Europa Island Scientific Mission
25th February – 21st March 2008

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Summary

Two Université de la Réunion ecologists (ECOMAR laboratory) visited Europa Island for approximately one month. Intensive studies were made of rat population biology and insect biodiversity. Additional observations were made on goats and the avifauna. Rat density was estimated at around 65 rats per hectare in the forest. The unanticipated arrival of a powerful tropical cyclone provided a unique opportunity to study the impact on the island. Temporary forest monitoring plots revealed damage to over 50% of the forest. This effect was compounded by more intense goat browse following the cyclone. These interactive effects are probably gradually changing the euphorbia forest to plains. In addition extensive flooding of the southern plains temporarily eradicated rat populations. The island management structure created unresolved conflict between the resident scientists and military which requires resolution. Eradication of goats and rats from Europa should be a priority within the next decade.

Introduction

Europa (2223 ha; 22°21'S, 40°21'E) is a coralline atoll lying in the southern Mozambique Channel (Fig. 1). It is classified as a nature reserve in the Îles Éparses managed by the Terres Australes et Antarctiques Françaises (TAAF) as French overseas territories.

The north-western area of the island about the airstrip is dominated by 5 m canopy dry indigenous forest composed of *Euphorbia stenoclada* and *Ficus marmorata*. At the northern point within this area approximately 45 ha is a historical sisal plantation (*Agave sisalina* and *Furcraea foetida*). The remainder of the island is 0.5 m height plains of herbaceous *Sclerodactylon macrostachyum*, which periodically floods following tropical cyclones. The large lagoon supports an additional 836 ha of mangrove (*Rhizophora mucronata*) and a 2.65 ha islet at the northern entrance. The only resident land birds are pied crows (*Corvus albus*) and a small (<30) population of barn owls (*Tyto alba*).

The island is a regionally important breeding site for red and white tailed tropicbirds (*Phaethon rubricauda* and *P. lepturus*), greater and lesser frigatebirds (*Fregata minor* and *F. ariel*), red footed boobies (*Sula sula*), sooty terns (*Sterna fuscata*) and green turtles (*Chelonia mydas*). The island is part of a long-term research programme managed by the Marine Ecology laboratory (ECOMAR) at the Université de la Réunion. Teams of two scientists regularly visit the island twice a year in late summer and winter. We describe here the observations and studies made from a 26 day trip from February to March 2008.

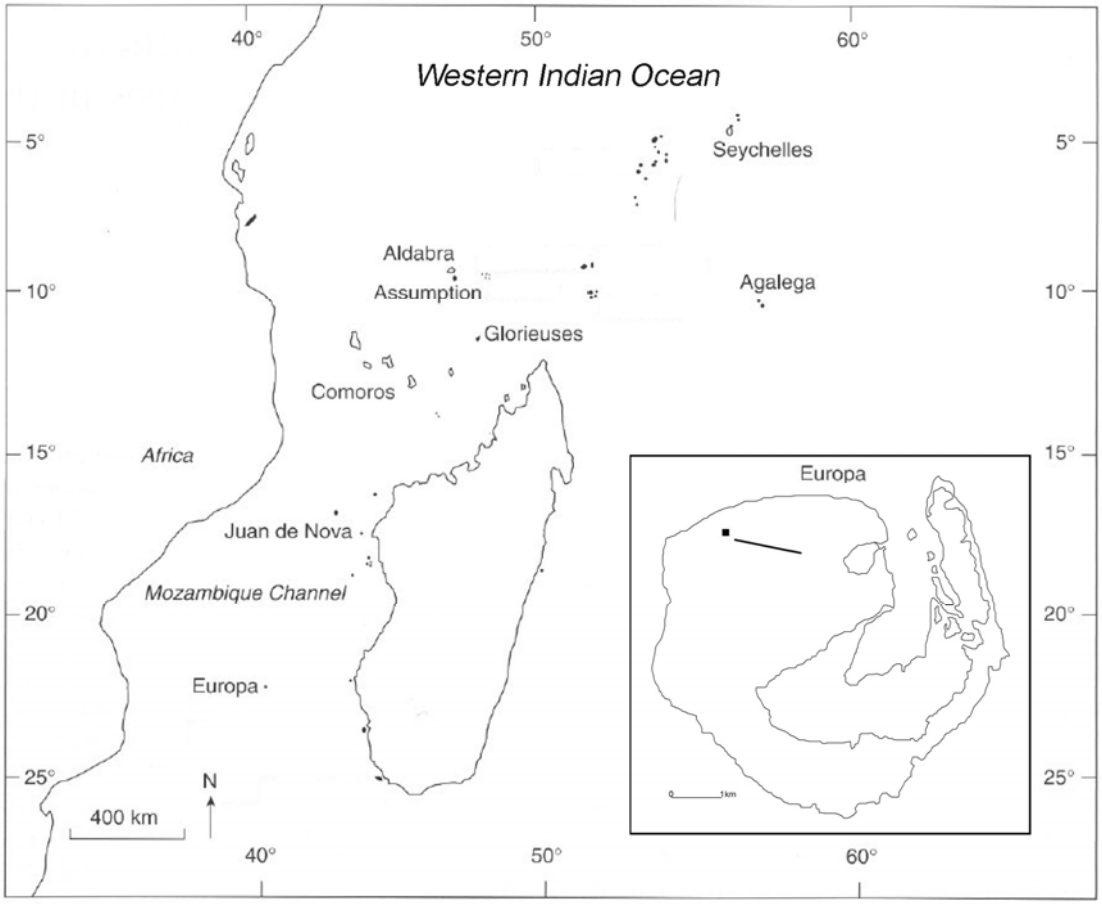

Figure 1: Western Indian Ocean Islands with Europa inset.
Buildings and airstrips are indicated.

Introduced Mammals

Europa Island has had introduced goats (*Capra hircus*) and black rats (*Rattus rattus*) since at least 1860. Both these species are recognised as among the worst invaders to remote islands, and over the last 150 years will have severely altered ecosystem and population dynamic processes on the island. Goats will have severely altered the forest habitat and regeneration regime, while rats will have altered the diversity and abundance of insects and birds. The cascading effects of these changes are generally not well understood.

No rigorous study of goats was made during this trip, however we observed that goats were most abundant throughout the forest, and in the late afternoon would migrate *en masse* (sometimes more than 50) to the airstrip and feed. Goats were present throughout the island but are unlikely to permanently reside in the plains. Their presence appears to be largely halting the regeneration of the euphorbia forest which is gradually being thinned out (Plate 1).

Plate 1: Goat browse on euphorbia.

The density of rats on the island was estimated in order to provide information on the quantity of poison that would be required for any eradication attempt. Rats were live-trapped in a 7 by 7 live-trap grid with traps spaced at 10 m baited with peanut butter and sweet potato. The first grid was placed south of the airstrip in forest (Plate 2) while the second grid was placed in the plains around the third kilometre mark (Plate 3). Rats were captured, marked and released for nine nights before two nights of removal (kill) trapping. Rats were marked with one ear-tag in each ear, to account for possible tag-loss. Dead rats were frozen for subsequent autopsy.

Density was estimated from these data using spatially explicit capture recapture methods implemented in the program DENSITY. By estimating the movement rate of rats from recapture data it is possible to estimate the distribution of home-range centres, and hence an estimate of density as number of rats within a specified area.

Plate 2: Forest rat trapping grid – south of airstrip.

Plate 3: Plains rat trapping grid – third kilometre.

A total of 75 rats were caught during 10 nights of trapping in the forest (Table 1). Cyclone Jokwe flooded the plains grid and no results were obtained.

	male	female	total
adult	14	13	27
juvenile	29	19	48
total	43	32	75

Table 1: Rats caught in forest.

There was no significant difference between the numbers of males and females caught (two-tailed binomial test $p = 0.25$) though more juveniles than adults were caught as would be expected in late summer after the breeding season. There was no interaction between the sexes caught in each age-class ($\chi^2 = 0.52$, $p = 0.47$, $df = 1$). The density of rats (without covariates but accounting for deaths) was estimated at 65 rats per hectare with a 95% confidence interval between 50 and 80 rats. This suggests the 60 x 60m trapping grid was trapping rats from well outside its nominal area. One night of trapping in the plains prior to cyclone Jokwe suggests the rats were at a much lower density in the plains.

Clearly the eradication of both goats and rats from Europa is desirable, and possible, in the near future. Goats could be readily eradicated given the small size of the island and population, however this might result in a release of the vegetation from goat browse, and cause indirect increases in invasive plants (e.g. sisal) and rat density. Provided the ongoing control or eradication of invasive plants and rats is planned for within a decade of goat eradication the removal of goats first is unlikely to cause major cascading effects. The eradication of rats is possible, but would be one of the largest black rat eradications undertaken to date, with the added complexity of the tropical environment (e.g. crabs) and remoteness of the island. Eradication could be undertaken either by aerial baiting with helicopters, or possibly through a ground-based operation given the flat topography of the island, with hand-spread bait where appropriate. The latter is more labour intensive but does not require helicopters to be transported to Europa, and allows more control over the distribution and monitoring of bait take and ultimately eradication progress. Eradication of rats from Europa should be a priority. Rats pose a manageable nuisance around human facilities, best managed by mechanical control (i.e. traps) to prevent immunity through ongoing toxin use.

Avifauna

No study of birds was undertaken on the island. However, observations were made of species present and apparent abundances and distributions (Appendix 1). Ongoing long-term monitoring of red-tailed tropic birds was made as part of a wider study on the use of seabirds as ecosystem health indicators. Red-tailed tropic birds were relatively abundant in the mid afternoon (10am to 3pm) but were predominantly prospecting for nests, with only a few nests containing chicks or eggs. Rat predation probably plays an important role in the low observed reproductive output of red-tailed tropic birds. Approximately 30 birds were banded within the triangular coastal area delimited by the meteo station to Baie des Congres.

Entomofauna

The insects of Europa were studied to evaluate the impact of native birds and introduced mammals, such as goats, on the arthropod communities. Insects play a vital regulatory role in ecosystem functioning through nutrient recycling and the maintenance of soil structure. The appropriateness of arthropods and other macro-invertebrates as bioindicators is a result of their large abundance and species richness along environmental gradients, whereas most vertebrates are insensitive to habitat heterogeneity on such small scales. Arthropods can be both directly or indirectly altered by trophic chain relationships. When introduced animals are present, arthropod abundance can be greatly reduced. On Europa, little is known about the entomofauna. In 1984 and 2000, entomological studies were undertaken but only in the context of island mosquito control. Prior to 2002, 86 species of insects had been recorded on Europa. In 2002, 11 new species for the island were added to the inventory. However, insect ecology has not been studied at all. Such studies would provide information not only on insect biology, but also the history of island colonisation by insects.

The study on Europa had several objectives: (1) to determine if the structures of the entomological communities differed between the impacted and non-impacted zones (by goats or seabirds), (2) to identify the insect groups that are sensitive to introduced and native vertebrate presence, and (3) to contribute to a greater understanding of the entomofauna inventory on Europa. The targeted entomological communities were in particular the terrestrial communities. Thus, three types of traps were used; pitfall trap, berlaise for litter, and attractive traps. Three habitat types were studied; forest (n = 4), savannah (n = 4) and the airstrip (n = 1). For pitfall traps, at each station there were five replicates, each containing five pitfall traps. Traps were placed 10 metres apart. A total of 225 pitfall traps were placed on the island, taking account of the different habitats. The trapping period was one week. Litter sampling was undertaken at random in each of the stations. Originally, a total of 60 litter samples (two cases goats/birds × 3 habitats × 2 methods × 5 replicates) were intended to be studied but the savannah and airstrip habitats contained very little litter due to environmental conditions (dry environment for the savannah and intense goat pressure on the airstrip). Finally, only 20 litter samples all from the forest habitat were able to be collected (two cases goats/birds × 2 methods × 5 replicates). For attractive traps three types of bait were used; goat pellets, seabird guano and dead rat (previously captured and killed). In each habitat (n = 3), five traps of each bait type (n = 3) were placed in order to better encompass vertebrate effects on the insects. Thus, 45 traps were placed. Due to the passage of cyclone Jokwé, only the forest habitat could be sampled since the savannah was flooded for several days and the strong winds on the airstrip damaged the traps.

Cyclone Jokwé

Cyclone Jokwé directly passed over Europa on the evening of March 10 with winds reaching a maximum speed of 270 km hr^{-1} (Fig. 2). The cyclone then persisted to the south for a further five days before finally dissipating.

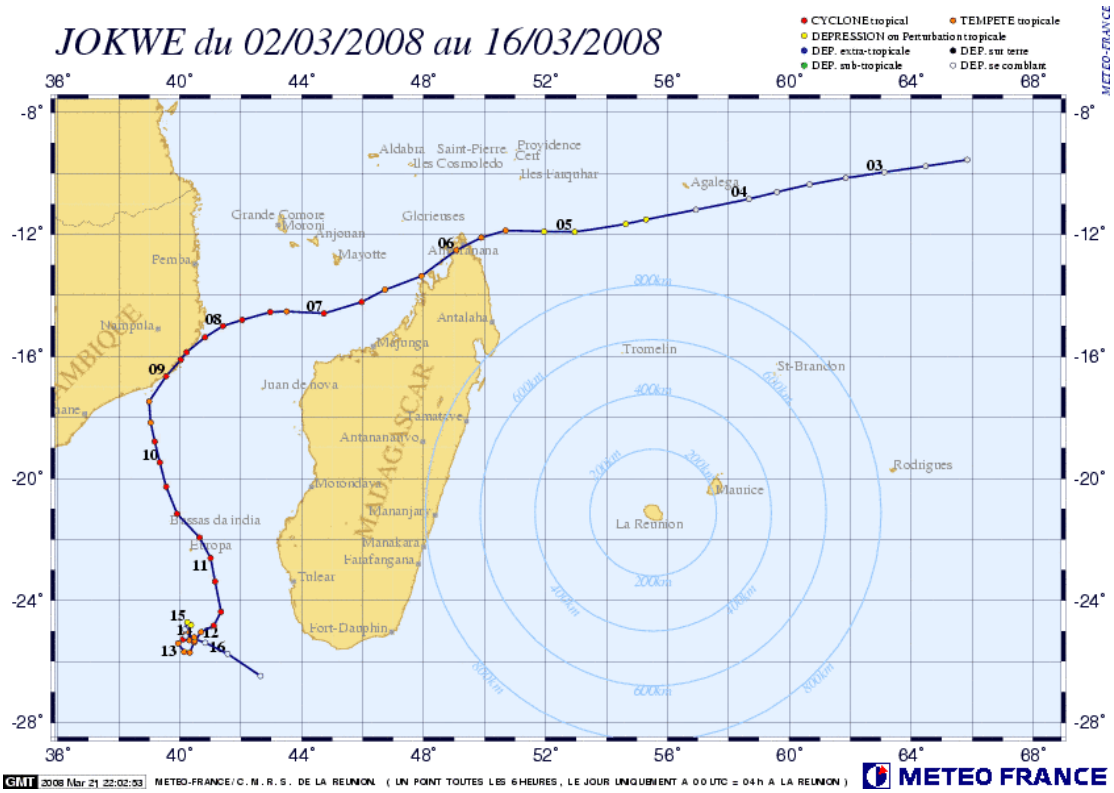

Figure 2: Trajectory of cyclone Jokwé.

This cyclone had notable effects across the entire island. Structural damage occurred to the buildings, including the meteo station losing the roof to the kitchen and interior flooding, and damage to small buildings around the military base. Dead and dieing goats were observed in the forest. Extensive flooding over half a metre in depth occurred across the island, mainly in the low-lying areas such as the plains (Plate 4). Drainage through the coral substrate was slow and the flooding did not subside until after 4-5 days, at which time putrefaction was taking place and could be smelt across the island. In the most low-lying areas (e.g. around the third kilometre mark) complete drainage had still not occurred after ten days. At first the flooding was freshwater, but over time this mixed with the lagoon salt water and allowed fish to swim throughout the plains. This flooding will have effectively caused local rat eradication, although the habitat will be rapidly recolonised from neighbouring forest blocks with a few months or towards the end of 2008 following summer breeding.

Extensive tree fall and damage occurred in the forest. Ten 25 x 25m plots were established in areas of dense forest (range 19 – 41 stems) around the airstrip to rapidly assess the extent of forest damage. Euphorbia trees were classified as intact, damaged, or fallen (Table 2).

class	mean	confidence interval
intact	0.43	0.07 - 0.78
damaged	0.22	0 - 0.52
fallen	0.35	0.01 - 0.69

Table 2: Proportion of euphorbia trees intact, damaged and fallen after cyclone Jokwé with 95% confidence intervals.

Plate 4: Flooding on the plains at the third kilometre mark.

Over 50% of euphorbia trees were impacted by cyclone Jokwé, although the small sample size (n = 10) gave large confidence intervals. Most damage occurred in the dense stands of euphorbia, were the collapse of one tree would lead to further damage to other nearby trees (Plate 5).

Plate 5: Damage to euphorbia forest following cyclone Jokwé

This thinning of dense stands would lead to a substantial decline in abundance but without the expected decline in distribution of the forest across the island. In effect, although the forest is as widespread as previously, its density is decreasing, and this effect would be masked if only aerial photos were inspected. This gradual decline in forest abundance is compounded by the impact of goats on the forest, which extensively browse the lower 2 m of the forest, effectively preventing most forest regeneration. Ultimately the euphorbia forest is gradually being transformed into savannah habitat. The establishment of a series of permanent plots which could be regularly inspected (e.g. annually) would greatly enhance the understanding of forest dynamics on the island.

Management Structure

We encountered many difficulties working with the military in the course of our scientific conservation research on the island. A regiment of fifteen military are posted on the island under the control of their lieutenant. Any scientists or civilians (e.g. volunteers) on the island are independent of the military, and are housed in the separate meteo buildings. Both military and civilians are ultimately under the jurisdiction of the gendarme posted on the island. The gendarme is also posted in the meteo buildings. Unfortunately the success of the mission comes down to the individual nature of the gendarme and the lieutenant. For our mission, the military had a great deal of trouble adapting to a chain of command outside their normal military structure, in that they were answerable to the gendarme, and had no control over the scientists and civilians. Despite the gendarme being the overall person in charge of the island however, he or she is isolated from the military base and does not have control of any of the facilities there, which include power and food for the island. In addition,

the lieutenant has fourteen other military supporting him or her, often overpowering the decisions of the gendarme. We found the military unsupportive and at times obstructive to our research, refusing to provide access to vital infrastructure such as transport and power for equipment (e.g. specimen freezers), or flexibility towards the timetables of the researchers (e.g. missing lunch due to fieldwork) At one point all power was removed from the meteo base for two days by military order. This led to conflict on the island when the gendarme insisted power be restored, and the military believed they were not accountable to the gendarme with regards to infrastructure. Generally the military behaved as if the island was under military and not TAAF ownership. In our view this does not serve the interests of the island, TAAF or the scientists conducting important conservation work on the island. The military also claimed that the activities of the scientists were not a priority for the military, although they did not state what the priority for the military was. Given that Europa is classified as a nature reserve and all native wildlife on the island is thus under legal protection, and the military are placed there to 'protect the interest of France', one would hope that such protection would extend to the wildlife. Unfortunately the military engaged in harassing wildlife through approaching it despite being advised not to by scientists, throwing rocks at and kicking wildlife, and fishing in the marine reserve. This behaviour by no means leads by example. In addition the military behaved ludely and dangerously. At one point a 'party' was held in the military lounge which led to intentional destruction of property and defecation in the lounge.

For human activities to be undertaken on the island in an efficient manner, for the benefit of the island, a change in the management or power structure is needed. This could be most easily achieved by making it clear to the military that they are being posted to a high conservation value site, and their primary duty there is to protect and maintain those conservation values, and support those undertaking research upon them. This is already done by the gendarmerie who provide a charter to the resident gendarme which includes regular surveys of the beach for turtles and other activities. The military could likewise engage in valuable conservation activities such as weed control and general monitoring, etc. Instead much of their time is spent engaging in unnecessary activities.

Recommendations

- Eradicate goats by a ground-based shooting campaign
- Planning for rat eradication within the following decade
- Review management structure of the island base
- Continue annual ongoing monitoring of indicator seabird species (red-tailed tropicbirds and sooty terns)
- Establish permanent forest monitoring plots (e.g. 25 x 25 metres)

Appendix 1 – Bird List

Seabirds

Red-tailed tropic-bird	*Phaethon rubricauda*	(many)
White-tailed tropic bird	*Phaethon lepturus*	(many)
Greater frigatebird	*Fregata minor*	(many)
Lesser frigatebird	*Fregata ariel*	(many)
Red footed booby	*Sula sula*	(many)
Sooty tern	*Sterna fuscata*	(many)
Caspian tern	*Hydroprogne caspia*	(some)
Common tern	*Sterna hirundo*	(few)
Common noddy	*Anous stolidus*	(one)

Waders

Grey plover	*Pluvialis squatarola*	(many)
Dimorphic egret	*Egretta dimorpha*	(some)
Whimbrel	*Numenius phaeopus*	(some)

Landbirds

Madagascar white eye	*Zosterops maderaspatana voeltzkowi*	(many)
Pied crow	*Corvus albus*	(many)
Barn owl	*Tyto alba*	(few)
Broad-billed roller	*Eurystomus glaucurus*	(one)