserve, Eastern Region, Ghana

N'goran Germain Kouamé, Caleb Ofori Boateng and Mark-Oliver Rödel

SUMMARY

We report the results of the first rapid amphibian survey in the Atewa Range Forest Reserve. We recorded a total of 32 species, but predict that overall species richness of the area can be expected to reach 40-50 species. The amphibian community of the Atewa Range is exceptional in that it comprises a) almost exclusively forest species and hence indicates a very intact forest ecosystem, b) a species mixture including species that, prior to our survey, were known only from either east or west of this site, c) a very high percentage of species that are endemic to the Upper Guinea forests or even much smaller parts of these forests, and d) an extremely high proportion of threatened species (almost one-third are ranked as threatened on the IUCN Red List). For one Critically Endangered species (*Conraua derooi*) the Atewa Range is likely to harbor the largest remaining populations. In summary, the Atewa Range clearly represents an exceptional site for the maintenance of West African amphibian diversity in particular and outstanding biodiversity in general. We urgently recommend an upgrading of its protection status to a national park and conclude that any exploitative activity in this area would have devastating effects to this irreplaceable ecosystem of national and regional importance.

INTRODUCTION

The Guinean Forests of West Africa rank as one of 34 global biodiversity hotspots (Bakarr et al. 2004). Within the western part of this region, mountainous forests are under particular pressure as montane habitats are a) extremely restricted in extent and b) almost all the focus of actual or planned mining activities. Within the Upper Guinea Highlands, larger areas of mountain forest are limited to eastern Sierra Leone, northern Liberia, south-eastern Guinea and western Côte d'Ivoire. These montane forest areas are unique ecosystems with exceptional species richness and high levels of endemism in general (Bakarr et al. 2004), and for amphibians in particular (Guibé and Lamotte 1958, 1963; Laurent 1958; Lamotte 1971, Rödel et al. 2004). In-between the Upper Guinea Highlands and the Cameroon Highlands, another hotspot of amphibian diversity (Gartshore 1986), only the Atewa Range in Ghana, the Volta Highlands in the Ghanaian/Togolese border region, and the Jos Plateau in Nigeria harbor significant upland forest patches. However, of these three areas, moist evergreen forest is found only in the Atewa Range (Swaine and Hall 1977). This area was designated a national forest reserve in 1925 and has recently been designated as a Globally Significant Biodiversity Area (GSBA), as well as an Important Bird Area (IBA) (Abu-Juam et al. 2003). The Priority-Setting Workshop for Upper Guinea ranked the Atewa Range Forest Reserve (Atewa) to be of "Very High" priority for overall biodiversity conservation. The participants recommended updating the scientific information of this area through surveys. An improved protection of the area seemed to be desirable (Bakarr et al. 2001). Although the scientific knowledge of the Atewa Range is still fragmentary, it has recently been the focus of mineral exploration, making a comprehensive survey of the biological richness more pressing than ever.

Atewa (23,665 ha) is located in the Eastern Region of Ghana and comprises a third of

the remaining closed forest there (Mayaux et al. 2004). The mountain range (highest peak 842 m a.s.l.) runs roughly from north to south with numerous plateaux separated by steep gorges. The misty conditions on the plateaux are the basis for a unique floristic composition here known as Upland Evergreen Forest (Swaine and Hall 1977). Hence, many plant species have their only Ghanaian record from Atewa and several butterfly species are endemic to the range (Larsen 2006). The northern part of the reserve is situated in the wet semi-equatorial climatic zone, with two wet seasons from May to July and from September to October/November with an annual precipitation of about 1650 mm. In addition to the upland forest, seasonal marshy grasslands, swamps and thickets are also thought to be nationally unique (Hall and Swaine 1981). Although most parts of the forest reserve are still in good condition, disturbance-indicating invasive species like *Chromolaena odorata* can be found along roads or other artificial openings of the forest.

This survey focused on the amphibians of Atewa, as this group generally seems to allow for a reliable judgment of the status of West African forests (Rödel and Branch 2002, Ernst and Rödel 2005, Ernst et al. 2006). Because standardized methods exist for estimating amphibian species richness, they are accurately assessable in a short time and with comparatively less effort (Heyer et al. 1994, Rödel and Ernst 2004). Furthermore, in tropical forests throughout the world, amphibians (i.e. anurans) comprise a significant portion of the vertebrates, and in these ecosystems they are important, both as predators and as prey (Inger 1980a, b; Duellman 1990). The whole taxonomic group is especially threatened by habitat degradation and conversion (Stuart et al. 2004). Recent amphibian surveys in Ghana revealed much higher species diversity than expected, including various recently or still undescribed taxa (Rödel and Agyei 2003, Rödel et al. 2005a, Leaché et al. 2006). Prior to our survey, the Atewa Range had not previously been sampled for amphibians.

METHODS

Our survey was undertaken from 6-22 June 2006 and covered three different areas within the Atewa range: Atiwiredu (06º12'22.7" N, 0º34'39.2" W, 817 m a.s.l.) was visited from 7-10 June, Asiakwa South (06º15'44.3" N, 0º33'18.8" W, 783 m a.s.l.) from 11-16 June, and Asiakwa North (06º16'16.1" N, 0º33'52.7" W, 814 m a.s.l.) from 17-22 June. Amphibians were mainly located opportunistically during day and night by visual and acoustic encounter surveys (Heyer et al. 1994, Rödel and Ernst 2004) of all habitats by two people (NGK, COB). Additional search techniques included refuge examination and dip-netting in all types of waters. As our sampling design provides only qualitative and semi-quantitative data we calculated the estimated species richness (and hence our sampling efficiency) with the Chao2 and Jack-knife 1 estimators (software: EstimateS, Colwell 2005). These estimators are incidence based, with calculations made using the presence/absence data of the daily species lists (13 days) for 32 species. To avoid order effects we performed 500 random runs of the daily species lists. Some voucher specimens were collected and killed using 1,1,1-Trichloro-2-methyl-2-propanol hemihydrate and preserved in 70 % ethanol. Vouchers and tissue samples are currently deposited in the research collection of M.-O. Rödel at Würzburg University, Germany and will be inventoried in the collection of the Natural History Museum Berlin later on (Table 9.1). Specimens not retained as vouchers were released at their original sites. The taxonomy is according to Frost et al. (2006).

RESULTS

Species richness

We recorded a total of 32 amphibian species, comprising one caecilian, *Geotrypetes seraphini*, and 31 anurans (Table 9.1). Richness of recorded species was highest in Atiwiredu (26 spp.), followed by Asiakwa South (23 spp.). Species richness was lowest in Asiakwa North (6 spp.). The overall species richness of Atewa hence was higher than that of known sites in the Volta-Togo region (Rödel and Agyei 2003, Leaché et al. 2006), but lower than in the Ankasa Conservation Area in western Ghana (Rödel et al. 2005a) and various other sites in Côte d'Ivoire and Guinea (Rödel and Branch 2002, Rödel et al. 2004). Although there seems to be a real gradient in amphibian species richness, with species numbers rising from the eastern to the western part of the Upper Guinean forests (Rödel and Agyei 2003; Rödel et al. 2004, 2005a), it can be taken as certain that we have not yet comprehensively assessed the Atewa amphibians. More intensive surveys, especially in areas and microhabitats not yet investigated, will result in an increasing number of species. Further species likely to be recorded in Atewa are *Leptopelis occidentalis*, *Amietophrynus superciliaris, Hydrophylax albolabris, Afrixalus dorsalis, Hyperolius concolor* and *H. laurenti*. The occurrence of *Astylosternus* sp., *Cardioglossa leucomystax, Leptopelis macrotis*, *Hyperolius viridigulosus, H. torrentis, Phlyctimantis boulengeri*, *Hydrophylax occidentalis*, *Phrynobatrachus annulatus*, *P. liberiensis* and *P. villiersi* also seems possible. We therefore estimate that the real number of amphibian species living in Atewa will probably be 40-50. This is also supported by our two species richness calculations (Figure 9.1). According to the Jack-knife 1 estimator 44.0 ± 4.7 species should occur in the area. The Chao2 estimator calculated 43.3 ± 8.8 species for Atewa. We hence recorded about 72.7% or 73.9% of the local species pool, respectively.

The huge differences in species richness between the three RAP sites are most likely due to differences in habitat variability. Whereas we searched many different microhabitats suitable for amphibians in Atiwiredu and Asiakwa South (small puddles, larger ponds, rivers, waterfalls and dense vegetation as well as partly broken canopy), the sites investigated in Asiakwa North were generally more uniform and relatively dry (i.e. no rivers, ponds or puddles present and almost exclusively inhabited by the direct-developing *Arthroleptis* sp. A and *Phrynobatrachus tokba*). In only a few valleys

Table 9.1. List of all amphibian species recorded during the Atewa RAP survey. For every species we indicate whether records are supported by a voucher (JP number), photos, or only call records, and at which sites the respective species was recorded. *Amietophrynus* is a new name for some African *Bufo*, this name and family assignation is according to Frost et al. (2006).

Taxa	Voucher / photo / calls	Atiwiredu	Asiakwa South	Asiakwa North
Gymnophiona				
Caecilidae				
Geotrypetes seraphini	JP 0028		x	
Anura				
Arthroleptidae				
Arthroleptis sp. A	JP 0012	x	x	x
Arthroleptis sp. B	JP 0019, JP 0027	x	x	
Leptopelis spiritusnoctis	JP 0004	x	x	
Bufonidae				
Amietophrynus maculatus	acoustic	x		
Amietophrynus togoensis	JP 0026	x		
Dicroglossidae				
Hoplobatrachus occipitalis	visual	x		
Hemisotidae				
Hemisus sp.	JP 0030		x	
Hyperoliidae				
Acanthixalus sonjae	JP 0017	x		
Afrixalus nigeriensis	JP 0021, JP 0042	x	x	
Afrixalus vibekensis	JP 0048		x	
Hyperolius baumanni	JP 0008, JP 0018, JP 0020, JP 0043, JP 0044	x	x	
Hyperolius bobirensis	JP 0005, JP 0007, JP 0047, JP 0050	x	x	
Hyperolius fusciventris	JP 0009	x	x	
Hyperolius guttulatus	JP 0045			x
Hyperolius picturatus	JP 0010, JP 0011	x	x	
Hyperolius sylvaticus	JP 0006	x	x	
Kassina arboricola	JP 0049	x	x	
Petropetedidae				
Conraua derooi	JP 0041.1-3		x	x
Phrynobatrachidae				
Phrynobatrachus accraensis	JP 0023	x		
Phrynobatrachus alleni	JP 0013	x		
Phrynobatrachus calcaratus	JP 0024	x	x	x
Phrynobatrachus ghanensis	JP 0015	x		
Phrynobatrachus gutturosus	JP 0014	x	x	
Phrynobatrachus plicatus	JP 0016	x	x	
Phrynobatrachus tokba	JP 0022	x	x	x
Pipidae				
Silurana tropicalis	JP 0025	x	x	
Ptychadenidae				
Ptychadena aequiplicata	JP 0002, JP 0004	x	x	x
Ptychadena bibroni	JP 0001	x		
Ptychadena longirostris	JP 0003	x	x	
Ranidae				
Aubria subsigillata	JP 0051		x	
Rhacophoridae				
Chiromantis rufescens	photos	x	x	
Total species (32)		**26**	**23**	**6**

here, shallow rills flowed over a number of very large granite rocks. After rainfall the water level here increased considerably to fast flowing creeks. Then *Conraua derooi* could be captured near or under the rocks.

Habitat requirements

The vast majority of the recorded species were forest specialists or at least species that require forest conditions (Table 9.2), hence representing a typical and intact forest fauna (compare e.g. Rödel and Branch 2002, Ernst and Rödel 2005, Ernst et al. 2006). All four species that never occur in closed forest conditions, *Amietophrynus maculatus*, *Hoplobatrachus occipitalis*, *Phrynobatrachus accraensis* and *Ptychadena bibroni*, were only recorded in Atiwiredu, hence showing that this area has already partially suffered from habitat degradation. On the other hand Atiwiredu showed high potential for amphibian diversity by harboring the only records for such forest specialists as *Amietophrynus togoensis*, *Acanthixalus sonjae*, *Phrynobatrachus alleni* and *P. ghanensis*. The occurrence of species that are dependant on fast-flowing waters in intact forest (*Amietophrynus togoensis, Conraua derooi*) is encouraging, as similar habitats seem to be decreasing in the Volta-Togo region, and recently the respective species could not be recorded (Rödel and Agyei 2003, Leaché et al. 2006) or were only found to be present in isolated sites that are threatened by human activities (*Conraua derooi*: A. Hillers et al. unpubl data).

DISCUSSION

Most recorded species (75%) do not occur outside West Africa (defined as the area West of the Cross River in Nigeria, Table 9.2), and are often restricted to smaller parts of West Africa. Half of all recorded species are endemic to the Guinean Forest zone. This percentage of endemicity is well within the upper range of other West African sites of outstanding importance to amphibian diversity (Rödel and Branch 2002, Rödel et al. 2004), higher than in other Ghanaian sites (Rödel and Agyei 2003, Rödel et al. 2005a), and may even increase with an increasing completeness of the recorded fauna (compare above). Two taxa were previously known only from eastern Ghana and western Togo (*Hyperolius baumanni*, *Conraua derooi*), one was known only from Ghana and eastern Côte d'Ivoire (*Phrynobatrachus ghanensis*), and two others are endemic to Ghana (*Hyperolius bobirensis*, *H. sylvaticus sylvaticus*; Schiøtz 1964, 1967, 1999, Hulselmans 1971, Hughes 1988, Rödel and Agyei 2003, Rödel et al. 2005a, Assemian et al. 2006, Leaché et al. 2006).

Several species have their easternmost record in Atewa: *Acanthixalus sonjae*, *Afrixalus vibekensis*, *Hyperolius bobirensis*, *H. picturatus*, *Kassina arboricola*, *Phrynobatrachus ghanensis* and *P. tokba* (compare Perret 1985, 1988; Rödel et al. 2002, 2003, 2005b). This is the third record of *H. bobirensis* (see Photos), and the fifth record of *Afrixalus vibekensis* (Schiøtz 1967, Rödel and Branch 2002, Rödel et al. 2005a). For *Hyperolius baumanni* and *Conraua derooi,* Atewa represents the westernmost locality of their known range. For *Amietophrynus togoensis* the Atewa reserve is the closest known locality to the type locality in Togo and therefore the record likely will contribute to resolve the taxonomic situation of these forest toads (Rödel and Bangoura 2004). The *Arthroleptis* spp. might represent taxa endemic to the Atewa area but this needs further investigation (compare general comments on West African *Arthroleptis* in Rödel and Bangoura 2004). This also applies to the *Hemisus* sp. (compare Rödel and Agyei 2003). Atewa is the only known site were *H. baumanni* and *H. picturatus* live in syntopy, thereby confirming Rödel and Agyei (2003) that the first is not only a subspecies of the second (compare Schiøtz 1967, 1999).

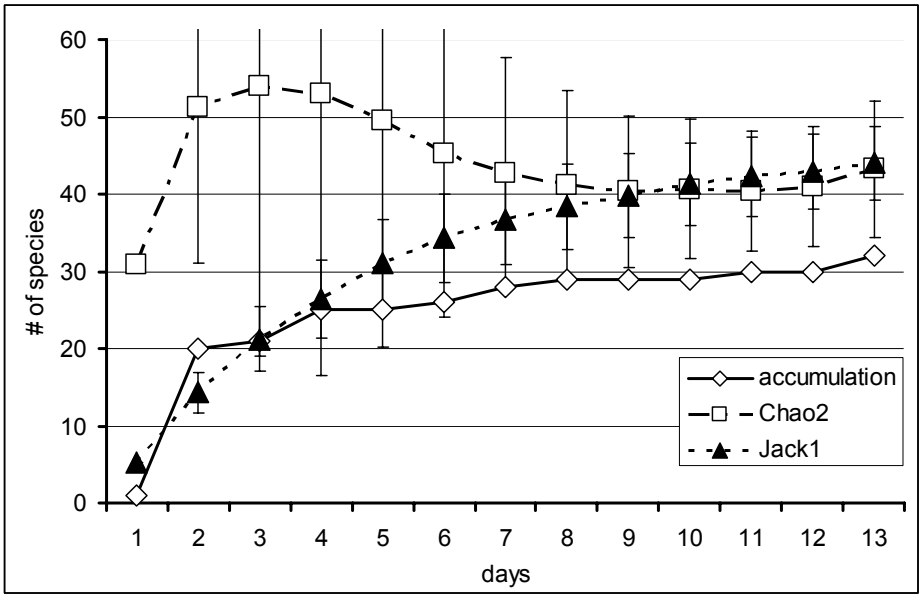

Figure 9.1. Species accumulation curve and estimated amphibian species richness of the Atewa Range Forest Reserve, Ghana. We recorded 32 different species in the course of 13 survey days and calculated that about 44 species can be expected for this forest reserve.

The amphibian species composition of the Atewa Range, comprising both species usually restricted to western or eastern parts of the Guinean Forest zone, is unique.

THREATENED SPECIES

Almost one-third of the recorded species (28%) fall into one of four IUCN Red List categories (Table 9.2). Five species are Near Threatened, one is Vulnerable, two are Endangered and one is Critically Endangered (*Conraua derooi*). Such a high percentage of threatened amphibian species is outstanding for West Africa. As the fauna can be assumed to be incompletely known and unrecorded species (see above) most likely comprise rarer species, the real percentage of threatened species may be even higher. For at least one species (*Conraua derooi*, see Photos), Atewa might harbor the most important remaining populations. This may also apply for *Hyperolius bobirensis*. *Conraua derooi* was originally described

Table 9.2. Distribution, habitat association and IUCN Red list categories (according to the Global Amphibian Assessment; 28 October 2006) of the Atewa amphibian species. Distribution: A = distributed also outside West Africa; WA = only in West Africa West of the Cross River; UG = endemic to the Upper Guinea forest zone (rainforest West of the Dahomey Gap); EGT = endemic to eastern Ghana and western Togo; EG = endemic to Ghana; Habitat: F = forest; FS = forest and secondary growth; S = savanna; Red list: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; ? = taxonomy not clarified and respective placement hence not certain, but likely.

Taxa	Distribution	Habitat			Red List
		F	FS	S	
Geotrypetes seraphini occidentalis	UG	x	x		
Arthroleptis sp. A	UG?	x?	x?		
Arthroleptis sp. B	UG?	x?	x?		
Leptopelis spiritusnoctis	WA	x	x		
Amietophrynus maculatus	A		x	x	
Amietophrynus togoensis	UG	x			NT
Hoplobatrachus occipitalis	A		x	x	
Hemisus sp.	UG?	x?			
Acanthixalus sonjae	UG	x	x		NT
Afrixalus nigeriensis	WA	x			NT
Afrixalus vibekensis	UG	x			NT
Hyperolius baumanni	EGT		x		
Hyperolius bobirensis	EG	x			EN
Hyperolius fusciventris burtoni	WA	x	x		
Hyperolius guttulatus	A		x		
Hyperolius picturatus	UG	x	x		
Hyperolius sylvaticus sylvaticus	EG	x			
Kassina arboricola	UG	x	x		VU
Conraua derooi	EGT	x	(x)		CR
Phrynobatrachus accraensis	WA		x	x	
Phrynobatrachus alleni	UG	x			NT
Phrynobatrachus calcaratus	A		x		
Phrynobatrachus ghanensis	UG	x			EN
Phrynobatrachus gutturosus	WA	x	x	x	
Phrynobatrachus plicatus	WA	x	x		
Phrynobatrachus tokba	UG	x	x		
Silurana tropicalis	WA	x	x		
Ptychadena aequiplicata	A	x			
Ptychadena bibroni	A		x	x	
Ptychadena longirostris	WA	x	x		
Aubria subsigillata	A	x			
Chiromantis rufescens	A	x	x		
Total (32 species)	**A = 8; WA = 8; UG = 12; EGT = 2; EG = 2**	**22 (25)**	**19 (22)**	**5**	**9**

from western Togo (Hulselmans 1971) and apart from there is only known from a few Ghanaian sites, close to the Togolese border (Schiøtz 1964 as *C. alleni*). Until very recently it had never been found again, although numerous suitable habitats were searched (Rödel and Agyei 2003, Leaché et al. 2006). Sites at which this species has previously been recorded are all close to human settlements and hence the persistence of the species in these areas is uncertain (A. Hillers et al. unpubl. data). Atewa seems to still hold large and viable populations of this Critically Endangered species in the fast flowing forest streams. Preliminary analyses showed that these are genetically distinct from those in the Volta region, again underlining the uniqueness of the Atewa range.

CONSERVATION RECOMMENDATIONS

Atewa is one of Ghana's few remaining intact forests which has survived the recent onslaught of forest destruction and degradation throughout the country as a whole (FAO 2006). It is recognized to hold one of the highest levels of biodiversity in Ghana, for some taxa even the highest (Larsen 2006). Similar results were obtained for amphibians throughout this survey. The overall composition of amphibians in Atewa is exceptional, because of a) the presence of species that have their center of distribution in eastern or western Ghana, b) the very high percentage of species that are restricted to forest environments and c) the outstanding percentage of threatened species, including some that most likely have their highest population numbers within Atewa.

It has been shown that amphibians are very sensitive to comparatively minor forest degradation, such as selective logging, with reactions including altered species composition, changes to community structure and the loss of particular functional groups (Ernst and Rödel 2005, Ernst et al. 2006). Ghanaian studies revealed dramatic negative effects of forest fragmentation on bird species composition (Beier et al. 2002) and local climatic conditions (Hill and Curran 2003). We observed similar effects on amphibian communities in forest fragments in western Côte d'Ivoire (A. Hillers et al. unpubl. data). All these studies underline the importance of maintaining larger intact forest blocks. Losses of particular species, and more importantly losses of particular functional groups, most likely also result in a decrease of resistance of a given ecosystem to disturbances, such as invasive species (Symstad 2000, Xu et al. 2004, Ernst et al. 2006).

In addition, mountain ranges are known to have played a significant role in maintaining biodiversity throughout times of higher temperature and drought (Amiet 1987, Moritz et al. 2000, Plana et al. 2004, Wieringa and Poorter 2004). They could also most likely play this role as refugias in the future. The Atewa Range holds the only larger Upland Evergreen Forest between the Upper Guinea Highlands and the Cameroon Mountains. The forests of Atewa hold large numbers of endemic and threatened species (e.g. the data presented herein, Swaine and Hall 1977, Larsen 2006, Weber and Fahr 2007 – see Chapter 11 of this report). If the Atewa Range were to be subject to development activities involving the wholesale removal of vegetation or riparian habitat, it is certain that the majority of specialized forest amphibians would be lost. We therefore recommend the following for long-term protection of Atewa's exceptional biodiversity:

- Undertake further surveys of Atewa to complete the amphibian inventory;
- Conduct in-depth studies focusing on threatened, rare and endemic species, i.e. *Conraua derooi* and *Hyperolius bobirensis*;
- Involve local communities in the management and conservation of the Atewa Range, including intensive capacity building in the knowledge of local biodiversity and sustainable use of forest resources;
- Prevent further illegal logging through involvement with local authorities;
- Strictly protect the watersheds of Atewa in order to secure water quality for the local biodiversity and water supply for surrounding communities as well as for Accra;
- Upgrade the protection status of Atewa, preferably to a national park, in recognition of Atewa's global significance for biodiversity conservation, as shown by its status as both a Globally Significant Biodiversity Area and as a result of the findings of the RAP survey;
- Decline all plans for the future development of Atewa in recognition of the outstanding nature of Atewa's biodiversity as, in the case of Atewa, impacts from development cannot be adequately mitigated (Phillips 2001, Dudley and Stolton 2002, Abu-Juam et al. 2003).

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Chapter 10

Rapid survey of the birds of the Atewa Range Forest Reserve, Ghana

Ron Demey and William Ossom

SUMMARY

During 16 days of field work (7 – 22 June 2006) in Atewa Range Forest Reserve, one of the two important remnants of Upland Evergreen rainforest in Ghana, 155 bird species were recorded. Of these, six are of conservation concern, amongst which three are classified as Vulnerable and three as Near Threatened. Six of the 11 species restricted to the Upper Guinea Forests Endemic Bird Area and 115 (or 64 %) of the 180 Guinea-Congo Forests biome species now known from Ghana were observed during the study. A song, heard and partly tape-recorded, was thought to be from Nimba Flycatcher *Melaenornis annamarulae*, a Vulnerable species not previously found in Ghana; this record, which constitutes a major eastward range extension, was confirmed by sightings of the species in May 2007. The site, listed in 2001 as an Important Bird Area, was found to have a remarkably rich avifauna, with relatively large mixed-species flocks being a particularly conspicuous feature. Some species, such as Green-tailed Bristlebill *Bleda eximius* and Yellow-bearded Greenbul *Criniger olivaceus*, are at the eastern limit of their known range here. Several species that are rare in Ghana and uncommon to rare in their global range also occur in the reserve.

INTRODUCTION

Birds have been proven to be useful indicators of the biological diversity of a site, because they occur in most habitats on land throughout the world and are sensitive to environmental change. Their taxonomy and global geographical distribution are relatively well known in comparison to other taxa (ICBP 1992). The conservation status of most species has been reasonably well assessed and is regularly updated (BirdLife International 2000, 2004). This permits rapid analysis of the results of an ornithological study and presentation of conservation recommendations. Birds are also among the most charismatic species, which can facilitate the acceptance of the necessity to implement protective measures by policy makers and stakeholders.

As West African forests are rapidly disappearing, the survival of the birds of the Upper Guinea forests is becoming increasingly dependent on ever fewer areas. Despite a number of field studies conducted in the region in recent years (e.g. Demey and Rainey 2004, 2005; Rainey and Asamoah 2005; Demey 2007), the avifaunas of the majority of these forests remain inadequately known.

Atewa Range Forest Reserve is, together with Tano Offin, one of only two main forest reserves in Ghana holding remnants of upland evergreen rainforest (Hall and Swaine 1976). The reserve, which has a roughly north-south alignment, covers 23,663 ha and consists of a steep-sided, mostly flat plateau at 700-800 m a.s.l. The forest has been logged in the past and numerous transects are being cut at present for mineral exploration. On lower slopes it has been severely degraded by encroaching cultivation and illegal wood cutting. The forest canopy on the plateau is of variable height and presents many gaps, with larger trees reaching up to 40-50 m emerging above a closed sub-canopy of 10-25 m height. A few small streams cross the ridge and some swampy areas occur.

The main reference on the avifauna of Atewa is a report by Dowsett-Lemaire and Dowsett (2005), presenting the results of a short survey carried out in February 2005, reviewing previously published and unpublished records from the site, and including an updated species list. Atewa was listed as an Important Bird Area (IBA) by Ntiamoa-Baidu et al. (2001).

METHODS

We carried out 16 days of field work, from 7 to 22 June 2006. We accessed the forest via the ascending track starting near the village of Sagyimase, north of Kibi, and established our camp at three consecutive sites: Atiwiredu (06°12'22"N, 00°34'39"W at 817 m), Asiakwa South (06°15'44"N, 00°33'18"W at 783 m) and Asiakwa North (06°16'16"N, 00°33'52"W at 814 m). Most of our field work was carried out in the forest on the ridge, with two visits to degraded habitat lower down, along the main track from the entrance gate to the intersection 4 km further up.

The weather was variable, with alternating overcast and sunny conditions. Mist was frequent in the morning and rain in the afternoon and at night. Although June is normally the height of the rainy season, a few entirely sunny days without any rain were experienced.

The principal method used during this study consisted of observing birds by walking slowly along tracks and the many transects that have recently been cut for mining prospection. Notes were taken on both visual observations and bird vocalizations. Some tape-recordings were made for later deposition in sound archives. Field work was carried out from dawn (usually 05:30) until 13:00–14:00, and in the afternoon from 15:00–16:00 until sunset (around 18.30). Some species were recorded opportunistically during the night and two birds were captured in mist-nets set up for bats.

For each field day a list was compiled of all the species that were recorded. Numbers of individuals or flocks were noted, as well as any evidence of breeding, such as the presence of juveniles, and basic information on the habitat in which the birds were observed. An attempt has been made to give indices of abundance based on the encounter rate. However, it should be noted that many bird species were not singing (e.g. cuckoos and owls) and several thus have remained unnoticed.

For the purposes of standardization, we have followed the nomenclature, taxonomy and sequence of Borrow and Demey (2001, 2004).

RESULTS

In total, 155 species were recorded of the c. 735 bird species known from Ghana; recorded species are listed in Appendix 7, along with the encounter rate, observed breeding evidence, threat status, endemism to the Upper Guinea forest block, membership of the Guinea-Congo Forests biome assemblage, and habitat. Six species of global conservation concern were observed during the survey (Table 10.1).

In addition, a number of scarce or poorly known species were observed, including Congo Serpent Eagle *Dryotriorchis spectabilis*, Brown Nightjar *Veles binotatus*, African Dwarf Kingfisher *Ceyx lecontei* and Blue-headed Bee-eater *Merops muelleri*.

Six of the 11 restricted-range species, i.e. species which have a global breeding range of less than 50,000 km^2, that make up the Upper Guinea Forests Endemic Bird Area, and 115 of the 180 Guinea-Congo forests biome species now recorded in Ghana (Fishpool and Evans 2001, Stattersfield et al. 1998) were recorded during the survey.

Notes on specific species

West African status from Borrow and Demey (2001). Ghanaian status from Grimes (1987) and Ntiamoa-Baidu et al. (2001).

Species of conservation concern

Bycanistes cylindricus Brown-cheeked Hornbill (NT)
This species was recorded only three times: a pair was seen flying over and calling individuals were heard on two occasions. This Upper Guinea endemic is uncommon to rare in south-western Ghana.

Bleda eximius Green-tailed Bristlebill (VU)
A single was singing at Atiwiredu and another was observed

Table 10.1. Bird species of global conservation concern recorded during the RAP survey of Atewa Range Forest Reserve

Species	Common Name	Threat Status
Bycanistes cylindricus	Brown-cheeked Hornbill	NT
Bleda eximius	Green-tailed Bristlebill	VU
Criniger olivaceus	Yellow-bearded Greenbul	VU
Melaenornis annamarulae	Nimba Flycatcher	VU
Illadopsis rufescens	Rufous-winged Illadopsis	NT
Lamprotornis cupreocauda	Copper-tailed Glossy Starling	NT

Threat status (BirdLife International 2000, 2004):
VU = Vulnerable: species facing a high risk of extinction in the medium-term future
NT = Near Threatened: species coming very close to qualifying as Vulnerable

in a mixed-species flock at Asiakwa South. This Upper Guinea endemic is rare in Ghana and reaches the eastern limit of its distribution in Atewa.

Criniger olivaceus Yellow-bearded Greenbul (VU)
This species was observed in mixed-species flocks at three different locations along the main track (twice a pair and once a calling individual). This Upper Guinea endemic is generally rare in Ghana and, like the previous species, it reaches the eastern limit of its distribution in Atewa.

Melaenornis annamarulae Nimba Flycatcher (VU)
A song heard at 13:00, coming from the canopy along the main track (06°13'52"N, 00°33'17"W at c. 620 m), was thought to be from this species. A few final phrases were tape-recorded before it started to rain and the singing stopped. In an attempt to confirm the identification by hearing the bird again and seeing it, the location was visited on the three following days, with long periods of time spent at or near the spot, but the bird was not observed again. The tape-recorded part of the song was compared to published (Chappuis 2000) and unpublished recordings of this species and was found to be very similar. The species was subsequently searched for by other observers visiting Atewa and the original identification could finally be confirmed on 27 May 2007, when excellent views of two individuals were obtained (A. Hester in litt.). This remarkable find constitutes a new species for Ghana and the eastermost record to date, extending the known range by c. 500 km, the previous easternmost locality being Mopri Forest Reserve (05°50'N, 04°55'W), in Côte d'Ivoire (Fishpool and Evans 2001). Apart from the latter country, this rare to scarce and local forest resident was previously known only from Guinea, Sierra Leone and Liberia.

Illadopsis rufescens Rufous-winged Illadopsis (NT)
Remarkably common, with up to four singing individuals heard daily. A generally uncommon forest resident, endemic to Upper Guinea. As it is often confused with its congener, Puvel's Illadopsis *I. puveli*, its precise status and distribution in Ghana is inadequately known.

Lamprotornis cupreocauda Copper-tailed Glossy Starling (NT)
Faily common, with up to six individuals recorded on the majority of days. A fairly common to locally common forest resident, endemic to Upper Guinea and reaching the eastern limit of its distribution at or near Atewa.

Other noteworthy records

Dryotriorchis spectabilis Congo Serpent Eagle
Up to two individuals heard calling at two different sites on three separate days. This forest resident, which is considered scarce to locally common, has been generally under-recorded in Ghana.

Poicephalus gulielmi Red-fronted Parrot
A group of eight visiting a fruiting tree on 15 June, and a single flying over on the same day are our only records. This species is generally scarce in West Africa.

Veles binotatus Brown Nightjar
An entirely dark brown nightjar seen at 18:45 above the main track deep inside the forest was identified as this species. It flew in the headlights of the car for c. 100 m before banking, thereby clearly showing its entirely dark upperparts without any white markings, and disappearing into the forest. There is only one previous record for Atewa, from February 2005 (Dowsett-Lemaire and Dowsett 2005).

Ceyx lecontei African Dwarf Kingfisher
One seen in forest understorey, while another (a juvenile?) was heard uttering high-pitched calls nearby. This species, which is rare to uncommon in West Africa, had not been recorded previously at Atewa, but its presence was expected (Dowsett-Lemaire and Dowsett 2005).

Merops muelleri Blue-headed Bee-eater
This generally scarce to rare forest resident, which reaches the easternmost limits of its Upper Guinea range in Atewa, was encountered remarkably frequently, either singly or in pairs. A trio was observed once. The species is known from only two other IBAs in Ghana (Ntiamoa-Baidu et al. 2001) and Atewa may well hold the largest population in the country.

Sheppardia cyornithopsis Lowland Akalat
Singles were seen clearly at three locations. This species has only recently been confirmed from Atewa, based on a specimen collected in 1995 (Roy et al. 2001). A female with an active brood patch was mist-netted in February 2005 (Dowsett-Lemaire and Dowsett 2005). The reserve is the easternmost locality for the species in Upper Guinea and the only site in Ghana where it is known to occur.

Apalis sharpii Sharpe's Apalis
This Upper Guinea Forests Biome endemic was found to be common and vocal in the canopy and sub-canopy, with daily observations of up to ten individuals.

Parus funereus Dusky Tit
A small group consisting of at least three adults and another of three adults and an independent juvenile were observed in mixed-species flocks.

Malaconotus cruentus Fiery-breasted Bush-shrike
Two singles and a pair were observed at three different locations. This species is generally rare and local in West Africa and Atewa is the only IBA in Ghana where it is known to occur.

Parmoptila rubrifrons Red-fronted Antpecker
An independent juvenile and a pair with two to three juveniles were seen at two locations. This generally scarce Upper Guinea endemic is rare in Ghana.

Evidence of breeding
Alethe diademata White-tailed (Fire-crested) Alethe
A juvenile photographed by P. Naskrecki on 17 June.

Macrosphenus concolor Grey Longbill
Parents with a begging juvenile seen on 20 June.

Eremomela badiceps Rufous-crowned Eremomela
A flock of four adults with an independent juvenile seen on 14 June.

Muscicapa epulata Little Grey Flycatcher
A pair with a begging juvenile seen on 7 June.

Dyaphorophyia castanea Chestnut Wattle-eye
Small family groups consisting of parent birds with a juvenile seen on seven occasions.

Deleornis fraseri Fraser's Sunbird
Begging juveniles seen on a few occasions.

Ploceus tricolor Yellow-mantled Weaver
Independent juveniles noted on a few occasions.

Ploceus albinucha Maxwell's Black Weaver
Independent juveniles accompanying adults observed on a few occasions.

Ploceus preussi Preuss's Weaver
A family group consisting of a pair with an independent juvenile observed on 10 June.

DISCUSSION

The Atewa Range Forest Reserve, which is listed as an IBA (Ntiamoa-Baidu et al. (2001), was found to have a remarkably rich avifauna, comprising a substantial component of forest-restricted species. It is therefore of considerable importance for the conservation of these birds. The total of 155 species recorded during this study is relatively high, although a higher number could have been found if the survey had been conducted at a different season, for example in February-March, when more species are vocally active and Palearctic migrants are still present. Cuckoos, owls and honeyguides were mainly silent, which explains the absence of several of these species from our list. Black Cuckoo *Cuculus clamosus* was heard (very briefly) once and African Emerald Cuckoo *Chrysococcyx cupreus* only five times, for short periods. An African Wood Owl *Strix woodfordi* was calling briefly near camp at Asiakwa North on two consecutive evenings. Of the three honeyguide species observed, only Thick-billed *Indicator (minor) conirostris* was heard to sing, although briefly (two individuals).

Hornbills were surprisingly scarce, with only Pied *Tockus fasciatus* and White-crested *Tropicranus albocristatus* being regularly encountered, albeit in low numbers (with a maximum of five in a day for the former, and three for the latter). We recorded Brown-cheeked Hornbill *Bycanistes cylindricus* on three occasions only, with just a single pair seen, whereas it was seen daily in February 2005, with up to 12 individuals in a day (Dowsett-Lemaire and Dowsett 2005). Several hornbill species are known to wander widely in search of fruiting trees, which may at least in part explain their scarcity during our survey. Great Blue Turaco *Corythaeola cristata*, normally a conspicuous feature of good forest, was also scarce, being only observed in low numbers (one to three birds) on four days.

Mixed-species flocks were particularly numerous, occurring on average every 500 m and comprising a relatively high number of individuals. Typical members of these flocks included Icterine Greenbul *Phyllastrephus icterinus* (usually the most common species, with up to 15 individuals in a single flock), Red-tailed Bristlebill *Bleda syndactylus*, Grey-headed Bristlebill *B. canicapillus*, Western Bearded Greenbul *Criniger barbatus*, Red-tailed Greenbul *C. calurus*, Black-capped Apalis *Apalis nigriceps*, Green Hylia *Hylia prasina*, Red-bellied Paradise Flycatcher *Terpsiphone rufiventer*, Chestnut Wattle-eye *Dyaphorophyia castanea*, Green Sunbird *Anthreptes rectirostris*, Fraser's Sunbird *Deleornis fraseri* (very common), Blue-throated Brown Sunbird *Cyanomitra cyanolaema*, Many-coloured Bush-shrike *Malaconotus multicolor* (typically one calling individual per flock), Black-headed Oriole *Oriolus brachyrhynchus*, Shining Drongo *Dicrurus atripennis*, and one to three *Malimbus* species (Crested *M. malimbicus*, Blue-billed *M. nitens* and/or Red-headed Malimbe *M. rubricollis*). Other species observed in these flocks include Buff-spotted Woodpecker *Campethera nivosa*, Brown-eared Woodpecker *C. caroli*, Purple-throated Cuckoo-shrike *Campephaga quiscalina* (remarkably common), Blue Cuckoo-shrike *Coracina azurea* (uncommon), Finsch's Flycatcher Thrush *Stizorhina finschi*, Sharpe's Apalis *Apalis sharpii*, Grey Longbill *Macrosphenus concolor*, Rufous-crowned Eremomela *Eremomela badiceps*, Violet-backed Hyliota *Hyliota violacea*, Fraser's Forest Flycatcher *Fraseria ocreata*, Chestnut-capped Flycatcher *Erythrocercus mccallii*, Dusky Crested Flycatcher *Elminia nigromitrata* (remarkably common), Shrike Flycatcher *Megabyas flammulatus*, Red-cheeked Wattle-eye *Dyaphorophyia blissetti*, Bioko Batis *Batis poensis*, Dusky Tit *Parus funereus*, Tit-hylia *Pholidornis rushiae*, Sabine's Puffback *Dryoscopus sabini*, Yellow-mantled Weaver *Ploceus tricolor*, Maxwell's Black Weaver *P. albinucha* (remarkably common), Preuss's Weaver *P. preussi*, Grey-headed Negrofinch *Nigrita canicapillus*, Chestnut-breasted Negrofinch *N. bicolor* and Red-fronted Antpecker *Parmoptila rubrifrons*.

Biogeographically, Atewa appears to be at the eastern limit of the range of some Upper Guinea endemics, such as Green-tailed Bristlebill *Bleda eximius*, Yellow-bearded

Greenbul *Criniger olivaceus* and Red-fronted Antpecker *Parmoptila rubrifrons*. To these, Nimba Flycatcher *Melaenornis annamarulae* can now be added. As one of the two main sites of upland evergreen rainforest remaining in Ghana, it constitutes a particularly favorable habitat for a species like Lowland Akalat *Sheppardia cyornithopsis*, for which Atewa is the only known site in the country. Because of the specific habitat characteristics of the site, both bird species typically occurring in closed-canopy as well as species frequenting open-canopy forest are found here. Several generally uncommon or scarce species are remarkably common here, such as Blue-headed Bee-eater *Merops muelleri* and Maxwell's Black Weaver *Ploceus albinucha*, the nominate subspecies of which, *P. a. albinucha*, reaches the eastern limits of its range in Atewa. The generally rare and local Fiery-breasted Bush-shrike *Malaconotus cruentus* also occurs.

Other species occurring in the reserve that are rare in Ghana and generally uncommon in their global range include Bates's Swift *Apus batesi*, Little Grey Flycatcher *Muscicapa epulata*, Dusky Tit *Parus funereus*, Johanna's Sunbird *Cinnyris johannae*, Preuss's Weaver *Ploceus preussi* and Red-fronted Antpecker *Parmoptila rubrifrons*.

CONSERVATION RECOMMENDATIONS

Considering the very high conservation value of Atewa Range Forest Reserve, the following recommendations are made:

1. The biological importance of the reserve in Ghana, and more generally in the Upper Guinea region, is such that it should, ideally, be fully and entirely protected.

2. If, contrary to the recommendations contained within this report, future development of the area should occur, a representative and continuous part of the reserve containing all the bird species restricted to the Guinea-Congo Forests biome occurring at Atewa, should be set aside and receive full protection, in order to preserve a substantial part of its biodiversity and, in the long term, possibly enable regeneration of the forest on the area that is impacted by such development. Furthermore, surveys should be conducted in all areas which will be impacted, prior to any additional impact occurring, to document current species richness and population sizes of all bird species of global conservation concern.

3. Further surveys should be carried out to determine the population size and habitat requirements of the Nimba Flycatcher, an Upper Guinea endemic of conservation concern whose song was heard for the first time in Ghana during this RAP and for which Atewa constitutes the only known site in the country.

4. Monitoring programs should be put in place to assess the impact of any development activities and subsequent regeneration operations on biodiversity and in particular on the bird species of conservation concern and those restricted to the Guinea-Congo Forests biome. Local villagers, especially hunters, who know the forest and its wildlife best, should be employed to participate in these programs.

5. Hunting should be curtailed. Although it currently mainly targets mammals, certain large bird species, such as Crested Guineafowl, Great Blue Turaco and large hornbills, also fall victim to these illegal practices, which could explain their relative rarity.

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Chapter 11

A rapid survey of small mammals from the Atewa Range Forest Reserve, Eastern Region, Ghana

Natalie Weber and Jakob Fahr

SUMMARY

We report on the results of a small mammal survey in the Atewa Range Forest Reserve. A total of 12 bat species were recorded. Composition of bat species clearly reflects a forest assemblage, with no savanna species being observed. Two rarely recorded bat species (*Hypsugo* [*crassulus*] *bellieri* and *Pipistrellus* aff. *grandidieri*) are reported for the first time for Ghana, raising the total number of species for this country to 86. Together with specimens from five localities in West Africa, *Pipistrellus* aff. *grandidieri* from Atewa might represent an undescribed species. *Hypsugo* (*crassulus*) *bellieri* is endemic to the Upper Guinean forests. Zenker's fruit bat *Scotonycteris zenkeri* is ranked on the Red List as Near Threatened (IUCN 2006). The three terrestrial small mammal species recorded during the survey are likewise forest-dependent and include two West African endemics: Edward's swamp rat *Malacomys edwardsi* and the shrew *Crocidura grandiceps*. The latter is ranked as Near Threatened on the IUCN Red List and had not been recorded from Ghana since its description. The overall species composition of small mammals indicates high habitat integrity of the Atewa Range Forest Reserve, which constitutes the most significant block of Upland Evergreen Forest in Ghana. The integral protection of Atewa is an outstanding priority for the preservation of (sub-) montane forests in West Africa, both for the conservation of small mammals and of biodiversity in general. In accordance with international conservation principles on mining and biodiversity (Dudley and Stolton 2002, Miranda et al. 2005), we recommend that exploration concessions for Atewa are cancelled, that its legal protection status is upgraded, that no development is allowed within the forest reserve, and that effective management measures are implemented.

INTRODUCTION

Although West African forests have been reduced to about 15% of their potential extent, the remaining and highly fragmented patches are still being degraded or completely lost at a high rate. Given this threat as well as the exceptional number of species endemic to the Guinean forests of West Africa, this region was ranked as one of 34 global biodiversity hotspots (Bakarr et al. 2004). Within this region, (sub-) montane forests are under particular pressure as montane habitats are extremely restricted in extent. Long-term geological erosion has turned West Africa into a mostly flat landscape that is broken by very few mountain ranges. Significant tracts of montane forest are limited to the Upper Guinea Highlands along the border region of Sierra Leone, Liberia, Guinea and Côte d'Ivoire in the West and the Cameroon Mountain Range in the East. These montane forest areas constitute unique ecosystems with exceptional species richness and high levels of endemism (Bakarr et al. 2001, 2004). In-between this wide geographic hiatus, only the Atewa Range in Ghana, the Volta Highlands between Ghana and Togo and the Jos Plateau in Nigeria harbor significant upland forest patches, however among these three, Upland Evergreen Forest is found only in the Atewa Range. The latter area has had the status of a national forest reserve since 1925 and was recently designated as a Globally Significant Biodiversity Area (GSBA) as well as an Important Bird Areas (IBA) (Abu-Juam et al. 2003). Together

with the highly degraded Tano Ofin, the Atewa Range is one of only two reserves in Ghana where Upland Evergreen Forest occurs (Hall and Swaine 1981, Abu-Juam et al. 2003). The Priority-Setting Workshop for Upper Guinea ranked the Atewa Range Forest Reserve (Atewa) to be of "Very High" priority for overall biodiversity conservation. As a result of the workshop, it was recommended that scientific information for this area be updated through surveys and that measures are implemented to achieve improved protection for the biodiversity of the area (Bakarr et al. 2001).

The target of our study was a survey of small mammals of Atewa, namely bats (Chiroptera), rodents (Rodentia) and shrews (Soricomorpha). Sampling of these groups was conducted at each of the three study sites, but survey effort focused on bats due to logistical constraints. In tropical communities, bats usually constitute the most species-rich group of mammals. They are regarded as a particularly suitable indicator group to assess habitat conditions and thus to set conservation priorities because of their high diversity, species-specific habitat requirements and patterns of endemism (many species have small distribution ranges). Moreover, they provide important ecosystem services as predators of insects as well as pollinators and seed dispersers of plants. Apart from a few occasional bat records (Grubb et al. 1999) and a limited survey of terrestrial small mammals (Abedi-Lartey and Guba-Kpelle 2005), Atewa had not previously been sampled for small mammals.

METHODS

Study site

Atewa is located within the moist semi-deciduous forest zone in the Eastern Region of Ghana. The two forest blocks Atewa Range and Atewa Range Extension combined cover an area of 258.3 km^2, with the Atewa Range alone having an extent of 237 km^2. According to the GLC2000 data (Mayaux et al. 2004), the entire Atewa Range represents 33.5% of the remaining closed forest in the Eastern Region. The mountain range, which peaks at 842 m a.s.l. (SRTM90 data), runs roughly from north to south and is characterized by plateaus, which are remnants of a Tertiary peneplain. These plateaus are covered with Upland Evergreen Forest and are dissected by steep ravines. The larger northern part is situated in the wet semi-equatorial climatic zone, with two wet seasons from May to July and from September to October/November and an annual precipitation of about 1650 mm. The forests are home to many endemic and rare species. The unique floristic composition of the Upland Evergreen Forest is generated by the misty conditions on top of the plateaus (Swaine and Hall 1977). The diverse flora contains submontane elements, with characteristic herbaceous species as well as abundant and diverse epiphytes. Many plant species found here are not known to occur elsewhere in Ghana and several butterfly species are strictly endemic to Atewa (Larsen 2006). Seasonal marshy grasslands, swamps and thickets that occur here are also thought to be nationally unique (Hall and Swaine 1981). Invasive species like *Chromolaena odorata* can be found along disturbed sites such as roads or other openings. Despite this disturbance, most parts of the forest reserve are still in good or excellent condition.

Sampling and data analysis

From 7 – 22 June 2006, three sites within Atewa were surveyed by NW. Atiwiredu was visited from 7-10 June, Asiakwa South from 11-16 June, and Asiakwa North from 17-22 June. Sampling was conducted mostly within a 500 m-radius of each camp site. At Asiakwa South and North, two additional sampling sites were visited, but these are not considered further as no specimens were captured there. The location of each site was recorded with a GPS-receiver (Garmin eTrex) (Table 11.1).

Table 11.1. Coordinates and elevation of three sites within the Atewa Range Forest Reserve, Ghana, where bats and terrestrial small mammals were sampled.

Site	Coordinates	Elevation
Atiwiredu	6°12'23"N, 0°34'39"W	817 m
Asiakwa South	6°15'44"N, 0°33'19"W	783 m
Asiakwa North	6°16'16"N, 0°33'53"W	814 m

Field work was conducted during the peak of the first wet season. Bats were captured with 6 m and 12 m mist nets near ground level, following standard methods (Wilson et al. 1996). Each night, at least two and up to seven mist nets were placed opportunistically across potential flyways within the forest, e.g. crossing trails or within treefall gaps. Nets were opened before sunset and checked at least every 30-45 minutes. They were closed at different times, depending on rainfall or overall moisture, and sometimes re-opened in the morning between 3:30-4:00 hrs and 6:00 hrs. Overall sampling effort was 217 net hours in 16 nights (calculated as 12 m-mist net equivalents, Table 11.2). Capture success was calculated as number of individuals captured per net hour. A two-bank harp trap (Bat Conservation & Management, model "G4 Forest Strainer", catch area 3.9 m^2) was employed at Atiwiredu and Asiakwa North. Capture success of the harp trap was nil, probably as a result of different line lengths that made it impossible to achieve sufficient and equal tension. Standard body measurements (body mass, forearm, tail, head and body, ear, hind foot) were taken of each bat specimen and their sex as well as their age class was determined. Identification in the field was aided by Rosevear (1965) and Hayman and Hill (1971). For each species, voucher specimens (12) were collected and preserved in 70% ethanol. They are currently deposited in the research collection of JF at the University of Ulm (see Appendix 7). Tissue samples were taken from all voucher specimens and preserved in 99% ethanol. Additionally, hand-held echolocation calls of rhinolophids and hipposiderids were recorded with a Pettersson D240x bat detector and transferred to a Sony Walkman Professional WM-D6C. The calls were analyzed

with the software Avisoft-SASLab Pro 4.2 to check species identifications of rhinolophids and hipposiderids, in particular those of released individuals. Within these families, the constant frequency (CF) component of the echolocation calls is highly species-specific.

At each site, traplines for terrestrial small mammals were set every night except for the arrival day at each site. Trapping effort consisted of 2-5 Tomahawk traps and 20-40 Sherman live traps during 13 nights altogether. The Tomahawk traps were placed close to burrows, the Sherman traps were set up in traplines of five traps along fallen trees and other structures presumed to channel movement patterns of target groups. Traps were baited with palm nut oil or peanut butter mixed with oats. Ten voucher specimens were collected and preserved as wet specimens in 70% ethanol. They were identified by Rainer Hutterer, Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Bonn, and deposited in the collections of this institution (see Appendix 8).

A smoothed species accumulation curve was generated for bats with the program EstimateS, Version 7.5 (Colwell 2005). This sample-based rarefaction curve was calculated with the "Mao Tau"-function (Colwell et al. 2004) and the graph was rescaled by individuals. Statistical methods estimating the total number of species from samples (Colwell 2005) were not employed as they require standardized sampling methods. The IUCN Red List status is based on the recent update that followed the Global Mammal Assessment (GMA) of African small mammals in January 2004 (IUCN 2006). Taxonomy follows Wilson and Reeder (2005) if not otherwise stated.

RESULTS

Bats

In total, 27 bats of 11 species belonging to five families were captured during this RAP survey (Tables 11.2 and 11.3, Appendix 7). A twelfth species was observed, heard, and unam-

Table 11.2. Capture effort (nh: total net hours per site, calculated as 12 m-net equivalents), capture success (number of individuals; bats per net hour) and species coverage (Total: all species) of the RAP survey. Mega: fruit bats only. Micro: insect bats only. One species is included in the species total of Asiakwa South that was not captured but was seen and heard.

	Effort [nh]	N° of Indiv.	Mega	Micro	Bats/ nh	Mega/ nh	Micro/ nh	Species Total
Atiwiredu	56.1	11	4	7	0.20	0.07	0.12	6
Asiakwa South	101.6	9	6	3	0.09	0.06	0.03	6
Asiakwa North	59.6	7	0	7	0.12	–	0.12	6
All sites	217.3	27	10	17	0.12	0.05	0.08	12

Table 11.3. Bat species recorded from three sites of the Atewa Range Forest Reserve, Ghana, during this / the RAP survey (numbers refer to captured individuals). Red List: international Red List status (NT: Near Threatened, n.a.: not assessed; IUCN 2006). Habitat: coarse assignment to preferred habitat types (F: forest; S: savannas and woodlands; in brackets: marginally including the respective habitat type).

Species	Sites			Total	Red List	Habitat	
	Atiwiredu	Asiakwa South	Asiakwa North				
Pteropodidae							
Hypsignathus monstrosus *		X		*		F	(S)
Scotonycteris zenkeri	1	2		3	NT	F	
Megaloglossus woermanni	1	3		4		F	
Myonycteris torquata	2	1		3		F	(S)
Nycteridae							
Nycteris grandis		1		1		F	(S)
Rhinolophidae							
Rhinolophus alcyone			1	1		F	(S)
Hipposideridae							
Hipposideros ruber	5		1	6		F	(S)
Hipposideros beatus			1	1		F	
Hipposideros cyclops			2	2		F	
Hipposideros gigas	1	2		3		F	
Vespertilionidae							
Hypsugo [*crassulus*] *bellieri*	1		1	2	n.a.	F	
Pipistrellus aff. *grandidieri*			1	1	n.a.	F	
Specimens total	**11**	**9**	**7**	**27**			
Species total	**6**	**6**	**6**	**12**			

*: species not caught, but two males observed and heard at the edge of the forest towards marshy grassland.

biguously identified as *Hypsignathus monstrosus*. The capture rate of 0.12 bats per net hour was very low (Table 11.2), consisting of 0.05 fruit bats per net hour and 0.08 insectivorous bats per net hour. No day-roosts of bats were found. Comparison between the three sites is highly limited because of the overall low number of captured individuals.

Four species (*Nycteris grandis*, *Rhinolophus alcyone*, *Hipposideros beatus*, *Pipistrellus* aff. *grandidieri*) were captured only once. The other species were captured in small numbers, with six being the highest number of individuals per species in *Hipposideros ruber*. At each site six species were recorded, whereby Asiakwa North had the highest number of species found only there (*Rhinolophus alcyone*, *Hipposideros beatus*, *H. cyclops*, *Pipistrellus* aff. *grandidieri*; Table 11.3). No fruit bats were recorded at Asiakwa North. Two species (*Hypsugo* [*crassulus*] *bellieri*, *Pipistrellus* aff. *grandidieri*) constitute first records for Ghana, raising the total number of bat species for this country from 84 to 86 (J. Fahr unpubl. data).

The 12 species encountered during the RAP survey depend exclusively (seven species) or largely (five species) on forest habitat and not a single species preferring savanna habitat was recorded (Table 11.3). Among the fruit bats, *Scotonycteris zenkeri* is ranked on the Red List as Near Threatened (IUCN 2006). The captured insectivorous bats belong to the families Nycteridae, Rhinolophidae, Hipposideridae and Vespertilionidae. High-flying species from the families Emballonuridae and Molossidae are completely lacking from the species list, which is most likely the result of captures being restricted to near ground level. The combined species accumulation curve for Atewa does not reach a plateau but rises steeply (Figure 11.1), indicating that sampling of the bat fauna during this short study was incomplete.

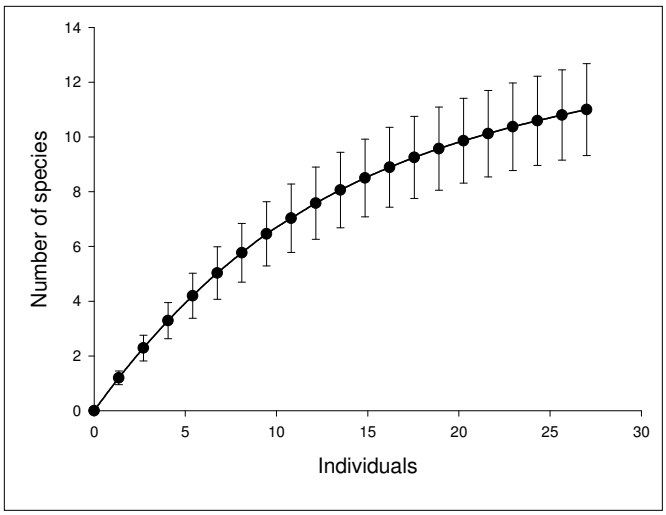

Figure 11.1. Smoothed species accumulation curve for bats captured during the RAP survey in the Atewa Range Forest Reserve, Ghana. Line and dots: sample-based rarefaction curve, rescaled by individuals ("Mao Tau"-curve, Colwell et al. 2004), vertical bars: ± 1 *SD*.

Terrestrial small mammals

In total, 11 individuals of three species of terrestrial small mammals were captured (Table 11.4, Appendix 8). Due to the small number of captures, comparison between sites cannot be made. Both rodent species and the shrew species depend on rainforest. Both Edward's swamp rat (*Malacomys edwardsi*) and the shrew *Crocidura grandiceps* are endemic to West Africa. The latter is ranked on the Red List as Near Threatened (IUCN 2006). Tullberg's soft-furred mouse (*Praomys tullbergi*) had previously been recorded from the Atewa Range (Abedi-Lartey and Guba-Kpelle 2005; see Appendix 9).

DISCUSSION

Bats

The present survey raised the number of bat species known to occur in Ghana from 84 to 86 despite the fact that Ghana is well-sampled compared to other West African countries. The very short survey and low capture numbers do not allow differentiating between single sampling sites, hence only a general assessment of species richness and composition of Atewa is possible. During the present RAP study, 12 bat species were recorded. Prior to our study, only seven bat species were claimed to occur in the area, all of them fruit bats (Pteropodidae: *Epomophorus gambianus*, *Micropteropus pusillus*, *Hypsignathus monstrosus*, *Nanonycteris veldkampii*, *Scotonycteris zenkeri*, *Megaloglossus woermanni*, *Eidolon helvum*) (Harris and Baker 1959, pers. comm. D. Smith and L. Grimes in Grubb et al. 1999, Abedi-Lartey and Guba-Kpelle 2005). Out of these species, we did not record *Epomophorus gambianus*, *Micropteropus pusillus*, *Nanonycteris veldkampii*

Table 11.4. Small terrestrial mammals recorded at three sites of the Atewa Range Forest Reserve during the 2006 RAP survey (numbers refer to captured individuals). Red List: global Red List status (NT: Near Threatened; IUCN 2006).

Species	Sites			Total	Red List
	Atiwiredu	Asiakwa South	Asiakwa North		
Soricomorpha					
Crocidura grandiceps	2			2	NT
Rodentia					
Praomys tullbergi	1	1	1	3	
Malacomys edwardsi	1	2	3	6	
Total specimens	**4**	**3**	**4**	**11**	
Total species	**3**	**2**	**2**	**3**	

or *Eidolon helvum*. During the wet season, both *Nanonycteris veldkampii* and *Eidolon helvum* are migrating to the North (Thomas 1983), hence these species might have been absent during our study period. However, *Epomophorus gambianus* as well as *Micropteropus pusillus* are species mainly found in savanna habitats (Fahr and Ebigbo 2003, 2004). We suspect that the latter records might either represent misidentifications of *Epomops* spp. and *N. veldkampii*, respectively, or that they were encountered in highly degraded and converted habitat along the periphery of the forest reserve where farmbush species might have invaded the forest zone. Surprisingly few fruit bats (Pteropodidae) were recorded during the present RAP survey, possibly due to a seasonal lack of fruiting trees in the vicinity of the sampling sites.

The species accumulation curve for Atewa rises steeply and does not reach an asymptotic plateau, indicating that our sampling of the bat fauna is far from being complete. Decher and Fahr (2007) estimated that 35-40 bat species can be expected to locally occur in forest reserves of southern Ghana. As this figure is about three times higher than the 12 species we encountered, extended surveys are necessary for a near-complete inventory of the bat fauna. Incompleteness of the present bat survey is also demonstrated by the occurrence of 2-4 additional species that were recorded in Atewa prior to but not during this RAP survey (see above). The discrepancy between our results and the expected number of species is based on several factors. During short-term inventories like RAP surveys, sampling is largely opportunistic and limited both in temporal and spatial coverage. This study focused on the plateau areas of Atewa and future assessments should include slope habitat. Recent surveys showed pronounced species turnover between sites that differ in altitude and vegetation (Fahr et al. 2006). Furthermore, Atewa has never been the target of an extended study covering all seasons. Previous surveys demonstrated that additional sampling methods such as a (functional) harp trap and canopy nets reveal species that are missed with mist nets set near ground level (Fahr and Ebigbo 2004, Monadjem and Fahr 2007).

The total of 12 species and the capture rate of 0.12 (0.09-0.20) bats per net hour is at the lower bound of previous RAP surveys (0.02-1.92 bats/nh: Fahr and Ebigo 2003, 2004; Decher et al. 2005b; Decher and Fahr 2006; Fahr et al. 2006; Monadjem and Fahr 2007). Most of these previous studies covered several forest reserves and forest edge as well as adjacent village areas. During the present RAP survey, sampling was conducted exclusively within the forest interior of Atewa. The surroundings of Atewa were not sampled as they were outside of the boundary of the reserve and therefore not the target of this study. Undisturbed rainforest habitat generally yields low capture rates compared to habitat mosaic or forest edges (Monadjem and Fahr 2007), hence the low captures of the Atewa survey do not indicate degraded habitat conditions. The number of 12 recorded species is remarkably high in proportion to the low number of 27 captured individuals (Table 11.3), again reflecting undisturbed rainforest habitat where many species occur in low abundance and with overall high evenness.

Terrestrial small mammals

During previous RAP surveys in West Africa, the number of shrew species recorded per sampling site was 0-5 species for a total of 2-7 species per RAP survey. Corresponding numbers for rodents (excluding anomalurids, squirrels and porcupines: not covered in our survey) are 1-8 species per sampling site for a total of 1-16 rodent species per RAP survey (Decher 2004; Decher et al. 2005a, 2005b; Norris 2006; Monadjem and Fahr 2007). The very low capture success of terrestrial mammals in Atewa, both in terms of individuals and species, is only comparable to that encountered during the Liberia RAP survey where trapping was largely conducted on a limited basis due to logistical problems (Monadjem and Fahr 2007). The field period for the present RAP survey was even more limited than in previous RAPs and the species list is certainly far from being complete. Unfortunately, previous species lists for Atewa (Abu-Juam et al. 2003, Abedi-Lartey and Guba Kpelle 2005) indicate substantial misidentifications and/or sampling in highly disturbed areas around Atewa (see Appendix 9). Only the reported *Praomys tullbergi* (also recorded during the present survey), *Thryonomys swinderianus* and *Cricetomys emini* seem sufficiently likely to accept their reported occurrence in Atewa.

Significant species

The fruit bat *Scotonycteris zenkeri* is ranked Near Threatened on the most recent Red List (IUCN 2006). This species depends on rainforest and shows a disjunct distribution pattern, with populations occurring in Upper Guinea, Lower Guinea, and Central Africa. It is known from several locations in Ghana, including Atewa (Grubb et al. 1999), but always represents a small percentage of all fruit bat captures (Fahr in press-a). Recent records were exclusively made in undisturbed forests and it is likely that this species has disappeared from many previous localities as a result of forest degradation and loss.

Hypsugo [*crassulus*] *bellieri*, a bat endemic to the Upper Guinean forests, was recorded for Ghana the first time. The taxon *bellieri* is currently recognized as a subspecies of *Hypsugo crassulus* (Heller et al. 1995, Simmons 2005). It has a very restricted distribution within Upper Guinea and probably represents a distinct species (Fahr in press-b). Due to its current taxonomic status as a subspecies, it has not yet been assessed for the IUCN Red List although it is likely to be threatened by habitat degradation and loss. The recognition of *bellieri* as a distinct species would qualify it as Vulnerable according to the Red List criteria (A4c; see Monadjem and Fahr 2007).

The large-sized "pipistrelle" captured in Asiakwa North cannot be referred to any described species known to occur in West Africa. It agrees in measurements and characters with four unpublished specimens from Ivory Coast, a single specimen from southwestern Cameroon and two specimens from western Liberia referred to *Pipistrellus* aff. *grandidieri* by Monadjem and Fahr (2007). Although these specimens agree in measurements and characters with *Pipistrellus grandidieri*, which was described from Zanzibar, the large distri-

butional hiatus between West and East Africa raises the possibility that West African specimens represent a distinct and undescribed species. Further morphological and genetic data are necessary to answer this question. The record of *Pipistrellus* aff. *grandidieri* from Atewa is the first for Ghana.

The shrew *Crocidura grandiceps* is ranked as Near Threatened on the Red List (IUCN 2006). This species was described from Krokosua Hills in Ghana (Hutterer 1983). Since then, only a few specimens have been recorded, mostly in undisturbed primary rainforest in southeastern Guinea (Decher 2004), western Ivory Coast (Meylan and Vogel 1982 [as *C.* cf. *nimbae*], Churchfield et al. 2004, Quérouil et al. 2005), southern Benin (Bekker and Ekoué 2004), southern Nigeria[1] (Hutterer and Happold 1983, Iyawe 1989, Angelici and Luiselli 2005 [as *C.* cf. *grandiceps*]), and possibly from southwestern Cameroon (Hutterer and Schlitter 1996) (Fig. 11.2). This species is threatened by loss and degradation of suitable rainforest habitat. A recent RAP survey of three forest reserves in southwestern Ghana, including the type locality Krokosua Hills, did not record *C. grandiceps* (Decher et al. 2005b) and our record from Atewa is the second for Ghana since its description.

CONSERVATION RECOMMENDATIONS

Overall species composition of small mammals within Atewa as assessed during the RAP survey clearly reflects an assemblage of forest-dependent species, including several globally threatened species, and underlines the ecological integrity of the surveyed area. Our findings confirm the results of the West Africa Priority-Setting Workshop, which ranked Atewa to be of "Very High" priority for overall biodiversity conservation in West Africa (Bakarr et al. 2001).

A study of the effects of habitat fragmentation on birds in Ghana revealed dramatic influence of patch size on species composition and only the largest fragments harbored area-sensitive species (Beier et al. 2002). Negative effects of climatic alterations as a result of fragmentation were demonstrated by Hill and Curran (2003), who furthermore emphasized the detrimental impact of fire on smaller forest fragments in Ghana. Both studies stressed the importance of maintaining larger intact forest blocks like Atewa to protect the last strongholds of forest-dependent species in Ghana. Montane areas are a particular case: as a result of orographic precipitation, they have offered long-term environmental stability and acted as refuges during drier times in the past. At the same time, adaptation to predictable conditions might confer a higher susceptibility of local populations to disturbance (Fjeldså and Lovett 1997). In line with this argument, Ricketts et al. (2005) predicted that future extinctions will be mainly found in species that are restricted to mountains. Atewa Range is the only significant Upland Evergreen Forest that remains between the Upper Guinea Highlands in the West and the Cameroon Mountain Range in the East. These mountainous areas are distinguished by a large number of endemic and threatened species. If Atewa is severely disturbed by large-scale impacts such as industrial surface mining, it is highly likely that the majority of specialized forest species will be lost, at least those species most vulnerable to altered habitat conditions.

Between 1990 and 2005, the deforestation rate in Ghana was very high (2.0%) compared to other countries in West Africa, resulting in the loss of 25.9% (1,931,000 ha) of Ghana's forest cover during 15 years (FAO 2006). Degradation and depletion of forests through logging, bushmeat hunting, encroaching agriculture and mining activities has severely reduced and fragmented the country's forest cover. Only designated forest reserves still contain significant forest blocks that serve as source areas for a broad variety of animal and plant species, protect watersheds and maintain Ghana's climate, thereby providing essential goods and ser-

[1] The record from Ilashe was erroneously given by Hutterer and Happold (1983) as 7°30'N, 6°30'E. However, the correct locality is "Idoforo, 4 mi S Ilashe, 6 mi

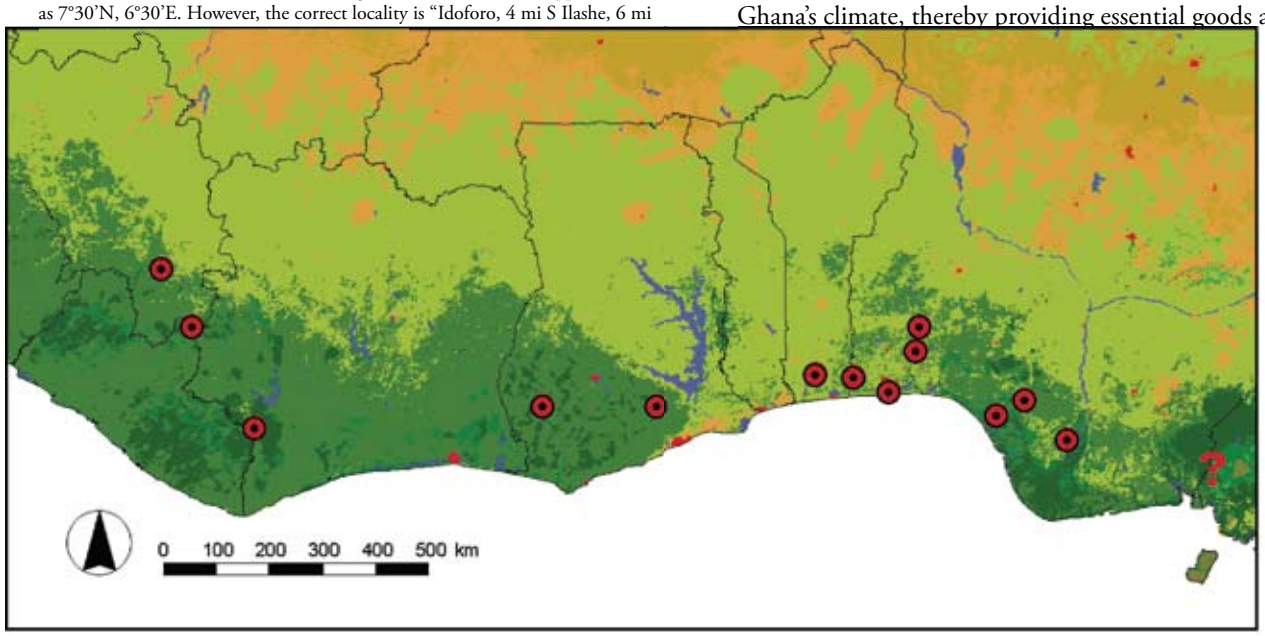

Figure 11.2. Known distribution of *Crocidura grandiceps*. Dark green: closed forest; medium green: degraded forest and farmland; pale green: woodland and humid savannas (GLC2000; Mayaux et al. 2004).

vices for the human population of the country (Agyarko 2001). Atewa constitutes the largest and most intact patch of Upland Evergreen Forest in Ghana, representing 75% of this habitat type countrywide, and was consequently designated one of 30 Globally Significant Biodiversity Areas (GBSA) in 1999. This forest reserve is distinguished by one of the highest levels of biodiversity in Ghana, for some taxa even the highest (Larsen 2006). Despite its pivotal role as one of the most important conservation areas in Ghana, it is still not adequately protected. In 1994, the Government of Ghana formulated a new Forest and Wildlife Policy aiming at both the "conservation and sustainable development of the nation's forest and wildlife resources" (Agyarko 2001). More recently, however, the Government is facing allegations of compromising its own policy by permitting unsustainable exploitation of forest reserves (Hilson and Nyame 2006). In order to reverse this worrying development and to implement Ghana's own strategy within the legally binding framework of the international Convention on Biological Diversity (CBD), we recommend the following points for an integral and long-term protection of Atewa:

- Undertake additional surveys of Atewa to complement the inventory of small mammals.
- Focus in-depth studies on threatened, rare and endemic species, including those that have not yet been assessed for the IUCN Red List.
- Encourage participation by local communities in decision-making regarding the management of Atewa and provide biodiversity education and training in sustainable use of forest resources.
- Prevent of further illegal logging by establishing patrols and enforcing existing regulations.
- Rigorously protect the watersheds of Atewa in order to secure the water supply for surrounding communities and cities.
- Upgrade of the legal status of Atewa to a fully protected conservation area – ideally a national park – in which development activities are prohibited, in recognition of Atewa's global biodiversity significance.
- Withdrawal of exploration concessions for Atewa granted by the Government of Ghana as Atewa represents an irreplaceable area of unique biodiversity, for which large-scale mining impacts could not be compensated by mitigation measures such as offsets (IUCN 2000, Phillips 2001, Dudley and Stolton 2002, Abu-Juam et al. 2003, Miranda et al. 2005).
- Update and implement the management plan established by the Forestry Commission of Ghana (Abu-Juam et al. 2003) and long-term development of Atewa's potential for eco-tourism (Lawson 1970, Larsen 2006).

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Chapter 12

A rapid survey of large mammals from the Atewa Range Forest Reserve, Eastern Region, Ghana

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SUMMARY

Large mammals were surveyed at three sites in the Atewa Range Forest Reserve from 7 – 23 June 2006. Altogether, 22 species were recorded with 12, 14 and 15 species observed from Atiwiredu, Asiakwa South and Asiakwa North respectively. Of the species recorded, Pel's flying squirrel (*Anomalurus pelii*) is listed as Near Threatened, Yellow-backed duiker (*Cephalophus silvicultor*), Black duiker (*Cephalophus niger*), Bay duiker (*Cephalophus dorsalis),* Maxwell's duiker (*Cephalophus maxwellii*) and Royal antelope (*Neotragus pygmaeus)* are listed as Lower Risk/Near Threatened, and West palm squirrel (*Epixerus ebii*) is listed as Data Deficient on the IUCN Red List. In addition to these species of international conservation concern, the African civet (*Civettictis civetta*), African palm civet (*Nandinia binotata*), Long-tailed pangolin (*Uromanis tetradactyla*) and Yellow-backed duiker (*Cephalophus silvicultor*) are nationally protected in Ghana. Interviews in selected fringe communities indicated that there could possibly be four other mammal species present in the reserve while five others could be locally extinct. Many illegal activities, especially related to hunting, were recorded during our assessment. It was also noted that deforestation along trail lines being constructed for mineral exploration and occasional illegal farms could be a significant factor affecting the conservation of large mammals in Atewa.

INTRODUCTION

At a time when deforestation is accelerating across Africa, survey information is particularly important for assessing and monitoring the long-term effects of habitat changes. Research and monitoring must anticipate the changes that lie ahead so that wildlife managers can prepare themselves. The challenge for biologists is not only to preserve species and representative biological communities for posterity, but also to conserve ecosystems that are large enough to continue providing the natural products and services that are essential for human communities.

As in many other countries in West Africa, wildlife resources in Ghana have dwindled drastically over the past few decades. This has largely been attributed to the growth in human population and poor enforcement of the country's wildlife laws, which combined has resulted in a virtually uncontrolled bushmeat trade, posing a major threat to biodiversity in general and to wildlife resources in particular. Consequently, many of the country's wildlife species such as duikers (forest antelopes), porcupine, tree pangolin, bare-headed rock fowl, forest elephant and primates have become threatened. Current estimates suggest that at least 20 of the larger mammal species in the forest zone of Ghana are globally threatened (Ntiamoa-Baidu 1987).

The large mammals of the Atewa Range Forest Reserve (Atewa) make an interesting case study for several reasons. The forest reserve belongs to the Upland Evergreen Forest type which is quite restricted in Ghana, with only one other example, Tano Ofin Forest Reserve, in the Ashanti Region of Ghana. The uniqueness of the terrain and micro-climatic conditions therefore predispose the reserve to many interesting fauna and flora.

During this survey, our aim was to investigate the large mammal (mammals larger than bats) population of Atewa using Rapid Assessment Program (RAP) survey methods. Measuring biodiversity is a difficult, expensive and time-consuming task (Hawksworth 1995), and

hardly feasible in the case of most tropical forests. Practical considerations mean that we must use particular groups of organisms as biodiversity indicators (Pearson 1995). For a project of modest duration, large mammals are one important and diverse group that can readily be inventoried. They fulfill most of the criteria listed by Pearson (1995) for a good indicator group for monitoring. According to White and Edwards (2000), as a focal group, large mammals and their signs are most readily visible. They tend to be the most heavily hunted animals and are therefore of special conservation concern. They also tend to be a good index of the overall integrity and conservation status of a region.

METHODS

From 7-23 June 2006 Atewa's large mammals were surveyed at three different sites (Atiwiredu, Asiakwa South and Asiakwa North) using a straight transect of least resistance. To determine the presence of species, visual observations of mammals and other signs of their presence such as tracks, droppings, dung, feeding signs, walking trails and nests were noted. The team also noted evidence of activities such as hunting, illegal farming and other such activities that impact the conservation of large mammals. A species list was generated including species that were observed through direct sightings, sounds and/or animal spoors, from transects of all areas surveyed.

To complement information from transect walks, interviews were conducted in forest fringe communities such as Ankaase and Anyinam to determine the presence or absence of previously recorded mammals. These interviews indicated the possible local extinction of some species previously known to occur in the area. Individuals selected for interview included those with extensive knowledge of the local fauna who had lived in the various communities for many years as well as seasoned hunters. A species list based on interviews with local community members was generated taking into consideration historical presence of recorded species.

The first site surveyed was Atiwiredu. This site has tree species endemic to Atewa, such as *Aframomum atewae*. *Cola boxiana* and *Chidlowia sanguinea* are two of the most dominant tree species at the site. In this area, ALCOA has been actively prospecting for bauxite. As a result of this, many roads have been constructed to enable transportation of personnel and equipment to the various parts of the site. The forest condition is rated 2 despite this development, indicating that the area is still in good shape.

Asiakwa South was the second site surveyed with a forest condition score 3. Some of the dominant tree species at the site are *Rinorea oblongifolia* and *Hymenostegia afzelii*. It is in slightly better condition than Site 1 in terms of habitat fragmentation, number of roads and automotive noise. This site shows evidence of previous prospecting work and lumbering operations, with clearly demarcated old roads which have given way to the development of forest undergrowth and other opportunistic plants. There are no signs of previous farming activities. Visibility here was about 10 m.

Asiakwa North was the third site surveyed. One of the most dominant tree species observed at this site was *Rinorea oblongifolia*. Of the three sites, this site had the highest quality habitat (condition score 2) with a fantastic dense evergreen canopy. Although there is evidence of illegal chain-saw activities here, this area contains no lumbering roads and access is restricted to footpaths. Resulting from the intactness of the canopy, the understorey is relatively clear increasing both accessibility and visibility which could be beyond 10 m at this site.

RESULTS

Overall, a total of 140 actual sightings and signs of animals indicating the presence of 22 different mammal species in five families were recorded during transects of the three sites. Rodentia was the most dominant family and accounted for eight of the recorded species while six species each of Artiodactyla and Carnivora were recorded and just one species each of Pholidota and Hydracoidea. Interviews indicated the possible presence of an additional four species in the reserve including Greater cane rat *(Thryonomys swinderianus*), Marsh mongoose (*Atilax paludinosus*), Dwarf mongoose (*Helogale parvula*) and Red river hog (*Potamochoerus porcus*). Interviews also suggested that five other mammals, believed to be present in Atewa but not encountered for over 20 years, are likely to be locally extinct. These include Bongo (*Tragelaphus euryceros*), Ogilby's duiker (*Cephalophus ogilbyi*), Water chevrotain (*Hyemoschus aquaticus*), Giant forest hog (*Hylochoerus meinertzhageni*) and Crested porcupine (*Hystrix cristata senegalica*).

In terms of large mammal observations, the greatest number of records came from Asiakwa North (15 spp.) followed by Asiakwa South (14 spp.) and finally Atiwiredu (12 spp.). Six species were common to all three sites, with nine species recorded at two sites and seven species recorded at only one site (see Table 12.1). Maxwell's duiker (*Cephalophus maxwellii*) was the most frequently observed species and accounted for about one-third (38 observations) of all detections followed by the Brush-tailed porcupine (*Atherurus africanus)* with 21 observations. The indices of animal signs were 2.9/hr, 2.67/hr and 1.41/hr for Asiakwa South, Asiakwa North and Atiwiredu respectively. Asiakwa North recorded the highest index of illegal activity (i.e total number of signs of illegal activities encountered per hour of survey) of 1.87/hr, followed by Atiwiredu with 1.07/hr and Asiakwa South, 1.05/hr.

DISCUSSION

Roads have left the habitats of the Atiwiredu site fragmented. There is also evidence of previous logging of economically important tree species. This has given way to growth of under-canopy plants making accessibility difficult and visibility under the canopy less than 10 m. Some spent cartridges, snares and hunting trails were encountered at this site.

Table 12.1. Preliminary Checklist of the Large Mammals of the Atewa Range Forest Reserve, Ghana and their conservation status.

Species		Sites			Status		Mode of Detection						
Scientific Name	**Common Name**	**Atiwiredu**	**Asiakwa South**	**Asiakwa North**	**IUCN**	**National**	**O**	**H**	**F**	**T**	**D**	**S**	**I**
RODENTIA													
Anomalurus pelii	Pel's flying squirrel	x			NT		x						
Anomalurus beecrofti	Beecroft's flying squirrel		x				x						x
Cricetomys gambianus	African giant rat	x	x	x			x		x	x		x	x
Atherurus africanus	Brush-tailed porcupine	x	x	x					x	x		x	x
Epixerus ebii	West palm squirrel	x		x	DD				x				x
Euxerus erythropus	Western ground squirrel	x	x				x						x
Heliosciurus rufobrachium	Red-footed squirrel	x					x						x
Protoxerus stangeri	African giant squirrel			x					x				x
Thryonomys swinderianus	Marsh cane-rat												x
PHOLIDOTA													
Uromanis tetradactyla	Long-tailed pangolin			x		I	x					x	
CARNIVORA													
Civettictis civetta	African civet	x	x			I				x		x	
Nandinia binotata	African palm civet	x		x		I		x					x
Genetta genetta	Common genet		x							x			x
Crossarchus obscurus	Cusimanse		x	x						x			x
Herpestes naso	Long-snouted mongoose		x	x								x	x
Herpestes sanguinea	Slender mongoose		x	x					x	x			x
Atilax paludinosus	Marsh Mongoose												x
Helogale parvula	Dwarf mongoose												x
HYRACOIDEA													
Dendrohyrax dorsalis	Tree hyrax	x	x	x				x			x		
ARTIODACTYLA													
Cephalophus dorsalis	Bay duiker	x	x	x	LR/nt					x	x		
Cephalophus maxwellii	Maxwell's duiker	x	x	x	LR/nt					x	x	x	x
Cephalophus niger	Black duiker			x	LR/nt					x	x	x	x
Cephalophus silvicultor	Yellow-backed duiker			x	LR/nt	I				x			x
Neotragus pygmaeus	Royal antelope	x	x	x	LR/nt					x	x	x	x
Tragelaphus scriptus	Bushbuck		x							x		x	x
Potamochoerus porcus	Red river hog												x
Total		**12**	**14**	**15**									

Mode of Detection:
O - observed
H - heard
F - feeding sign
T - track
D - dung
S - specimen
I - interview

IUCN:
NT – Near Threatened
LR/nt – Lower Risk / Near Threatened
DD – Data Deficient

National:
I – included on Schedule I of Ghana Wildlife Conservation Regulation (wholly protected in Ghana).

Asiakwa South shows clear evidence of excessive hunting from people. There were many spent cartridges and different types of wire snares for trapping. This site is also rich in non-timber forest products (NTFPs) and there is evidence of high levels of chewing stick, sponge and cane harvesting from this site. There are no signs of previous farming activities here, however, there were signs of the area having been subject to mineral prospecting in the past.

Asiakwa North is probably the best refuge for large mammals in Atewa. This is revealed in the high number of species seen there. Notwithstanding the promising nature of this site it shows evidence of excessive hunting by local people. A high number of snares, spent cartridges and hunting trails were seen in this site. The hills at this site also serve as the source of many rivers and NTFPs are not frequently harvested here though other forms of illegal activities such as hunting with guns and wire snaring are predominant (Table 12.2).

On the whole, most of the species that were recorded during the RAP survey are those that can be hunted under the Ghana Wildlife Conservation Regulation, LI 685. However four species, Long-tailed pangolin (*Uromanis tetradactyla*), African civet (*Civettictis civetta*), African palm civet (*Nandinia binotata*), and Yellow-backed duiker (*Cephalophus silvicultor*) are species that are listed under Schedule I of the Ghana Wildlife Conservation Regulation and thus are wholly protected in Ghana. In terms of species of global conservation concern, Pel's flying squirrel (*Anomalurus pelii*) is listed as Near Threatened, Yellow-backed duiker (*Cephalophus silvicultor*), Black duiker (*Cephalophus niger*), Bay duiker (*Cephalophus dorsalis),* Maxwell's duiker (*Cephalophus maxwellii*) and Royal antelope (*Neotragus pygmaeus)* are listed as Lower Risk/Near Threatened, and West palm squirrel (*Epixerus ebii*) is listed as Data Deficient under the IUCN categorization of threatened species of the world (IUCN 2006).

CONSERVATION RECOMMENDATIONS

Evidence of more mammal species was found in Asiakwa South and North compared to Atiwiredu. However, Asiakwa North showed a higher level of illegal activities. It is important to address this situation through various conservation education programs and the introduction of alternative/additional livelihood ventures after a detailed socio-economic survey has been undertaken.

Mining and other exploitative development not only results in (at least temporary) deforestation, but also increases access to otherwise intact or undisturbed ecosystems. This was confirmed during the surveys through the many illegal activities observed, particularly along access roads and trails developed for exploration. One mining company worker was even seen carrying a shotgun. It is therefore essential that access to forest resources be monitored.

This RAP survey was conducted during the rainy season when *Mapania bakdwinii* and *Leptapisi cochleata* form a carpet covering much of the forest floor making footprints, dung and other signs of animals difficult to see. Undertaking a similar survey during the dry season and sampling additional areas, especially towards the periphery of the reserve would most likely increase the number of mammal species directly or indirectly encountered, thus adding to our species list for the reserve.

Finally, monitoring the effects of forest management regimes on wild animal populations requires that periodic biological surveys be carried out to assess the impact of such forest management regimes on our forest fauna.

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Table 12.2: Illegal activities recorded in the Atewa Range Forest Reserve during the RAP survey**.**

	Sites		
Illegal Activity	**Atiwiredu**	**Asiakwa South**	**Asiakwa North**
Spent Cartridge	3	9	11
Wire snare	0	5	10
Hunters trail	12	4	12
Illegal farm	3	1	0
Illegal logging/Chain sawing	4	2	4
Totals	22	21	37
Time spent in the field (hours)	20.63	19.98	19.83
Total # of signs per hour of survey	1.07	1.05	1.87

Chapter 13

A rapid survey of primates from the Atewa Range Forest Reserve, Ghana

Nicolas Granier and Vincent Awotwe-Pratt

SUMMARY

During a RAP survey of the Atewa Range Forest Reserve, we recorded six primate species belonging to four families including two families of nocturnal prosimian represented by the potto, *Perodicticus potto* and Demidoff's galago, *Galagoides demidovii.* Four diurnal simians belonging to two families were identified, including two Red-Listed colobus monkeys (the olive colobus, *Procolobus verus* and Geoffroy's pied colobus, *Colobus vellerosus*) and two cercopithecus monkeys (the lesser spot-nosed monkey, *Cercopithecus petaurista buettikoferi* and Lowe's monkey, *Cercopithecus campbelli lowei*). Based on our results, Sites 2 and 3 appear to be the most important for primates in Atewa and particularly slopes and plateaux, at least during this season in which our survey was conducted. Additionally, observations of leftover fruits suggest that gallery forest found in valleys constitutes an important habitat in terms of primate diet. Taken together, our results suggest that the primate populations of the Atewa Range require the integrity of this mountainous biotope to survive.

INTRODUCTION

The taxonomy of the primate order is liable to frequent modifications resulting from identification of new taxa, extinction or systematic revisions (Oates et al. 2000, McGraw and Oates 2002, Grubb et al. 2003, Jones et al. 2005, Davenport et al. 2006). To date, almost 300 primate species have been identified worldwide, including approximately 60 in the African continent (Gautier-Hion et al. 1999). It is estimated that 85% of African primate taxa are living exclusively in tropical rainforests and have consequently developed specific ecological and behavioral adaptations (Oates 1994). Based on available data, the monitoring of certain key primate populations is becoming a powerful tool allowing indirect and continuous follow-up on the status of targeted habitats. Temporal variations in the relative abundance of particular monkey species can be a very good indicator of habitat disturbance that might otherwise go undetected using remote sensing tools.

Primates play an important role in the ecology of tropical rainforest and especially in the reproductive biology of flowering plants. They are highly frugivorous mammals with expansive habitat ranges, making them particularly efficient seed-dispersers (Chapman 1995). The digestion and consequent dispersal of seeds promotes seedling establishment and survival, influencing the regeneration of the consumed plant species (Dominy and Duncan 2005). Chapman and Onderdonk (1998) suggest that the extinction of primates, and to a lesser extent their increasing rarity, could cause a prominent threat to the structure, composition and diversity of tropical forests. Furthermore, primates represent an important component of the forest food web. In addition to fruits, their omnivorous diets include numerous species of insects, rodents, hyraxes, duikers, and even monkeys in the case of chimpanzees (Clutton-Brock 1977, Sugiyama and Koman 1987, Yamakoshi 2004). In return, they are prey for species such as the crowned eagle *Stephanoaetus coronatus*, the leopard *Panthera pardus* and snakes (Cowlishaw 1994, Mitani et al. 2001, Zuberbülher and Jenny 2002).

Besides, probably because of their fascinating similarity to human beings, monkeys and apes are amongst the most important tourist attractions of the African intertropical zone (Weber 1993). The Republic of Ghana, with its sixteen inventoried primate species (Gartlan 1982) and ecotourism projects such as the Kakum National Park (Central region) and the Boabeng-Fiema monkey sanctuary (Brong-Ahafo region), is no exception. In this context, primate conservation and the preservation of primates' natural habitat are ecologically essential, but also become an economic challenge for local authorities and communities. In terms of politics as well, the charismatic images of simians can be used to influence conservation decisions and environmental policies in general.

Despite all this, since the early 1980's over 50% of primate diversity faces some form of threat (Chapman and Peres 2001). Primates and their natural habitat are increasingly threatened globally by hunting and other human activities including logging, slash-and-burn agriculture and mining (Mittermeier et al. 2005). Such activities, leading to destruction and fragmentation of the forest, not only affect primate species' abundance and ranging patterns, but also their group size and composition (Dominy and Duncan 2005). Given this tenuous conservation context, any area hosting threatened primate populations deserves attention and in particular those areas representing rare ecosystems or remnant habitats benefiting from protected status.

The Republic of Ghana, located in the Guinean Forests of West Africa, is one of the 34 global Hotspots for biodiversity conservation, and probably the most important one in terms of primate diversity (Bakarr et al. 2004). The Atewa Range Forest Reserve (Atewa), located in the Eastern Region of Ghana (see Map), is part of the eastern sub-region of this biodiversity hotspot, which is known to contain severely fragmented forests of high conservation value. Atewa consists of a 23,660 ha range of hills oriented approximately north-south, and is characterized by steep-sided slopes topped by flat plateaux. The reserve lies within the moist semi-deciduous forest zone, and three-quarters of it is composed of healthy Upland Evergreen Forest. Atewa is one of only two reserves in Ghana representing this forest type, and those two reserves together hold 95% of the Upland Evergreen Forest of Ghana (BirdLife International 2005). The very ancient soils of the Atewa Range, which are reputed to be bauxite laden, contain the headwaters of several of Ghana's major watercourses including the Birim, Densu and Ayensu rivers. This area has been legally protected for over eighty years, and was more recently declared a Globally Significant Biodiversity Area (GSBA). Despite these measures, Atewa is still threatened by illegal logging and hunting, and has recently been granted by the Ghanaian government on concession to ALCOA for bauxite mineral exploration.

METHODS

A survey of primate diversity, abundance and distribution was conducted in Atewa from 7-22 June 2006. The RAP survey focused on three study sites with campsites located on the top of the large plateaus dominating the reserve at an altitude of 800 m. Atiwiredu (Site 1) still contains relatively healthy forest although it is the zone most impacted by mineral prospecting activities and a number of roads and large trenches have increased access to the top of the Atiwiredu plateau. Asiakwa South (Site 2), located at an intermediate latitude between Sites 1 and 3, shows evidence of disturbance, with moderate scars resulting from drilling activities and other human disturbance (mainly hunting and clearing of forest for wood). Asiakwa North (Site 3) presents the healthiest forest of the three sites, but it is also the site where the highest hunting pressure was recorded.

Five to six days were spent in each of the three sampling sites to get an overall picture of Atewa's primate diversity (see Map for site locations). Sixteen days were spent surveying the forest, using a combination of field methods complemented by interviews with local villagers. Primates and evidence of their presence were recorded both from line transects and "reconnaissance surveys" during thirteen days (a total of 93 hours). One full day was devoted to interviews with local hunters and cultivators in villages surrounding the reserve.

Table 13.1. Starting location, bearing, length and survey time of four line transects employed during the 2006 RAP survey of the Atewa Range Forest Reserve, Ghana.

Transect	Start location	Bearing	Length (km)	Number of visits	Time spent surveying (h)
T1 (Site 1)	N 06°11'26.9" W 00°34'48.3"	N 30°	0.880	3	3h20
T2 (Site 2)	N 06°15'14.5" W 00°33'14.4"	N 30°	1.210	2	4h05
T3 (Site 3)	N 06°16'09.4" W 00°33'56.5"	N 30°	0.850	2	2h50
T4 (Site 3)	N 06°15'52.0" W 00°33'51.6"	N 30°	0.430	1	0h55
Total			**7.19 km**		**11 h 10 min**

Line Transect (T)

The line transect count method allows an estimation of animal population density in a sampled area. To calculate such a density, critical parameters have to be measured at the time of each contact with the targeted species (Buckland et al. 1993, White and Edwards 2000). We established four parallel line transects, randomly located within the three sampled sites. To undertake our survey, one to three observers walked transects very silently at an average speed of between 0.5 and 1 km/h, scanning and listening for primates and recording evidence of their presence. Table 13.1 presents general characteristics of the four transects.

One transect was employed per site and walked two or three times at different hours of the day. Transect 1 (T1) was walked once at night to look for nocturnal primates. A fourth short transect (T4) was set up at Site 3 and walked only once. The total time spent walking transects was 11h 10min, surveying a total of 7,190 m.

Reconnaissance surveys (R)

Reconnaissance surveys were conducted following pre-established itineraries that were adapted with respect to the reality of field conditions. Itineraries consisted of loops radiating from campsites and following pre-existing paths or low resistance routes in the forest. One to four observers recording clues of primate presence walked each of these once, silently and slowly. Compared to line transects, reconnaissance surveys are less time and effort consuming, they have the least impact on surrounding vegetation and allow the survey of greater distances while giving a picture of the spatial distribution of primate populations (Walsh and White 1999). Nevertheless, this method does not permit access to a population density estimate, but to a Kilometrical Index of Abundance (KIA) of a selected item. KIA refers to the ratio between the number of contacts with the selected item and the walked distance (White and Edwards 2000, Maillard et al. 2001). Table 13.2 describes distance covered and time spent on reconnaissance surveys per site.

During thirteen days (a total of 82h 30min), 64 km were walked including reconnaissance surveys in all studied areas. This included one nocturnal survey, made at Site 2 where almost 3 km were walked in two hours.

Table 13.2. Distance covered and time spent on Reconnaissance surveys per site during the 2006 RAP survey of the Atewa Range Forest Reserve, Ghana.

Study sites	Reconnaissance survey	Length (km)	Time spent (h)
Site 1 - Atiwiredu	R1	24	28
Site 2 – Asiakwa South	R2	17	24.5
Site 3 – Asiakwa North	R3	23	30
Total		**64**	**82.5**

Interviews

The interview methodology permits a precise assessment of human knowledge on studied species with minimum time and effort requirements. Combined with field survey techniques, interviews increase and diversify data sources, allowing further data comparison and reliability checks. On 19 June, we visited villages surrounding Atewa to question local hunters and farmers about primates that can potentially be found in the reserve. Interviews were conducted in a standard manner (Boyd and Stanfield 1998): plates showing both photos and drawings of 11 forest primates known to occur in Ghana (Oates et al. 1997) were presented to interviewees. They were asked to point toward items identified as being present in Atewa, and to specify whether any other species not depicted on the plates would also be present or not. Interviews were conducted in English, and when necessary Vincent Pratt, field assistant from the University of Ghana (Accra), translated into the local dialect (Twi). However, primates' local names in Twi were systematically asked. We used the variability recorded in each primate local name as a reliability-check index (RI), defined as the ratio of interviewees who have given the same local name to a given primate, to the total number of interviewees. Thirty-eight villagers (12 hunters, 20 farmers and 6 local guides who were working with the RAP team) were individually contacted in nine communities surrounding the Reserve.

RESULTS

Overall, six primate species belonging to four families were identified in the Atewa forest (Table 13.3). We recorded the presence of two families of nocturnal prosimian represented by the potto, *Perodicticus potto* and Demidoff's galago, *Galagoides demidovii*. Four diurnal simians belonging to two families were also identified, including two Red-Listed colobus (IUCN 2006) (the olive colobus, *Procolobus verus* and Geoffroy's pied colobus, *Colobus vellerosus*) and two cercopithecus monkeys (the lesser spot-nosed monkey, *Cercopithecus petaurista buettikoferi* and Lowe's monkey, *Cercopithecus campbelli loweï* (Grubb et al. 2003)).

During surveys, three kinds of observation related to primate presence were recorded: 1) direct visual observation, 2) direct observation of vocalizations, and 3) indirect observation of alimentary leftovers, which were exclusively fruit leftovers. Sixty percent of the recorded observations (n = 58) were feeding remains, which cannot be easily attributed to one specific primate. Consequently, species' identification was based on visual and vocal observations, which have enabled the unequivocal identification of five primate species. The sixth species' presence was deduced from interviews, observations of the habitat and bibliography. Table 13.4 describes the results obtained from both surveys and interviews.

The presence of *Perodicticus potto* was reported in 72% of interviews with a Reliability Index (RI) of 0.97, which means that all interviewees except one have attributed the same local name ("aposso") to its illustration. Despite the

Table 13.3. Primate species identified in the three sampled sites of the Atewa Range Forest Reserve, Ghana, during the 2006 RAP survey.

Species	Vernacular name	Local name	Site (see methods)	IUCN Status (IUCN 2006)
Perodicticus potto	Potto	Aposso	Atewa	LC
Galagoïdes demidovii	Demidoff's galago	Aprékéssima	1, 2, 3	LC
Procolobus verus	Olive colobus	Assébé	2	NT
Colobus vellerosus	Geoffroy's pied colobus	Afuo	1, 2, 3	VU
Cercopithecus petaurista buettikoferi	Lesser spot-nosed monkey	Ahwéhéma	1, 2, 3	LC
Cercopithecus campbelli loweï	Lowe's monkey	Okokuo	3	LC

fact that we did not observe this species during the two nocturnal surveys carried out, we believe the potto actually occurs in Atewa because it is a common and widespread nocturnal prosimian found in a large variety of habitats across equatorial Africa (Kingdon 1997, Pimley et al. 2005).

G*alagoides demidovii*, quoted as present in 74% of interviews with 95% of reliability, was abundantly heard all over the three study sites. Different members of the RAP team observed it three times in Atewa and a nest was seen on reconnaissance survey R3. Based on these observations, we are reporting galago's presence mainly on the tops of plateaux.

Two cercopithecus monkeys were identified in Atewa as well (Table 13.3). The lesser spot-nosed monkey or *Cercopithecus petaurista buettikoferi* was directly observed on two occasions and heard three times across the three sites: on plateaux, slopes and down in the valleys. Its presence was reported in 74% of the interviews with good reliability (RI=0.84). The second identified guenon, Lowe's monkey or *Cercopithecus campbelli loweï,* belongs to the West African group of mona guenons, and was cited in 63% of the interviews (RI=0.81). On one occasion, characteristic alarm calls were heard and subsequent agitation in trees was seen in the higher part of the east slope of Asiakwa North plateau (Site 3). Evidence of an individual kept in captivity was also reported in an interview.

Finally, we are reporting the presence of two colobus monkeys, both classified as threatened on the IUCN Red List (IUCN 2006). The West African endemic olive colobus, or *Procolobus verus*, was heard once on reconnaissance R2, in the higher part of the northwestern slope leading to Asiakwa South plateau (Site 2), and was indicated as present in 72% of interviews (RI=0.81). The second species, a regional subspecies of black-and-white colobus named Geoffroy's pied colobus or *Colobus vellerosus*, was selected in 79 % of interviews (RI=0.87), directly observed twice and heard on plateaux, slopes and valleys in the three study sites.

Three primate species that were quoted as present by less than half of the interviewees and never observed during surveys are presumed absent from Atewa. *Procolobus badius waldroni* (quoted as present in 55% of interviews with 0.39 of reliability) and *Cercocebus atys lunulatus*, (presence quotation=42%; RI=0.52) exhibit low indexes of reliability, reflecting interviewees' difficulty in identifying these species properly. By contrast, the chimpanzee *Pan troglodytes verus* (presence quotation of 24%) shows a very high reliability index (RI=0.97), probably because of the fame attached to this well-known ape. We believe that the interviewees have good capacities for distinguishing primates from pictures and/or drawings since they were able to recognize all the species we identified during surveys.

A fourth monkey, the Roloway guenon or *Cercopithecus diana roloway* was cited as present in 66% of interviews and exhibits the highest index of reliability (RI=1). The Diana monkey is listed as Threatened on the IUCN Red List (IUCN 2006) and the Roloway subspecies is particularly in danger of extinction (Magnuson 2003). Nevertheless, this guenon was not added to the list of Atewa's primates because so far the species has only been described in the western part of Ghana and Côte d'Ivoire (Oates 1988), and we did not see any evidence of its presence. The high index of reliability recorded for this beautiful and characteristic species probably results from a similar "fame effect" as described for the chimpanzee.

Polyspecific associations between Geoffroy's pied colobus and lesser spot-nosed guenons were observed on two consecutive days in the higher part of the northeastern slope leading to the top of Asiakwa North plateau (Site 3). In both cases, we heard one species and visually identified the other.

We compared the results of monkeys' presence between sites, as shown in Figure 13.1. At Site 2, the presence of two Red-Listed species of colobus was recorded. Furthermore Sites 2 and 3 show the highest primate diversity, with four species recorded from each. Therefore, it appears that Asiakwa South and Asiakwa North are the most important in terms of primates.

We then compared the nature and number of observations made in each of the physical environment types present in Atewa: plateaux, slopes and valleys (Figure 13.2). Approximately the same surveying distance was walked in each of these environments. The most evidence of primates was recorded on slopes and plateaux (respectively n=22 and n=15), which suggests these constitute the most important habitat types for the primates of Atewa.

Table 13.4. Primate observations made during transects and Reconnaissance Surveys (Recon): Voc = vocalization heard; Obs = visual observation made; Al = Feeding remains observed. Interview results: Present = Percentage of interviewees affirming the presence of the species; RI = Reliability index.

Species	Surveys (71 km)		Interviews (n=38)	
	Transect	Recon	Present (%)	RI
Perodicticus potto			72	0.97
Galagoides demidovii	1 Voc	4 Voc, 1 Obs	74	0.95
Procolobus verus		1 Voc	72	0.81
Procolobus badius waldroni			55	0.39
Colobus vellerosus	5 Voc	2 Obs, 3 Voc	79	0.87
Cercocebus atys lunulatus			42	0.52
Cercopithecus diana roloway			66	1
Cercopithecus campbelli lowei	1 Voc		63	0.81
Cercopithecus petaurista buettikoferi	3 Voc	2 Obs, 1 Voc	74	0.84
Pan troglodytes verus			24	0.97
Unknown Species	11 Al	23 Al		

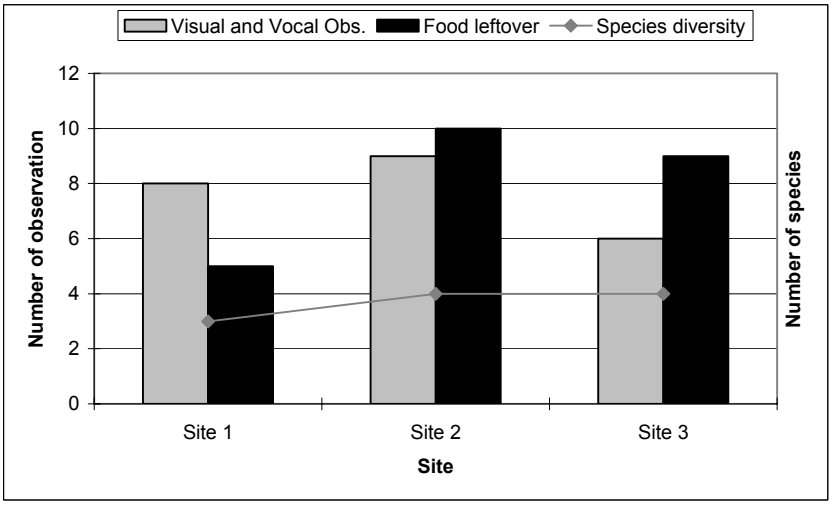


Figure 13.1. Amount of primate evidence and number of species recorded per site during the 2006 RAP survey of the Atewa Range Forest Reserve, Ghana.

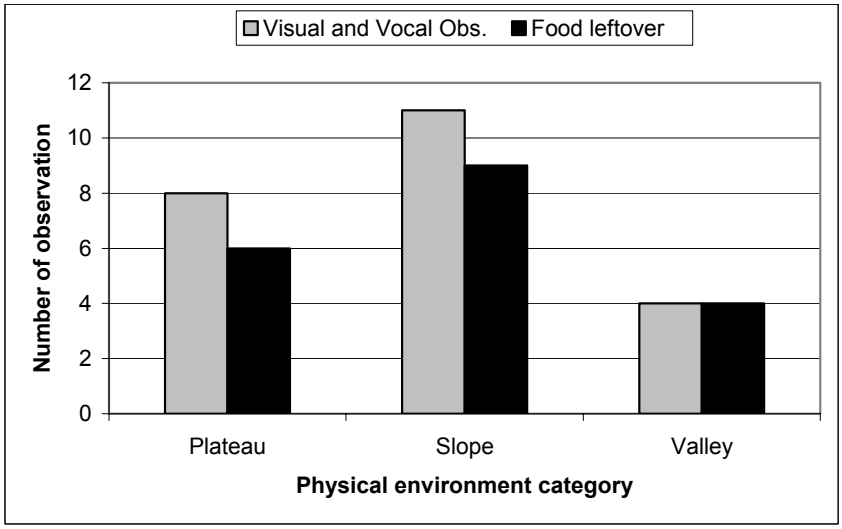
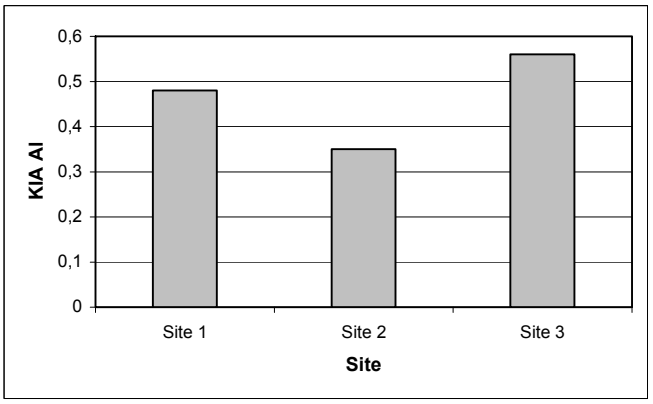


Figure 13.2. Primate evidence recorded per type of environment during the 2006 RAP survey of the Atewa Range Forest Reserve, Ghana.



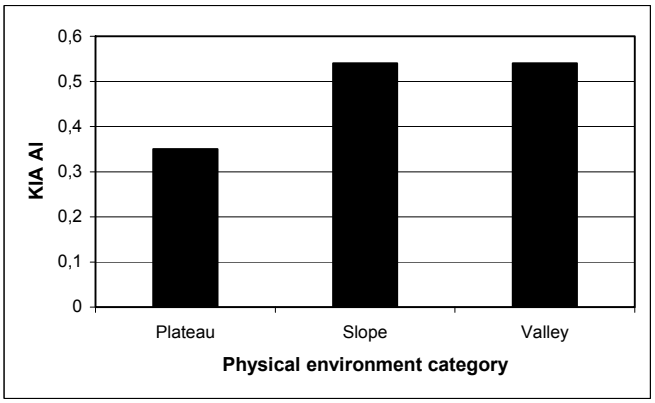


Figure 13.3. KIA of Alimentary leftovers (KIA AI) per site (i) and per environment type (ii).

Down in the valleys, we observed feeding remains left by six primates and heard vocalizations by four different species.

No direct observation of primates was recorded on transects, preventing any density estimation of monkey populations. Therefore, to get an idea of primate abundance in Atewa we grouped observations of feeding remains recorded on both transects and reconnaissance surveys to calculate the Kilometrical Index of Abundance (KIA) of primates' alimentary leftovers. KIAs of alimentary leftovers were compared between sites and environment types, as shown in Figure 13.3.

Site 2 shows the smallest KIA of all sites, but is also the site where survey time and distance were the shortest (see Tables 13.1 and 13.2). Site 3 exhibits the highest KIA of primate alimentary leftovers, with 0.56 items seen per kilometer. Taking all sites into account, primates seem to rely mostly on slopes and valleys for feeding on fruits (0.54 alimentary leftovers observed per kilometer in both).

DISCUSSION

The Kilometrical Index of Abundance of alimentary leftovers (KIA Al) does not directly reflect primate abundance, but rather the relative abundance and distribution of places where they have fed on fruits. Thus, fruits represent only a fraction of the omnivorous and seasonally changing diet of primates, and each of the six described species has different alimentary requirements. Consequently, the KIA of feeding remains gives an indirect and global picture of all primate species populating the Atewa forest. This practical monitoring tool is easy to set up and to carry out, and allows for the assessment of general changes in primate demographics as well as the comparison of overall population dynamics across habitats and time (White and Edwards 2000, Thibault et al. 2001) and indirect analysis of the impacts of development activities or other alterations to the habitat.

Based on the RAP results, Sites 2 and 3 appear to be the most important for primates in Atewa, particularly slopes and plateaux, at least during the season of our survey. The least evidence of primates per environmental category was recorded in valleys (as shown in Figure 13.2), nevertheless, observations of primate feeding remains here suggest that the gallery forest found in valleys definitely constitutes an important habitat in terms of primate diet. It emerges that the primate populations of the Atewa Range, taken as a whole, require the integrity of this mountainous biotope to survive. Moreover, the numerous observations of other large mammals' tracks in valleys lead to the conclusion that this particular type of environment is important for large fauna in general.

Habitat disturbance resulting from human activities in Atewa appeared to be characterized by two opposite gradients: the mining impact, which decreases when going north, and activities of local communities, which decrease when going south. In addition to these gradients, the topography also influences the spatial distribution of human disturbances: mining activities focus on the top of the plateaux whereas local community activities mainly target slopes and valleys, as well as Atewa's peripheral areas. This explains how, up to now, mineral exploration has spared the forest cover of slopes, which remain outwardly nearly unsullied in the three sampled sites.

Species of general interest

The potto (*Perodicticus potto*) is a solitary animal living in secondary and lower mountain forests. It has a relatively large home range (from 5 to 40 ha) and exhibits seasonal variations in its diet, mainly composed of gum, insects, and fruits (Rowe 1996). In this nocturnal species, days are spent in trees (Pimley et al. 2005). The galago (*Galagoides demidovii*) is common and widely distributed throughout tropical Africa's secondary forests, populating mainly open areas such as forest and road margins. Individuals live in groups of about ten but forage at night on their own. The high canopy forest in the top of Atewa's plateaus seems to be a suitable habitat for the species.

Primates of the *Cercopithecus cephus* group inhabit the Central African forest block, but the "*petaurista*" sub-group is exclusively found in the Guinean Forest ecosystem in West Africa (Gautier-Hion et al. 1999). The lesser spot-nosed monkey (*Cercopithecus petaurista buettikoferi*) is a common

species highly adaptable to a large spectrum of disruptive factors, known to live in a wide range of forested habitats ranging from primary lowland and medium-altitude forests or galleries, to secondary regeneration and coastal bushes. It feeds mainly on fruits and buds but also on leaves, stems and insects. Lowe's monkey (*Cercopithecus campbelli lowei*) is distributed only between the Sassandra and Volta rivers, where it is a recognized target for hunters but nevertheless is still relatively common. This arboreal subspecies of mona monkey is also adapted to most tropical forest types, relying on trees where fruits (like cola and figs) and flowers essential to its diet can be found (Rowe 1996).

Species of particular interest

Two colobus monkeys, both classified as threatened on the IUCN Red List (IUCN 2006) were identified in Atewa. African colobus, or thumbless monkeys, are arboreal primates populating the forest tropical zone and are highly dependent on good quality forest comprised of several levels of closed canopy. Chapman et al. (2004) have shown that the presence and abundance of colobus monkeys was influenced by very subtle ecological factors linked to forest structure and composition. They have a highly specialized digestive system allowing them to process difficult or "uncommon" plant materials: the most important part of their diet consists of leguminous plants, whose fruits and leaves are protected by chemicals. Thus, in comparison to many other primate species, colobus monkeys aid in dispersal of "uncommon" vegetal species.

To date, the olive colobus (*Procolobus verus*) was not known to occur in this part of Ghana. This colobus is classified as Near Threatened on the Red List (IUCN 2006). In 2000, this relict species confined to the forested zone of West Africa was classified as Endangered, showing a recent and significant improvement of its conservation status. However, it is still a fragile monkey, which is difficult to observe because it is very shy and communicates infrequently by quietly chirping. It is the smallest of all colobus, very light and exclusively arboreal; the olive colobus usually groups in units of five to twenty animals that exploit the highest part of the forest canopy in the secondary growth of high forests, margins of forested zones as well as swamps. They easily associate with other monkey species foraging in lower layers of the canopy without any inter-specific food competition (McGraw 1998).

Geoffroy's pied colobus (*Colobus vellerosus*), classified as Vulnerable on the IUCN Red List (IUCN 2006), is more widely distributed than the olive colobus. Nevertheless, this subspecies of black-and-white colobus is likely to soon become Endangered if the present rate of hunting and habitat destruction continues in its ecological range. This monkey ranges in restricted lowland rainforest and galleries of Côte d'Ivoire, Ghana and Togo, relying on food items mainly consisting of leaves (Wong and Sicotte 2006). It usually forages in the shaded middle layer of the canopy. In Atewa, we frequently observed this species on the slopes and, less often, on plateaux. Geoffroy's pied colobus groups can be composed of up to 50 individuals and in Boabeng-Fiema monkey sanctuary (Ghana), particularly high densities have been recorded, such as 119 indiv/km^2 (Wong and Sicotte 2006).

Primates living in tropical rainforest often form large mixed-species associations, which can include up to eight species (Zuberbühler and Jenny 2002). Here we report the association of two species: the Geoffroy's pied colobus and lesser spot-nosed monkey, which can stay together for several days. Actually, the lesser spot-nosed monkeys are known to be highly visually oriented, and to warn other species of danger (mainly linked to predation) in such polyspecific associations (Rowe 1996).

CONSERVATION RECOMMENDATIONS

Ghana has a long history of forest exploitation. It is estimated that the forest cover has been reduced to nearly one-sixth of its original size during the past century, leaving only 1,500,000 ha of undisturbed forest (IUCN 1996). Struhsaker and Oates (1995) have long warned the Ghanaian authorities and the scientific community of this critical situation and its potentially tragic consequences for the high and original primate diversity of the country. Amongst the ten forest species of monkeys occurring in Ghana, three species, all endemic to southwestern Ghana and eastern Côte d'Ivoire, are highly threatened by extinction (Oates et al. 1997): Miss Waldron's red colobus (*Procolobus badius waldroni)*, white-naped mangabey (*Cercocebus atys lunulatus)*, and the Roloway subspecies of Diana monkey (*Cercopithecus diana roloway*). We strongly believe that an essential prerequisite to protect primates is to take conservation action and promote the sustainable use of natural ecosystems so as to avoid irreversible extinction of species. Given the particular context and history of Ghana, each forest fragment presently populated by primates, regardless of size, should be actively protected from further destruction and fragmentation. The rich upland ecosystem of Atewa Reserve is a relatively large and isolated forest fragment, which constitutes one of Ghana's last refuges for six primate species including two Red-Listed species of colobus monkeys.

For these reasons, our overall recommendation is that Atewa should receive full protection and no development activities should proceed in the area. Clearing plateaus would undeniably affect headwaters of major rivers and have long-term destructive consequences on the environment, principally by increasing soil erosion on surrounding slopes and disturbing the hydrographical net of the entire sub-region. Habitat loss would put several primate species under serious threat of local extinction. The galago would probably be the most impacted species, but colobus and guenons would also suffer from the opening up of their habitat and subsequent disruption. However, it would be very difficult and hazardous to give an opinion on the future of Atewa's primates if development were to happen because data are largely unavailable on the adaptive capacities of the different species.

Specific conservation recommendations

If, against our strong recommendation, development activities within Atewa are to proceed, exposing Atewa to a high risk of biodiversity loss, we submit some important recommendations related to the conservation of primates populating the area.

- **Integrally protect the northern part of the Atewa Range**

  Based on our results and analysis we strongly recommend to the concerned authorities that they safeguard an integrally protected area in Atewa. Actively protecting a large zone from development and all other human impacts is the only way to ensure the survival of the multiple species of primates present. The area of protection should have clear boundaries delimited and should be given a high protection status, with limits and regulations strictly enforced. The northern part of Atewa appears to be the most valuable in terms of primate presence and forest quality, and thus emerges as the obvious candidate. We propose Sites 2 and 3 to become an integrally protected reservoir zone for primates and general biodiversity. More precisely, the protected area should include plateaux, slopes and valleys of all the north part of Atewa, as far as the southern foothills of Asiakwa South plateau (Site 2). Findings that have motivated the choice of this zone are detailed below.

  Site 2, which contains the two Red-Listed species identified in this study, olive colobus and Geoffroy's pied colobus, is a priority site to protect for the conservation of Atewa's primates. Both of these species are reliant on good quality forest with several levels of closed canopy. We strongly believe that olive colobus is exploiting all described environment types of the northern part of Atewa. However that may be, the unsuccessful breeding of this monkey in captivity (Kingdon 1997) is an indicator of its fragility and low capacity for adaptation. The presence of Geoffroy's pied colobus was confirmed at Sites 2 and 3. We assume that both of these threatened species would drastically suffer from upland forest clearing and that the only option to ensure their survival consists in maintaining large intact areas of forest on the top of plateaux. Additionally, Sites 2 and 3, the most preserved in terms of forest quality, contain the highest primate diversity recorded during our survey. Excepting the two colobus, the other species recorded at these sites are not particularly threatened, but they are nevertheless fragile and isolated populations totally dependant on their habitat and its natural resources. In the case of a relatively large but isolated patch of forest like Atewa, destruction of the habitat would critically jeopardize all primate populations present (Mittermeier 2005). Their number and diversity would likely rapidly decline as a result of habitat fragmentation and loss (Tutin 1999).

- **Undertake a sensitization program targeting surrounding communities**

  In order to prevent local villagers from hunting and cutting the forest in the proposed integrally protected area, it is necessary to carry out a sensitization program involving all communities surrounding Atewa. Such a program should aim to inform local people of the importance of preserving their natural heritage and to help them organize to achieve this goal. The program would have greater impact and more sustainable effects if conducted over the long term. Furthermore, effort should be taken to employ villagers, who will be the real actors of local conservation, advised and supported by officers of the sensitization program.

- **Incorporate restoration plans into any proposed development**

  Any development of Atewa which would lead to the removal of vegetative cover and the upper stratum of soil from the plateaux would leave little chance for short- or medium-term natural regeneration of the forest. Forest primates cannot live in such a bare landscape, hence a restoration program favoring rapid regeneration of impacted sites has to be elaborated and implemented, as a matter of urgency, in respect to the specifics of Atewa.

  Linking patches of forest using corridors is one conservation alternative to address the problem of habitat fragmentation. This technique can also be used in the context of a restoration program to partially mitigate for any destruction, degradation or fragmentation inherent to development activities by enlarging natural habitat to new perspectives. Kwahu plateau forested zone, located about fifteen kilometers north from Atewa contains similar upland habitat and is consequently a good candidate for such a project. A feasibility study including assessment of primate diversity in Kwahu and landscape description should be carried out prior to take any action.

- **Publicize and enforce environmental protection guidelines for those working in Atewa**

  Any company that may become involved in development activities within Atewa should elaborate, in collaboration with scientists and conservationists, strict guidelines for the conservation of Atewa's biodiversity. This conservation plan should provide and explain a set of rules for employees concerning garbage management, chemical pollution prevention, hunting and bush-meat trade prohibition, and forest preservation. Defining these guidelines is an essential point considering that hundreds of people coming from various regions would possibly enter into the forest daily.

- **Undertake a longitudinal assessment program for primate populations**

  This RAP survey was the first primate assessment conducted in Atewa. A longer-term survey should be carried out to precisely estimate primate abundance and to monitor the different primate populations across time. This census should cover a larger area of the Atewa Range, during a longer time and over different seasons of the year. Considering the low rate of direct observations of primates, a statistically valid estimation of populations' density cannot be obtained without such a long-term work. Moreover, a specific survey is needed to settle the point of the Roloway guenon's hypothetical presence in the Atewa Range. If such an unexpected presence was reported by direct evidence, urgent research and conservation measures should rapidly be taken, due to the rarity and importance of this species, sadly emblematic of primate biodiversity decline.

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Gazetteer

This RAP survey was conducted in the Atewa Range Forest Reserve and Range Extension located in southeastern Ghana. Atewa is a 23,663 hectare forest reserve that contains four plateaus. The RAP survey took place from June 6 – 24, 2006 at the beginning of the rainy season.

Site 1: Atiwiredu (Southern Plateau)
6°12'22.7"N; 0°34'39.2"W
817 m a.s.l.
Numerous trail lines had been cut at this site, some for mineral exploration. Despite this disturbance, the moist upland forest was in good condition and contained a mixture of primary and secondary growth forest. Species composition varied with the undulating topography of the plateau and the valleys. Some invasive species were present (e.g., *Chromolaena odorata*).

Site 2: Asiakwa South
6°15'44.3"N; 0°33'18.8"W
783 m a.s.l.
This site was located in moist upland forest with some degree of human disturbance. Trails cut here have introduced an edge effect. The forest habitat of this site is of very high quality from a biodiversity perspective and contains considerable primary growth mixed in with some secondary forest. Some swampland is also found within site boundaries. Some invasive species were present (e.g., *Chromolaena odorata*).

Site 3: Asiakwa North
6°16'16.1"N; 0°33'52.7"W
814 m a.s.l.
This site was situated atop the Asiakwa plateau at the northern edge. The site was the most intact of the three surveyed with the largest proportion of undisturbed upland humid forest, a number of old growth emergents and very little understory except for in light gaps. The terrain was interesting as the site was located on a narrow end of the Asiakwa plateau and surrounded by deep valleys and ravines so the elevation ranged from 300 to around 800 m a.sl. Although the forest was in excellent condition, it was evidently impacted heavily by surrounding villages. Snares and cartridges were found throughout this site, as was evidence of illegal logging in the area.

Appendix 1

List of Vascular Plants known from the Atewa Range

Carel Jongkind

The species list shows 765 different species of vascular plants including 106 Upper Guinea endemics printed in **bold** (Upper Guinea sensu White, 1979).

The species list is combined from different sources. The larger part is taken from the list in an unpublished 1998 report by William Hawthorne (HAW) that is itself a combination of different sources. A smaller part is taken from the herbarium database at the Wageningen University (WUR), this database includes records for Atewa of specimens from several collectors found in several herbaria. A few other species on the list are mentioned by Hall and Swaine (1981) (H&S) or by Summerhayes in the Flora of West tropical Africa (FWTA 3).

The list is without doubt incomplete as many other species have been collected on Atewa and are stored in herbaria around the world. Most of these were not seen for this report and furthermore have not been cited in earlier reports or publications. On top of this, more species in the range are doubtless yet to be discovered, particularly in the canopy.

Family	Species name	source
Acanthaceae	*Acanthus guineensis* Heine & P.Taylor	WUR & HAW
Acanthaceae	*Adhatoda guineensis* (synonym of *Justicia guineensis*)	WUR
Acanthaceae	*Asystasia buettneri* Lindau	HAW
Acanthaceae	*Brillantaisia owariensis* P.Beauv.	WUR
Acanthaceae	*Justicia guineensis* (Heine) W.D. Hawthorne	WUR
Acanthaceae	*Justicia tenella* (Nees) T.Anderson	WUR
Acanthaceae	*Mendoncia combretoides* (A.Chev.) Benoist	WUR
Acanthaceae	*Phaulopsis ciliata* (Willd.) Hepper	WUR
Acanthaceae	*Pseuderanthemum tunicatum* (Afzelius) Milne-Redhead	WUR & HAW
Acanthaceae	*Rhinacanthus virens* (Nees) Milne-Redh.	WUR
Acanthaceae	*Ruellia primuloides* (T.Anders. ex Bentham) Heine	WUR & HAW
Acanthaceae	*Staurogyne capitata* E.A.Bruce	HAW
Acanthaceae	*Stenandrium guineense* (Nees) Vollesen	HAW
Acanthaceae	*Thunbergia vogeliana* Bentham	HAW
Amaryllidaceae	*Crinum jagus* (Thomps.) Dandy	HAW
Amaryllidaceae	*Scadoxus cinnabarinus* (Decne) Friis & Nordal	WUR & HAW
Anacardiaceae	*Antrocaryon micraster* A.Chevalier & Guillaum.	HAW
Anacardiaceae	*Lannea welwitschii* (Hiern) Engler	HAW
Anacardiaceae	*Pseudospondias microcarpa* (A.Rich.) Engler	WUR & HAW
Anacardiaceae	*Trichoscypha arborea* (A.Chevalier) A.Chevalier	WUR & HAW
Annonaceae	*Annickia polycarpa* (A.DC.) Van Setten & Maas	WUR & HAW
Annonaceae	*Anonidium mannii* (Oliver) Engler & Diels	HAW
Annonaceae	*Artabotrys jollyanus* Pierre ex Engl. & Diels	WUR

Family	Species name	source
Annonaceae	*Artabotrys stenopetalus* Engler & Diels	HAW
Annonaceae	*Cleistopholis patens* (Bentham) Engler & Diels	HAW
Annonaceae	*Duguetia staudtii* (Engler & Diels) Chatrou	HAW
Annonaceae	*Friesodielsia enghiana* (Diels) Verdcourt	HAW
Annonaceae	*Friesodielsia velutina* (Sprague & Hutch.) van Steenis	WUR & HAW
Annonaceae	*Greenwayodendron oliveri* (Engler) Verdcourt	WUR & HAW
Annonaceae	*Hexalobus crispiflorus* A.Rich.	HAW
Annonaceae	*Isolona campanulata* Engler & Diels	HAW
Annonaceae	*Isolona hexaloba* Engler & Diels	HAW
Annonaceae	*Mischogyne elliotianum* (Engl. & Diels) R.E.Fr.[1]	WUR
Annonaceae	*Monanthotaxis barteri* (Baillon) Verdcourt	HAW
Annonaceae	*Monanthotaxis stenosepala* aff. spec.nov.	WUR & HAW
Annonaceae	*Monodora crispata* Engl. & Diels	WUR
Annonaceae	*Monodora myristica* (Gaertn.) Dunal	WUR & HAW
Annonaceae	*Monodora tenuifolia* Bentham	HAW
Annonaceae	*Neostenanthera gabonensis* (Engler & Diels) Exell	HAW
Annonaceae	*Piptostigma fasciculatum* (De Wild.) Paiva	WUR & HAW
Annonaceae	*Piptostigma fugax* A.Chevalier ex Hutch. & Dalziel	WUR & HAW
Annonaceae	*Uvaria doeringii* Diels	HAW
Annonaceae	*Uvaria mocoli* De Wildeman & Durand	HAW
Annonaceae	*Uvariastrum pierreanum* Engler	HAW
Annonaceae	*Uvariodendron calophyllum* R.E.Fries	HAW
Annonaceae	*Uvariopsis globiflora* Keay	WUR & HAW
Annonaceae	*Xylopia aethiopica* (Dunal) A.Rich.	HAW
Annonaceae	*Xylopia elliotii* Engler	HAW
Annonaceae	*Xylopia quintasii* Engler & Diels	WUR & HAW
Annonaceae	*Xylopia rubescens* Oliver	HAW
Annonaceae	*Xylopia staudtii* Engler & Diels	HAW
Annonaceae	*Xylopia villosa* Chipp	HAW
Apocynaceae	*Alafia schumannii* Stapf	HAW
Apocynaceae	*Alafia whytei Stapf*	HAW
Apocynaceae	*Alstonia boonei* De Wildeman	HAW
Apocynaceae	*Baissea baillonii* Hua	HAW
Apocynaceae	*Baissea leonensis* Bentham	WUR & HAW
Apocynaceae	*Baissea multiflora* A.DC.	HAW
Apocynaceae	*Callichilia subsessilis* (Benth.) Stapf	WUR
Apocynaceae	*Dictyophleba leonensis* (Stapf) Pichon	WUR & HAW
Apocynaceae	*Funtumia africana* (Bentham) Stapf	HAW
Apocynaceae	*Funtumia elastica* (Preuss) Stapf	WUR & HAW
Apocynaceae	*Holarrhena floribunda* (G.Don) Dur. & Schinz.	HAW
Apocynaceae	*Hunteria umbellata* (K.Schum.) Hallier f.	WUR & HAW
Apocynaceae	*Landolphia calabarica* (Stapf) E.A.Bruce	HAW
Apocynaceae	*Landolphia dulcis* (R.Br. ex Sabine) Pichon	WUR & HAW
Apocynaceae	*Landolphia foretiana* (Pierre ex Jum.) Pichon	WUR
Apocynaceae	*Landolphia incerta* (K.Schum.) Persoon	WUR & HAW
Apocynaceae	*Landolphia micrantha* (A.Chevalier) Pichon	WUR & HAW
Apocynaceae	*Landolphia owariensis* P.Beauv.	HAW
Apocynaceae	*Motandra guineensis* (Thonning) A.DC.	WUR & HAW
Apocynaceae	*Oncinotis glabrata* (Baillon) Stapf ex Hiern.	WUR & HAW
Apocynaceae	*Oncinotis gracilis* Stapf	WUR
Apocynaceae	*Oncinotis pontyi* Dubard	WUR

Family	Species name	source
Apocynaceae	*Orthopichonia barteri* (Stapf) H.Huber	WUR & HAW
Apocynaceae	*Orthopichonia indeniensis* (A.Chev.) H.Huber	WUR
Apocynaceae	*Picralima nitida* (Stapf) Th. & H.Durand	HAW
Apocynaceae	*Pleiocarpa mutica* Bentham	WUR & HAW
Apocynaceae	*Rauvolfia vomitoria* Afzelius	WUR & HAW
Apocynaceae	*Saba thompsonii* (A.Chevalier) Pichon	HAW
Apocynaceae	*Strophanthus barteri* Franch.	HAW
Apocynaceae	*Strophanthus gratus* (Hooker) Franch.	WUR & HAW
Apocynaceae	*Strophanthus preussii* Engl. & Pax	WUR
Apocynaceae	*Tabernaemontana africana* A.DC.	WUR & HAW
Apocynaceae	*Tabernaemontana glandulosa* (Stapf) Pichon	WUR & HAW
Apocynaceae	*Tabernaemontana pachysiphon* Stapf	WUR & HAW
Apocynaceae	*Vahadenia caillei* (A.Chevalier) Stapf ex Hutch. & Dalziel	HAW
Araceae	*Amorphophallus johnsonii* N.E.Br.	HAW
Araceae	*Anchomanes difformis* (Blume) Engler	HAW
Araceae	*Cercestis afzelii* Schott	WUR & HAW
Araceae	*Cercestis dinklagei* Engler	HAW
Araceae	*Cercestis ivorensis* A.Chevalier	HAW
Araceae	*Culcasia angolensis* Welwitsch ex Schott	HAW
Araceae	*Culcasia glandulosa* Hepper	HAW
Araceae	*Culcasia parviflora* N.E.Br.	HAW
Araceae	*Culcasia scandens* P.Beauv.	HAW
Araceae	*Culcasia striolata* Engler	HAW
Araceae	*Nephthytis afzelii* Schott	HAW
Araceae	*Rhaphidophora africana* N.E.Br.	HAW
Araliaceae	*Cussonia bancoensis* Aubréville & Pellegrin	HAW
Araliaceae	*Schefflera barteri* (Seem.) Harms	HAW
Aristolochiaceae	*Pararistolochia goldieana* (Hook.f.) Hutch. & Dalziel	WUR
Aristolochiaceae	*Pararistolochia macrocarpa* (Duch.) Poncy	HAW
Aristolochiaceae	*Pararistolochia promissa* (Mast.) Keay	HAW
Asclepiadaceae	*Epistemma assianum* D.V.Field & J.B.Hall	WUR
Asclepiadaceae	*Gongronema latifolium* Bentham	HAW
Asclepiadaceae	*Pergularia daemia* (Forsskal) Chiov.	HAW
Asclepiadaceae	*Tylophora conspicua* N.E.Br.	WUR
Asclepiadaceae	*Tylophora oblonga* N.E.Br.	WUR
Asclepiadaceae	*Tylophora oculata* N.E.Br.	WUR
Aspleniaceae	*Asplenium africanum* Desvaux	HAW
Aspleniaceae	*Asplenium barteri* Hooker	HAW
Aspleniaceae	*Asplenium dregeanum* Kunze	HAW
Aspleniaceae	*Asplenium schnellii* Tardieu	H&S
Aspleniaceae	*Asplenium unilaterale* Lam.	WUR
Balanitaceae	*Balanites wilsoniana* Dawe & Sprague	HAW
Begoniaceae	*Begonia eminii* Warb.	WUR & HAW
Begoniaceae	*Begonia fusialata* Warb.	WUR
Begoniaceae	*Begonia macrocarpa* Warb.	WUR
Begoniaceae	*Begonia oxyloba* Welwitsch ex Hooker f.	WUR
Begoniaceae	*Begonia polygonoides* Hook.f.	WUR
Begoniaceae	*Begonia quadrialata* Warb.	WUR & HAW
Begoniaceae	*Begonia scutifolia* Hook.f.	WUR
Bignoniaceae	*Kigelia africana* (Lamarck) Bentham	HAW
Bignoniaceae	*Newbouldia laevis* (P.Beauv.) Seemann ex Bureau	HAW

Family	Species name	source
Bignoniaceae	*Spathodea campanulata* P.Beauv.	HAW
Bignoniaceae	*Stereospermum acuminatissimum* K.Schum.	HAW
Bombacaceae	*Bombax buonopozense* P.Beauv.	HAW
Bombacaceae	*Ceiba pentandra* (Linné) Gaertn.	HAW
Bombacaceae	*Rhodognaphalon brevicuspe* (Sprague) Roberty	HAW
Boraginaceae	*Cordia millenii* Baker	HAW
Boraginaceae	*Ehretia trachyphylla* C.H.Wright	HAW
Burseraceae	*Canarium schweinfurthii* Engler	HAW
Burseraceae	*Dacryodes klaineana* (Pierre) H.J.Lam	HAW
Capparaceae	*Buchholzia coriacea* Engler	HAW
Capparaceae	*Euadenia eminens* Hooker f.	HAW
Capparaceae	*Euadenia trifoliolata* (Schum. & Thonning) Oliver	HAW
Capparaceae	*Ritchiea capparoides* (Andr.) Britten	HAW
Celastraceae	*Bequaertia mucronata* (Exell) R.Wilczek	HAW
Celastraceae	*Helictonema velutinum* (Afzelius) Wilczek ex Hallé	HAW
Celastraceae	*Hippocratea myriantha* Oliver	HAW
Celastraceae	*Loeseneriella africana* (Willd.) Wilczek ex Hallé	WUR & HAW
Celastraceae	*Loeseneriella clematoides* (Loesener) R.Wilczek	WUR & HAW
Celastraceae	*Loeseneriella ectypetala* N.Hallé	HAW
Celastraceae	*Salacia adolfi-fridericii* Loesener ex Harms	WUR & HAW
Celastraceae	*Salacia alata* De Wildeman	HAW
Celastraceae	*Salacia columna* N.Hallé	HAW
Celastraceae	*Salacia cornifolia* Hooker f.	WUR & HAW
Celastraceae	*Salacia elegans* Welwitsch ex Oliver	HAW
Celastraceae	*Salacia erecta* (G.Don) Walp.	HAW
Celastraceae	*Salacia ituriensis* Loes.	WUR
Celastraceae	*Salacia longipes* (Oliver) N.Hallé[2]	HAW
Celastraceae	*Salacia preussii* Loesener	HAW
Celastraceae	*Salacia staudtiana* Loesener	WUR & HAW
Celastraceae	*Salacighia letestuana* (Pellegr.) Blakelock	WUR
Celastraceae	*Simicratea welwitschii* (Oliver) N.Hallé	WUR & HAW
Celastraceae	*Simirestis tisserantii* N.Hallé	WUR
Chrysobalanaceae	*Maranthes glabra* (Oliver) Prance	HAW
Chrysobalanaceae	*Maranthes robusta* (Oliv.) Prance ex F.White	WUR
Chrysobalanaceae	*Parinari excelsa* Sabine	HAW
Combretaceae	*Combretum fuscum* Planchon ex Bentham	WUR
Combretaceae	*Combretum multinervium* Exell	WUR
Combretaceae	*Combretum platypterum* (Welw.) Hutch. & Dalziel	WUR
Combretaceae	*Combretum racemosum* P.Beauv.	WUR
Combretaceae	*Pteleopsis hylodendron* Mildbraed	HAW
Combretaceae	*Strephonema pseudocola* A.Chevalier	HAW
Combretaceae	*Terminalia ivorensis* A.Chevalier	WUR & HAW
Combretaceae	*Terminalia superba* Engler & Diels	WUR & HAW
Commelinaceae	*Buforrestia obovata* Brenan	HAW
Commelinaceae	*Coleotrype laurentii* K.Schum.	WUR & HAW
Commelinaceae	*Commelina capitata* Benth.	WUR
Commelinaceae	*Commelina macrosperma* J.K.Morton	WUR & HAW
Commelinaceae	*Palisota barteri* Hooker	HAW
Commelinaceae	*Palisota bracteosa* C.B.Clarke	HAW
Commelinaceae	*Palisota hirsuta* (Thunb.) K.Schum.	HAW
Commelinaceae	*Pollia condensata* C.B.Clarke	HAW

Family	Species name	source
Commelinaceae	*Polyspatha paniculata* Bentham	WUR & HAW
Commelinaceae	*Stanfieldiella axillaris* J.K.Morton	WUR
Commelinaceae	*Stanfieldiella imperforata* (C.B.Clarke) Brenan	HAW
Compositae	*Acmella caulirhiza* Delile	WUR
Compositae	*Microglossa pyrifolia* (Lamarck) O.Ktze.	HAW
Compositae	*Mikania natalensis* DC.	WUR
Compositae	*Mikaniopsis tedliei* (Oliver & Hiern) C.D.Adams	HAW
Compositae	*Sparganophorus sparganophora* (L.) C.Jeffrey	HAW
Compositae	*Vernonia andohii* C.D.Adams	WUR
Compositae	*Vernonia colorata* (Willd.) Drake	HAW
Compositae	*Vernonia conferta* Bentham	HAW
Compositae	*Vernonia titanophylla* Brenan	WUR & HAW
Connaraceae	*Agelaea paradoxa* Gilg	HAW
Connaraceae	*Agelaea pentagyna* (Lamarck) Baillon	HAW
Connaraceae	*Cnestis ferruginea* Vahl ex DC.	HAW
Connaraceae	*Cnestis racemosa* Don.	HAW
Connaraceae	*Connarus africanus* Lamarck	HAW
Connaraceae	*Manotes expansa* Soland. ex Planchon	HAW
Connaraceae	*Rourea coccinea* (Thonning ex Schum.) Bentham	HAW
Connaraceae	*Rourea minor* (Gaertn.) Alston	HAW
Connaraceae	*Rourea thomsonii* (Baker) Jongkind	HAW
Convolvulaceae	*Calycobolus africanus* (G.Don) Heine	HAW
Convolvulaceae	*Lepistemon parviflorum* Pilg. ex Büsgen	WUR
Convolvulaceae	*Merremia dissecta* (Jacq.) Hallier f.	WUR
Convolvulaceae	*Neuropeltis acuminata* (P.Beauv.) Bentham	WUR & HAW
Costaceae	*Costus deistelii* K.Schum.	WUR & HAW
Costaceae	*Costus dubius* (Afzelius) K.Schum.	HAW
Costaceae	*Costus englerianus* K.Schum.	WUR & HAW
Cucurbitaceae	*Coccinia longicarpa* Jongkind	WUR
Cucurbitaceae	*Momordica cissoides* Planchon ex Bentham	WUR
Cucurbitaceae	*Momordica multiflora* Hook.f.	WUR
Cucurbitaceae	*Ruthalicia eglandulosa* (Hook.f.) C.Jeffrey	WUR
Cucurbitaceae	*Ruthalicia longipes* (Hook.f.) C.Jeffrey	WUR
Cucurbitaceae	*Zehneria keayana* R.& A.Fernandes	WUR & HAW
Cyatheaceae	*Cyathea manniana* Hooker	HAW
Cyperaceae	*Cyperus halpan* L.	WUR
Cyperaceae	*Cyperus renschii* Boeckeler	WUR
Cyperaceae	*Hypolytrum poecilolepis* Nelmes	HAW
Cyperaceae	*Mapania baldwinii* Nelmes	WUR & HAW
Cyperaceae	*Mapania coriandrum* Nelmes	HAW
Dennstaedtiaceae	*Blotiella currori* (Hooker) Tryon	HAW
Dichapetalaceae	*Dichapetalum crassifolium* Chodat	HAW
Dichapetalaceae	*Dichapetalum heudelotii* (Planchon ex Oliver) Baillon	WUR & HAW
Dichapetalaceae	*Dichapetalum madagascariense* Poiret	WUR & HAW
Dichapetalaceae	*Dichapetalum oblongum* (Hooker f. ex Bentham) Engler	HAW
Dichapetalaceae	*Dichapetalum pallidum* (Oliver) Engler	WUR & HAW
Dichapetalaceae	*Tapura fischeri* Engler	HAW
Dioscoreaceae	*Dioscorea minutiflora* Engler	WUR & HAW
Dioscoreaceae	*Dioscorea smilacifolia* De Wildeman	HAW
Dracaenaceae	*Dracaena arborea* (Willd.) Link	HAW
Dracaenaceae	*Dracaena camerooniana* Baker	HAW

Family	Species name	source
Dracaenaceae	*Dracaena cristula* W.Bull	WUR & HAW
Dracaenaceae	*Dracaena mannii* Baker	HAW
Dracaenaceae	*Dracaena mildbraedii* K.Krause	WUR
Dracaenaceae	*Dracaena phrynioides* Hooker	WUR & HAW
Dracaenaceae	*Dracaena surculosa* Lindley	WUR & HAW
Dryopteridaceae	*Diplazium hylophilum* (Hieronymus) C.Chr.	HAW
Dryopteridaceae	*Tectaria fernandensis* (Baker) C.Chr.	HAW
Dryopteridaceae	*Triplophyllum jenseniae* (C.Chr.) Holttum	HAW
Dryopteridaceae	*Triplophyllum pilosissimum* (J.Smith) Holttum	HAW
Dryopteridaceae	*Triplophyllum securidiforme* (Hook.) Holttum	WUR
Dryopteridaceae	*Triplophyllum vogelii* (Hooker) Holttum	HAW
Ebenaceae	*Diospyros canaliculata* De Wildeman	HAW
Ebenaceae	*Diospyros chevalieri* De Wildeman	HAW
Ebenaceae	*Diospyros gabunensis* Gürke	HAW
Ebenaceae	*Diospyros kamerunensis* Gürke	HAW
Ebenaceae	*Diospyros mannii* Hiern	HAW
Ebenaceae	*Diospyros monbuttensis* Gürke	HAW
Ebenaceae	*Diospyros piscatoria* Gürke	HAW
Ebenaceae	*Diospyros sanza-minika* A.Chevalier	WUR & HAW
Ebenaceae	*Diospyros viridicans* Hiern	HAW
Erythroxylaceae	*Erythroxylum mannii* Oliver	WUR & HAW
Euphorbiaceae	*Acalypha racemosa* Wall. ex Baillon	HAW
Euphorbiaceae	*Alchornea cordifolia* (Schum. & Thonning) Muell.Arg.	HAW
Euphorbiaceae	*Alchornea floribunda* Müll.Arg.	WUR & HAW
Euphorbiaceae	*Anthostema aubryanum* Baillon	HAW
Euphorbiaceae	*Antidesma laciniatum* Müll.Arg.	WUR & HAW
Euphorbiaceae	*Bridelia grandis* Pierre ex Hutchinson	HAW
Euphorbiaceae	*Bridelia micrantha* (Hochstetter) Baillon	HAW
Euphorbiaceae	*Croton penduliflorus* Hutchinson	WUR & HAW
Euphorbiaceae	*Crotonogyne chevalieri* (Beille) Keay	HAW
Euphorbiaceae	*Discoclaoxylon hexandrum* (Muell.Arg.) Pax & K.Hoffm.	WUR & HAW
Euphorbiaceae	*Discoglypremna caloneura* (Pax) Prain	HAW
Euphorbiaceae	*Elaeophorbia grandifolia* (Haw.) Croizat	HAW
Euphorbiaceae	*Erythrococca africana* (Baillon) Prain	HAW
Euphorbiaceae	*Erythrococca anomala* (Juss. ex Poiret) Prain	WUR & HAW
Euphorbiaceae	*Grossera vignei* Hoyle	HAW
Euphorbiaceae	*Macaranga barteri* Müll.Arg.	HAW
Euphorbiaceae	*Macaranga heterophylla* (Muell.Arg.) Muell.Arg.	HAW
Euphorbiaceae	*Macaranga heudelotii* Baillon	HAW
Euphorbiaceae	*Macaranga hurifolia* Beille	HAW
Euphorbiaceae	*Macaranga spinosa* Müll.Arg.	HAW
Euphorbiaceae	*Maesobotrya barteri* (Baillon) Hutch.	HAW
Euphorbiaceae	*Manniophyton fulvum* Müll.Arg.	HAW
Euphorbiaceae	*Mareya micrantha* (Bentham) Müll.Arg.	HAW
Euphorbiaceae	*Margaritaria discoidea* (Baillon) Webster	HAW
Euphorbiaceae	*Phyllanthus profusus* N.E.Br.	HAW
Euphorbiaceae	*Protomegabaria stapfiana* (Beille) Hutch	WUR & HAW
Euphorbiaceae	*Pycnocoma macrophylla* Bentham	WUR & HAW
Euphorbiaceae	*Ricinodendron heudelotii* (Baillon) Pierre ex Pax	HAW
Euphorbiaceae	*Sapium aubrevillei* (synonym of *Shirakiopsis aubrevillei*)	WUR & HAW
Euphorbiaceae	*Shirakiopsis aubrevillei* (Leandri) Esser	WUR & HAW

Family	Species name	source
Euphorbiaceae	*Spondianthus preussii* Engler	HAW
Euphorbiaceae	*Suregada occidentalis* (Hoyle) Croizat	HAW
Euphorbiaceae	*Tetrorchidium didymostemon* (Baillon) Pax & K.Hoffm.	WUR & HAW
Euphorbiaceae	*Thecacoris stenopetala* (Muell.Arg.) Muell.Arg.	WUR & HAW
Euphorbiaceae	*Tragia spathulata* Benth.	WUR
Euphorbiaceae	*Uapaca guineensis* Müll.Arg.	HAW
Flacourtiaceae	*Dasylepis racemosa* Oliver	WUR & HAW
Flacourtiaceae	*Homalium africanum* (Hooker f.) Bentham	HAW
Flacourtiaceae	*Homalium letestui* Pellegrin	HAW
Flacourtiaceae	*Homalium longistylum* Mast.	HAW
Flacourtiaceae	*Homalium stipulaceum* Welwitsch ex Mast.	HAW
Flacourtiaceae	*Oncoba dentata* Oliver	WUR & HAW
Flacourtiaceae	*Oncoba echinata* Oliver	HAW
Flacourtiaceae	*Oncoba gilgiana* Sprague	HAW
Flacourtiaceae	*Ophiobotrys zenkeri* Gilg	HAW
Flacourtiaceae	*Scottellia klaineana* Pierre	HAW
Flagellariaceae	*Flagellaria guineensis* Schum.	HAW
Gentianaceae	*Anthocleista microphylla* Wernham	H&S
Gentianaceae	*Anthocleista nobilis* G.Don	HAW
Gentianaceae	*Anthocleista vogelii* Planchon	HAW
Gramineae	*Isachne buettneri* Hackel	HAW
Gramineae	*Leptaspis zeylanica* Nees	HAW
Gramineae	*Olyra latifolia* Linné	HAW
Gramineae	*Oplismenus hirtellus* (Linné) P.Beauv.	HAW
Gramineae	*Paspalum conjugatum* Bergius	HAW
Guttiferae	*Allanblackia parviflora* A.Chevalier	WUR & HAW
Guttiferae	*Garcinia epunctata* Stapf	HAW
Guttiferae	*Garcinia kola* Heckel	HAW
Guttiferae	*Garcinia smeathmannii* (Planchon & Triana) Oliver	HAW
Guttiferae	*Harungana madagascariensis* Lamarck ex Poiret	HAW
Guttiferae	*Mammea africana* Sabine	HAW
Guttiferae	*Pentadesma butyracea* Sabine	HAW
Guttiferae	*Symphonia globulifera* Linné f.	HAW
Guttiferae	*Vismia guineensis* (Linné) Choisy	WUR & HAW
Hernandiaceae	*Illigera pentaphylla* Welwitsch	HAW
Hymenophyllaceae	*Trichomanes cupressoides* Desv.	WUR
Icacinaceae	*Alsodeiopsis staudtii* Engler	HAW
Icacinaceae	*Iodes liberica* Stapf	HAW
Icacinaceae	*Leptaulus daphnoides* Bentham	WUR & HAW
Icacinaceae	*Pyrenacantha acuminata* Engler	HAW
Icacinaceae	*Rhaphiostylis beninensis* (Hook.f. ex Planch.) Planch. ex Benth	WUR
Icacinaceae	*Rhaphiostylis ferruginea* Engler	HAW
Icacinaceae	*Rhaphiostylis preussii* Engler	WUR & HAW
Irvingiaceae	*Irvingia gabonensis* (Aubry-Lecomte) Baillon	HAW
Irvingiaceae	*Klainedoxa gabonensis* Pierre ex Engler	HAW
Labiatae	*Plectranthus epilithicus* B.J.Pollard	WUR
Labiatae	*Plectranthus occidentalis* B.J.Pollard	WUR
Lauraceae	*Beilschmiedia mannii* (Meisn.) Bentham & Hooker f.	WUR & HAW
Lecythidaceae	*Napoleonaea vogelii* Hooker & Planchon	HAW
Lecythidaceae	*Petersianthus macrocarpus* (P.Beauv.) Liben	HAW
Leguminosae-Caes.	*Afzelia bella* Harms	HAW

Family	Species name	source
Leguminosae-Caes.	*Anthonotha fragrans* (Baker f.) Excell & Hillcoat	HAW
Leguminosae-Caes.	*Anthonotha macrophylla* P.Beauv.	HAW
Leguminosae-Caes.	*Berlinia tomentella* Keay	WUR
Leguminosae-Caes.	*Bussea occidentalis* Hutchinson	WUR & HAW
Leguminosae-Caes.	*Chidlowia sanguinea* Hoyle	WUR & HAW
Leguminosae-Caes.	*Copaifera salikounda* Heckel	HAW
Leguminosae-Caes.	*Daniellia ogea* (Harms) Holland	HAW
Leguminosae-Caes.	*Dialium aubrevillei* Pellegrin	WUR & HAW
Leguminosae-Caes.	*Dialium dinklagei* Harms	HAW
Leguminosae-Caes.	*Dialium guineense* Willd.	HAW
Leguminosae-Caes.	*Distemonanthus benthamianus* Baillon	HAW
Leguminosae-Caes.	*Erythrophleum ivorense* A.Chevalier	HAW
Leguminosae-Caes.	*Gilbertiodendron limba* (Scott Elliot) J.Léonard	WUR & HAW
Leguminosae-Caes.	*Griffonia simplicifolia* (Vahl ex DC.) Baillon	HAW
Leguminosae-Caes.	*Guibourtia ehie* (A.Chevalier) J.Léonard	HAW
Leguminosae-Caes.	*Hymenostegia afzelii* (Oliver) Harms	WUR & HAW
Leguminosae-Caes.	*Stemonocoleus micranthus* Harms	HAW
Leguminosae-Mim.	*Acacia kamerunensis* Gandoger	HAW
Leguminosae-Mim.	*Acacia pentagona* (Schum. & Thonning) Hooker f.	HAW
Leguminosae-Mim.	*Albizia adianthifolia* (Schum.) W.F.Wight	HAW
Leguminosae-Mim.	*Albizia ferruginea* (Guillaumet & Perr.) Bentham	HAW
Leguminosae-Mim.	*Albizia glaberrima* (Schum. & Thonning) Bentham	HAW
Leguminosae-Mim.	*Albizia zygia* (DC.) J.F.Macbr.	HAW
Leguminosae-Mim.	*Aubrevillea platycarpa* Pellegrin	HAW
Leguminosae-Mim.	*Calpocalyx brevibracteatus* Harms	HAW
Leguminosae-Mim.	*Cylicodiscus gabunensis* Harms	HAW
Leguminosae-Mim.	*Newtonia aubrevillei* (Pellegrin) Keay	HAW
Leguminosae-Mim.	*Parkia bicolor* A.Chevalier	HAW
Leguminosae-Mim.	*Pentaclethra macrophylla* Bentham	HAW
Leguminosae-Mim.	*Piptadeniastrum africanum* (Hooker f.) Brenan	HAW
Leguminosae-Mim.	*Samanea dinklagei* (Harms) Keay	HAW
Leguminosae-Mim.	*Tetrapleura tetraptera* (Schum. & Thonning) Taub.	HAW
Leguminosae-Mim.	*Xylia evansii* Hutchinson	WUR & HAW
Leguminosae-Pap.	*Aganope leucobotrya* (Dunn) Polhill	HAW
Leguminosae-Pap.	*Amphimas pterocarpoides* Harms	HAW
Leguminosae-Pap.	*Baphia nitida* Lodd.	HAW
Leguminosae-Pap.	*Baphia pubescens* Hooker f.	HAW
Leguminosae-Pap.	*Dalbergia afzeliana* G.Don	HAW
Leguminosae-Pap.	*Dalbergia hostilis* Bentham	HAW
Leguminosae-Pap.	*Dalbergia oblongifolia* G.Don	HAW
Leguminosae-Pap.	*Dalbergia saxatilis* Hooker f.	HAW
Leguminosae-Pap.	*Desmodium adscendens* (Sw.) DC.	HAW
Leguminosae-Pap.	*Leptoderris brachyptera* (Bentham) Dunn.	HAW
Leguminosae-Pap.	*Leptoderris sassandrensis* Jongkind	HAW
Leguminosae-Pap.	*Lonchocarpus sericeus* (Poiret) Kunth	HAW
Leguminosae-Pap.	*Millettia chrysophylla* Dunn	HAW
Leguminosae-Pap.	*Millettia lucens* (Scott Elliot) Dunn	WUR & HAW
Leguminosae-Pap.	*Millettia rhodantha* Baillon	HAW
Leguminosae-Pap.	*Millettia zechiana* Harms	HAW
Leguminosae-Pap.	*Mucuna flagellipes* T.Vogel ex Benth.	WUR
Leguminosae-Pap.	*Physostigma venenosum* Balf.f.	WUR

Family	Species name	source
Leguminosae-Pap.	*Platysepalum hirsutum* (Dunn) Hepper	HAW
Leguminosae-Pap.	*Pterocarpus santalinoides* DC.	HAW
Leguminosae-Pap.	*Rhynchosia brunnea* Baker f.	WUR
Leguminosae-Pap.	*Rhynchosia pycnostachya* (DC.) Meikle	WUR
Liliaceae	*Chlorophytum orchidastrum* Lindley	HAW
Liliaceae	*Chlorophytum togoense* Engler	HAW
Liliaceae	*Smilax anceps* Willd.	HAW
Linaceae	*Hugonia planchonii* Hooker f.	HAW
Linaceae	*Hugonia platysepala* Welwitsch ex Oliver	HAW
Linaceae	*Phyllocosmus africanus* (Hooker f.) Klotzsch	WUR & HAW
Loganiaceae	*Strychnos aculeata* Solereder	HAW
Loganiaceae	*Strychnos afzelii* Gilg	WUR & HAW
Loganiaceae	*Strychnos asterantha* Leeuwenberg	WUR & HAW
Loganiaceae	*Strychnos camptoneura* Gilg & Busse	HAW
Loganiaceae	*Strychnos congolana* Gilg	WUR
Loganiaceae	*Strychnos cuminodora* Leeuwenberg	WUR & HAW
Loganiaceae	*Strychnos floribunda* Gilg	HAW
Loganiaceae	*Strychnos icaja* Baillon	WUR & HAW
Loganiaceae	*Strychnos malacoclados* C.H.Wright	HAW
Loganiaceae	*Strychnos splendens* Gilg	HAW
Loganiaceae	*Strychnos usambarensis* Gilg	HAW
Loganiaceae	*Usteria guineensis* Willd.	WUR & HAW
Lomariopsidaceae	*Bolbitis auriculata* (Lam.) Alston	HAW
Lomariopsidaceae	*Bolbitis gemmifera* (Hieronymus) C.Chr.	HAW
Lomariopsidaceae	*Lomariopsis guineensis* (Underwood) Alston	HAW
Lomariopsidaceae	*Lomariopsis rossii* Holttum	HAW
Loranthaceae	*Tapinanthus bangwensis* (Engl. & Krause) Danser	WUR
Malpighiaceae	*Acridocarpus plagiopterus* Guill. & Perr.	WUR & HAW
Marantaceae	*Ataenidia conferta* (Bentham) Milne-Redhead	HAW
Marantaceae	*Halopegia azurea* (K.Schum.) K.Schum.	WUR & HAW
Marantaceae	*Hypselodelphys poggeana* (K.Schum.) Milne-Redhead	HAW
Marantaceae	*Marantochloa congensis* (K.Schum.) Léonard & Mullend	HAW
Marantaceae	*Marantochloa leucantha* (K.Schum.) Milne-Redhead	HAW
Marantaceae	*Marantochloa mannii* (Bentham) Milne-Redhead	HAW
Marantaceae	*Marantochloa purpurea* (Ridl.) Milne-Redhead	HAW
Marantaceae	*Sarcophrynium brachystachys* (Bentham) K.Schum.	HAW
Marantaceae	*Sarcophrynium prionogonium* (K.Schum.) K.Schum.	HAW
Medusandraceae	*Soyauxia grandifolia* Gilg & Stapf	HAW
Medusandraceae	*Soyauxia velutina* Hutch. & Dalziel	WUR & HAW
Melastomataceae	*Calvoa monticola* A.Chevalier ex Hutch. & Dalziel	HAW
Melastomataceae	*Heterotis rotundifolia* (Sm.) Jacq.-Fél.	WUR
Melastomataceae	*Medinilla entii* (synonym of *M. manii*)	WUR
Melastomataceae	*Medinilla manii* Hook.f.	WUR
Melastomataceae	*Memecylon afzelii* G.Don	WUR & HAW
Melastomataceae	*Memecylon aylmeri* Hutch. & Dalziel	WUR & HAW
Melastomataceae	*Memecylon lateriflorum* (G.Don) Bremek.	HAW
Melastomataceae	*Memecylon normandii* Jacq.-Félix	HAW
Melastomataceae	*Preussiella kamerunensis* Gilg	WUR
Melastomataceae	*Tristemma akeassii* Jacq.-Fél.	WUR
Melastomataceae	*Tristemma mauritianum* J.-F.Gmelin	HAW
Melastomataceae	*Warneckea cinnamomoides* (G.Don) Jacq.-Félix	HAW

Family	Species name	source
Melastomataceae	*Warneckea guineensis* (Keay) Jacq.-Félix	HAW
Melastomataceae	*Warneckea membranifolia* (Hooker f.) Jacq.-Félix	WUR & HAW
Meliaceae	*Carapa procera* DC.	HAW
Meliaceae	*Entandrophragma angolense* (Welwitsch) DC.	HAW
Meliaceae	*Entandrophragma candollei* Harms	HAW
Meliaceae	*Entandrophragma cylindricum* (Sprague) Sprague	HAW
Meliaceae	*Entandrophragma utile* (Dawe & Sprague) Sprague	HAW
Meliaceae	*Guarea cedrata* (A.Chevalier) Pellegrin	HAW
Meliaceae	*Guarea thompsonii* Sprague & Hutch.	HAW
Meliaceae	*Khaya ivorensis* A.Chevalier	HAW
Meliaceae	*Lovoa trichilioides* Harms	HAW
Meliaceae	*Trichilia monadelpha* (Thonning) J.J.de Wilde	HAW
Meliaceae	*Trichilia prieuriana* A.Juss.	HAW
Meliaceae	*Trichilia tessmannii* Harms	HAW
Meliaceae	*Turraea vogelii* Hook.f. ex Benth.	WUR
Meliaceae	*Turraeanthus africanus* (Welwitsch ex C.DC.) Pellegrin	HAW
Menispermaceae	*Albertisia scandens* (Mangenot & Miège) Forman	WUR & HAW
Menispermaceae	*Dioscoreophyllum cumminsii* (Stapf) Diels	HAW
Menispermaceae	*Dioscoreophyllum volkensii* Engl.	WUR
Menispermaceae	*Penianthus patulinervis* Hutch. & Dalziel	HAW
Menispermaceae	*Rhigiocarya racemifera* Miers	WUR
Menispermaceae	*Sphenocentrum jollyanum* Pierre	HAW
Menispermaceae	*Triclisia dictyophylla* Diels	HAW
Menispermaceae	*Triclisia patens* Oliver	HAW
Moraceae	*Antiaris toxicaria* (Rumph. ex Pers.) Leschen.	HAW
Moraceae	*Dorstenia embergeri* Mangenot	WUR
Moraceae	*Ficus bubu* Warb.	HAW
Moraceae	*Ficus exasperata* Vahl	HAW
Moraceae	*Ficus kamerunensis* Mildbraed & Burrett	HAW
Moraceae	*Ficus mucuso* Ficalho	HAW
Moraceae	*Ficus ottoniifolia* (Miq.) Miq.	WUR & HAW
Moraceae	*Ficus ovata* Vahl	HAW
Moraceae	*Ficus recurvata* De Wildeman	HAW
Moraceae	*Ficus sagittifolia* Warb.	WUR
Moraceae	*Ficus sansibarica* Warb.[3]	HAW
Moraceae	*Ficus saussureana* DC.	WUR & HAW
Moraceae	*Ficus sur* Forsskal	HAW
Moraceae	*Ficus umbellata* Vahl	HAW
Moraceae	*Ficus variifolia* Warb.	HAW
Moraceae	*Milicia excelsa* (Welwitsch) C.C.Berg	HAW
Moraceae	*Milicia regia* (A.Chevalier) C.C.Berg	WUR & HAW
Moraceae	*Morus mesozygia* Stapf	HAW
Moraceae	*Musanga cecropioides* F.Br.	HAW
Moraceae	*Myrianthus arboreus* P.Beauv.	HAW
Moraceae	*Myrianthus libericus* Rendle	HAW
Moraceae	*Streblus usambarensis* (Engler) Berg	HAW
Moraceae	*Treculia africana* Decne	HAW
Moraceae	*Trilepisium madagascariense* DC.	HAW
Myristicaceae	*Coelocaryon oxycarpum* Stapf	HAW
Myristicaceae	*Coelocaryon sphaerocarpum* Fouilloy	WUR
Myristicaceae	*Pycnanthus angolensis* (Welwitsch) Warb.	HAW

Family	Species name	source
Myrtaceae	*Syzygium guineense* (Willd.) DC.	WUR & HAW
Nyctaginaceae	*Pisonia aculeata* Linné	HAW
Ochnaceae	*Campylospermum flavum* (Schum. & Thonning ex Stapf) Farron	HAW
Ochnaceae	*Campylospermum sulcatum* (van Tieghem) Farron	HAW
Ochnaceae	*Lophira alata* Banks ex Gaertn.	WUR & HAW
Ochnaceae	*Ochna staudtii* Engler & Gilg.	HAW
Ochnaceae	*Rhabdophyllum calophyllum* (Hooker f.) van Tieghem	WUR & HAW
Olacaceae	*Coula edulis* Baillon	HAW
Olacaceae	*Octoknema borealis* Hutch. & Dalziel	HAW
Olacaceae	*Olax gambecola* Baillon	HAW
Olacaceae	*Ongokea gore* (Hua) Pierre	HAW
Olacaceae	*Ptychopetalum anceps* Oliver	HAW
Olacaceae	*Strombosia pustulata* Oliver	HAW
Oleaceae	*Chionanthus mannii* (Solereder) Stearn	HAW
Oleaceae	*Jasminum pauciflorum* Bentham	HAW
Oleandraceae	*Arthropteris monocarpa* (Cordem.) C.Chr.	HAW
Oleandraceae	*Arthropteris palisotii* (Desvaux) Alston	HAW
Oleandraceae	*Oleandra distenta* Kunze	HAW
Orchidaceae	*Aerangis biloba* (Lindl.) Schltr.	WUR
Orchidaceae	*Angraecum bancoense* Burg	WUR
Orchidaceae	*Angraecum birrimense* Rolfe	HAW
Orchidaceae	*Auxopus kamerunensis* Schltr.	WUR
Orchidaceae	*Bulbophyllum oreonastes* Reichb.f.	FWTA 3: 239 *(as B. zenkeranum)*
Orchidaceae	*Corymborkis corymbosa* Thou.	FWTA 3: 211
Orchidaceae	*Cyrtorchis ringens* (Rchb.f.) Summerh.	WUR
Orchidaceae	*Diaphananthe pellucida* (Lindley) Schlechter	HAW
Orchidaceae	*Diaphananthe rohrii* (Reichb.f.) Summerhayes	HAW
Orchidaceae	*Epigonium roseum* (Don) Lind.	FWTA 3: 207
Orchidaceae	*Hetaeria occidentalis* Summerhayes	WUR & HAW
Orchidaceae	*Manniella gustavii* Reichb.f.	HAW
Orchidaceae	*Polystachya affinis* Lindl.	WUR
Orchidaceae	*Polystachya paniculata* (Sw.) Rolfe	WUR
Orchidaceae	*Rhipidoglossum rutilum* (Rchb.f.) Schltr.	WUR
Orchidaceae	*Tridactyle armeniaca* (Lindley) Schlechter	WUR & HAW
Orchidaceae	*Zeuxine elon*gata Rolfe	FWTA 3: 208
Palmae	*Calamus deeratus* Mann & Wendl.	HAW
Palmae	*Elaeis guineensis* Jacq.	HAW
Palmae	*Eremospatha hookeri* (Mann & Wendl.) Wendl.	HAW
Palmae	*Eremospatha macrocarpa* (Mann & Wendl.) Wendl.	HAW
Palmae	*Raphia hookeri* Mann & Wendl.	WUR & HAW
Pandaceae	*Microdesmis keayana* J.Léonard	WUR & HAW
Pandaceae	*Panda oleosa* Pierre	HAW
Pandanaceae	*Pandanus abbiwii* Huynh	HAW
Passifloraceae	*Adenia cissampeloides* (Planch. ex Benth.) Harms	WUR
Passifloraceae	*Adenia mannii* (Mast.) Engler	HAW
Passifloraceae	*Adenia rumicifolia* Engl. & Harms	WUR
Passifloraceae	*Crossostemma laurifolium* Planchon ex Bentham	WUR
Passifloraceae	*Smeathmannia pubescens* Soland. ex R.Br.	HAW
Piperaceae	*Peperomia fernandopoiana* C.DC.	WUR & HAW
Piperaceae	*Peperomia rotundifolia* (Linné) H.B. & K.	HAW
Piperaceae	*Piper capense* L.f.	WUR
Piperaceae	*Piper guineense* Schum. & Thonning	HAW

Family	Species name	source
Piperaceae	*Piper umbellatum* Linné	HAW
Polygalaceae	*Atroxima liberica* Stapf	HAW
Polygalaceae	*Carpolobia lutea* G.Don	WUR & HAW
Polypodiaceae	*Drynaria laurentii* (Christ) Hieron.	H&S
Polypodiaceae	*Microgramma lycopodioides* (L.) Copeland	HAW
Polypodiaceae	*Microsorium punctatum* (L.) Copeland	HAW
Polypodiaceae	*Platycerium stemaria* (P.Beauv.) Desvaux	HAW
Pteridaceae	*Pteris burtonii* Baker	HAW
Pteridaceae	*Pteris togoensis* Hieronymus	HAW
Putranjivaceae	*Drypetes afzelii* (Pax) Hutch	HAW
Putranjivaceae	*Drypetes aubrevillei* Leandri	HAW
Putranjivaceae	*Drypetes aylmeri* Hutch. & Dalziel	WUR & HAW
Putranjivaceae	*Drypetes chevalieri* Beille	HAW
Putranjivaceae	*Drypetes gilgiana* (Pax) Pax & K.Hoffm.	HAW
Putranjivaceae	*Drypetes pellegrinii* Léandri	WUR & HAW
Putranjivaceae	*Drypetes principum* (Muell.Arg.) Hutch.	HAW
Rhamnaceae	*Gouania longipetala* Hemsley	HAW
Rhamnaceae	*Lasiodiscus fasciculiflorus* Engler	HAW
Rhamnaceae	*Maesopsis eminii* Engler	HAW
Rhizophoraceae	*Anopyxis klaineana* (Pierre) Engler	HAW
Rhizophoraceae	*Cassipourea congoensis* R.Br. ex DC.	HAW
Rhizophoraceae	*Cassipourea glabra* Alston	WUR
Rhizophoraceae	*Cassipourea gummiflua* Tulasne	WUR & HAW
Rosaceae	*Rubus pinnatus* Willd.[4]	HAW
Rubiaceae	*Aidia genipiflora* (DC.) Dandy	WUR & HAW
Rubiaceae	*Aulacocalyx jasminiflora* Hooker f.	HAW
Rubiaceae	*Bertiera bracteolata* Hiern	WUR & HAW
Rubiaceae	*Bertiera breviflora* Hiern	WUR & HAW
Rubiaceae	*Bertiera racemosa* (G.Don) K.Schum.	WUR & HAW
Rubiaceae	*Calycosiphonia macrochlamys* (K.Schum.) Leroy	HAW
Rubiaceae	*Calycosiphonia spathicalyx* (K.Schum.) Robbrecht	HAW
Rubiaceae	*Chassalia afzelii* (Hiern) K.Schum.	WUR & HAW
Rubiaceae	*Chassalia corallifera* (A.Chev. ex De Wild.) Hepper	WUR
Rubiaceae	*Chassalia kolly* (Schum.) Hepper	WUR & HAW
Rubiaceae	*Chazaliella sciadephora* (Hiern) Petit & Verdcourt	WUR & HAW
Rubiaceae	*Corynanthe pachyceras* K.Schum.	WUR & HAW
Rubiaceae	*Craterispermum caudatum* Hutchinson	WUR & HAW
Rubiaceae	*Craterispermum cerinanthum* Hiern	HAW
Rubiaceae	*Cremaspora triflora* (Thonning) K.Schum.	WUR & HAW
Rubiaceae	*Cuviera nigrescens* (Scott Elliot ex Oliver) Wernham	HAW
Rubiaceae	*Dictyandra arborescens* Welwitsch ex Hooker f.	WUR & HAW
Rubiaceae	*Didymosalpinx abbeokutae* (Hiern) Keay	WUR & HAW
Rubiaceae	*Diodia sarmentosa* Sw.	WUR
Rubiaceae	*Euclinia longiflora* Salisb.	WUR & HAW
Rubiaceae	*Gaertnera cooperi* Hutch. & M.B.Moss	HAW
Rubiaceae	*Geophila afzelii* Hiern	WUR & HAW
Rubiaceae	*Geophila obvallata* (Schum.) F.Didr.	HAW
Rubiaceae	*Geophila repens* (L.) I.M.Johnst.	WUR
Rubiaceae	*Hallea stipulosa* (DC.) Leroy	HAW
Rubiaceae	*Hymenocoleus hirsutus* (Bentham) Robbrecht	HAW
Rubiaceae	*Hymenocoleus libericus* (A.Chevalier ex Hutch. & Dalziel) Robbrecht	HAW

Family	Species name	source
Rubiaceae	*Hymenocoleus multinervis* Robbrecht	WUR & HAW
Rubiaceae	*Hymenocoleus neurodictyon* (K.Schum.) Robbrecht	WUR & HAW
Rubiaceae	*Hymenodictyon floribundum* (Steud. ex Hochst.) B.L.Robinson	H&S
Rubiaceae	*Ixora hiernii* Scott Elliot	HAW
Rubiaceae	*Ixora nigerica* Keay[5]	WUR & HAW
Rubiaceae	*Ixora tenuis* De Block	WUR
Rubiaceae	*Keetia bridsoniae* Jongkind	WUR & HAW
Rubiaceae	*Keetia hispida* (Bentham) Bridson	HAW
Rubiaceae	*Keetia venosa* (Oliver) Bridson	HAW
Rubiaceae	*Lasianthus batangensis* K.Schum.	WUR & HAW
Rubiaceae	*Lasianthus repens* Hepper	WUR & HAW
Rubiaceae	*Leptactina densiflora* Hooker f.	HAW
Rubiaceae	*Leptactina involucrata* Hooker f.	HAW
Rubiaceae	*Massularia acuminata* (G.Don) Bullock ex Hoyle	HAW
Rubiaceae	*Morinda lucida* Bentham	HAW
Rubiaceae	*Morinda morindoides* (Baker) Milne-Redhead	HAW
Rubiaceae	*Mussaenda chippii* Wernham	WUR
Rubiaceae	*Mussaenda linderi* Hutch. & Dalziel	WUR
Rubiaceae	*Mussaenda nivea* A.Chev. ex Hutch. & Dalziel	WUR
Rubiaceae	*Mussaenda tristigmatica* Cummins	WUR & HAW
Rubiaceae	*Nauclea diderrichii* (De Wild. & Th.Dur.) Merrill	WUR & HAW
Rubiaceae	*Oxyanthus formosus* Hooker f. ex Planchon	HAW
Rubiaceae	*Oxyanthus pallidus* Hiern	HAW
Rubiaceae	*Oxyanthus speciosus* DC.	HAW
Rubiaceae	*Oxyanthus unilocularis* Hiern	WUR & HAW
Rubiaceae	*Pauridiantha afzelii* (Hiern) Bremek.	HAW
Rubiaceae	*Pauridiantha sylvicola* (Hutch. & Dalziel) Bremek.	WUR & HAW
Rubiaceae	*Pausinystalia lane-poolei* (Hutch.) Hutch. ex Lane-Poole	HAW
Rubiaceae	*Pavetta akeassii* J.B.Hall	WUR & HAW
Rubiaceae	*Pavetta ixorifolia* Bremek.	WUR & HAW
Rubiaceae	*Pavetta owariensis* P.Beauv.	HAW
Rubiaceae	*Pleiocoryne fernandensis* (Hiern) Rauschert	WUR
Rubiaceae	*Psilanthus ebracteolatus* Hiern	HAW
Rubiaceae	*Psilanthus mannii* Hooker f.	WUR & HAW
Rubiaceae	*Psychotria biaurita* (Hutch. & Dalziel) Verdcourt	WUR & HAW
Rubiaceae	*Psychotria brachyantha* Hiern	WUR
Rubiaceae	*Psychotria elongato-sepala* (Hiern) Petit	WUR & HAW
Rubiaceae	*Psychotria gabonica* Hiern	WUR & HAW
Rubiaceae	*Psychotria peduncularis* (Salisb.) Verdcourt	HAW
Rubiaceae	*Psychotria psychotriodes* (DC.) Roberty	HAW
Rubiaceae	*Psychotria reptans* Bentham	WUR & HAW
Rubiaceae	*Psychotria rufipilis* De Wildeman	HAW
Rubiaceae	*Psychotria subglabra* De Wildeman	HAW
Rubiaceae	*Psychotria subobliqua* Hiern	WUR & HAW
Rubiaceae	*Psydrax arnoldiana* (De Wild. & Th.Dur.) Bridson	HAW
Rubiaceae	*Psydrax horizontalis* (Schum. & Thonning) Bridson	HAW
Rubiaceae	*Psydrax manensis* (Aubréville & Pellegrin) Bridson	WUR & HAW
Rubiaceae	*Psydrax subcordata* (DC.) Bridson	HAW
Rubiaceae	*Robynsia glabrata* Hutchinson	WUR & HAW
Rubiaceae	*Rothmannia hispida* (K.Schum.) Fagerlind	WUR & HAW
Rubiaceae	*Rothmannia longiflora* Salisb.	HAW

Family	Species name	source
Rubiaceae	*Rothmannia whitfieldii* (Lindl.) Dandy	WUR & HAW
Rubiaceae	*Rutidea dupuisii* De Wildeman	HAW
Rubiaceae	*Rutidea membranacea* Hiern	WUR & HAW
Rubiaceae	*Rutidea olenotricha* Hiern	WUR
Rubiaceae	*Rytigynia canthioides* (Benth.) Robyns	WUR
Rubiaceae	*Sabicea calycina* Bentham	WUR & HAW
Rubiaceae	*Sabicea ferruginea* Benth.	WUR
Rubiaceae	*Sabicea multibracteata* J.B.Hall	WUR & HAW
Rubiaceae	*Sabicea rosea* Hoyle	WUR
Rubiaceae	*Sarcocephalus pobeguinii* Hua ex Pobeguin; Pellegrin	HAW
Rubiaceae	*Sherbournia bignoniiflora* (Welwitsch) Hua	HAW
Rubiaceae	*Sherbournia calycina* (G.Don) Hua	WUR & HAW
Rubiaceae	*Spermacoce mauritiana* Osia Gideon	WUR
Rubiaceae	*Tarenna bipindensis* (K.Schum.) Bremek.	WUR & HAW
Rubiaceae	*Tarenna eketensis* Wernham	WUR & HAW
Rubiaceae	*Tarenna gracilis* (Stapf) Keay	WUR & HAW
Rubiaceae	*Tarenna vignei* Hutch. & Dalziel	WUR & HAW
Rubiaceae	*Tricalysia discolor* Brenan	WUR & HAW
Rubiaceae	*Tricalysia elliotii* (K.Schum.) Hutch. & Dalziel	WUR
Rubiaceae	*Tricalysia oligoneura* K.Schum.	HAW
Rubiaceae	*Tricalysia pallens* Hiern	HAW
Rubiaceae	*Tricalysia reticulata* (Bentham) Hiern	WUR & HAW
Rubiaceae	*Trichostachys aurea* Hiern	HAW
Rubiaceae	*Uncaria africana* G.Don	HAW
Rubiaceae	*Uncaria talbotii* Wernham	WUR
Rubiaceae	*Vangueriella orthacantha* (Mildbraed) Bridson & Verdcourt	WUR & HAW
Rubiaceae	*Vangueriella vanguerioides* (Hiern) Verdcourt	WUR & HAW
Rubiaceae	*Virectaria procumbens* (Sm.) Bremek.	HAW
Rutaceae	*Citropsis articulata* (W. ex Spr.) Swingle & Kellerm	HAW
Rutaceae	*Vepris hiernii* Gereau	HAW
Rutaceae	*Vepris suaveolens* (Engler) W.Mziray	HAW
Rutaceae	*Zanthoxylum gilletii* (De Wild.) Waterman	HAW
Santalaceae	*Okoubaka aubrevillei* Pellegrin & Normand	WUR & HAW
Sapindaceae	*Allophylus africanus* P.Beauv.	HAW
Sapindaceae	*Allophylus talbotii* Baker f.	HAW
Sapindaceae	*Blighia sapida* Konig	HAW
Sapindaceae	*Blighia unijugata* Baker	HAW
Sapindaceae	*Blighia welwitschii* (Hiern) Radlk.	HAW
Sapindaceae	*Cardiospermum grandiflorum* Swartz	WUR
Sapindaceae	*Chytranthus carneus* Radlk.	HAW
Sapindaceae	*Deinbollia grandifolia* Hooker f.	HAW
Sapindaceae	*Eriocoelum pungens* Radlk. ex Engler	HAW
Sapindaceae	*Lecaniodiscus cupanioides* Planchon ex Bentham	HAW
Sapindaceae	*Lecaniodiscus punctatus* J.B.Hall	HAW
Sapindaceae	*Lychnodiscus reticulatus* Radlk.	HAW
Sapindaceae	*Majidea fosteri* (Sprague) Radlk.	HAW
Sapindaceae	*Pancovia pedicellaris* Radlk. & Gilg	HAW
Sapindaceae	*Pancovia sessiliflora* Hutch. & Dalziel	HAW
Sapindaceae	*Placodiscus attenuatus* J.B.Hall	HAW
Sapindaceae	*Placodiscus boya* Aubréville & Pellegrin	HAW
Sapotaceae	*Chrysophyllum africanum* A.DC.	HAW

Family	Species name	source
Sapotaceae	*Chrysophyllum beguei* Aubréville & Pellegrin	HAW
Sapotaceae	*Chrysophyllum giganteum* A.Chevalier	HAW
Sapotaceae	*Chrysophyllum perpulchrum* Mildbraed ex Hutch. & Dalziel	WUR & HAW
Sapotaceae	*Chrysophyllum pruniforme* Pierre ex Engler	WUR & HAW
Sapotaceae	*Chrysophyllum subnudum* Baker	HAW
Sapotaceae	*Chrysophyllum ubanguiense* (De Wild.) Harris	HAW
Sapotaceae	*Chrysophyllum welwitschii* Engler	HAW
Sapotaceae	*Manilkara obovata* (Sabine & G.Don) Hemsley	HAW
Sapotaceae	*Neolemonniera clitandrifolia* (A.Chevalier) Heine	WUR & HAW
Sapotaceae	*Omphalocarpum elatum* Miers	HAW
Sapotaceae	*Omphalocarpum procerum* P.Beauv.	HAW
Sapotaceae	*Pouteria aningeri* Baehni	HAW
Sapotaceae	*Synsepalum afzelii* (Engler) Pennington	HAW
Sapotaceae	*Synsepalum brevipes* (Baker) Pennington	HAW
Sapotaceae	*Synsepalum msolo* (Engler) Pennington	WUR & HAW
Sapotaceae	*Tieghemella heckelii* Pierre ex A.Chevalier	HAW
Scytopetalaceae	*Scytopetalum tieghemii* (A.Chevalier) Hutch. & Dalziel	HAW
Selaginellaceae	*Selaginella blepharophylla* Alston	WUR
Selaginellaceae	*Selaginella versicolor* Spring	WUR
Selaginellaceae	*Selaginella vogelii* Spring.	HAW
Simaroubaceae	*Brucea guineensis* G.Don	WUR
Simaroubaceae	*Hannoa klaineana* Pierre & Engler	HAW
Solanaceae	*Solanum welwitschii* C.H.Wright	WUR
Sterculiaceae	*Cola boxiana* Brenan & Keay	WUR
Sterculiaceae	*Cola caricifolia* (G.Don) K.Schum.	HAW
Sterculiaceae	*Cola gigantea* A.Chevalier	HAW
Sterculiaceae	*Cola lateritia* K.Schum.	HAW
Sterculiaceae	*Cola millenii* K.Schum.	HAW
Sterculiaceae	*Cola nitida* (Vent.) Schott. & Endl.	WUR & HAW
Sterculiaceae	*Cola reticulata* A.Chevalier	WUR & HAW
Sterculiaceae	*Cola verticillata* (Thonning) Stapf ex A.Chevalier	HAW
Sterculiaceae	*Heritiera utilis* (Sprague) Sprague	HAW
Sterculiaceae	*Leptonychia pubescens* Keay	HAW
Sterculiaceae	*Mansonia altissima* (A.Chevalier) A.Chevalier	HAW
Sterculiaceae	*Nesogordonia papaverifera* (A.Chevalier) R.Capuron	HAW
Sterculiaceae	*Octolobus spectabilis* Welwitsch	HAW
Sterculiaceae	*Pterygota macrocarpa* K.Schum.	HAW
Sterculiaceae	*Sterculia oblonga* Mast.	HAW
Sterculiaceae	*Sterculia rhinopetala* K.Schum.	HAW
Sterculiaceae	*Sterculia tragacantha* Lindley	HAW
Sterculiaceae	*Triplochiton scleroxylon* K.Schum.	HAW
Thelypteridaceae	*Cyclosorus afer* (Christ) Ching	HAW
Thymelaeaceae	*Craterosiphon scandens* Engler & Gilg.	HAW
Thymelaeaceae	*Dicranolepis persei* Cummins	WUR & HAW
Tiliaceae	*Desplatsia chrysochlamys* (Mildbraed & Burr.) Mildbraed & Bu	HAW
Tiliaceae	*Duboscia viridiflora* (K.Schum.) Mildbraed	WUR & HAW
Tiliaceae	*Glyphaea brevis* (Sprengel) Monachino	HAW
Tiliaceae	*Grewia hookeriana* Exell & Mendonça	WUR & HAW
Tiliaceae	*Grewia malacocarpa* Mast.	HAW
Ulmaceae	*Celtis adolfi-friderici* Engler	HAW
Ulmaceae	*Celtis mildbraedii* Engler	HAW

Family	Species name	source
Ulmaceae	*Celtis prantlii* Priemer ex Engl.	WUR
Ulmaceae	*Celtis wightii* Planchon	HAW
Ulmaceae	*Celtis zenkeri* Engler	HAW
Ulmaceae	*Trema orientalis* (Linné) Blume	HAW
Urticaceae	*Elatostema paivaeanum* Wedd.	WUR & HAW
Urticaceae	*Urera keayi* Letouzey	WUR
Verbenaceae	*Clerodendrum capitatum* (Willd.) Schum. & Thonning	HAW
Verbenaceae	*Clerodendrum cephalanthum* Oliver[6]	WUR
Verbenaceae	*Clerodendrum silvanum* Henriq.	HAW
Verbenaceae	*Clerodendrum umbellatum* Poiret	WUR & HAW
Verbenaceae	*Vitex ferruginea* Schum. & Thonning	HAW
Verbenaceae	*Vitex grandifolia* Gürke	HAW
Verbenaceae	*Vitex micrantha* Gürke	HAW
Verbenaceae	*Vitex rivularis* Gürke	HAW
Verbenaceae	*Vitex thyrsiflora* Baker	WUR & HAW
Violaceae	*Decorsella paradoxa* A.Chevalier	HAW
Violaceae	*Rinorea ilicifolia* Kuntze	HAW
Violaceae	*Rinorea oblongifolia* (C.H.Wright) Marquand ex Chipp	WUR & HAW
Violaceae	*Rinorea welwitschii* (Oliver) O.Ktze.	WUR & HAW
Violaceae	*Rinorea yaundensis* Engler	HAW
Vitaceae	*Cissus aralioides* (Welwitsch ex Baker) Planchon	WUR & HAW
Vitaceae	*Cissus diffusiflora* (Baker) Planch.	WUR
Vitaceae	*Cissus miegei* Tchoumé	WUR
Vitaceae	*Cyphostemma adenocaule* (Steud. ex A.Rich.) Desc. ex Wild & R.B.Drumm.	WUR
Vitaceae	*Cyphostemma vogelii* (Hook.f.) Desc.	WUR
Vitaceae	*Leea guineensis* G.Don	HAW
Zingiberaceae	*Aframomum atewae* Lock & Hall	WUR & HAW
Zingiberaceae	*Aframomum chrysanthum* Lock	WUR
Zingiberaceae	*Aframomum geocarpum* Lock & Hall	HAW
Zingiberaceae	*Renealmia battenbergiana* Cummins ex Baker	WUR

(Endnotes)

1 var. *glabrum* Keay
2 var. *camerunensis* (Loesener) N.Hallé
3 var. *macrosperma* (Mildbraed & Burr.) C.C. Berg
4 var. *afrotropicus* (Engler) C.E.Gust.
5 ssp. *occidentalis* De Block
6 subsp. *occidentale* Jongkind

Appendix 2

List of plant species recorded during the Atewa RAP survey, June 2006

D.E.K.A. Siaw and Jonathan Dabo

Family	Scientific name	Star rating	Habit	Atiwiredu	Asiakwa South	Asiakwa North
Acanthaceae	*Acanthus guineensis*	Gold	Herb	x		
	Lankesteria elegans	Green	Herb		x	
Agavaceae	*Draceana adamii*	Gold	Shrub	x		x
	Draceana mannii	Green	Shrub	x	x	
	Draceana phrynoides	Green	Shrub			x
	Draceana surculosa	Green	Shrub	x	x	
Anacardiaceae	*Antocaryon micraster*	Red	Tree	x	x	
	Lannea welwitschii	Green	Tree	x	x	x
	Trichoscypha arborea	Green	Tree	x	x	
	Trichoscypha lecenes	Gold	Tree			x
Annonaceae	*Anonnidium mannii*	Blue	Tree	x	x	
	Cleistopholis patens	Green	Tree	x	x	x
	Enantia polycarpa	Green	Tree	x	x	
	Greenwayodendron oliveri	Green	Tree	x	x	x
	Hexalobus crispiflorus	Green	Tree	x	x	x
	Isolona companulata	Green	Tree			x
	Monodora myristica	Green	Tree	x	x	x
	Monodora tenuifolia	Green	Tree	x	x	x
	Pachypodanthium staudtii	Green	Tree	x	x	x
	Piptostigma fasciculatum	Green	Tree	x	x	x
	Piptostigma fugax	Gold	Tree	x	x	x
	Uvariodendon calophyllum	Green	Tree			x
	Xylopia aethiopica	Green	Tree	x	x	x
	Xylopia quiintasii	Green	Tree			x
	Xylopia rubescens	Gold	Tree			x
	Xylopia staudttii	Green	Tree	x	x	
	Xylopia villosa	Green	Tree	x	x	x
Apocynaceae	*Alafia barteri*	Green	Climber	x	x	
	Alstonia boonei	Green	Tree	x	x	x
	Baissia leonensis	Blue	Climber		x	x
	Funtumia africana	Green	Tree	x	x	
	Funtumia elastica	Green	Tree	x	x	x
	Hunteria eburnea	Green	Tree	x	x	x
	Hunteria umbellata	Green	Climber	x	x	x
	Landolphia hirsuta	Green	Tree	x	x	x

Family	Scientific name	Star rating	Habit	Atiwiredu	Asiakwa South	Asiakwa North
	Landolphia owariensis	Green	Tree	x	x	x
	Landolphia calabaraica	Green	Climber		x	
	Landolphia foretiana	Blue	Climber	x		
	Landolphia micrantha	Blue	Climber		x	x
	Picralima nitida	Blue	Tree	x	x	x
	Rauvolfia vomitoria	Green	Tree	x	x	x
	Strophanthus hispidus	Pink	Climber		x	
	Tabernaemontana africana	Green	Tree	x	x	x
	Voacanga africana	Green	Tree	x	x	x
Araceae	*Amorphophallus johnsonii*	Green	Herb	x	x	x
	Anchomanes difformis	Green	Herb	x	x	x
	Cercestis afzelii	Green	Herb	x	x	x
	Culcasia angolensis	Green	Climber	x	x	x
Araliaceae	*Cussonia bancoensis*	Gold	Climber	x	x	
Aspidiaceae	*Ctenitis lanigera*	Green	Fern			
	Ctenitis lenseniae	Green	Fern			
Aspleniaceae	*Aspenium africanum*	Green			x	x
Bignoniaceae	*Spathodea campanulata*	Green	Tree	x	x	x
Bombacaceae	*Ceiba pentandra*	Pink	Tree	x		
Boraginaceae	*Cordia millenii*	Green	Tree	x		x
Burseraceae	*Canarium schweinfurthii*	Pink	Tree	x	x	x
	Dacryodes klaineana	Green	Tree		x	x
Caesalpinaceae	*Amphimas pterocarpioides*	Green	Tree	x	x	x
	Anthonotha macrophylla	Green	Tree	x	x	x
	Bussea occidentalis	Green	Tree	x	x	x
	Chidlowia sanguinea	Blue	Tree	x	x	x
	Gilbertiodendron splendidum	**Black**	**Tree**	**x**		**x**
	Hymenostegia afzelii	Green	Tree	x	x	x
	Anthonotha fragans	Green	Tree			x
	Dialium aubrevillei	Green				
	Dialium dinklagei	Green				x
	Distemonanthus benthamianus	Pink				
	Gilbertiodendron limba	Green				x
	Milbraediodendron excelsum	Gold				x
Capparaceae	*Buchholzia coriacea*	Green			x	
	Euadenia trifoliolata	Blue	Shrub	x		x
Celastraceae	*Salacia columna*	Green	Climber	x	x	
	Salacia elegans	Green	Climber			
Chrysubalanaceae	*Maranthes robusta*	Blue			x	
Combretaceae	*Combretum mucronatum*	Green	Climber		x	x
	Pteleopsis hylodendron	Blue	Tree			x
	Terminalia ivorensis	Scarlet			x	x
	Terminalia superba	Pink			x	x
Commelinaceae	*Commelina benghalensis*	Green	Herb		x	
	Commelina macrosperma	Green	Herb		x	x
Compositae	*Ageratum conyzoides*			x	x	
	Chromolaena odorata	Green			x	
	Synedrella nodiflora	x		x	x	
	Vernonia conferta	Green		x	x	x

Family	Scientific name	Star rating	Habit	Atiwiredu	Asiakwa South	Asiakwa North
Convolvulaceae	*Calycobolus africanus*	Green		x	x	x
Cucurbitaceae	*Momordica angustisepala*			x	x	
	Momordica spp.			x	x	
	Telfairia occidentalis	Blue		x	x	
Cyatheaceae	*Cyathea manniana*	Blue	Fern			
Cyperaceae	*Cyperus difformis*		Herb		x	
	Cyperus distans		Herb		x	
	Cyperus rotundus			x	x	
	Cyperus tuberosus		Herb		x	
	Mapania baldwinii	Blue	Herb	x	x	x
Dichapetalaceae	*Dichapetalum angolense*	Green	Climber		x	x
Dilleniaceae	*Tetracera affinis*		Climber		x	
Dioscoreaceae	*Dioscorea praehensilis*	Pink		x	x	
	Dioscorea smilacifolia	Green		x	x	
Ebenaceae	*Diospyros kamarunensis*	Green			x	x
	Diospyros mannii	Blue			x	
	Diospyros monbuttensis	Green		x		
	Diospyros sanza-Minika	Blue			x	
Euphorbiaceae	*Alchornea cordifolia*	Green	Tree		x	
	Alchornea floribunda	Green	Tree	x	x	x
	Anthostema aubryanum	Blue	Tree	x		
	Bridelia atroviridis	Green	Tree	x	x	x
	Bridelia grandis	Green	Tree	x	x	
	Caloncoba echinata	Green	Tree			
	Croton penduliflorus	Green	Tree	x	x	x
	Discoclaoxylon hexandrum	Green	Tree		x	x
	Discoglypremna caloneura	Green	Tree	x	x	x
	Drypetes aubrevillei	Blue	Tree	x	x	x
	Drypetes aylmeri	Blue	Tree	x	x	
	Drypetes pellegrinii	Gold	Tree			
	Drypetes principum	Green	Tree	x		x
	Elaeophorbia grandifolia	Green	Tree		x	
	Macaranga barteri	Green	Tree		x	x
	Macaranga heterophylla	Green	Tree		x	x
	Macaranga hurifolia	Green	Tree	x	x	x
	Maesobotrya barteri	Green	Tree	x	x	x
	Manniophytion fulvum	Green	Climber			
	Margaritaria discoidea	Green	Tree		x	x
	Phyllanthus muellerianus	Green	Tree		x	x
	Phyllanthus urinaris		Tree		x	
	Protomegabaria stapfiana	Blue	Tree	x		x
	Pycnocoma macrophylla	Green	Shrub	x	x	x
	Ricinodendron heudelotii	Green	Tree	x	x	
	Sapium aubrevillei	**Black**	**Tree**			**x**
	Tetrorchidium didymostemon	Green	Tree		x	x
	Tragia sp. 1			x	x	x
	Tragia sp. 2			x	x	x
	Tragia sp. 3		Tree		x	
	Uapaca corbisieri	Green	Tree		x	x
	Uapaca guineensis	Green	Tree	x		x

Family	Scientific name	Star rating	Habit	Atiwiredu	Asiakwa South	Asiakwa North
	Uapaca heudelotii		Tree			x
Erythroxylaceae	*Erythroxylum mannii*	Green	Tree		x	x
Flacourtiaceae	*Scottelia klaineana*	Pink	Tree		x	x
Flagellariacetae	*Flagellaria guineensis*	Green	Climber		x	
Guttifereae	*Allanblackia parviflora*	Green	Tree		x	
	Garcinia epunctata	Red	Tree	x	x	x
	Garcinia smeathmannii	Green	Tree	x	x	
	Harungana madagascariensis	Green	Tree	x	x	x
	Mammea africana	Pink	Tree		x	
Gramineae	*Axonopus compressus*		Herb		x	
	Bambusa vulgaris		Herb		x	
	Brachiaria deflexa		Herb		x	
	Eleusine indica		Herb		x	
	Leptaspis cochleata	Green	Herb	x	x	
	Olyra latifolia	Green	Grass	x	x	
	Panicum maximum		Herb		x	
	Setoria megaphylla		Herb	x	x	
Icacinaceae	*Leptaulus daphnoides*	Green	Tree		x	
	Raphinostylis pressii	Green	Climber		x	x
Irvingiaceae	*Klainedoxa gabonensis*	Green	Tree		x	
Ixonanthaceae	*Phyllocosmus africanus*	Green	Tree		x	x
Lauraceae	*Beilschmiedia mannii*	Green	Tree	x	x	x
Lecythidaceae	*Napoleonaea vogelii*	Green	Tree	x	x	x
	Petersianthus macrocarpus	Green	Tree		x	
Linaceae	*Hugonia rufipilis*	Blue	Climber		x	
Loganiaceae	*Anthocleista nobilis*	Green	Tree		x	x
	Strychnos floribunda	Green	Climber	x	x	x
	Strychnos unsambarensis	Green	Climber			x
Maranthaceae	*Ataenidia conferta*	Green	Herb	x	x	x
	Hypselodelphys poggeana	Green	Shrub		x	
	Marantochloa congensis	Green	Herb			x
	Marantochloa leucantha	Green	Herb	x	x	
	Marantochloa mannii	Green	Herb		x	
	Marantochloa purpurea	Green	Herb	x	x	
	Sarcophrynium brachystachys	Green	Herb	x	x	x
	Thaumatococcus danielii	Red			x	x
	Megaphrynium macrostachyrum	Green	Herb			x
	Marantochloa congensis	Green	Herb			x
Medusandraceae	*Soyauxia grandifolia*	Gold	Tree			x
Melastomataceae	*Memecylon afzelii*	Green		x	x	
	Memecylon barterii			x	x	
	Memecylon blackeoides			x	x	
	Memecylon lateriflorum	Green			x	
	Warneckea guineensis	Green	Tree		x	x
Meliaceae	*Carapa procera*	Green	Tree			x
	Entandrophragma angolense	Red	Tree		x	x
	Entandrophragma candollei	Scarlet	Tree	x	x	
	Entandrophragma cylindricum	Scarlet	Tree		x	x
	Entandrophragma utile	Scarlet	Tree		x	x

Family	Scientific name	Star rating	Habit	Atiwiredu	Asiakwa South	Asiakwa North
	Guarea cedrata	Pink	Tree	x	x	x
	Khaya anthotheca	Scarlet	Tree		x	x
	Khaya ivorensis	Scarlet	Tree		x	
	Lovoa trichilioides	Red	Tree		x	x
	Trichilia martineaui	Gold	Tree		x	x
	Trichilia monodelpha	Green	Tree		x	x
	Trichilia prieureana	Green	Tree		x	x
	Trichilia tessmannii	Green	Tree			x
	Turreanthus africanus	Pink	Tree	x	x	x
Moraceae	*Ficus cyathistipula*	Green	Tree		x	
	Ficus exasperata	Green	Tree		x	
	Ficus sagittifolia	Green	Tree	x	x	
	Ficus saussureana	Blue	Tree		x	
	Ficus sp.			x		
	Ficus sur	Green	Tree		x	x
	Milicia excelsa	Scarlet	Tree		x	x
	Morus mesozygia	Green	Tree		x	
	Musanga cecrepioides	Green	Tree		x	x
	Myrianthus arboreaus	Green	Tree		x	x
	Myrianthus libericus	Green	Tree		x	x
	Treculia africana	Green	Tree		x	
	Trilepisium madagascariense	Green	Tree	x	x	x
Myristicaceae	*Lophira alata*	Red	Tree		x	x
	Pycnanthus angolensis	Pink	Tree		x	x
Ochnaceae	*Ochna afzelii*	Blue	Tree		x	
	Ochna membranacea	Green	Tree			x
	Ochna staudtii	Green	Tree		x	x
	Ouratea calantha	Blue	Tree		x	
Olacaceae	*Octoknema borealis*	Green	Tree	x	x	x
	Olax subscorpioidea	Green	Tree		x	
	Strombosia glaucescens	Green	Tree	x	x	x
Palmae	*Calamus deeratus*	Pink	Climber	x	x	
	Elaeis guineensis	Pink	Tree		x	x
	Eresmospata hookeri	Pink	Climber	x	x	x
	Eresmospata macrocarpa	Pink	Climber	x	x	x
	Laccosperma secundiflorum	Pink	Climber			x
	Laccosperma opacum	Pink	Climber	x	x	x
	Raphia hookeri	Green	Tree	x	x	
Pandaceae	*Microdesmis puberula*	Green	Tree		x	x
	Panda oleosa	Green	Tree		x	
Papilionaceae	*Baphia nitida*	Green	Tree		x	x
	Baphia pubescens	Green	Tree		x	x
	Erythrina mildbraedii	Green	Tree		x	
	Erythrina vogelii	Blue	Tree		x	
Passifloraceae	*Smeathmannia pubescens*	Green	Tree		x	
Piperaceae	*Piper capense*	Green	Herb		x	
	Piper guineensis	Green	Climber		x	x
	Piper umbellatum	Green	Herb		x	
Rhamnaceae	*Maesopsis eminii*	Green	Tree	x		x

Family	Scientific name	Star rating	Habit	Atiwiredu	Asiakwa South	Asiakwa North
Rhizophoraceae	*Anopyxis klaineana*	Red	Tree	x	x	x
Rutaceae	*Zanthoxylum gilletii*	Green	Tree		x	x
	Zanthoxylum leprieurii	Green	Tree		x	x
Rubiaceae	*Aidia genipiflora*	Green	Tree		x	x
	Aulacocalyx jasminiflora	Green	Tree	x		x
	Bertiera racemosa	Green	Tree	x	x	x
	Corynanthe pachyceras	Green	Tree		x	x
	Craterispermum caudatum	Green	Tree		x	x
	Geophila afzelii	Green	Herb		x	
	Geophila hirsuta		Herb	x	x	x
	Ixora occidentalis	Green	Shrub			x
	Ixora tenuis	**Black**	**Shrub**		**x**	**x**
	Massularia acuminata	Green	Tree		x	
	Nauclea diderrichii	Scarlet	Tree	x	x	x
	Oxyanthus speciosus	Green	Shrub		x	x
	Oxyanthus unilocularis	Green	Shrub	x	x	
	Pausinystalia lane-poolei	Gold	Tree		x	x
	Pavetta mollis	Green	Shrub		x	x
	Psychotria brassii	Blue	Shrub	x		x
	Psychotria ivorensis	Gold	Shrub	x		x
	Psychotria longituba	**Black**	**Herb**	**x**		
	Psychotria subglabra	**Black**	**Herb**	**x**		
	Psydrax arnoldiana	Blue	Tree		x	
	Psydrax subcordata	Green	Tree		x	
	Psydrax parviflora	Green	Tree		x	
	Robynsia glabrata	Gold	Tree			x
	Rothmania hispida	Green	Tree	x	x	x
	Rothmania megalostigma	Blue	Tree			x
	Tricalysia discolour	Green	Tree	x	x	x
	Tricalysia pallens	Green	Tree			x
Santalaceae	*Okoubaka aubrevillei*	Gold	Tree		x	
Sapindaceae	*Blighia sapida*	Green	Tree	x	x	x
	Chytranthus carneus	Green	Tree	x	x	
	Chytranthus caulifloris	Blue	Tree			x
	Chytranthus macrobotrys	Blue	Tree			x
	Milletia chrysophylla		Climber		x	x
	Placodiscus boya	Gold	Tree		x	x
Sapotaceae	*Afrosersalisia afzelii*	Green	Tree	x		x
	Bequaertiodendron oblanceolatum	Blue	Tree			x
	Chrysophyllum albidum	Pink	Tree	x		x
	Chrysophyllum gigantum	Pink	Tree		x	x
	Chrysophyllum perpulchrum	Green	Tree		x	
	Chrysophyllum subnudum	Green	Tree	x	x	x
	Neolemonniera clitandrifolia	**Black**	**Tree**			**x**
	Omphalocarpum ahia	Blue	Tree		x	x
	Omphalocarpum elatum	Green	Tree		x	x
	Tieghemella heckeii	Scarlet	Tree	x		x
Simaroubaceae	*Hannoa klaineana*	Green	Tree	x	x	x
Smilacaceae	*Smilax kraussiana*	Green			x	x

Family	Scientific name	Star rating	Habit	Atiwiredu	Asiakwa South	Asiakwa North
Solanaceae	*Solanum erianthum*	Green			x	
	Solanum torvum		Shrub		x	
Sterculiaceae	*Cola boxiana*	Gold		x	x	x
	Cola gigantea	Green	Tree		x	x
	Cola lateritia	Green	Tree		x	x
	Cola nitida	Pink	Tree	x	x	
	Cola verticillata	Green		x	x	x
	Nesogordonia papaverifera	Pink	Tree		x	x
	Sterculia oblonga	Green	Tree	x		
	Sterculia tragacantha	Green	Tree		x	
	Triplochiton scleroxylon	Scarlet	Tree		x	
Tiliaceae	*Desplatsia chrysochlamys*	Green	Tree	x	x	
	Desplatsia dewevrei	Green	Tree	x		x
	Desplatsia suberiacarpa	Green	Tree	x	x	
	Duboscia viridiflora	Green	Tree	x		
Ulmaceae	*Celtis adolfi-friderici*	Green	Tree		x	
	Celtis mildbraedii	Green	Tree		x	x
	Trema orientalis	Green	Tree		x	x
Verbenaceae	*Lantana camara*				x	
	Vitex ferruginea	Green	Tree		x	
	Vitex grandifolia	Blue	Tree	x	x	x
Violaceae	*Rinorea dentata*	Green			x	
	Rinorea oblongifolia	Green	Tree	x	x	x
Vitaceae	*Cisuss aralioides*	Green	Climber		x	x
	Cisuss producta	Green	Climber		x	x
Zingiberaceae	*Aframomum atewae*	Blue		x	x	x
	Aframomum stanfieldii	Blue		x	x	x
	Costus afer	Green			x	x
	Costus deistelii	Green	Herb	x	x	
	Costus dubius	Green	Herb	x		
	Costus engleranus	Green	Herb	x	x	x

Star ratings:

Black – Highly significant in context of global biodiversity; Rare globally and not widespread in Ghana
Gold – Significant in context of global biodiversity; fairly rare globally and/or nationally
Blue – Mainly of national biodiversity interest; e.g. globally widespread, nationally rare; or globally rare but of low concern in Ghana due to commonness
Scarlet – Common and widespread commercial species; potentially seriously threatened by overexploitation
Red – Common and widespread commercial species; under significant pressure from exploitation
Pink – Common and widespread commercial species; not currently under significant pressure from exploitation
Green – Species common and widespread in tropical Africa; no conservation concern

Appendix 3

Checklist of Odonata recorded from Ghana

Klaas-Douwe B. Dijkstra

Ghana: 1: recent records (also from current survey) obtained and/or identified by author (unpublished new national records marked with !); **2:** specimens kept in collections and identification confirmed by author; **3:** literature records, regarded as reliable because specimens were described well or record agrees with known biogeographic pattern; ***:** type locality lies in Ghana.
Atewa area / ARFR (strictly within boundaries of Atewa Range Forest Reserve): **1:** recorded during surveys (new national records marked with !); **0:** recorded previously.

		Atewa	inside	inside ARFR				outside ARFR			
	Ghana	area	ARFR	On0	Ade	Swp	For	Wan	Den	Bir	Aye
ZYGOPTERA											
Calopterygidae Selys, 1850											
***Phaon* Selys, 1853**											
Phaon camerunensis Sjöstedt, 1900	1!	1	1	1				1			
Phaon iridipennis (Burmeister, 1839)	1	1							1	1	
***Sapho* Selys, 1853**											
Sapho bicolor Selys, 1853	1	1	1	1	1	1					
Sapho ciliata (Fabricius, 1781)	1	1	1	1	1		1	1	1	1	1
***Umma* Kirby, 1890**											
Umma cincta (Hagen in Selys, 1853)	1	1	1	1				1	1		
Chlorocyphidae Cowley, 1937											
***Chlorocypha* Fraser, 1928**											
Chlorocypha curta (Hagen in Selys, 1853)	1	1							1		
Chlorocypha dispar (Palisot de Beauvois, 1805)	1	1	1	1	1						
Chlorocypha luminosa (Karsch, 1893)	1	1						1	1	0	1
Chlorocypha pyriformosa Fraser, 1947	1!										
Chlorocypha radix Longfield, 1959	1	1						1	1	1	
Chlorocypha rubida (Hagen in Selys, 1853)	2!										
Chlorocypha selysi Karsch, 1899	1	1	1	1							
Lestidae Calvert, 1901											
***Lestes* Leach, 1815**											
Lestes dissimulans Fraser, 1955	1	1	1			1					
Lestes ochraceus Selys, 1862	3										
Lestes pallidus Rambur, 1842	1!										
Lestes pinheyi Fraser, 1955	1!										
Coenagrionidae Kirby, 1890											
***Aciagrion* Selys, 1891**											
Aciagrion hamoni Fraser, 1955	1!										
***Africallagma* Kennedy, 1920**											
Africallagma glaucum (Burmeister, 1839)	3										

		Atewa	inside	inside ARFR				outside ARFR			
	Ghana	area	ARFR	On0	Ade	Swp	For	Wan	Den	Bir	Aye
Africallagma vaginale (Sjöstedt, 1917)	1!	1!	1			1					
***Agriocnemis* Selys, 1877**											
Agriocnemis exilis Selys, 1872	1!										
Agriocnemis maclachlani Selys, 1877	1	1							1		
Agriocnemis zerafica Le Roi, 1915	1	1							1		
***Azuragrion* May, 2002**											
Azuragrion vansomereni (Pinhey, 1955)	1!	1						1			
***Ceriagrion* Selys, 1876**											
Ceriagrion bakeri Fraser, 1941	2										
Ceriagrion corallinum Campion, 1914	1!	1						1			
Ceriagrion glabrum (Burmeister, 1839)	1	1	1			1			1		
Ceriagrion ignitum Campion, 1914	2*										
Ceriagrion rubellocerinum Fraser, 1947	1!	1	1			1	1				
Ceriagrion suave Ris, 1921	1										
***Ischnura* Charpentier, 1840**											
Ischnura senegalensis (Rambur, 1842)	1										
***Pseudagrion* Selys, 1876**											
Pseudagrion camerunense (Karsch, 1899)	1										
Pseudagrion emarginatum Karsch, 1893	1										
Pseudagrion epiphonematicum Karsch, 1891	1										
Pseudagrion gigas Schmidt in Ris, 1936	1!										
Pseudagrion glaucescens Selys, 1876	1										
Pseudagrion glaucoideum Schmidt, 1936	1!	1							1		
Pseudagrion glaucum (Sjöstedt, 1900)	1!										
Pseudagrion hamoni Fraser, 1955	1	1						1	1		
Pseudagrion hemicolon Karsch, 1899	1!										
Pseudagrion kersteni (Gerstäcker, 1869)	1	1							1		
Pseudagrion malagasoides Pinhey, 1973	1!										
Pseudagrion melanicterum Selys, 1876	1	1	1	1				1	1	1	1
Pseudagrion nubicum Selys, 1876	1										
Pseudagrion sjoestedti Förster, 1906	1	1						1	1	1	1
Pseudagrion sublacteum (Karsch, 1893)	1										
Pseudagrion sudanicum Le Roi, 1915	3										
Pseudagrion torridum Selys, 1876	1!										
Platycnemidae Tillyard, 1917											
***Mesocnemis* Karsch, 1891**											
Mesocnemis robusta (Selys, 1886)	1										
Mesocnemis singularis Karsch, 1891	1	1							1	0	1
***Platycnemis* Burmeister, 1839**											
Platycnemis guttifera Fraser, 1950	1	0								0	
Platycnemis sikassoensis (Martin, 1912)	1	1							1	0	
Protoneuridae Tillyard, 1917											
***Chlorocnemis* Selys, 1863**											
Chlorocnemis elongata Hagen in Selys, 1863	1	1	1			1					
Chlorocnemis flavipennis Selys, 1863	1	1	1	1	1						
Chlorocnemis subnodalis (Selys, 1886)	1	0					0				
***Elattoneura* Cowley, 1935**											
Elattoneura balli Kimmins, 1938	1!	0					0				
Elattoneura girardi Legrand, 1980	1!										
Elattoneura nigra Kimmins, 1938	1	1						1	1	0	

		Atewa	inside	inside ARFR				outside ARFR			
	Ghana	area	ARFR	OnO	Ade	Swp	For	Wan	Den	Bir	Aye
***Prodasineura* Cowley, 1934**											
Prodasineura villiersi Fraser, 1948	1	1	1	1							
ANISOPTERA											
Aeshnidae Rambur, 1842											
***Anax* Leach, 1815**											
Anax ephippiger (Burmeister, 1839)	1										
Anax imperator Leach, 1815	1!	1						1			
Anax tristis Hagen, 1867	1										
***Gynacantha* Rambur, 1842**											
Gynacantha africana (Palisot de Beauvois, 1805)	1!										
Gynacantha bullata Karsch, 1891	1	1	1			1	1	1			
Gynacantha cylindrata Karsch, 1891	1										
Gynacantha manderica Grünberg, 1902	1										
Gynacantha nigeriensis (Gambles, 1956)	1!										
Gynacantha sextans McLachlan, 1896	1										
Gynacantha vesiculata Karsch, 1891	1										
***Heliaeschna* Selys, 1882**											
Heliaeschna fuliginosa Selys, 1883	1!										
Gomphidae Rambur, 1842											
***Crenigomphus* Selys, 1892**											
Crenigomphus renei Fraser, 1936	1										
***Diastatomma* Burmeister, 1839**											
Diastatomma gamblesi Legrand, 1992	1!	1	1	1							
***Gomphidia* Selys, 1854**											
Gomphidia gamblesi Gauthier, 1987	1!	1						1	1	1	
Gomphidia madi Pinhey, 1961	1										
***Ictinogomphus* Cowley, 1934**											
Ictinogomphus ferox (Rambur, 1842)	1										
Ictinogomphus fraseri Kimmins, 1958	1	1							1		
***Lestinogomphus* Martin, 1911**											
Lestinogomphus cf. *africanus* Fraser, 1926	3										
Lestinogomphus matilei Legrand & Lachaise, 2001	1!										
***Microgomphus* Selys, 1858**											
Microgomphus camerunensis Longfield, 1951	1!										
***Neurogomphus* Karsch, 1890**											
Neurogomphus fuscifrons Karsch, 1890	1!										
***Onychogomphus* Selys, 1854**											
Onychogomphus sp.	1!	1!	1	1							
***Paragomphus* Cowley, 1934**											
Paragomphus genei (Selys, 1841)	1										
Paragomphus nigroviridis Cammaerts, 1969	1										
Paragomphus serrulatus (Baumann, 1898)	1!	1!							1		
Paragomphus cf. *cognatus* (Rambur, 1842)	1!										
***Phyllogomphus* Selys, 1854**											
Phyllogomphus aethiops Selys, 1854	1!										
Phyllogomphus moundi Fraser, 1960	1!	1!							1		
***Tragogomphus* Sjöstedt, 1900**											
Tragogomphus sp.	1!	1!	1	1							
Corduliidae Selys, 1850											
***Neophya* Selys, 1881**											

		Atewa	inside	inside ARFR				outside ARFR			
	Ghana	area	ARFR	OnO	Ade	Swp	For	Wan	Den	Bir	Aye
Neophya rutherfordi Selys, 1881	3										
***Phyllomacromia* Selys, 1878**											
Phyllomacromia africana Hagen, 1871	1!										
Phyllomacromia contumax Selys, 1879	1										
Phyllomacromia hervei (Legrand, 1980)	1!										
Phyllomacromia legrandi (Gauthier, 1987)	1!	1!	1	1							
Phyllomacromia pseudafricana (Pinhey, 1961)	1										
Phyllomacromia sophia (Selys, 1871)	2*										
Libellulidae Rambur, 1842											
***Acisoma* Rambur, 1842**											
Acisoma panorpoides Rambur, 1842	1	1						1			
Acisoma trifidum Kirby, 1889	1!										
***Aethiothemis* Martin, 1908**											
Aethiothemis palustris Martin, 1912	1!										
***Aethriamanta* Kirby, 1889**											
Aethriamanta rezia Kirby, 1889	1	1						1			
***Atoconeura* Karsch, 1899**											
Atoconeura luxata Dijkstra, 2006	1!	1!	1	1							
***Brachythemis* Brauer, 1868**											
Brachythemis lacustris (Kirby, 1889)	1										
Brachythemis leucosticta (Burmeister, 1839)	1										
***Bradinopyga* Kirby, 1893**											
Bradinopyga strachani (Kirby, 1900)	1										
***Chalcostephia* Kirby, 1889**											
Chalcostephia flavifrons Kirby, 1889	1										
***Crocothemis* Brauer, 1868**											
Crocothemis divisa Baumann, 1898	1										
Crocothemis erythraea (Brullé, 1832)	1										
Crocothemis sanguinolenta (Burmeister, 1839)	1!	1						1			
***Cyanothemis* Ris, 1915**											
Cyanothemis simpsoni Ris, 1915	1	1							1	1	
***Diplacodes* Kirby, 1889**											
Diplacodes lefebvrii (Rambur, 1842)	1	1						1			
Diplacodes luminans (Karsch, 1893)	1										
***Eleuthemis* Ris, 1910**											
Eleuthemis buettikoferi Ris, 1910	1!	0								0	
Eleuthemis n. sp.	1!	1						1			
***Hadrothemis* Karsch, 1891**											
Hadrothemis camarensis (Kirby, 1889)	1	1	1				1				
Hadrothemis coacta (Karsch, 1891)	1	1	1				1				
Hadrothemis defecta (Karsch, 1891)	1!										
Hadrothemis infesta (Karsch, 1891)	1	1	1			1					
Hadrothemis versuta (Karsch, 1891)	1!										
***Hemistigma* Kirby, 1889**											
Hemistigma albipunctum (Rambur, 1842)	1										
***Lokia* Ris, 1919**											
Lokia incongruens (Karsch, 1893)	1!										
***Micromacromia* Karsch, 1890**											
Micromacromia zygoptera (Ris, 1909)	1	1	1	1	1						
***Neodythemis* Karsch, 1889**											

		Atewa	inside	inside ARFR				outside ARFR			
	Ghana	area	ARFR	OnO	Ade	Swp	For	Wan	Den	Bir	Aye
*Neodythemis klingi (*Karsch, 1890)	1	1	1	1	1			1	1		
***Nesciothemis* Longfield, 1955**											
Nesciothemis minor Gambles, 1966	1!	1							1		
Nesciothemis pujoli Pinhey, 1971	1	1						1	1		
***Notiothemis* Ris, 1919**											
Notiothemis robertsi Fraser, 1944	1!	0					0				
***Olpogastra* Karsch, 1895**											
Olpogastra lugubris (Karsch, 1895)	1	1							1		
***Orthetrum* Newman, 1833**											
Orthetrum abbotti Calvert, 1892	1										
Orthetrum africanum (Selys, 1887)	1!										
Orthetrum angustiventre (Rambur, 1842)	1										
Orthetrum austeni (Kirby, 1900)	1!	1						1			
Orthetrum brachiale (Palisot de Beauvois, 1805)	1										
Orthetrum chrysostigma (Burmeister, 1839)	1										
Orthetrum guineense Ris, 1909	1										
Orthetrum hintzi Schmidt, 1951	1										
Orthetrum icteromelas Ris, 1910	1!										
Orthetrum julia Kirby, 1900	1	1	1	1	1	1	1	1			
Orthetrum microstigma Ris, 1911	1	1						1			
Orthetrum monardi Schmidt, 1951	1										
Orthetrum saegeri Pinhey, 1966	1!	1!	1	1							
Orthetrum stemmale (Burmeister, 1839)	1	1							1		
Orthetrum trinacria (Selys, 1841)	1!										
***Oxythemis* Ris, 1909**											
Oxythemis phoenicosceles Ris, 1909	1!										
***Palpopleura* Rambur, 1842**											
Palpopleura deceptor (Calvert, 1899)	1										
Palpopleura lucia (Drury, 1773)	1	1	1			1	1	1	1		
Palpopleura portia (Drury,1773)	1	1							1		
***Pantala* Hagen, 1861**											
Pantala flavescens (Fabricius, 1798)	1	1						1	1		1
***Parazyxomma* Pinhey, 1961**											
Parazyxomma flavicans (Martin, 1908)	1										
***Rhyothemis* Hagen, 1867**											
Rhyothemis fenestrina (Rambur,1842)	1!										
Rhyothemis notata (Fabricius, 1781)	1!										
Rhyothemis semihyalina (Desjardins, 1832)	1!										
***Tetrathemis* Brauer, 1868**											
Tetrathemis camerunensis (Sjöstedt, 1900)	1	1	1			1		1			
Tetrathemis godiardi Lacroix, 1921	1*										
Tetrathemis polleni (Selys, 1877)	1!										
***Thermochoria* Kirby, 1889**											
Thermochoria equivocata Kirby, 1889	1	1	1			1					
***Tholymis* Hagen, 1867**											
Tholymis tillarga (Fabricius, 1798)	1	0					0				
***Tramea* Hagen, 1861**											
Tramea basilaris (Palisot de Beauvois, 1805)	1	1	1				1	1			
Tramea limbata (Desjardins, 1832)	1	1						1			
***Trithemis* Brauer, 1868**											

		Atewa	inside	inside ARFR				outside ARFR			
	Ghana	area	ARFR	OnO	Ade	Swp	For	Wan	Den	Bir	Aye
Trithemis aconita Lieftinck, 1969	1										
Trithemis annulata (Palisot de Beauvois, 1805)	1										
Trithemis arteriosa (Burmeister, 1839)	1	1						1	1		
Trithemis basitincta Ris, 1912	1!										
Trithemis bifida Pinhey, 1970	1!										
Trithemis bredoi Fraser, 1953	1!										
Trithemis dejouxi Pinhey, 1978	1										
Trithemis dichroa Karsch, 1893	1										
Trithemis grouti Pinhey, 1961	1										
Trithemis imitata Pinhey, 1961	1!										
Trithemis kirbyi Selys, 1891	1										
Trithemis pruinata Karsch, 1899	1										
Trithemis stictica (Burmeister, 1839)	1!										
***Trithetrum* Dijkstra & Pilgrim, 2007**											
Trithetrum navasi (Lacroix, 1921)	1!	1						1			
***Urothemis* Brauer, 1868**											
Urothemis assignata (Selys, 1872)	1										
Urothemis edwardsii (Selys, 1849)	1	1						1			
***Zygonoides* Fraser, 1957**											
Zygonoides fraseri Pinhey, 1955	1!										
***Zygonyx* Hagen, 1867**											
Zygonyx chrysobaphes (Ris, 1915)	1!	1						1	1		
Zygonyx flavicosta (Sjöstedt, 1900)	1	1						1			
Zygonyx geminunca Legrand, 1997	1!										
Zygonyx natalensis (Martin, 1900)	1!										
Zygonyx torridus (Kirby, 1889)	1	1							1		

Appendix 4

Checklist of butterflies from the Atewa Range Forest Reserve with a list of those collected at each site during the 2006 RAP survey

Kwaku Aduse-Poku and Ernestina Doku-Marfo

This is the latest butterfly checklist of Ghana and it is adopted from Larsen (2006). It includes all butterfly species known from Ghana.

Abbreviations:

The following three-letter codes are used for study sites:
ATE = Atewa Forest Reserve
ANT = Atiwiredu camp site
ASS = Asiakwa South camp site
ASN = Asiakwa North camp site
MRT = Main road transect
RAP = all species recorded during the RAP mission

CAPITAL letters	imply that the species has been authoritatively recorded from the locality e.g. ATE
lower case letters	imply that the species is almost certain to occur in the locality e.g. ate
ooo	implies that the species might occur in the locality
—	implies that the species does not occur in the locality

All species are roughly allocated to a main habitat type. Many butterflies are quite flexible in their requirements and the classification is still a rough guide (**hab**)
WEF implies that the species is centered on Wet Evergreen Forest
MEF implies that the species is centered on Moist Forests
DRF implies that the species is centered on Drier Semi-deciduous and marginal forests
ALF implies that the species is found in any type of forest
GUI implies that the species is centered on the Guinea Savannah
SUD implies that the species is centered on the Sudan Savannah
SPE implies that the species is found in special habitats
UBQ species that are practically ubiquitous through all habitats in most of Africa

The species are roughly graded by rarity, though this is always a difficult call to make. Very rare species may one day be numerous in a single locality. Very common butterflies are sometimes absent. However, the following notations are used (**rarity**):
VC = very common – species that are usually found on any visit to a suitable locality
CO = common – species that are usually found on 75% of visits to most suitable localities
NR = not rare – met with frequently but often not common
RA = rare – species that are usually found on less than 10-20% of visits to most suitable localities
VR = very rare – species that are usually found on less than 5% of visits to most suitable localities

The superscript ($^{ww, en, vo}$) denote endemism. Below is the meaning of the notations.
ww = endemic to Africa west of the Dahomey Gap
en = endemic to the Ghana subregion of West Africa
vo = endemic to the Volta Region of Ghana and Togo

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
	PAPILIONIDAE											
			Papilio									
1				*antimachus*	*antimachus*	WEF	VR	ATE				
2				*zalmoxis*		WEF	VR	ooo				
4				*dardanus*	*dardanus*	ALF	NR	ATE				x
5				*phorcas*	*phorcas*	ALF	RA	ATE				
7				*horribilis*		WEF	NR	ATE^{ww}				
9				*chrapkowskoides*	*nurettini*	MEF	CO	ATE				
10				*sosia*	*sosia*	ALF	NR	ATE				
11				*nireus*	*nireus*	ALF	CO	ATE				
12				*menestheus*	*menestheus*	WEF	CO	ATE				
13				*demodocus*	*demodocus*	UBQ	VC	ATE		x		
15				*cyproeofila*	*cyproeofila*	MEF	CO	ATE		x		
16				*zenobia*		MEF	NR	ATE		x		
17				*nobicea*		MEF	NR	—vo				
18				*cynorta*	*cynorta*	MEF	NR	ATE				
			Graphium									
20				*angolanus*	*baronis*	GUI	CO	ATE				
22				*tynderaeus*		WEF	RA	ATE				
23				*latreillianus*	*latreillianus*	WEF	NR	ATE	x			
24				*almansor*	*carchedonius*	DRF	NR	—				
25				*adamastor*		DRF	NR	ooo				
26				*agamedes*		DRF	RA	—				
28				*rileyi*		WEF	RA	ATE^{en}				
29				*leonidas*	*leonidas*	UBQ	CO	ATE				x
30				*illyris*	*illyris*	WEF	NR	ATE				
31				*policenes*		ALF	CO	ATE		x		
32				*liponesco*		WEF	NR	ate				
34				*antheus*		ALF	NR	ATE				
	PIERIDAE											
		PSEUDOPONTIINAE										
			Pseudopontia									
35				*paradoxa*	*paradoxa*	WEF	NR	ooo				
		COLIADINAE										
			Catopsilia									
36				*florella*		UBQ	VC	ATE	x	x	x	
			Eurema									
38				*senegalensis*		MEF	CO	ATE	x	x	x	
39				*hecabe*	*solifera*	UBQ	VC	ATE	x	x	x	
40				*floricola*	*leonis*	UBQ	NR	ATE		x		
41				*hapale*		SPE	VR	ate				
42				*desjardinsii*	*regularis*	UBQ	NR	ate				
43				*brigitta*	*brigitta*	GUI	NR	ATE				x
		PIERINAE										

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
			Pinacopteryx									
44				*eriphia*	*tritogenia*	SUD	NR	—				
			Nepheronia									
45				*argia*	*argia*	ALF	CO	ATE				x
46				*thalassina*	*thalassina*	ALF	CO	ATE	x	x		
47				*pharis*	*pharis*	ALF	CO	ATE				
			Colotis									
54				*vesta*	*amelia*	SUD	NR	—				
57				*celimene*	*sudanicus*	SUD	RA	—				
58				*ione*		SUD	NR	—				
60				*danae*	*eupompe*	SUD	NR	—				
61				*aurora*	*evarne*	SUD	NR	—				
62				*antevippe*	*antevippe*	SUD	NR	ooo				
63				*euippe*	*euippe*	UBQ	CO	ATE				
65				*evagore*	*antigone*	SUD	CO	ooo				
			Belenois									
68				*aurota*		SUD	CO	ooo				
69				*creona*	*creona*	SUD	VC	ate				
70				*gidica*	*gidica*	SUD	NR	ooo				
72				*subeida*	*frobeniusi*	SUD	NR	—				
73				*calypso*	*calypso*	ALF	VC	ATE				
74				*theora*	*theora*	MEF	CO	ATE				x
76				*hedyle*	*hedyle*	DRF	NR	ATE				
			Dixeia									
78				*doxo*	*doxo*	SUD	NR	—				
79				*orbona*	*orbona*	SUD	NR	—				
80				*cebron*		DRF	NR	ooo				
81				*capricornus*	*capricornus*	DRF	NR	ooo				
			Appias									
84				*sylvia*	*sylvia*	ALF	CO	ATE				
85				*phaola*	*phaola*	WEF	NR	ATE				
86				*sabina*	*sabina*	MEF	CO	ATE				
87				*epaphia*	*epaphia*	UBQ	CO	ate				
			Leptosia									
88				*alcesta*	*alcesta*	ALF	vc	ATE	x	x	x	
90				*hybrida*	*hybrida*	ALF	CO	ATE	x	x	x	
91				*medusa*		ALF	CO	ATE	x	x	x	
92				*marginea*		MEF	NR	ATE				
93				*wigginsi*	*pseudalcesta*	ALF	NR	ate				
			Mylothris									
95				*chloris*	*chloris*	UBQ	VC	ATE				
100				*dimidiata*		WEF	NR	ATE^{ww}				
103				*aburi*		DRF	NR	—				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
106				*poppea*		MEF	NR	ATE[ww]				
107				*spica*		MEF	NR	ATE[en]				
109				*rhodope*		ALF	CO	ATE		x		
110				*jaopura*		ALF	CO	ATE				
111				*schumanni*	*schumanni*	MEF	NR	ATE				
112				*atewa*		WEF	NR	ATE[en]				
	LYCAENIDAE											
		MILETINAE										
			Euliphyra									
114				*hewitsoni*		MEF	RA	ate				
115				*mirifica*		MEF	RA	ate				
116				*leucyania*		WEF	RA	ate				
			Aslauga									
117				*ernesti*		DRF	VR	—				
118				*marginalis*		MEF	NR	ate				
121				*lamborni*		WEF	RA	ATE		x		
124				*imitans*		MEF	RA	—				
			Megalopalpus									
127				*zymna*		ALF	CO	ATE				
129				*metaleucus*		MEF	NR	ATE		x		
			Spalgis									
130				*lemolea*		DRF	NR	ATE				
			Lachnocnema									
131				*vuattouxi*		DRF	NR	ATE				
133				*emperanus*		DRF	NR	ate				
135				*disrupta*		MEF	RA	???				
136				*reutlingeri*	*reutlingeri*	MEF	RA	ATE				
137				*luna*		WEF	RA	—				
139				*albimacula*		WEF	RA	???				
		LIPTENINAE										
			Ptelina									
141				*carnuta*		MEF	NR	ATE		x		
			Pentila									
142				*pauli*	*pauli*	DRF	NR	ATE				
144				*petreoides*		WEF	VR	ATE[ww]				
147				*petreia*		MEF	CO	ATE				
152				*picena*		MEF	NR	ATE				
155				*phidia*		MEF	NR	ATE[en]				
157				*hewitsonii*	*hewitsonii*	MEF	NR	ATE				
			Telipna									
159				*acraea*	*acraea*	WEF	NR	ATE				
160				*semirufa*		WEF	NR	ATE[ww]				
161				*maesseni*		WEF	NR	—[vo]				
			Ornipholidotos									

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
170				*nigeriae*		WEF	RA	ATE				
171				*onitshae*		WEF	RA	ATE		x	x	
172				*irwini*		WEF	RA	ATE				
173				*issia*		WEF	RA	ATE[ww]				
174				*tiassale*		WEF	NR	ATE[ww]				
175				*nympha*		WEF	RA	ATE				
			Torbenia									
177				*wojtusiaki*		WEF	RA	ATE				
			Mimacraea									
179				*neurata*		WEF	RA	ATE				
181				*darwinia*		WEF	NR	ATE[ww]				
182				*maesseni*		WEF	NR	—[en]				
			Mimeresia									
184				*libentina*		ALF	CO	ATE				
185				*moyambina*		WEF	VR	ATE[ww]				
186				*debora*	*catori*	WEF	VR	ooo				
187				*semirufa*		WEF	RA	ATE[en]				
190				*cellularis*		WEF	RA	ATE			x	
191				*issia*		WEF	RA	ATE[en]				
			Pseuderesia									
192				*eleaza*	*eleaza*	WEF	NR	ATE				
			Eresiomera									
193				*bicolor*		MEF	NR	ATE				
194				*isca*	*occidentalis*	WEF	RA	ATE				
195				*jacksoni*		WEF	VR	ate[en]				
197				*petersi*		WEF	RA	ATE[en]				
			Citrinophila									
199				*marginalis*		MEF	CO	ATE				
200				*similis*		MEF	CO	ATE				
202				*erastus*	*erastus*	WEF	NR	ATE				
			Eresina									
204				*maesseni*		MEF	RA	ate				
206				*pseudofusca*		MEF	RA	ooo				
210				*saundersi*		MEF	RA	ooo				
212				*theodori*		MEF	RA	ate				
			Argyrocheila									
213				*undifera*	*undifera*	WEF	RA	ATE				
			Liptena									
216				*submacula*		MEF	NR	ATE				
217				*griveaudi*		WEF	VR	ATE[en]				
218				*simplicia*		MEF	CO	ATE				
222				*tiassale*		MEF	RA	ooo[en]				
224				*albicans*		WEF	RA	ATE				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
225				*alluaudi*		WEF	NR	ATE				
226				*fatima*		???	VR	ooo				
227				*pearmani*		WEF	VR	—				
229				*ferrymani*	*bigoti*	DRF	RA	—				
231				*septistrigata*		DRF	NR	ATE				
232				*evanescens*		WEF	RA	ate				
234				*xanthostola*	*coomassiensis*	WEF	RA	ATE				
236				*rochei*		DRF	RA	ATE				
237				*flavicans*		MEF	RA	ATE				
239				*seyboui*		WEF	VR	ooo^{en}				
240				*similis*		WEF	RA	ATE				
242				*helena*		WEF	NR	ATE^{ww}				
243				*catalina*		WEF	NR	ATE	x			
			Kakumia									
246				*otlauga*		WEF	NR	ATE				
			Falcuna									
249				*leonensis*		MEF	CO	ATE^{ww}				
252				*campimus*		WEF	NR	ATE				
			Tetrarhanis									
254				*symplocus*		MEF	CO	ATE	x	x	x	
255				*baralingam*		WEF	RA	ate^{ww}	x			
260				*stempfferi*	*stempfferi*	WEF	VR	ATE				
			Larinopoda									
264				*aspidos*		MEF	NR	—				
265				*eurema*		MEF	CO	ATE^{ww}	x	x		
			Micropentila									
266				*adelgitha*		MEF	CO	ATE				
267				*adelgunda*		MEF	VR	ate				
268				*dorothea*		MEF	NR	ATE				
270				*brunnea*	*brunnea*	WEF	RA	ATE				
275				*mamfe*		WEF	VR	ooo^{en}				
			Iridana									
278				*incredibilis*		ALF	RA	ate				
279				*ghanana*		ALF	VR	—				
280				*exquisuta*		MEF	RA	ate				
281				*nigeriana*		ALF	RA	ate				
282				*hypocala*		MEF	VR	ooo				
			Hewitsonia									
283				*boisduvalii*		WEF	NR	ATE				
284				*occidentalis*		MEF	RA	ate				
286				*inexpectata*		MEF	NR	ATE				
			Cerautola									
289				*crowleyi*	*crowleyi*	MEF	NR	ate				
291				*ceraunia*		MEF	NR	ate				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
			Epitola									
294				*posthumus*		MEF	NR	ATE				
295				*uranoides*	*occidentalis*		RA	ate				
296				*urania*		MEF	RA	ATE				
			Cephetola									
297				*cephena*	*cephena*	MEF	NR	ate				
299				*pinodes*	*pinodes*	MEF	RA	ate				
300				*subcoerulea*		MEF	RA	ooo				
302				*mercedes*	*ivoriensis*	MEF	RA	ooo				
303				*obscura*		MEF	RA	ATE				
305				*sublustris*		MEF	NR	ooo				
306				*maesseni*		MEF	RA	ooo^{vo}				
307				*collinsi*		MEF	VR	—^{en}				
			Hypophytala									
308				*hyettoides*		MEF	NR	ate				
310				*hyettina*		MEF	RA	ATE				
311				*henleyi*		MEF	RA	ate				
312				*benitensis*	*benitensis*	WEF	RA	ate				
			Phytala									
314				*elais*	*elais*	WEF	RA	ATE				
			Geritola									
315				*gerina*		WEF	RA	ooo				
320				*virginea*		WEF	RA	ate				
			Stempfferia									
322				*cercene*		WEF	RA	ate				
324				*moyambina*		WEF	NR	ATE				
326				*dorothea*		WEF	NR	ate^{ww}				
330				*leonina*		MEF	NR	ate^{ww}				
334				*ciconia*	*ciconia*	WEF	NR	ATE				
335				*zelza*		WEF	RA	—				
340				*michelae*	*michelae*	ALF	NR	ATE				
342				*kholifa*		WEF	NR	ate				
344				*staudingeri*		WEF	RA	ATE^{ww}				
			Aethiopana									
346				*honorius*	*divisa*	WEF	NR	ATE				
			Epitolina									
347				*dispar*		MEF	CO	ATE		x		
348				*melissa*		MEF	CO	ATE				
350				*catori*	*catori*	WEF	NR	ATE				
			Neaveia									
352				*lamborni*	*lamborni*	MEF	RA	ate		x		
		THECLINAE										
			Myrina									
354				*silenus*	*silenus*	GUI	NR	ooo				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
355				*subornata*	*subornata*	GUI	RA	—				
			Oxylides									
356				*faunus*	*faunus*	MEF	CO	ATE	x	x	x	
			Dapidodigma									
359				*hymen*		MEF	NR	ate				
360				*demeter*	*demeter*	MEF	RA	ATE				
			Aphnaeus									
361				*orcas*		MEF	NR	ate				
362				*argyrocyclus*		MEF	RA	ooo				
363				*asterius*			RA	ATE				
364				*brahami*		GUI	RA	—				
365				*jefferyi*			VR	ooo				
366				*charboneli*			VR	ooo				
367				*gilloni*		MEF	VR	ooo				
			Apharitis									
368				*nilus*		SUD	RA	—				
			Spindasis									
369				*mozambica*		GUI	NR	ate				
370				*avriko*		GUI	RA	—				
371				*crustaria*			RA	—				
372				*iza*			RA	ATE[ww]				
373				*menelas*			VR	ate				
			Zeritis									
374				*neriene*		SUD	NR	ooo				
			Axiocerses									
375				*harpax*		GUI	NR	ATE				
377				*amanga*		SUD	RA	—				
			Lipaphnaeus									
378				*leonina*	*leonina*	MEF	NR	ATE				
379				*aderna*	*aderna*	GUI	NR	ooo				
			Pseudaletis									
380				*agrippina*		MEF	VR	ooo				
386				*subangulata*			VR	—[en]				
390				*dardanella*		MEF	VR	ooo				
391				*leonis*		MEF	RA	ate				
			Iolaus									
			Subgenus *Iolaus*									
392				*eurisus*		ALF	NR	ATE	x		x	
			Subgenus *Iolaphilus*									
393				*menas*	*menas*	SUD	NR	—				
395				*carolinae*		MEF	VR	ate[en]				
397				*iulus*		MEF	NR	ATE	x	x		
			Subgenus *Argiolaus*									

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
398				*ismenias*		SUD	NR	ooo				
400				*alcibiades*		MEF	RA	ate				
401				*parasilanus*	*maesseni*	MEF	RA	—				
402				*paneperata*		MEF	NR	ATE				
403				*lukabas*		MEF	RA	ate				
404				*mane*		MEF	RA	ATE[ww]				
405				*theodori*		MEF	VR	—[vo]				
406				*likpe*		MEF	VR	—[vo]				
407				*calisto*		MEF	NR	ate				
408				*laonides*		WEF	RA	ooo				
			Subgenus *Tanuetheira*									
410				*timon*	*timon*	MEF	RA	ATE				
			Subgenus *Epamera*									
411				*alienus*	*bicaudatus*	SUD	RA	—				
414				*scintillans*		SUD	NR	—				
415				*laon*	*laon*	MEF	NR	ooo				
418				*banco*		WEF	RA	—[en]				
426				*sappirus*		WEF	RA	ooo				
428				*bellina*	*bellina*	MEF	NR	ate				
432				*fontainei*		WEF	RA	—				
434				*aethria*		MEF	RA	ATE	x			
435				*farquharsoni*		MEF	RA	ate				
436				*iasis*	*iasis*	ALF	NR	ate				
437				*maesa*		MEF	RA	ate				
			Etesiolaus									
439				*catori*	*catori*	ALF	RA	ate				
440				*kyabobo*		DRF	RA	ooo				
			Stugeta									
441				*marmoreus*	*marmoreus*	SUD	NR	—				
			Hypolycaena									
443				*philippus*	*philippus*	GUI	CO	ATE				x
444				*kadiskos*		MEF	RA	ATE				
445				*liara*	*liara*	MEF	RA	ATE				
446				*lebona*	*lebona*	WEF	NR	ATE		x		
447				*clenchi*		WEF	RA	ATE[ww]			x	
449				*scintillans*		ALF	CO	ATE				
450				*dubia*		ALF	CO	ATE	x			
451				*kakumi*		MEF	CO	ATE				
452				*antifaunus*	*antifaunus*	MEF	NR	ATE	x	x		
453				*hatita*	*hatita*	MEF	CO	ATE				
455				*nigra*		WEF	CO	ATE				
			Pilodeudorix									
457				*camerona*	*camerona*	MEF	NR	ate				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
458				*diyllus*	*diyllus*	MEF	NR	ATE				
460				*caerulea*	*caerulea*	GUI	NR	ate				
461				*zela*		WEF	RA	ATE				
462				*catori*		DRF	RA	ooo				
467				*otraeda*		MEF	NR	ATE				
468				*leonina*	*leonina*	MEF	NR	ATE				
469				*virgata*		MEF	RA	ATE				
473				*deritas*		MEF	RA	ate				
474				*aucta*		MEF	RA	—				
475				*pseudoderitas*		MEF	RA	ate				
476				*laticlavia*		MEF	RA	ATE				
477				*aurivilliusi*		WEF	RA	ATE[ww]				
478				*kiellandi*		WEF	RA	ATE				
479				*corruscans*	*kakumi*	WEF	VR	ooo				
480				*violetta*		WEF	RA	ATE				
481				*fumata*		WEF	VR	ooo				
			Paradeudorix									
484				*eleala*	*viridis*	ALF	NR	ATE				
487				*moyambina*		WEF	VR	ATE				
			Hypomyrina									
491				*mimetica*		MEF	RA	ate				
492				*nomion*	*nomion*	DRF	NR	ate				
			Deudorix									
494				*antalus*		GUI	CO	ATE				
495				*livia*		SUD	VR	—				
496				*lorisona*	*lorisona*	ALF	NR	ATE				
497				*kayonza*	*ssp*	WEF	RA	ATE				
498				*dinochares*		GUI	RA	ooo				
499				*dinomenes*	*diomedes*	DRF	RA	ate				
500				*odana*	*odana*	ALF	NR	ATE				
501				*galathea*		ALF	NR	ATE				
502				*caliginosa*		MEF	RA	ATE				
			Capys									
506				*vorgasi*		SPE	VR	—[vol]				
		POLYOMMATINAE										
			Anthene									
507				*rubricinctus*		MEF	CO	ATE		x		
508				*ligures*		MEF	RA	ate				
510				*sylvanus*	*sylvanus*	ALF	CO	ATE				
512				*liodes*	*liodes*	ALF	NR	ATE				
513				*definita*		GUI	NR	ATE				
514				*princeps*	*princeps*	GUI	NR	ATE				
515				*starki*		GUI	RA	—				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
516				*amarah*		SUD	NR	ooo				
517				*lunulata*		GUI	CO	ATE				
518				*kikuyu*		GUI	RA	ooo				
519				*talboti*		SUD	VR	—				
520				*wilsoni*		GUI	RA	—				
521				*levis*		ALF	NR	ate				
522				*irumu*		ALF	NR	ate				
523				*larydas*		ALF	CO	ATE				x
524				*crawshayi*	*crawshayi*	GUI	NR	ATE				
525				*lachares*	*lachares*	MEF	NR	ATE				
527				*lysicles*		WEF	NR	ATE				
530				*atewa*		WEF	RA	ATE^{en}				
532				*radiata*		WEF	VR	ATE^{ww}				
534				*locuples*		WEF	RA	ate				
537				*scintillula*	*aurea*	WEF	RA	ATE				
538				*helpsi*		WEF	VR	ATE^{en}				
539				*juba*		WEF	NR	ATE				
			Neurypexina									
540				*lyzanius*		MEF	CO	ATE				
			Neurellipes									
542				*lusones*	*fulvimacula*	WEF	RA	ATE				
543				*chryseostictus*		WEF	NR	ATE				
544				*fulvus*		WEF	VR	ATE				
545				*staudingeri*		WEF	VR	ate				
546				*gemmifera*		DRF	RA	ooo				
			Triclema									
547				*rufoplagata*		MEF	RA	ooo				
548				*lucretilis*	*lucretilis*	MEF	NR	ATE				
549				*lamias*	*lamias*	ALF	NR	ate				
550				*fasciatus*		WEF	NR	ate				
551				*obscura*		WEF	RA	ate				
552				*inconspicua*		WEF	RA	ate				
554				*hades*		MEF	NR	ATE				
555				*phoenicis*		DRF	RA	ooo				
556				*nigeriae*		GUI	NR	ATE				
			Cupidesthes									
560				*jacksoni*		WEF	NR	ATE^{en}				
561				*mimetica*		DRF	RA	ooo				
562				*lithas*		MEF	NR	ATE				
564				*leonina*		MEF	NR	ATE				
564				*pungusei*		WEF	VR	ooo^{en}				
			Pseudonacaduba									
565				*sichela*	*sichela*	GUI	CO	ATE				
			Lampides									

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
567				*boeticus*		UBQ	NR	ate				
			Uranothauma									
568				*falkensteini*		ALF	CO	ATE				
			Phlyaria									
574				*cyara*	*stactalla*	ALF	CO	ATE				
			Cacyreus									
575				*lingeus*		UBQ	CO	ATE				
577				*audeoudi*		WEF	RA	ate				
			Leptotes									
578				*pirithous*		UBQ	CO	ATE				
579				*babaulti*		GUI	NR	ate				
580				*jeanneli*		UBQ	CO	ate				
581				*brevidentatus*		GUI	NR	ate				
582				*pulchra*		SPE	RA	ooo				
			Tuxentius									
583				*cretosus*	*nodieri*	SUD	CO	—				
584				*carana*	*carana*	ALF	CO	ATE				
			Tarucus	*check*								
586				*ungemachi*		SUD	NR	—				
588				*rosacea*		SUD	RA	—				
			Actizera									
592				*lucida*		GUI	EA	—				
			Eicochrysops									
593				*hippocrates*		SPE	CO	ATE				
594				*dudgeoni*		GUI	NR	—				
			Cupidopsis									
595				*jobates*	*mauritanica*	SUD	RA	—				
596				*cissus*	*cissus*	GUI	NR	ATE				
			Euchrysops									
598				*albistriata*	*greenwoodi*	GUI	NR	ooo				
600				*reducta*		SUD	NR	—				
601				*malathana*		UBQ	CO	ATE				
604				*osiris*		GUI	CO	ATE				
605				*barkeri*		GUI	NR	ooo				
606				*sahelianus*		SUD	NR	—				
			Lepidochrysops									
607				*victoriae*	*occidentalis*	GUI	RA	—				
608				*parsimon*		GUI	RA	—				
611				*synchrematiza*		GUI	RA	—[ww]				
615				*quassi*		GUI	NR	ooo				
			Thermoniphas									
617				*micylus*	*micylus*	MEF	CO	ATE				
			Oboronia									
622				*punctatus*		MEF	CO	ATE				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
623				*liberiana*		WEF	NR	—ww				
624				*pseudopunctatus*		MEF	NR	—				
625				*guessfeldti*		DRF	NR	ATE				
626				*ornata*	*ornata*	ALF	CO	ATE				
			Azanus	*check*								
627				*ubaldus*		SUD	RA	—				
628				*jesous*		SUD	RA	—				
629				*moriqua*		SUD	NR	—				
630				*mirza*		UBQ	CO	ATE				
631				*natalensis*		GUI	RA	—				
632				*isis*		ALF	CO	ATE				
			Chilades									
633				*eleusis*		SUD	RA	—				
634				*trochylus*		GUI	NR	ooo				
			Zizeeria									
635				*knysna*		UBQ	CO	ATE				
			Zizina									
636				*antanossa*		GUI	NR	ate				
			Zizula									
637				*hylax*		UBQ	CO	ate				
		RIODINIDAE										
			Abisara									
638				*intermedia*		WEF	VR	ate				
639				*tantalus*	*tantalus*	WEF	VR	ate				
642				*gerontes*	*gerontes*	WEF	RA	ATE				
	NYMPHALIDAE											
		LIBYTHEINAE										
			Libythea									
646				*labdaca*	*labdaca*	ALF	CO	ATE				x
		DANAINAE										
			Danaus									
647				*chrysippus*	*chrysippus*	UBQ	VC	ATE		x		x
			Tirumala									
648				*petiverana*		GUI	CO	ATE				
			Amauris									
650				*niavius*	*niavius*	GUI	CO	ATE				
651				*tartarea*	*tartarea*	ALF	NR	ATE				
652				*hecate*	*hecate*		NR	ATE				
653				*damocles*		DRF	CO	ATE				
		SATYRINAE										
			Gnophodes									
656				*betsimena*	*parmeno*	ALF	CO	ATE	x	x	x	
657				*chelys*			CO	ATE	x	x	x	
			Melanitis									

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
658				*leda*		UBQ	CO	ATE		x		
659				*libya*		UBQ	NR	ate				
			Elymniopsis									
661				*bammakoo*	*bammakoo*		CO	ATE		x		
			Bicyclus									
663				*xeneas*	*occidentalis*	ALF	NR	ATE				
665				*evadne*	*evadne*	WEF	NR	ATE		x		
669				*ephorus*	*ephorus*	WEF	RA	ATE				
672				*italus*		WEF	NR	—				
673				*zinebi*		ALF	NR	ATE[ww]	x		x	
674				*uniformis*		WEF	RA	ATE				
678				*procora*		WEF	NR	ATE	x	x	x	
679				*pavonis*		GUI	CO	—				
680				*milyas*		GUI	NR	—				
681				*trilophus*	*jacksoni*	WEF	RA	ATE			x	
682				*ignobilis*	*ignobilis*	ALF	RA	ATE				
683				*maesseni*		ALF	NR	ATE[ww]	x			
684				*nobilis*		WEF	RA	ATE		x		
687				*taenias*		MEF	CO	ATE	x	x	x	
690				*vulgaris*		ALF	VC	ATE	x	x	x	
691				*dorothea*	*dorothea*	ALF	VC	ATE	x	x	x	
692				*sandace*		ALF	VC	ATE		x	x	
693				*sambulos*	*unicolor*	WEF	NR	ATE			x	
694				*sangmelinae*		WEF	NR	ATE		x		
695				*mandanes*		DRF	NR	ATE	x			
696				*auricruda*	*auricruda*	MEF	RA	ate			x	
697				*campa*		GUI	NR	—				
698				*angulosa*	*angulosa*	GUI	CO	—				
699				*sylvicolus*		WEF	NR	—				
700				*abnormis*		WEF	NR	ATE[ww]				
701				*safitza*	*safitza*	GUI	NR	ate				
702				*funebris*		DRF	CO	ATE				
704				*dekeyseri*		WEF	RA	ATE[ww]				
705				*istaris*		WEF	NR	ATE	x	x		
707				*madetes*	*madetes*	MEF	NR	ATE	x	x	x	
709				*martius*	*martius*	MEF	CO	ATE	x			
			Hallelesis									
712				*halyma*		WEF	NR	ATE[ww]		x		
			Henotesia									
713				*elisi*		DRF	RA	—[ww]				
			Heteropsis									
714				*peitho*		WEF	RA	ATE	x	x	x	
			Ypthima									
715				*asterope*	*asterope*	SUD	RA	—				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
716				*condamini*	*nigeriae*	GUI	CO	—				
717				*antennata*	*cornesi*	ALF	NR	—				
718				*vuattouxi*		DRF	NR	ate[en]				
719				*doleta*		ALF	VC	ATE				
721				*pupillaris*	*pupillaris*	GUI	NR	—				
722				*impura*	*impura*	GUI	RA	—				
			Ypthimomorpha									
724				*itonia*		SPE	NR					
		CHARAXINAE										
			Charaxes									
725				*varanes*	*vologeses*	GUI	CO	ATE	x	x	x	
726				*fulvescens*	*senegala*	ALF	NR	ATE	x	x	x	
728				*candiope*	*candiope*	GUI	RA	ATE				
729				*protoclea*	*protoclea*	ALF	CO	ATE	x		x	
730				*boueti*		DRF	NR	ATE				
731				*cynthia*	*cynthia*	ALF	CO	ATE				x
732				*lucretius*	*lucretius*	ALF	CO	ATE				
733				*lactetinctus*	*lactetinctus*	GUI	RA	—				
734				*epijasius*		GUI	CO	ATE				
736				*castor*	*castor*	DRF	NR	ATE				
737				*brutus*	*brutus*	MEF	CO	ATE				x
738				*pollux*	*pollux*	MEF	RA	ATE				
740				*eudoxus*	*eudoxus*	ALF	VR	ooo				
741				*tiridates*	*tiridates*	ALF	CO	ATE				
742				*bipunctatus*	*bipunctatus*	WEF	NR	ATE				
743				*numenes*	*numenes*	ALF	NR	ATE				
744				*smaragdalis*	*butleri*	ALF	NR	ATE				
745				*imperialis*	*imperialis*	ALF	RA	ATE				
746				*ameliae*	*doumeti*	ALF	NR	ATE				
747				*pythodoris*	*davidi*	DRF	VR	ooo				
748				*hadrianus*	*hadrianus*	WEF	RA	—				
750				*nobilis*	*claudei*	WEF	VR	ATE				
752				*fournierae*	*jolybouyeri*	WEF	VR	ATE				
753				*zingha*		MEF	NR	ATE				
754				*etesipe*	*etesipe*	DRF	NR	ATE				
755				*achaemenes*	*atlantica*	GUI	CO	ATE				
756				*eupale*	*eupale*	ALF	VC	ATE				
757				*subornatus*	*couilloudi*	WEF	RA	ATE				
758				*anticlea*	*anticlea*	ALF	NR	ATE				
759				*hildebrandti*	*gillesi*	MEF	RA	ATE				
760				*etheocles*	*etheocles*	ALF	CO	ATE				x
762				*petersi*		MEF	VR	ATE[ww]				
765				*bocqueti*	*bocqueti*	WEF	VR	ATE				
767				*virilis*	*virilis*	MEF	NR	ATE				

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768				*cedreatis*		MEF	NR	ATE				
769				*plantroui*		DRF	RA	ATE[ww]				
770				*viola*	*viola*	SUD	CO	—				
771				*northcotti*		GUI	RA	—				
772				*pleione*	*pleione*	ALF	CO	ATE				
773				*paphianus*	*falcata*	WEF	NR	ATE				
774				*nichetes*	*bouchei*	DRF	RA	ATE				
775				*porthos*	*gallayi*	MEF	RA	ATE				
776				*zelica*	*zelica*	WEF	RA	ATE				
777				*lycurgus*	*lycurgus*	ALF	CO	ATE				
778				*mycerina*	*mycerina*	WEF	RA	ATE				
779				*doubledayi*		WEF	RA	ATE				
			Euxanthe									
780				*eurinome*	*eurinome*	MEF	NR	ATE				
			Palla									
783				*violinitens*	*violinitens*	MEF	NR	ATE				
784				*decius*		MEF	NR	ATE				
785				*ussheri*	*ussheri*	ALF	CO	ATE				
786				*publius*	*publius*	MEF	NR	ATE				
		APATURINAE										
			Apaturopsis									
786a				*cleochares*	*cleochares*	MEF	RA	ATE				
		NYMPHALINAE										
			Kallimoides									
787				*rumia*	*rumia*	ALF	CO	ATE	x		x	
			Vanessula									
788				*milca*	*milca*	WEF	RA	ATE			x	
			Antanartia									
789				*delius*	*delius*	MEF	CO	ATE				
			Vanessa									
791				*cardui*	*cardui*	UBQ	NR	ate				
			Precis									
792				*octavia*	*octavia*	GUI	NR	ate				
793				*antilope*		GUI	NR	ate				
796				*ceryne*	*ceruana*	SPE	NR	ooo				
797				*pelarga*		ALF	NR	ATE	x			
798				*sinuata*		WEF	RA	ATE	x	x		
			Hypolimnas									
801				*misippus*		UBQ	CO	ATE				
802				*anthedon*	*anthedon*	ALF	CO	ATE				
803				*dinarcha*	*dinarcha*	WEF	NR	ATE				
806				*salmacis*	*salmacis*	MEF	CO	ATE	x	x	x	
			Salamis									
808				*cacta*	*cacta*	MEF	CO	ATE				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
			Protogoniomorpha									
809				*cytora*		MEF	NR	ATE[ww]				
811				*parhassus*		MEF	CO	ATE		x		
812				*anacardii*	*anacardii*	DRF	NR	ooo				
			Junonia									
813				*orithya*	*madagascariensis*	SUD	CO	ooo				
814				*oenone*	*oenone*	UBQ	VC	ATE				
815				*hierta*	*cebrene*	SUD	CO	ooo				
816				*cymodoce*	*cymodoce*	MEF	NR	ATE		x		
817				*westermanni*	*westermanni*	DRF	NR	ATE				
818				*hadrope*		DRF	RA	—[vo]				
819				*sophia*	*sophia*	ALF	CO	ATE				
820				*stygia*		ALF	CO	ATE	x			
822				*chorimene*		GUI	CO	ooo				
823				*terea*	*terea*	ALF	VC	ATE		x		
			Catacroptera									
824				*cloanthe*	*ligata*	GUI	NR	ate				
		CYRESTINAE										
			Cyrestis									
825				*camillus*	*camillus*	ALF	CO	ATE				
		BIBLIDINAE										
			Byblia									
826				*anvatara*	*crameri*	UBQ	CO	ATE		x		
827				*ilithyia*		SUD	RA	—				
			Mesoxantha									
828				*ethosea*	*ethosea*	MEF	NR	ATE		x		
			Ariadne									
829				*enotrea*	*enotrea*	ALF	VC	ATE	x			
830				*albifascia*		ALF	NR	ATE				
			Nepidopsis									
833				*ophione*	*ophione*	ALF	CO	ATE				
			Eurytela									
834				*dryope*	*dryope*	DRF	NR	ATE				
836				*hiarbas*	*hiarbas*	MEF	CO	ATE				
			Sevenia	*check*								
837				*occidentalium*	*occidentalium*	ALF	NR	ATE				
838				*boisduvali*	*omissa*	ALF	NR	ATE				
839				*umbrina*		DRF	NR	—				
		LIMENITIDINAE										
			Harma									
843				*theobene*	*theobene*	MEF	CO	ATE	x	x		
			Cymothoe									
846				*fumana*	*fumana*	MEF	CO	ATE				
851				*egesta*	*egesta*	MEF	CO	ATE				x

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
853				*lurida*	*lurida*	WEF	VR	ATE				
858				*aubergeri*		MEF	NR	—ww				
859				*herminia*	*gongoa*	MEF	RA	ATE				
860				*weymeri*	*mulatta*	WEF	RA	ATE				
863				*caenis*		ALF	CO	ATE			x	
866				*althea*	*althea*	MEF	NR	ooo				
868				*jodutta*		WEF	CO	ATE		x		
872				*coccinata*	*coccinata*	MEF	NR	ATE				
873				*mabillei*		MEF	CO	ATEww	x			
878				*'sangaris'*		WEF	NR	ATE	x	x	x	
			Pseudoneptis									
879				*bugandensis*	*ianthe*	ALF	CO	ATE	x	x	x	
			Pseudacraea									
880				*eurytus*		ALF	CO	ATE				
884				*boisduvalii*	*boisduvalii*	DRF	NR	ate				
887				*lucretia*	*lucretia*	ALF	CO	ATE				
888				*warburgi*		MEF	NR	ATE				
889				*hostilia*		WEF	RA	ATEww				
900				*semire*		ALF	CO	ATE				
			Neptis									
901				*nemetes*	*nemetes*	ALF	CO	ATE				
903				*metella*	*metella*	ALF	CO	ATE				
905				*serena*	*serena*	DRF	NR	ATE				
906				*kiriakoffi*		DRF	NR	ate				
907				*morosa*		GUI	CO	ate				
908				*loma*		MEF	RA	ATE				
910				*angusta*		MEF	VR	—				
911				*alta*		MEF	NR	ATE				
912				*seeldrayersi*		MEF	RA	ATE				
913				*puella*		MEF	NR	ATE				
914				*conspicua*		MEF	RA	ate				
915				*najo*		MEF	RA	ate				
916				*metanira*		MEF	RA	ate				
917				*continuata*		MEF	???	ate				
918				*nysiades*		MEF	NR	ATE				
921				*nicomedes*		MEF	RA	ATE				
922				*quintilla*		MEF	RA	ATE				
926				*paula*		WEF	RA	ATE				
927				*strigata*	*strigata*	MEF	RA	ATE				
929				*nicoteles*		MEF	CO	ATE				
930				*nicobule*		MEF	NR	ATE	x	x		
931				*mixophyes*		WEF	RA	ATE				
933				*nebrodes*		MEF	NR	ATE				

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934				*trigonophora*	*melicertula*	MEF	NR	ATE				
936				*agouale*	*agouale*	ALF	VC	ATE				
937				*melicerta*		MEF	CO	ATE	x			
938				*troundi*		MEF	CO	ATE	x	x		
			Catuna									
941				*crithea*		ALF	VC	ATE	x			
942				*niji*		WEF	RA	—				
943				*oberthueri*		ALF	CO	ATE		x	x	
944				*angustatum*		MEF	CO	ATE	x			
			Euryphura									
946				*togoensis*		MEF	NR	ATE				
948				*chalcis*		ALF	CO	ATE				
			Hamanumida									
951				*daedalus*		GUI	CO	ATE				
			Aterica									
953				*galene*	*galene*	ALF	CO	ATE	x	x	x	
			Cynandra									
954				*opis*	*opis*	MEF	NR	ATE				
			Euriphene									
959				*incerta*	*incerta*	WEF	RA	ATE		x		
960				*barombina*		ALF	VC	ATE				
961				*veronica*		WEF	CO	—[ww]				
964				*grosesmithi*	*muehlenbergi*	MEF	RA	ooo				
968				*simplex*		WEF	NR	ATE[ww]				
974				*amicia*	*amicia*	MEF	NR	ATE		x		
976				*aridatha*	*transgressa*	MEF	NR	ATE		x		
978				*coerulea*		WEF	CO	ATE		x		
985				*ernestibaumanni*		WEF	RA	ooo				
986				*gambiae*	*vera*	ALF	CO	ATE	x			
987				*ampedusa*		ALF	NR	ATE		x		
988				*leonis*		WEF	VR	—[ww]				
989				*atossa*	*atossa*	MEF	NR	ATE				
990				*doriclea*	*doriclea*	MEF	NR	ATE				
			Bebearia									
994				*lucayensis*		MEF	RA	ATE				
995				*tentyris*		MEF	CO	ATE	x	x	x	
996				*osyris*		WEF	NR	ATE[ww]				
998				*carshena*		MEF	NR	ATE		x		
999				*absolon*	*absolon*	ALF	CO	ATE		x	x	
1001				*zonara*		MEF	CO	ATE		x		
1002				*mandinga*	*mandinga*	ALF	CO	ATE	x			
1003				*oxione*	*oxione*	MEF	NR	ATE				
1004				*abesa*	*abesa*	MEF	NR	ATE				
1006				*barce*	*barce*	WEF	RA	ATE				

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1008				*mardania*		ALF	CO	ATE				
1011				*cocalia*	*cocalia*	ALF	CO	ATE	x			
1012				*paludicola*	*blandi*	MEF	NR	ATE				
1014				*sophus*	*phreone*	ALF	CO	ATE		x	x	
1017				*arcadius*		WEF	RA	ATE^{ww}		x	x	
1021				*laetitia*	*laetitia*	WEF	CO	ATE				
1027				*phantasina*		ALF	CO	ATE	x	x		
1029				*demetra*	*demetra*	MEF	RA	ate				
1033				*maledicta*		WEF	VR	ATE	x			
1035				*ashantina*		WEF	RA	ATE^{en}				
1037				*cutteri*	*cutteri*	WEF	RA	ATE				
			Euphaedra									
			Subgenus *Medoniana*									
1046				*medon*	*medon*	ALF	CO	ATE	x	x	x	
			Subgenus *Gausapia*									
1047				*gausape*		WEF	NR	ATE^{ww}	x		x	
1047				*mariaechristinae*		WEF	NR	ATE^{en}	x	x	x	
			Subgenus *Xypetana*									
1055				*xypete*		MEF	CO	ATE			x	
1057				*hebes*		WEF	NR	ATE		x	x	
1059				*diffusa*	*albocoerulea*	DRF	NR	ATE				
1060				*crossei*	*akani*	DRF	RA	—				
1061				*crockeri*	*crockeri*	MEF	NR	ATE^{ww}		x		
			Subgenus *Radia*									
1062				*eusemoides*		WEF	VR	ATE^{ww}				
			Subgenus *Euphaedra*									
1064				*cyparissa*	*cyparissa*	DRF	NR	ATE			x	
1065				*sarcoptera*	*sarcoptera*	MEF	NR	ATE			x	
			Subgenus *Euphaedrana*									
1066				*themis*	*themis*	DRF	NR	ATE				
1067				*laboureana*	*eburnensis*	WEF	RA	ATE^{ww}				
1071				*minuta*		WEF	RA	ooo^{en}				
1072				*modesta*		WEF	NR	ATE^{en}				
1075				*janetta*		ALF	CO	ATE	x	x		
1076				*splendens*		WEF	RA	ATE	x			
1077				*aberrans*		WEF	VR	ooo^{ww}				
1078				*vetusta*		WEF	VR	ooo^{ww}				
1083				*ceres*	*ceres*	ALF	CO	ATE	x	x	x	
1085				*phaethusa*	*phaethusa*	ALF	CO	ATE^{ww}	x	x	x	
1086				*inanum*		MEF	RA	ATE^{ww}				
1096				*ignota*		WEF	VR	ATE^{en}				

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1106				*francina*	*francina*	WEF	NR	ATE[ww]				
1108				*eleus*	*eleus*	WEF	NR	ATE				
1112				*zampa*		WEF	NR	ATE[ww]	x		x	
1115				*edwardsii*		ALF	CO	ATE				
1116				*ruspina*		WEF	NR	—				
1117				*perseis*		WEF	NR	ATE[ww]				
1118				*harpalyce*	*harpalyce*	ALF	VC	ATE			x	
1119				*eupalus*		WEF	RA	ATE[ww]		x		
			Euptera									
1121				*crowleyi*	*crowleyi*	ALF	RA	ate				
1122				*elabontas*	*elabontas*	ALF	NR	ate				
1123				*dorothea*	*warrengashi*	MEF	VR	—[ww]				
1124				*zowa*		ALF	NR	ate				
			Pseudathyma									
1133				*falcata*		MEF	RA	ATE				
1134				*sibyllina*		MEF	RA	ATE				
		HELICONIINAE										
			Acraea									
			Subgenus *Actinote*									
1139				*perenna*	*perenna*	MEF	NR	ATE				
1144				*circeis*		ALF	CO	ATE				
1147				*translucida*		MEF	NR	ATE				
1148				*peneleos*	*peneleos*	ALF	NR	ATE				
1149				*parrhasia*	*parrhasia*	MEF	NR	ATE				
1150				*orina*		MEF	RA	ATE	x			
1152				*pharsalus*	*pharsalus*	ALF	CO	ATE				
1153				*encedon*	*encedon*	UBQ	CO	ATE				
1154				*encedana*		SPE	NR	ooo				
1155				*alciope*		ALF	VC	ATE				
1156				*aurivillii*	*aurivillii*	ALF	NR	ATE				
1157				*jodutta*	*jodutta*	ALF	CO	ATE				
1158				*lycoa*	*lycoa*	ALF	CO	ATE				
1159				*serena*		UBQ	CO	ATE				
1160				*acerata*		ALF	NR	ATE				
1161				*pseudepaea*		WEF	RA	ATE				
1165				*bonasia*	*bonasia*	ALF	CO	ATE		x	x	
1167				*orestia*	*orestia*	MEF	RA	ATE				
1168				*polis*		MEF	NR	ATE				
1169				*vesperalis*		WEF	VR	ATE				
			Subgenus *Acraea*									
1172				*kraka*	*kibi*	WEF	RA	ATE				
1173				*rogersi*	*rogersi*	WEF	NR	ATE				
1174				*abdera*	*eginopsis*	MEF	RA	ate				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
1176				*egina*	*egina*	ALF	CO	ATE		x		
1178				*pseudegina*		UBQ	CO	ATE				
1179				*caecilia*	*caecilia*	SUD	CO	ooo				
1180				*zetes*	*zetes*	DRF	NR	ATE	x			
1181				*endoscota*		ALF	RA	ATE				
1182				*leucographa*		MEF	NR	ATE				
1184				*quirina*	*quirina*	ALF	CO	ATE	x	x	x	
1185				*neobule*	*neobule*	UBQ	CO	ATE				
1186				*eugenia*		DRF	NR	—				
1187				*camaena*		DRF	RA	—				
1188				*vestalis*	*vestalis*	ALF	NR	ATE				
1189				*macaria*		WEF	RA	ATE[ww]				
1190				*umbra*	*umbra*	MEF	NR	ATE				
1191				*alcinoe*	*alcinoe*	MEF	CO	ATE				
1192				*consanguinea*	*sartina*	WEF	RA	ooo				
1196				*epaea*	*epaea*	ALF	CO	ATE	x	x		
			Lachnoptera									
1199				*anticlia*		MEF	CO	ATE				
			Phalanta									
1200				*phalantha*	*aethiopica*	UBQ	CO	ATE				
1201				*eurytis*	*eurytis*	MEF	CO	ATE				
	HESPERIIDAE											
		COLIADINAE										
			Coeliades									
1203				*chalybe*	*chalybe*	ALF	CO	ATE				
1204				*bixana*		MEF	RA	ate				
1206				*libeon*		ALF	NR	ATE				
1207				*forestan*	*forestan*	UBQ	CO	ATE				
1208				*pisistratus*		ALF	CO	ATE				
1209				*hanno*		MEF	NR	ATE				
			Pyrrhiades									
1210				*lucagus*		DRF	CO	—				
			Pyrrhochalcia									
1211				*iphis*		ALF	CO	ATE[en]				
		PYRGINAE										
			Loxolexis									
1212				*holocausta*		WEF	VR	ATE				
1213				*dimidia*		WEF	VR	ooo				
1214				*hollandi*		WEF	RA	ATE				
			Katreus									
1215				*johnstonii*		WEF	RA	ATE				
			Celaenorrhinus									
1216				*rutilans*		WEF	RA	ATE				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
1217				*sagamase*		WEF	VR	ATE[en]				
1219				*leona*		WEF	RA	ATE[ww]				
1223				*ankasa*		WEF	VR	ATE[en]				
1224				*galenus*	*galenus*	ALF	CO	ATE	x			
1225				*cf galenus*	*galenus*	WEF	RA	ATE		x		
1226				*meditrina*		WEF	RA	ATE				
1227				*ovalis*		WEF	RA	ATE				
1230				*proxima*	*maesseni*	ALF	CO	ATE				
1231				*plagiatus*		MEF	NR	ATE				
			Tagiades									
1232				*flesus*		ALF	CO	ATE				
			Eagris									
1233				*denuba*	*denuba*	ALF	CO	ATE				
1234				*decastigma*		WEF	RA	ATE				
1235				*tigris*	*liberti*	WEF	RA	ATE				
1236				*subalbida*	*subalbida*	WEF	RA	ATE				
1237				*hereus*	*quaterna*	MEF	NR	ATE				
1238				*tetrastigma*	*subolivescens*	MEF	NR	ATE				
			Calleagris									
1239				*lacteus*	*dannatti*	WEF	NR	ate				
			Procampta									
1241				*rara*		MEF	NR	ATE				
			Eretis									
1242				*lugens*		GUI	CO	ATE				
1243				*plistonicus*		ALF	NR	ATE				
1244				*melania*		DRF	NR	ate				
			Sarangesa									
1245				*laelius*		GUI	NR	—				
1246				*phidyle*		SUD	NR	—				
1247				*tertullianus*		MEF	NR	ate				
1248				*majorella*		MEF	NR	ate				
1249				*tricerata*	*tricerata*	MEF	NR	ooo				
1250				*thecla*	*thecla*	ALF	CO	ATE				
1251				*bouvieri*		DRF	CO	ATE				
1252				*brigida*	*brigida*	MEF	NR	ATE				
			Caprona									
1253				*adelica*		GUI	RA	—				
1254				*pillaana*		SUD	VR	—				
			Netrobalane									
1255				*canopus*		GUI	RA	—				
			Abantis									
1256				*bismarcki*		GUI	RA	—				
1257				*leucogaster*	*leucogaster*	WEF	RA	ATE				
1258				*nigeriana*		GUI	NR	ooo				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
1259				*pseudonigeriana*		SUD	RA	—				
1261				*lucretia*	*lucretia*	MEF	RA	ATE				
1262				*elegantula*	*elegantula*	DRF	RA	ATE				
1263				*ja*		WEF	VR	ATE				
1263				*tanobia*		WEF	VR	ooo[en]				
			Spialia									
1265				*spio*		SUD	CO	ooo				
1267				*diomus*	*diomus*	SUD	NR	ooo				
1268				*dromus*		GUI	NR	ooo				
1269				*ploetzi*	*occidentalis*	ALF	NR	ATE				
			Gomalia									
1270				*elma*	*elma*	DRF	NR	ooo				
		HESPERIINAE										
			Astictopterus									
1276				*anomoeus*		WEF	NR	ATE[ww]	x		x	
1277				*abjecta*		GUI	CO	ooo				
			Prosopalpus									
1278				*debilis*		MEF	RA	ATE				
1279				*styla*		DRF	NR	ate				
1280				*saga*		WEF	RA	ate				
			Kedestes									
1282				*protensa*		GUI	VR	—				
			Gorgyra									
1284				*aretina*		ALF	NR	ATE				
1285				*heterochrus*		MEF	NR	ate				
1286				*mocquerysii*		ALF	NR	ATE				
1287				*aburae*		WEF	RA	ATE				
1289				*bina*		MEF	NR	ATE				
1290				*sola*		MEF	RA	ooo				
1291				*afikpo*		MEF	VR	ATE				
1292				*diversata*		MEF	NR	ate				
1293				*bule*		MEF	RA	ooo				
1294				*minima*		DRF	NR	ooo				
1295				*sara*		ALF	NR	ATE				
1296				*subfacatus*		ALF	NR	ATE				
1297				*pali*		MEF	RA	ATE				
			Gyrogra									
1299				*subnotata*		ALF	NR	ATE				
			Ceratrichia									
1301				*phocion*	*phocion*	MEF	CO	ATE	x	x	x	
1302				*semilutea*		MEF	RA	ATE	x	x	x	
1303				*clara*	*clara*	WEF	NR	ATE	x	x	x	
1305				*crowleyi*		WEF	RA	—[ww]				
1306				*nothus*	*nothus*	WEF	NR	ate				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
1307				*argyrosticta*	*argyrosticta*	WEF	NR	ATE				
1308				*maesseni*		WEF	RA	ATE[en]	x			
			Teniorhinus									
1309				*watsoni*		MEF	RA	ate				
1310				*ignita*		MEF	NR	ooo				
			Pardaleodes									
1311				*incerta*	*murcia*	GUI	CO	ooo				
1312				*edipus*		ALF	VC	ATE				
1313				*sator*	*sator*	MEF	NR	ATE				
1314				*tibullus*	*tibullus*	MEF	NR	ATE				
1315				*xanthopeplus*		WEF	VR	ATE				
			Xanthodisca									
1317				*rega*		ALF	NR	ate				
1318				*astrape*		MEF	NR	ATE				
			Parosmodes									
1320				*morantii*	*axis*	SUD	RA	—				
1321				*lentiginosa*		ALF	RA	ATE				
			Rhabdomantis									
1322				*galatia*		MEF	NR	ATE				
1323				*sosia*		MEF	NR	ATE				
			Osmodes									
1324				*laronia*		ALF	CO	ATE				
1325				*omar*		DRF	NR	ate				
1326				*lux*		WEF	NR	ATE				
1328				*thora*		ALF	CO	ATE				
1329				*distincta*		WEF	RA	ATE				
1330				*adon*		WEF	RA	ATE				
1332				*adosus*		WEF	RA	ATE				
1333				*lindseyi*	*occidentalis*	MEF	NR	ATE				
1334				*costatus*		WEF	RA	ATE				
1335				*banghaasi*		WEF	RA	ATE				
			Osphantes									
1336				*ogowena*	*ogowena*	WEF	VR	ate				
			Paracleros									
1337				*placidus*		MEF	NR	ate[ww]				
1338				*biguttulus*		ALF	CO	ATE				
1339				*substrigata*		MEF	RA	ate				
1340				*maesseni*		MEF	NR	ATE				
			Acleros									
1341				*ploetzi*		ALF	CO	ATE				
1342				*mackenii*	*olaus*	ALF	CO	ATE				
1343				*nigrapex*		MEF	NR	ATE				
1344				*bala*		MEF	RA	ate[en]				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
			Semalea									
1345				*pulvina*		ALF	CO	ATE		x		
1346				*sextilis*		WEF	NR	ATE				
1347				*atrio*		WEF	RA	ATE				
1349				*arela*		DRF	NR	ATE				
			Hypoleucis									
1350				*ophiusa*	*ophiusa*	ALF	CO	ATE				
1351				*tripunctata*	*tripunctata*	MEF	NR	ATE				
1352				*sophia*		WEF	RA	ate				
			Meza									
1353				*indusiata*		MEF	NR	ate				
1354				*meza*		ALF	VC	ATE				
1355				*mabea*		MEF	VR	ooo				
1356				*leucophaea*		MEF	NR	ATE				
1357				*elba*		MEF	RA	ATE				
1358				*mabillei*		WEF	RA	ATE				
1359				*cybeutes*	*volta*	ALF	NR	ATE				
			Paronymus									
1361				*xanthias*	*xanthias*	WEF	RA	ATE				
1363				*ligora*		MEF	NR	ATE				
1364				*nevea*		WEF	VR	ooo				
			Andronymus									
1365				*neander*		ALF	NR	ATE				
1367				*caesar*	*caesar*	ALF	CO	ATE				
1368				*hero*		MEF	NR	ATE				
1369				*helles*		MEF	NR	ATE				
1370				*evander*		MEF	NR	ATE				
			Zophopetes									
1373				*ganda*		DRF	RA	ooo				
1374				*cerymica*		ALF	NR	ATE				
1376				*quaternata*		DRF	RA	ooo				
			Gamia									
1377				*buchholzi*		WEF	NR	ATE				
1378				*shelleyi*		WEF	NR	ate				
			Artitropa									
1379				*comus*		MEF	NR	ATE				
			Mopala									
1380				*orma*		MEF	RA	ate				
			Gretna									
1381				*waga*		ALF	CO	ate				
1383				*cylinda*		ALF	NR	ate				
1386				*balenge*	*zowa*	MEF	RA	ate				
			Pteroteinon									
1387				*laufella*		ALF	CO	ATE				

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
1388				*iricolor*		WEF	RA	ATE				
1389				*laterculus*		WEF	RA	ate				
1390				*capronnieri*		WEF	VR	ooo				
1391				*caenira*		ALF	CO	ATE				
1392				*ceucaenira*		WEF	RA	ATE				
1393				*concaenira*		WEF	RA	ate				
1394				*pruna*		WEF	RA	ate				
			Leona									
1395				*binoevatus*		WEF	RA	ate				
1397				*lota*		WEF	VR	ooo				
1399				*leonora*	*leonora*	WEF	RA	ate				
1401				*stoehri*		WEF	RA	ate				
1402				*meloui*		WEF	RA	ate				
1403				*halma*		WEF	???	???				
1405				*luehderi*	*luehderi*	WEF	RA	ate				
			Caenides									
1406				*soritia*		WEF	RA	ATE				
1407				*kangvensis*		MEF	NR	ATE				
1408				*xychus*		MEF	RA	ate				
1409				*benga*		WEF	RA	ate				
1410				*otilia*		WEF	RA	ate				
1411				*dacenilla*		MEF	RA	ate				
1412				*dacela*		ALF	CO	ATE				
1413				*hidarioides*		WEF	RA	ATE				
1414				*dacena*		MEF	CO	ATE				
			Monza									
1415				*alberti*		ALF	VC	ATE				
1416				*cretacea*		ALF	CO	ATE				
			Melphina									
1417				*noctula*		WEF	RA	ate				
1419				*unistriga*		WEF	NR	ATE				
1420				*tarace*		MEF	RA	ATE				
1421				*flavina*		MEF	RA	ate				
1422				*statirides*		MEF	NR	ATE				
1423				*statira*		WEF	RA	ooo				
1425				*malthina*		WEF	RA	ate				
1426				*maximiliani*		MEF	RA	ooo^{ww}				
			Fresna									
1427				*netopha*		DRF	NR	ATE				
1428				*maesseni*		MEF	RA	—				
1429				*nyassae*		DRF	RA	ATE				
1430				*cojo*		ALF	NR	ATE				
1431				*carlo*		MEF	VR	ate				
			Platylesches									

No.	Family	Subfamily	Genus	Species	subspecies	hab	rarity	status	ANT	ASS	ASN	MRT
1432				*galesa*		ALF	NR	ATE				
1434				*moritili*		GUI	NR	ate				
1435				*rossi*		DRF	VR	ooo^{ww}				
1437				*picanini*		ALF	NR	ATE				
1438				*lamba*		MEF	RA	ooo				
1439				*affinissima*		DRF	NR	ooo				
1440				*chamaeleon*	*chamaeleon*	DRF	NR	ooo				
1441				*batangae*		DRF	RA	ooo				
			Pelopidas									
1444				*mathias*		UBQ	CO	ATE				
1445				*thrax*		UBQ	CO	ATE				
			Borbo									
1446				*fallax*		GUI	NR	ooo				
1447				*fanta*		GUI	NR	ate				
1448				*perobscura*		GUI	NR	ATE				
1449				*micans*		SPE	RA	ATE				
1450				*borbonica*	*borbonica*	GUI	NR	ate				
1451				*gemella*		GUI	NR	ooo				
1452				*binga*		WEF	RA	ooo				
1453				*fatuellus*	*fatuellus*	ALF	CO	ATE				
1454				*holtzi*		GUI	NR	ooo				
			Parnara									
1456				*monasi*		GUI	RA	ate				
			Gegenes									
1457				*'pumilio'*	*gambica*	SUD	NR	—				
1459				*niso*	*brevicornis*	GUI	NR	ooo				
1460				*hottentota*		DRF	NR	ooo				

Appendix 5

Ant species collected from the Atewa Range Forest Reserve during the 2006 RAP survey

Lloyd R. Davis Jr. and Leeanne E. Alonso

Species	Collection date	Number of specimens	Collector	Method	Atiwiredu	Asiakwa So.	Asiakwa No.	Other sites
Ankylomyrma coronacantha		1	L. Alonso	By hand	X			
Calyptomyrmex brevis	14-Jun-06	1	H. Wright	Winkler		X		
Calyptomyrmex kaurus	9-Jun-06	2		Winkler	X			
Calyptomyrmex nummuliticus	16-Jun-06	1	H. Wright	Winkler		X		
Calyptomyrmex sp. 1	16-Jun-06	1	H. Wright	Winkler		X		
Calyptomyrmex tensus	22-Jun-06	1	H. Wright	Winkler			X	
Camponotus sp. 1	20-Jun-06	1	H. Wright	By hand	X		X	X
Camponotus sp. 2	8-Jun-06	2	L. Alonso	By hand	X			
Carebara B	20-Jun-06	1	H. Wright	Winkler	X	X	X	
Carebara C	11-Jun-06	2	H. Wright	Winkler	X			
Carebara sp. 1	20-Jun-06	1	H. Wright	Winkler	X	X	X	
Carebara sp. 2	20-Jun-06	1	H. Wright	Winkler		X	X	
Cataulacus adpressus	10-Jun-06	1	H. Wright	By hand	X	X		
Cataulacus egenus	8-Jun-06	1	L. Alonso	By hand	X			
Cataulacus moloch	14-Jun-06	1	H. Wright	Winkler		X		
Cataulacus sp. 1	10-Jun-06	14	N. Granier	By hand				X
Cerapachys foreli	9-Jun-06	2		Winkler	X			
Crematogaster sp. 3	14-Jun-06	1	H. Wright	Winkler		X		
Crematogaster sp. 4	20-Jun-06	1	H. Wright	Winkler	X		X	
Crematogaster sp. 1	14-Jun-06	1	H. Wright	Winkler	X	X		
Crematogaster sp. 2	8-Jun-06	25	L. Alonso	By hand	X			
Discothyrea sp. 1	9-Jun-06	1		Winkler	X			
Dorylus sp. 1	8-Jun-06	16	L. Alonso	By hand	X			
Dorylus sp. 2	8-Jun-06	24	L. Alonso	By hand	X			
Dorylus sp. 3	12-Jun-06	11	N. Granier	By hand				X
Dorylus sp. 4	10-Jun-06	14	N. Granier	By hand				X
Dorylus sp. 5	10-Jun-06	18	N. Granier	By hand				X
Hypoponera sp. 1	14-Jun-06	1	H. Wright	Winkler	X	X		
Hypoponera sp. 2	14-Jun-06	1	H. Wright	Winkler		X		
Lepisiota sp. 2	8-Jun-06	1	L. Alonso	By hand	X			
Lepisiota sp. 1	8-Jun-06	1	L. Alonso	By hand	X			
Leptogenys occidentalis	14-Jun-06	1	H. Wright	Winkler		X		
Monomorium sp. 1	20-Jun-06	1	H. Wright	Winkler	X		X	

Species	Collection date	Number of specimens	Collector	Method	Atiwiredu	Asiakwa So.	Asiakwa No.	Other sites
Monomorium sp. 2	14-Jun-06	1	H. Wright	Winkler		X		
Pachycondyla sp. 4	20-Jun-06	1	H. Wright	Winkler			X	
Pachycondyla sp. 1	16-Jun-06	5	H. Wright	Winkler	X	X		
Pachycondyla sp. 2	9-Jun-06	2		Winkler	X			
Pachycondyla tarsata	20-Jun-06	1	H. Wright	Winkler	X		X	
Paratrechina sp. 3	8-Jun-06	2	L. Alonso	By hand	X			
Paratrechina sp. 1	22-Jun-06	1	H. Wright	Winkler				
Pheidole sp. 1	14-Jun-06	3	H. Wright	Winkler	X	X		
Pheidole sp. 2	20-Jun-06	1	H. Wright	Winkler	X	X	X	
Pheidole sp. 3	16-Jun-06	1	H. Wright	Winkler	X	X		
Pheidole sp. 4	11-Jun-06	1	H. Wright	Winkler	X			
Pheidole sp. 5	11-Jun-06	3	H. Wright	Winkler	X			
Pheidole sp. 6	16-Jun-06	14	H. Wright	Winkler		X		
Pheidole sp. 7	22-Jun-06	2	H. Wright	Winkler			X	
Phrynoponera gabonensis	10-Jun-06	1	H. Wright	By hand		X		
Polyrhachis rufipalpis	8-Jun-06	1	L. Alonso	By hand	X			
Pristomyrmex sp. 1	14-Jun-06	3	H. Wright	Winkler	X	X		
Pyramica concolor	20-Jun-06	1	H. Wright	Winkler	X	X	X	
Pyramica lujae	14-Jun-06	10	H. Wright	Winkler	X	X		
Pyramica minkara	20-Jun-06	1	H. Wright	Winkler			X	
Pyramica sp. 1	22-Jun-06	6	H. Wright	Winkler		X	X	
Solenopsis sp. 1	22-Jun-06	1	H. Wright	Winkler			X	
Strumigenys petiolata	20-Jun-06	1	H. Wright	Winkler	X	X	X	
Strumigenys sp. 2	20-Jun-06	2	H. Wright	Winkler		X	X	
Strumigenys sp. 3	16-Jun-06	1	H. Wright	Winkler		X		
Technomyrmex sp. 1	14-Jun-06	4	H. Wright	Winkler	X	X	X	
Technomyrmex sp. 2	20-Jun-06	2	H. Wright	Winkler			X	
Temnothorax sp. 1	8-Jun-06	1	L. Alonso	By hand	X			
Tetramorium aculeatum	14-Jun-06	2	H. Wright	Winkler	X	X		
Tetramorium guineense	20-Jun-06	3	H. Wright	Winkler	X	X	X	
Tetramorium invictum	16-Jun-06	2	H. Wright	Winkler		X		
Tetramorium lanuginosum	14-Jun-06	1	H. Wright	Winkler	X	X		
Tetramorium simillimum	22-Jun-06	2	H. Wright	Winkler	X	X	X	
Tetramorium sp. 1	22-Jun-06	1	H. Wright	Winkler	X		X	
Tetramorium sp. 2	8-Jun-06	1	L. Alonso	By hand		X		

Appendix 6

List of bird species recorded in the Atewa Range Forest Reserve, Ghana

Ron Demey and William Ossom

		Encounter Rate	Threat Status	Endemism	GC Forests Biome	Habitat
ACCIPITRIDAE (7)						
Gypohierax angolensis	Palm-nut Vulture	R				a
Dryotriorchis spectabilis	Congo Serpent Eagle	U			GC	f
Polyboroides typus	African Harrier Hawk	U				f, a
Accipiter tachiro	African Goshawk	U				f
Urotriorchis macrourus	Long-tailed Hawk	U			GC	f
Spizaetus africanus	Cassin's Hawk Eagle	R			GC	f
Stephanoaetus coronatus	Crowned Eagle	U				f, a
PHASIANIDAE (1)						
Francolinus lathami	Latham's Forest Francolin	F			GC	f
NUMIDIDAE (1)						
Guttera pucherani	Crested Guineafowl	R				f
RALLIDAE (2)						
Himantornis haematopus	Nkulengu Rail	R			GC	f
Sarothrura pulchra	White-spotted Flufftail	C			GC	w
COLUMBIDAE (4)						
Treron calvus	African Green Pigeon	C				f, e
Turtur brehmeri	Blue-headed Wood Dove	C			GC	f
Turtur tympanistria	Tambourine Dove	U				f, e
Columba iriditorques	Western Bronze-naped Pigeon	F			GC	f
PSITTACIDAE (1)						
Poicephalus gulielmi	Red-fronted Parrot	R				f, a
MUSOPHAGIDAE (2)						
Corythaeola cristata	Great Blue Turaco	U				f
Tauraco macrorhynchus	Yellow-billed Turaco	C			GC	f
CUCULIDAE (6)						
Cuculus clamosus	Black Cuckoo	R				f
Chrysococcyx cupreus	African Emerald Cuckoo	U				f
Chrysococcyx klaas	Klaas's Cuckoo	U				f, e
Ceuthmochares aereus	Yellowbill	C				f, e
Centropus leucogaster	Black-throated Coucal	U			GC	f, e
Centropus monachus	Blue-headed Coucal	R				e
STRIGIDAE (1)						
Strix woodfordii	African Wood Owl	R				f
CAPRIMULGIDAE (1)						

		Encounter Rate	Threat Status	Endemism	GC Forests Biome	Habitat
Veles binotatus	Brown Nightjar	R			GC	f
APODIDAE (5)						
Rhaphidura sabini	Sabine's Spinetail	R			GC	a
Neafrapus cassini	Cassin's Spinetail	R			GC	a
Cypsiurus parvus	African Palm Swift	R				a
Apus batesi	Bates's Swift	R			GC	a
Apus affinis	Little Swift	U				a
TROGONIDAE (1)						
Apaloderma narina	Narina's Trogon	F				f
ALCEDINIDAE (5)						
Halcyon badia	Chocolate-backed Kingfisher	C			GC	f
Halcyon malimbica	Blue-breasted Kingfisher	R				f
Ceyx lecontei	African Dwarf Kingfisher	R			GC	f
Ceyx pictus	African Pygmy Kingfisher	R				o
Alcedo leucogaster	White-bellied Kingfisher	U			GC	f, w
MEROPIDAE (1)						
Merops muelleri	Blue-headed Bee-eater	F			GC	f, e
CORACIIDAE (1)						
Eurystomus gularis	Blue-throated Roller	R			GC	f
PHOENICULIDAE (1)						
Phoeniculus bollei	White-headed Wood-hoopoe	R				f
BUCEROTIDAE (4)						
Tropicranus albocristatus	White-crested Hornbill	F			GC	f
Tockus camurus	Red-billed Dwarf Hornbill	U			GC	f
Tockus fasciatus	African Pied Hornbill	F			GC	f, e
Bycanistes cylindricus	Brown-cheeked Hornbill	U	NT	UG	GC	f
CAPITONIDAE (7)						
Gymnobucco calvus	Naked-faced Barbet	C			GC	f, e
Pogoniulus scolopaceus	Speckled Tinkerbird	C			GC	f, e
Pogoniulus atroflavus	Red-rumped Tinkerbird	C			GC	f
Pogoniulus subsulphureus	Yellow-throated Tinkerbird	C			GC	f, e
Buccanodon duchaillui	Yellow-spotted Barbet	C			GC	f
Tricholaema hirsuta	Hairy-breasted Barbet	C			GC	f
Trachylaemus purpuratus	Yellow-billed Barbet	C			GC	f
INDICATORIDAE (3)						
Prodotiscus insignis	Cassin's Honeybird	U			GC	e
Indicator (minor) conirostris	Thick-billed Honeyguide	U				f
Indicator willcocksi	Willcocks's Honeyguide	R			GC	e
PICIDAE (4)						
Campethera nivosa	Buff-spotted Woodpecker	U			GC	f
Campethera caroli	Brown-eared Woodpecker	U			GC	f
Dendropicos gabonensis	Gabon Woodpecker	F			GC	f, e
Dendropicos pyrrhogaster	Fire-bellied Woodpecker	U			GC	f, e
EURYLAIMIDAE (1)						
Smithornis rufolateralis	Rufous-sided Broadbill	U			GC	f
HIRUNDINIDAE (2)						
Psalidoprocne nitens	Square-tailed Saw-wing	F			GC	o

		Encounter Rate	Threat Status	Endemism	GC Forests Biome	Habitat
Hirundo abyssinica	Lesser Striped Swallow	R				a
CAMPEPHAGIDAE (2)						
Campephaga quiscalina	Purple-throated Cuckoo-shrike	F				f
Coracina azurea	Blue Cuckoo-shrike	U			GC	f
PYCNONOTIDAE (19)						
Andropadus virens	Little Greenbul	C				e
Andropadus gracilis	Little Grey Greenbul	U			GC	e
Andropadus ansorgei	Ansorge's Greenbul	F			GC	f
Andropadus curvirostris	Cameroon Sombre Greenbul	C			GC	f
Andropadus gracilirostris	Slender-billed Greenbul	C				f, e
Andropadus latirostris	Yellow-whiskered Greenbul	C				f
Calyptocichla serina	Golden Greenbul	C			GC	f, e
Baeopogon indicator	Honeyguide Greenbul	C			GC	f, e
Chlorocichla simplex	Simple Leaflove	R			GC	o
Thescelocichla leucopleura	Swamp Palm Bulbul	U			GC	f
Phyllastrephus icterinus	Icterine Greenbul	C			GC	f
Bleda syndactylus	Red-tailed Bristlebill	F			GC	f
Bleda eximius	Green-tailed Bristlebill	R	VU	UG	GC	f
Bleda canicapillus	Grey-headed Bristlebill	C			GC	f
Criniger barbatus	Western Bearded Greenbul	C			GC	f
Criniger calurus	Red-tailed Greenbul	C			GC	f
Criniger olivaceus	Yellow-bearded Greenbul	U	VU	UG	GC	f
Pycnonotus barbatus	Common Bulbul	U				o
Nicator chloris	Western Nicator	C			GC	f
TURDIDAE (6)						
Stiphrornis erythrothorax	Forest Robin	C			GC	f
Sheppardia cyornithopsis	Lowland Akalat	R			GC	f
Alethe diademata	White-tailed (Fire-crested) Alethe	C / b			GC	f
Alethe poliocephala	Brown-chested Alethe	R				f
Neocossyphus poensis	White-tailed Ant Thrush	F			GC	f
Stizorhina finschi	Finsch's Flycatcher Thrush	C			GC	f
SYLVIIDAE (12)						
Apalis nigriceps	Black-capped Apalis	C			GC	f, e
Apalis sharpii	Sharpe's Apalis	C		UG	GC	f, e
Camaroptera brachyura	Grey-backed Camaroptera	R				e, o
Camaroptera superciliaris	Yellow-browed Camaroptera	C			GC	e
Camaroptera chloronota	Olive-green Camaroptera	C			GC	f, e
Macrosphenus kempi	Kemp's Longbill	C			GC	f, e
Macrosphenus concolor	Grey Longbill	C / b			GC	f, e
Eremomela badiceps	Rufous-crowned Erememela	C / b			GC	f, e
Sylvietta virens	Green Crombec	F			GC	e
Sylvietta denti	Lemon-bellied Crombec	U			GC	f, e
Hyliota violacea	Violet-backed Hyliota	R			GC	f, e
Hylia prasina	Green Hylia	C			GC	f, e
MUSCICAPIDAE (6)						
Fraseria ocreata	Fraser's Forest Flycatcher	U			GC	f, e

		Encounter Rate	Threat Status	Endemism	GC Forests Biome	Habitat
Melaenornis annamarulae	Nimba Flycatcher	R	VU	UG	GC	f
Muscicapa epulata	Little Grey Flycatcher	U / b			GC	f
Muscicapa ussheri	Ussher's Flycatcher	U			GC	f, e
Myioparus griseigularis	Grey-throated Flycatcher	R			GC	e
Myioparus plumbeus	Lead-coloured Flycatcher	R				e
MONARCHIDAE (4)						
Erythrocercus mccallii	Chestnut-capped Flycatcher	F			GC	f
Elminia nigromitrata	Dusky Crested Flycatcher	F			GC	f
Trochocercus nitens	Blue-headed Crested Flycatcher	F			GC	f, e
Terpsiphone rufiventer	Red-bellied Paradise Flycatcher	C			GC	f, e
PLATYSTEIRIDAE (4)						
Megabyas flammulatus	Shrike Flycatcher	U			GC	f
Dyaphorophyia castanea	Chestnut Wattle-eye	C / b			GC	f
Dyaphorophyia blissetti	Red-cheeked Wattle-eye	U			GC	f
Batis poensis	Bioko Batis	U			GC	f, e
TIMALIIDAE (4)						
Illadopsis rufipennis	Pale-breasted Illadopsis	C				f
Illadopsis fulvescens	Brown Illadopsis	F			GC	e
Illadopsis cleaveri	Blackcap Illadopsis	C			GC	f
Illadopsis rufescens	Rufous-winged Illadopsis	C	NT	UG	GC	f
PARIDAE (1)						
Parus funereus	Dusky Tit	R / b			GC	f, e
REMIZIDAE (1)						
Pholidornis rushiae	Tit-hylia	U			GC	f, e
NECTARINIIDAE (10)						
Anthreptes rectirostris	Green Sunbird	C			GC	f, e
Anthreptes seimundi	Little Green Sunbird	R			GC	f
Deleornis fraseri	Fraser's Sunbird	C / b			GC	f
Cyanomitra cyanolaema	Blue-throated Brown Sunbird	C			GC	f, e
Cyanomitra olivacea	Olive Sunbird	C				f, e
Chalcomitra adelberti	Buff-throated Sunbird	U			GC	f, e
Hedydipna collaris	Collared Sunbird	F				f, e, o
Cinnyris chloropygius	Olive-bellied Sunbird	U				o
Cinnyris johannae	Johanna's Sunbird	U			GC	f
Cinnyris superbus	Superb Sunbird	R			GC	e
ZOSTEROPIDAE (1)						
Zosterops senegalensis	Yellow White-eye	R				e
MALACONOTIDAE (4)						
Malaconotus cruentus	Fiery-breasted Bush-shrike	U			GC	f
Malaconotus multicolor	Many-coloured Bush-shrike	F				f
Dryoscopus sabini	Sabine's Puffback	U			GC	f
Laniarius leucorhynchus	Sooty Boubou	U			GC	f, e
PRIONOPIDAE (1)						
Prionops caniceps	Red-billed Helmet-shrike	U			GC	f
ORIOLIDAE (2)						
Oriolus nigripennis	Black-winged Oriole	U			GC	f

		Encounter Rate	Threat Status	Endemism	GC Forests Biome	Habitat
Oriolus brachyrhynchus	Western Black-headed Oriole	C			GC	f
DICRURIDAE (2)						
Dicrurus atripennis	Shining Drongo	C			GC	f
Dicrurus modestus	Velvet-mantled Drongo	F				f, e
STURNIDAE (3)						
Poeoptera lugubris	Narrow-tailed Starling	R			GC	f, e
Onychognathus fulgidus	Forest Chestnut-winged Starling	U			GC	f
Lamprotornis cupreocauda	Copper-tailed Glossy Starling	F	NT	UG	GC	f, e
PLOCEIDAE (8)						
Malimbus malimbicus	Crested Malimbe	F			GC	f
Malimbus nitens	Blue-billed Malimbe	U			GC	f
Malimbus rubricollis	Red-headed Malimbe	F			GC	f, e
Ploceus nigricollis	Black-necked Weaver	R			GC	o
Ploceus nigerrimus	Vieillot's Black Weaver	R			GC	o
Ploceus tricolor	Yellow-mantled Weaver	U / b			GC	f, e
Ploceus albinucha	Maxwell's Black Weaver	F / b			GC	f, e
Ploceus preussi	Preuss's Weaver	U / b			GC	f
ESTRILDIDAE (4)						
Nigrita canicapillus	Grey-headed Negrofinch	C				f, e
Nigrita bicolor	Chestnut-breasted Negrofinch	C			GC	f, e
Parmoptila rubrifrons	Red-fronted Antpecker	R / b			GC	f
Pyrenestes ostrinus	Black-bellied Seedcracker	U			GC	e

Encounter rate:
C = Common: encountered daily, either singly or in significant numbers
F = Fairly common: encountered on most days
U = Uncommon: irregularly encountered and not on the majority of days
R = Rare: rarely encountered, one or two records of single individuals

Breeding:
b = evidence of breeding observed (juveniles with parents)

Threat Status:
VU = Vulnerable
NT = Near Threatened

Endemism:
UG = endemic to the Upper Guinea forest block

Biome:
GC = restricted to the Guinea-Congo Forests biome

Habitat:
f = forest interior
e = forest edge
o = open areas (large clearings, cultivation, etc)
w = streams, swamps and ponds
a = aerial and flying overhead

Appendix 7

Bats collected during the Atewa RAP survey and deposited in the research collection of Jakob Fahr, University of Ulm

Natalie Weber and Jakob Fahr

Species	Locality	F-N°	Date
Scotonycteris zenkeri	Asiakwa South	NW 17	11.06.2006
Megaloglossus woermanni	Atiwiredu	NW 10	09.06.2006
Myonycteris torquata	Atiwiredu	NW 06	08.06.2006
Nycteris grandis	Asiakwa South	NW 22	13.06.2006
Rhinolophus alcyone	Asiakwa North	NW 28	17.06.2006
Hipposideros ruber	Atiwiredu	NW 04	08.06.2006
Hipposideros beatus	Asiakwa North	NW 37	21.06.2006
Hipposideros cyclops	Asiakwa North	NW 29	17.06.2006
Hipposideros gigas	Atiwiredu	NW 08	09.06.2006
Hypsugo (*crassulus*) *bellieri*	Asiakwa North	NW 35	20.06.2006
	Atiwiredu	NW 05	08.06.2006
Pipistrellus aff. *grandidieri*	Asiakwa North	NW 36	20.06.2006

Appendix 8

Shrews and rodents collected during the Atewa RAP survey and deposited in the collections of the Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK)

Natalie Weber and Jakob Fahr

Species	Locality	Catalogue N°
Crocidura grandiceps	Atiwiredu	ZFMK 2006.100, -.101
Praomys tulbergi	Atiwiredu	ZFMK 2006.102
	Asiakwa South	ZFMK 2006.103
	Asiakwa North	ZFMK 2006.104
Malacomys edwardsi	Atiwiredu	ZFMK 2006.105
	Asiakwa South	ZFMK 2006.106
	Asiakwa North	ZFMK 2006.107 – .109

Appendix 9

List of small mammal species reported from Atewa Range Forest Reserve in previous surveys

Natalie Weber and Jakob Fahr

Abedi-Lartey and Guba-Kpelle (2005) present the following list of species recorded during an earlier survey of the Atewa Range Forest Reserve. The identification of shrews as *Sylvisorex granti* is certainly an error as this species is only known from Central and East Africa. The occurrence of both *T. swinderianus* and *C. emini* in the Atewa Range is likely but apparently not documented by voucher specimens (see below).

Order	Family	Species	Atiwiredu	Asiakwa North	Asiakwa South
Chiroptera	Pteropodidae	*Eidolon helvum*	X		
		Hypsignathus monstrosus	X		
Soricomorpha	Soricidae	*Sylvisorex granti*	X	X	X
Rodentia	Thryonomyidae	*Thryonomys swinderianus*		X	X
	Muridae	*Cricetomys emini*	X	X	X
		Praomys tullbergi	X	X	X

Atiwiredu: 6°13.9'N, 0°34.4'W; Asiakwa North: 6°13.9'N, 0°33.5'W; Asiakwa South: 6°15.3'N, 0°34.0'W.

Additionally, the otherwise excellent management plan for Atewa Range Forest Reserve by Abu-Juam et al. (2003) listed the following terrestrial small mammals for Atewa Range (excluding squirrels [Sciuridae] and scaly-tailed squirrels [Anomaluridae], which are not considered in the present report). Several of these species would be typical for savanna habitats, farmbush or highly degraded forest (like other mammal species listed by Abu-Juam et al. (2003): patas monkey [*Erythrocebus patas*], Senegal galago [*Galago senegalensis*] and rock hyrax ["*Procavia ruficeps*"]). If these species should have indeed been recorded from the Atewa Range, we suspect that they were sampled in highly degraded or disturbed areas along the periphery of the forest reserve. Consequently, we exclude species records for Atewa Range that are not yet reliably documented with voucher specimens:

[*Crocidura crossei* possible but difficult to distinguish from *C. jouvenetae*]
[*Cricetomys gambianus* possibly mistaken for *C. emini*]
[*Lemniscomys striatus* usually in farmbush and disturbed areas; could be also *L. bellieri*]
[*Lophuromys sikapusi* possible, but more in disturbed sites]
[*Mastomys erythroleucus* unlikely savanna / farmbush species]
[*Myomys daltoni* unlikely savanna species; now *Praomys daltoni*]
[*Mus musculus* commensal, in disturbed areas; possibly confused with *Mus* (*Nannomys*) spp.]
Praomys tullbergi accepted, also recorded during the present RAP-survey
Thryonomys swinderianus also recorded by Abedi-Lartey and Guba-Kpelle (2005)

Appendix 10

Atewa Range Forest Reserve Initial Biodiversity Assessment and Planning (IBAP) Working Group Results from the Consultative Workshop held at Okyehene's Palace, Kibi

Following the RAP survey, a one-day consultative workshop was held on 26 June, 2006 at the Palace of Paramount Chief Okyehene in Kibi. The following summarizes some of the workshop results.

Uses of Atewa's Biodiversity		Users/Stakeholders	Impact of use on Biodiversity	Suggested Conservation Actions
Animals				
	Consumption - Bushmeat	Communities; Hunters	Decreased fertility of soil; Negative impact on pollination / seed dispersal	Breeding locally (snails, grasscutter, etc); Ban on hunting periods by Forestry Commission; Increased aquaculture; Empower local authorities (chiefs and elders) to protect biodiversity
	Pet trade (e.g., parrots for export			
Plants				
	Consumption - wild growing plants	Communities	Deforestation; Soil degradation; Invasion of non-native species; Increased dryness; Migration of Fauna; Lack of Shade; Decrease in air quality	
	Herbal uses	Local and other communities; Traditional doctors		Educate practitioners; Make alternative health facilities available, accessible, and affordable
	Building - furniture, roofing, bridges, boats	Carpenters; Fishermen		Chieftancy control of forestry resources; Planned logging; Adopting alternative building methods; Education; Report chain saw operations; Government support in law enforcement
	Firewood and charcoal	All (within communities)		Use of gas as alternate domestic fuel source; make alternatives available, affordable and accessible; Report chain saw operations; Government support in law enforcement
	Chewing sticks	All (within communities)		
	Pestle/fufu pounding	All (within communities)		Afforestation
	Baskets	Market women, farmers		

Uses of Atewa's Biodiversity		Users/Stakeholders	Impact of use on Biodiversity	Suggested Conservation Actions
Water				
	Drinking	All (communities throughout Ghana, animals, plants)	Decrease in water leads to migration of fauna; Protection of Atewa's watersheds will have immense positive impacts for the country, whereas activities that decrease/degrade the water supply here will have a highly negative impact	Education; Regulation; Restriction of Farming along stream and river banks
	Washing	All		
	Bathing	All		
General ecosystem				
	Good environment			
	Tourism	International community; Ghanaians	Positive image for Ghana; Education; Recreation	
	Windbreak	Communities east and west of Atewa		
	Heritage			
	Traditional uses (drums and hide)			
	Absorption of carbon dioxide		Positive	Prevent logging through education; enforcement of laws; prohibition of charcoal burning
	Kaolin			
	Pottery	Communities	Erosion / soil depletion	
	Illegal farming	Villagers, hunters, communities	Forest destruction; Fire; Animal migration	
	Scientific research	Scientific community		

Appendix 11

Participants in the Consultative Workshop held at Okyehene's Palace, Kibi

Name	Institution
1. Alahasi M. M. Karikari	Okyehene Councilor
2. OP. J. B. Frempong	Okyehene Councilor
3. Abubarkari Moro II	Nsong Chief
4. Okyeame Ampofo	Okyehene Kyeame
5. BA. Kwante Agyemang	Mnenapofohene
6. Torgbe Gborchie	Eve Com. Chief
7. Mame Adwoa Botwe	Okyehene Councilor
8. Dr. Omane	Okyehene Councilor
9. OP. Benjamin Danfo	Ankobea Abusuapanin
10. OP. Kwaku Boakye	Okyehene
11. Osabarima Agyemang III	Nifahene Akyem Abuakwa
12. Osabarima Twiretwie B. Dankwa	Abontendomhene
13. Nana Adutwumwaa Dokua	Okyehene
14. Osabarima Apegya Ofori	Amantoameasa
15. Okyeame Atta	Nifahene
16. Baafour Afoakwa	
17. Okyeheneba OP. Yaw Takyi	Okyehene Councilor
18. Nana Amankrado Larbi	Amankrado
19. Baafour Kyere Koranteng	Amankrado
20. OP. Yeboa	Abusuapanin
21. Baafour Agyei Awoako	Okyehene Councilor
22. Nana Mintah Brakohiapa	Okyeman State Secretary
23. OP. Kwame Kwapong	Asokwahene Councilor
24. OP. Kwapi Amonkoapta	Nsafoahene
25. Madam Dora Nima	Asokwahemaa
26. Joseph Yaw Aboagye	Minerals Commission
27. Dr. Steve Amisah (Dean)	Faculty of Renewable Natural Resources, KNUST
28. Frank Kopi Botehway	OEF
29. Kwame Dauguah	Okyehenefie
30. Biagya Yakubu	Min. Lands, Forestry, and Mines
31. Joyce R. Aryee	Chamber of Mines
32. Eric Black	Alcoa
33. Oumar Toguyeni	Alcoa
34. John Gardner	Alcoa
35. Ibrahima Danso	Alcoa
36. Hon. Abraham Osbem	Dep. Minister LGRD
37. Hon. I. V. Asihene	DCE EADA
38. Maxwell Apeakoromg	Info. Serv. Dept.
39. Nana Osusu	EADA
40. Owusu Akyem	Security
41. Mr. Taw Sardong	C. L. S. Staff
42. OP. Foratour	Okyehene Councilor
43. Asare Hayford	A. A. T. C.
44. Madam Mina Owusua	Okyehene Councilor
45. OP. Rexford Afoakwa	Okyehene Councilor

Name	Institution
46. Okyeame Kofi Brako	Okyehene Kyeame
47. Okyeame Otsibu Darko	Abontendomhene / Kyeame
48. Madam Afia Donkor	Okyehene Councilor
49. Baafour Yeboa	Okyehene Councilor
50. Baafour Aboafe Dampare	Akwasrayene
51. Nana Akua Dokua	Gyasehemau
52. Nana Akuffo	Okyehene Councilor
53. Abena Twumwaa	Okyehemaa Kyeame
54. Adwoa Marteki	Okyehemaa Kyeame
55. Edith Abrufuah	Forest Service Dir.
56. Rosemound Dansoa	Okyehemaa Ouifii
57. Kwame Twum	
58. Beatrice Ankomaa	Okyehene Councilor
59. OP. Kwame Asamoah	Kyidom Asusuapanin
60. Emmanuel Owusu	Conservation International
61. Yaw Osei-Owusu	Conservation International
62. Marielle Canter	Conservation International
63. Madam Alice Andam	A.A.T.C.
64. Solomon Osei Danso	E.A.D.A.
65. Ansah William	P.P.T.A.P.
66. OP. Asafori	Kyidomhene.
67. Nana Duah	Okyemam Bailiff
68. OP. Yaw Mortey	Okyehene Councilor
69. Madam Aboagyewaa J.	Okyehene Councilor
70. Okyeame Anyam	Okyehene / Okyeame
71. Baafour Sagemase	Samansuhene

Appendix 12

IUCN Red-listed amphibian, bird and mammal species recorded from 16 reserves studied during West African RAP surveys

Threat Status based on the IUCN Red List categories which include, from most to least threatened:

Critically Endangered (CR)
Endangered (EN)
Vulnerable (VU)
Near Threatened (NT)
Lower Risk/near threatened (LR/nt)
Data Deficient (DD) (IUCN 2007)
#IUCN = total number of species recorded in the above categories that are listed on the IUCN Red List
* = not of conservation concern during this survey
** = possibly present

Taxon	Species Name	Common Name	Threat status	Cote d'Ivoire		Guinea					Liberia			Ghana					
				Haute Dodo	Cavally	Pic de Fon	Déré	Diécké	Mt. Béro	Boké	North Lorma	Gola	Grebo	Draw River	Boi-Tano	Krokosua	Atewa	Ajenjua Bepo	Mamang River
# sites				**1**	**1**	**2**	**1**	**2**	**1**	**3**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**1**	**1**
# survey days				**8**	**8**	**11**	**3**	**8**	**6**	**18**	**6**	**7**	**5**	**5**	**5**	**5**	**16**	**7**	**5**
# IUCN				**29**	**40**	**27**	**14**	**31**	**25**	**7**	**26**	**24**	**39**	**19**	**13**	**14**	**28**	**1**	**4**
# CR				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
# EN				**3**	**4**	**0**	**0**	**4**	**0**	**2**	**4**	**2**	**4**	**3**	**2**	**1**	**2**	**0**	**0**
# VU				**6**	**7**	**4**	**3**	**5**	**6**	**0**	**4**	**5**	**10**	**5**	**3**	**2**	**5**	**0**	**1**
Amphibian	*Connaua derooi*		CR														X		
Amphibian	*Amnirana occidentalis*		EN	X				X				X		X					
Amphibian	*Hyperolius bobirensis*		EN														X		
Amphibian	*Phrynobatrachus annulatus*		EN								X		X	X	X				
Amphibian	*Phrynobatrachus ghanensis*		EN											X	X		X		
Bird	*Malimbus ballmanni*	Gola Malimbe	EN					X				X							
Small Mammal	*Micropotamogale lamottei*	Mt. Nimba Otter Shrew	EN			x**													
Bat	*Hipposideros marisae*	Aellen's Roundleaf Bat	EN																
Bat	*Rhinolophus ziama*		EN																
Primate	*Cercopithecus diana diana*	Diana Monkey	EN	X	X	x**		X	x**		X		X						
Primate	*Pan troglodytes verus*	West African Chimpanzee	EN	X	X	x**		X	x**	X	X		X	X		X			
Primate	*Procolobus badius*	Western Red Colobus	EN		X			x**	x**	X	X		X						
Large mammal	*Liberiictis kuhni*		EN		X														
Amphibian	*Connaua alleni*		VU					X	X			X	X						
Amphibian	*Kassina arboricola*		VU														X		
Amphibian	*Kassina lamottei*		VU		X														
Amphibian	*Hyperolius laurenti*		VU											X	X				

Taxon	Species Name	Common Name	Threat status	Cote d'Ivoire		Guinea					Liberia			Ghana					
				Haute Dodo	Cavally	Pic de Fon	Déré	Diécké	Mt. Béro	Boké	North Lorma	Gola	Grebo	Draw River	Boi-Tano	Krokosua	Atewa	Ajenjua Bepo	Mamang River
Amphibian	*Hyperolius viridigulosus*		VU											X	X				
Amphibian	*Phrynobatrachus villiersi*		VU	X	X						X	X	X						
Bird	*Agelastes meleagrides*	White-breasted Guineafowl	VU	X	X								X						
Bird	*Bleda eximius*	Green-tailed Bristlebill	VU		X			X					X	X	X	X	X		X
Bird	*Campephaga lobata*	Ghana Cuckoo-shrike	VU																
Bird	*Criniger olivaceus*	Yellow-bearded Bulbul	VU	X	X	X	X	X	X		X	X	X	X			X		
Bird	*Lobotos lobatus*	Western Wattled Cuckoo-shrike	VU	X		X			X				X						
Bird	*Melaenornis annamarulae*	Nimba Flycatcher	VU	X			X						X				X		
Bird	*Picathartes gymnocephalus*	Yellow-headed Picathartes	VU						X		X								
Bird	*Schistolais leontica*	Sierra Leone Prinia	VU			X													
Bat	*Mops trevori*	Trevor's Free-tailed Bat	VU						X										
Bat	*Rhinolophus guineensis*	Guinean Horseshoe Bat	VU			X	X		X										
Bat	*Rhinolophus hillorum*	Hill's Horseshoe Bat	VU					X				X							
Bat	*Scotophilus nucella*		VU													X			

Taxon	Species Name	Common Name	Threat status	Cote d'Ivoire		Guinea					Liberia			Ghana					
				Haute Dodo	Cavally	Pic de Fon	Déré	Diécké	Mt. Béro	Boké	North Lorma	Gola	Grebo	Draw River	Boi-Tano	Krokosua	Atewa	Ajenjua Bepo	Mamang River
Primate	*Colobus vellerosus*	Geoffroy's pied colobus	VU														X		
Large mammal	*Cephalophus zebra*		VU		X														
Large mammal	*Cephalophus jentinki*	Jentink's Duiker	VU										X						
Large mammal	*Hexaprotodon liberiensis*	Pygmy Hippopotamus	VU		X			X					X						
Large mammal	*Loxodonta africana*	African Elephant	VU	X							X	X	X	X					
Amphibian	*Acanthixalus sonjae*		NT	X	X											X	X		
Amphibian	*Afrixalus nigeriensis*		NT	X	X							X	X			X	X		
Amphibian	*Afrixalus vibekensis*		NT	X													X		
Amphibian	*Amietophrynus togoensis*		NT														X		
Amphibian	*Bufo togoensis*		NT	X	X	X		X	X		X		X						
Amphibian	*Hyperolius chlorosteus*		NT	X	X	X	X	X	X			X	X						
Amphibian	*Hyperolius zonatus*		NT				X	X	X										
Amphibian	*Kassina cochranae*		NT			X	X												
Amphibian	*Leptopelis macrotis*	Big-eared Forest Frog	NT	X	X			X					X	X					
Amphibian	*Leptopelis occidentalis*	Tai Forest Tree Frog	NT	X	X								X	X					X
Amphibian	*Petropedetes natator*		NT			X			X			X							
Amphibian	*Phrynobatrachus alleni*		NT	X	X	X	X	X	X		X	X	X	X	X	X	X		
Amphibian	*Phrynobatrachus guineensis*		NT	X	X			X					X						
Amphibian	*Phrynobatrachus liberiensis*		NT	X	X	X	X	X	X		X	X	X	X	X				
Amphibian	*Phrynobatrachus phyllophilus*		NT		X	X	X	X			X	X	X						
Amphibian	*Ptychadena superciliaris*		NT					X	X				X						

Taxon	Species Name	Common Name	Threat status	Cote d'Ivoire		Guinea					Liberia			Ghana					
				Haute Dodo	Cavally	Pic de Fon	Déré	Diécké	Mt. Béro	Boké	North Lorma	Gola	Grebo	Draw River	Boi-Tano	Krokosua	Atewa	Ajenjua Bepo	Mamang River
Bird	*Bathmocercus cerviniventris*	Black-headed Rufous Warbler	NT			X			X		X								
Bird	*Bycanistes cylindricus*	Brown-cheeked Hornbill	NT	X	X			X			X	X	X			X	X		
Bird	*Ceratogymna elata*	Yellow-casqued Hornbill	NT	X	X	X	X	X	X		X	X	X						
Bird	*Illadopsis rufescens*	Rufous-winged Illadopsis	NT	X	X	X	X	X	X		X	X	X		X	X	X		
Bird	*Lamprotornis cupreocauda*	Copper-tailed Glossy Starling	NT	X	X			X			X	X	X	X		X	X		
Bird	*Malaconotus lagdeni*	Lagden's Bush-shrike	NT										X						
Bird	*Pteronetta hartlaubii*		NT		X														
Small Mammal	*Crocidura grandiceps*	Large-headed shrew	NT														X		
Bat	*Hipposideros fuliginosus*	Sooty Roundleaf Bat	NT			X					X				X	X			
Bat	*Hipposideros jonesi*	Jones's Roundleaf Bat	NT			X													
Bat	*Kerivoula cuprosa*	Copper Woolly Bat	NT			X													
Bat	*Kerivoula phalaena*		NT			X													
Bat	*Saccolaimus peli*	Pel's Pouched Bat	NT																
Bat	*Scotonycteris zenkeri*	Zenker's Fruit Bat	NT	X									X				X		
Primate	*Cercocebus atys atys*	Sooty Mangabey	LR/nt	X	X	X		X		X	X	X	X						
Primate	*Colobus polykomos*	Western Black-and-White Colobus	NT		X			x**	x**		X		X						

Taxon	Species Name	Common Name	Threat status	Cote d'Ivoire		Guinea					Liberia			Ghana					
				Haute Dodo	Cavally	Pic de Fon	Déré	Diécké	Mt. Béro	Boké	North Lorma	Gola	Grebo	Draw River	Boi-Tano	Krokosua	Atewa	Ajenjua Bepo	Mamang River
Primate	*Papio papio*		LR/nt							X									
Primate	*Procolobus verus*	Olive Colobus	LR/nt		X	X							X	X			X		
Large mammal	*Anomalurus pelii*	Pel's flying squirrel	NT														X		
Large mammal	*Cephalophus dorsalis*	Bay Duiker	LR/nt	X	X	x*		X			X	X	X	X	X	X	X		
Large mammal	*Cephalophus maxwelli*	Maxwell's Duiker	LR/nt	X	X	x*	X	X	X	X	X	X	X	X	X	X	X	X	X
Large mammal	*Cephalophus niger*	Black Duiker	LR/nt	X	X	x*		X	X		X	X	X	X	X	X	X		X
Large mammal	*Cephalophus ogilbyi*	Ogilby's Duiker	LR/nt								X		X						
Large mammal	*Cephalophus silvicultor*	Yellow-backed Duiker	LR/nt			x*	X	X	X				X				X		
Large mammal	*Neotragus pygmaeus*	Royal Antelope	LR/nt											X	X	X	X		
Large mammal	*Tragelaphus eurycerus*	Bongo	LR/nt		X								X						
Large mammal	*Cephalophus rufilatus*	Red-flanked Duiker	LR/cd					X	X										
Large mammal	*Syncerus caffer*	African Buffalo	CD	X	X	x*		X	X		X								
Amphibian	*Ptychadena retropunctata*		DD						X	X									
Bird	*Lamprotornis iris*	Emerald Starling	DD			X			X										
Bird	*Melignomon eisentrauti*	Yellow-footed Honeyguide	DD		X						X								
Bird	*Phyllastrephus baumanni*	Baumann's Greenbul	DD			X			X	X									
Bird	*Tigriornis leucolophus*	White-crested Tiger Heron	DD		X			X											
Small Mammal	*Crocidura douceti*	Doucet's Musk Shrew	DD		X														

Taxon	Species Name	Common Name	Threat status	Cote d'Ivoire		Guinea					Liberia			Ghana					
				Haute Dodo	Cavally	Pic de Fon	Déré	Diécké	Mt. Béro	Boké	North Lorma	Gola	Grebo	Draw River	Boi-Tano	Krokosua	Atewa	Ajenjua Bepo	Mamang River
Small Mammal	*Epixerus ebii*	Western Palm Squirrel	DD		X			X	X			X					X		
Small Mammal	*Protoxerus aubinnii*	Slender-tailed Squirrel	DD		X														
Large mammal	*Hyemoschus aquaticus*	Water Chevrotain	DD		X		X												
Bat	*Hypsugo (crassulus) bellieri*	Bellier's Pipistrelle	n.a.									X					X		
Bat	*Pipistrellus* aff. *grandidieri*	Grandidier's Pipistrelle	n.a.									X					X		

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ISBN 978-1-934151-09-9