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PREFACE

The European Elasmobranch Association (EEA) was set up in 1996 to coordinate the activities of all European organizations dedicated to the study or conservation of sharks and rays. So far, EEA is represented in seven European countries by the following national bodies: Shark Trust in UK, the "Deutsche Elasmobranchier Gesellschaft" in Germany, the Irish Elasmobranch Group in Ireland, the "Gruppo Italiano Ricercatori Sugli Squali" in Italy, the "Associacao Portuguesa para o Estudo e Conservacao de Elasmobranqueos" in Portugal, the Netherlands Group of EEA and "ElasmoFrance", which is the shark group within the French Society of Ichthyology (SFI).

Every year, an annual meeting with a seminar is organized in the frame of the EEA activities. The first meeting was held in Amsterdan in 1997, the second in London in 1998 and the third in Boulogne-sur-Mer (northern France) in 1999.

The 3rd EEA meeting held in Boulogne-sur-Mer on 27 and 29 May 1999 was hosted by "ElasmoFrance" with the support of the "Institut de Recherche pour le Développement" (IRD) and the aquarium Nausicaa.

This meeting gathered 40 participants from seven countries (France, Germany, Italy, Luxembourg, the Netherlands, Portugal and UK). During the seminar, 15 oral presentations and 7 posters were presented. Seven articles and 15 abstracts are published in these proceedings. Among these papers, the article by Ferguson and Compagno was not presented at the Boulogne meeting but it was included in this volume by the editors because it concerns the distribution of a shark in the European waters.

The topics of the communications reflect the diversity of the studies on sharks and rays in Europe, and they ranged from basal morphological studies on fossil and living species to *in situ* observations with submersibles.

An increasing number of aquariums exhibit sharks and rays in Europe, and this permits specific technical and scientific studies to develop. The communications that have dealt with this latter subject were not included in this volume because the European Union of Aquarium Curators has planned to publish an Elasmobranch Husbandry Manual in the next future.

The last article is devoted to shark attacks in a French oversea territory.

Bernard SÉRET
Chair of ElasmoFrance

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TOOTH INTERNAL MORPHOLOGY OF DEVONIAN PHOEBODONT SHARKS

by

Alexander IVANOV (1)

ABSTRACT. - For the first time, the description of the vascularization system of the teeth in some Devonian-Carboniferous representatives of family Phoebodontidae is presented. Some groups of species are established on the basis of the structure of this vascularization system.

RÉSUMÉ. - Morphologie interne des dents de requins phoebodontes du Dévonien.

Pour la première fois, la description du système vasculaire des dents de quelques représentants de la famille des Phoebodontidae du Dévonien-Permien est présentée. Des groupements d'espèces sont établis à partir de la structure de ce système vasculaire.

Key words. - Phoebodontidae - Sharks - Devonian - Teeth - Morphology.

Most of the descriptions of Palaeozoic elasmobranchian teeth, except xenacanthids have been based on the external morphology. However, the internal morphology of the tooth, the histological structures and the type of vascularization system are important features of shark dentitions and helps the analysis of the relationships of taxa. The Devonian phoebodonts is one of first fossil shark groups to have a well-developed dentition. The phoebodont taxa are known by isolated teeth from Middle-Upper Devonian deposits of different regions of the world.

MATERIAL AND METHODS

The studied material is represented by isolated teeth, which are found in the Middle Devonian - Lower Carboniferous of the South Urals, Timan, Moscow Syneclise and Kuznetsk Basin (Fig. 1):

Phoebodus bifurcatus Ginter & Ivanov. - Upper Devonian, Frasnian, South Urals, Timan;

P. fastigatus Ginter & Ivanov. - Middle Devonian, Givetian - Upper Devonian, Frasnian, South Urals and Kuznetsk Basin;

P. gothicus Ginter. - Upper Devonian, Famennian, South Urals;

P. latus Ginter & Ivanov. - Upper Devonian, Frasnian, South Urals, Timan;

P. limpidus Ginter. - Upper Devonian, Famennian, South Urals;

P. sophiae St. John & Worthen. - Middle Devonian, Givetian, Kuznetsk Basin;

P. turnerae Ginter & Ivanov. - Upper Devonian, Famennian, South Urals;

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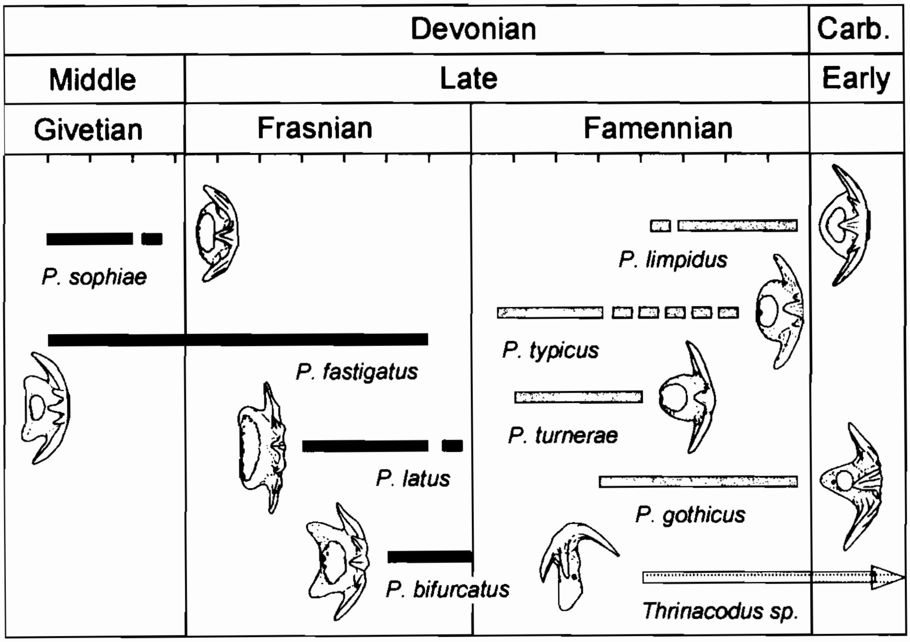

Fig. 1. - Stratigraphic distribution of phoebodontid species. Conodont zonation is shown as vertical scale; a number of zones in the stage corresponds to a number of scale units. Carb.: Carboniferous, P.: *Phoebodus*.

P. typicus Ginter & Ivanov. - Upper Devonian, Famennian, South Urals;

Thrinacodus sp. - Upper Devonian, Famennian - Lower Carboniferous, Urals, Timan, Moscow Syneclise.

Teeth were examined whole, in a scanning electron microscope and immersed in aniseed oil, as well as in cross sections, using a "Zeiss" optical microscope and "Sony" digital camcorder. The specimens and cross sections are kept at the Laboratory of Palaeontology of St. Petersburg University (LP) and at the Institute of Geology of Warsaw University (IGPUW).

Abbreviations: a.b.: apical button; c.c.: central cusp; c.v.can.: circular vascular canal; d.t.: dentine tubules; e.: enameloid; f.m.v.can.: foramen of main vascular canal; f.v.can: foramen of secondary vascular canal; i.c.: intermediate cusp; lb.pr.: labio-basal projection; l.c.: lateral cusp; m.v.can.: main vascular canal; or.: orthodentine; os.: osteodentine; sh.f.: Sharpey's fibers; v.can.: vascular canal; v.can.c.: vascular canal of cusp; v.l.: vascular lacuna.

RESULTS

External morphology of phoebodont teeth

The first phoebodontid species, *Phoebodus sophiae* St. John & Worthen, was described from the Middle Devonian of USA in 1875 (St. John & Worthen, 1875). At present, nine species are attributed with confidence to the genus *Phoebodus*: *P. bifurcatus* Ginter & Ivanov, *P. fastigatus* Ginter & Ivanov, *P. gothicus* Ginter, *P. latus* Ginter & Ivanov, *P. limpidus* Ginter, *P. politus* Newberry, *P. sophiae* St. John & Worthen, *P. turnerae* Ginter & Ivanov, and *P. typicus* Ginter & Ivanov (Ginter, 1990; Ginter and Ivanov, 1992, 1995a,

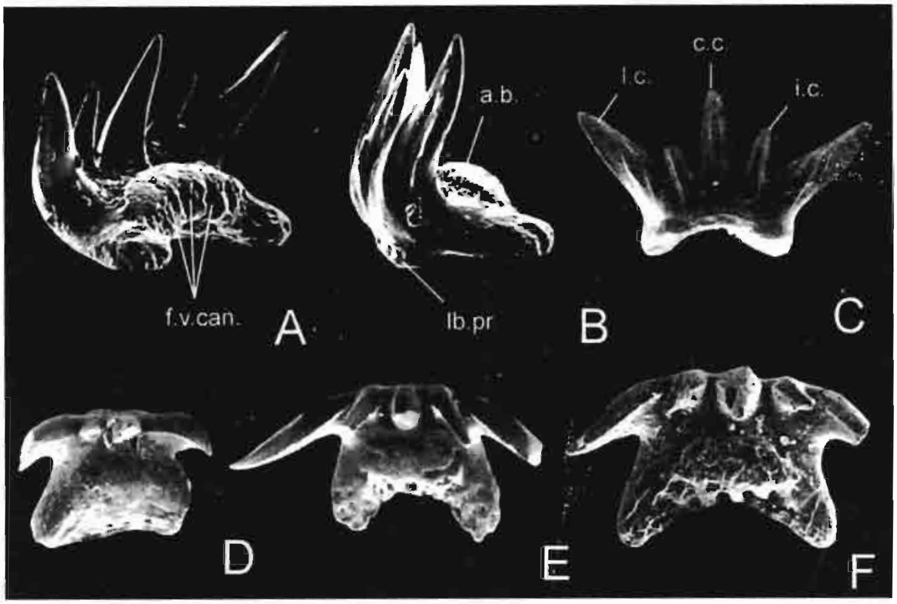

Fig. 2. - ***Phoebodus bifurcatus*** Ginter & Ivanov, teeth. **A**: Oblique lingual view; **B**: Lateral view; **C**: Labial view; **D-F**: Three stages of tooth grown, occlusal views. **A-B**: LP 19-3, x30; **C**: LP 7-8, x20; **D**: LP 19-1, x70; **E**: LP 7-7, x30; **F**: LP 7-9, x40.

1995b). Their teeth have a crown with three main and some intermediate cusps, and a lingually directed, arched base with a distinct apical button on its occlusal side and a projection on the labio-basal edge (Figs 2, 3). The central cusp is equal or slightly less in height than lateral ones (so called "phoebodont crown"). The button and projection are the elements of articulation in the tooth row (= tooth family). The projection of one tooth is placed between the crown and button of another tooth, the button of the latter inserting into the concavity of basal surface of the former tooth (Fig. 6A). The size and shape of the button, as well as its position on the occlusal side, are precisely correlated with the size and shape of projection, as well as with the depth of basal concavity. The button varies from longitudinal oval to round in the shape, and from loose-textured, perforated by numerous foramina, to dense; the projection varies in the form between a lamina and a semicircular tubercle.

Besides *Phoebodus*, a second genus *Thrinacodus* is assigned to the family Phoebodontidae. The following species of *Thrinacodus* have been described: *T. ferox* (Turner), *T. incurvus* (Newberry & Worthen) and *T. nanus* St. John & Worthen (Newberry and Worthen, 1866; St. John and Worthen, 1875; Turner, 1982). The real number of species and their validation can be determined only after a revision of the old North American species and new material. Until then, *Thrinacodus* sp. is used in this paper. The teeth of representatives of this genus show the symmetrical or asymmetrical phoebodont tricuspid crown and asymmetrical, twisted base without apical button or labio-basal projection (Fig. 3H, 3I). The degree of asymmetry, the shape and length of base very vary. Sometimes, third cusp disappears, and the tooth has a crown with two cusps.

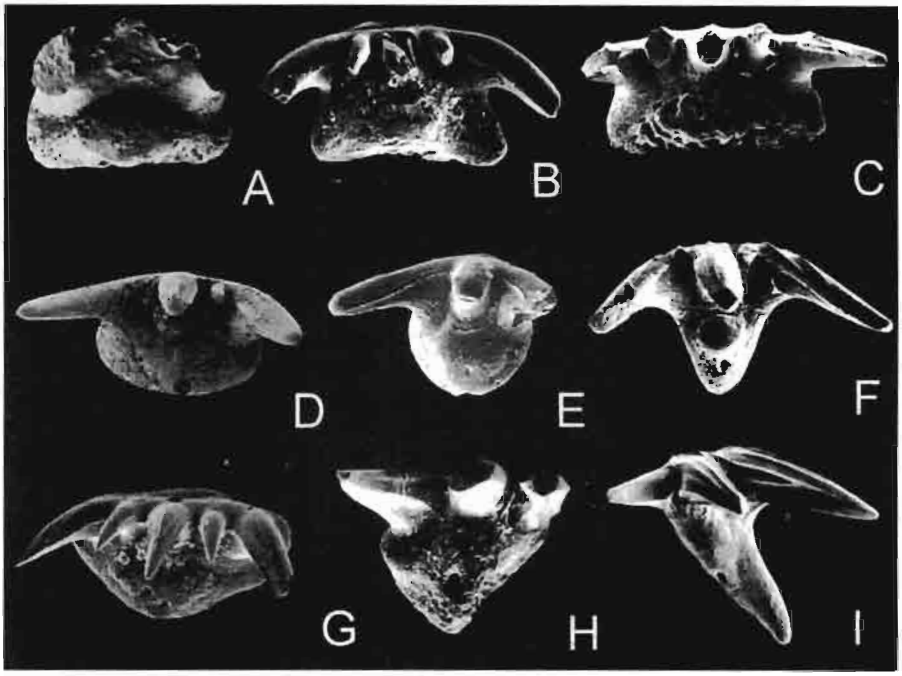

Fig. 3. - Teeth of phoebodontids in occlusal view. **A**: *Phoebodus sophiae* St. John & Worthen, LP 19-2, x30; **B**: *Phoebodus fastigatus* Ginter & Ivanov, LP 7-2, x40; **C**: *Phoebodus latus* Ginter & Ivanov, LP 6-11, x40; **D**: *Phoebodus typicus* Ginter & Ivanov, IGPUW/Ps/1/209, x30; **E**: *Phoebodus turnerae* Ginter & Ivanov, LP 13-7, x20; **F**: *Phoebodus gothicus* Ginter, LP 7-26, x20; **G**: *Phoebodus limpidus* Ginter, LP 19-3, x40; **H-I**: *Thrinacodus* sp. H: LP 11-4, x50; **I**: LP 11-1, x40.

Histological structure and vascularization system

The teeth of a Frasnian representative of *Phoebodus*, *P. bifurcatus*, consist of orthodentine in the lateral and intermediate cusps, and of osteodentine (= trabecular dentine) in the base (Figs 4, 5, 6B). The central cusp is built of the osteodentine in lower (Fig. 5e), and of the orthodentine in the upper part (Fig. 5b). The osteodentine may run to one third of cusp height. The cusp are covered with enameloid which is not always preserved (Figs 4c, 4e; 5b). The dentine tubules of the orthodentine are numerous and strongly ramified, especially in the upper part of central cusp; they are often arranged into tufts. The orthodentine is not subdivided into layers, it extends below the external crown/base boundary, into the base. Such extension of the orthodentine into the base occurs in the recent frilled shark *Chlamydoselachus anguineus* (Herman *et al.*, 1993, fig. 1b). The main vascular canal of lateral cusp in *P. bifurcatus* is narrow throughout the length of the cusp. The moderate vascular canals in the base and lower part of central cusp are almost equal in the size of their cross section. They form a network which is concentrated under and around the apical button (Fig. 6C). Tiny lacunae are located in the intersection of some canals. This canal concentration under the button is connected with the main vascular canals of cusp by circular vascular canals (Fig. 6C). The canals open mainly around the apical button on the occlusal surface and behind the inner edge of labio-basal projection on the basal surface. The extended linguo-lateral angles of the base contain accumulations of Sharpey's fibers (Fig. 5h).

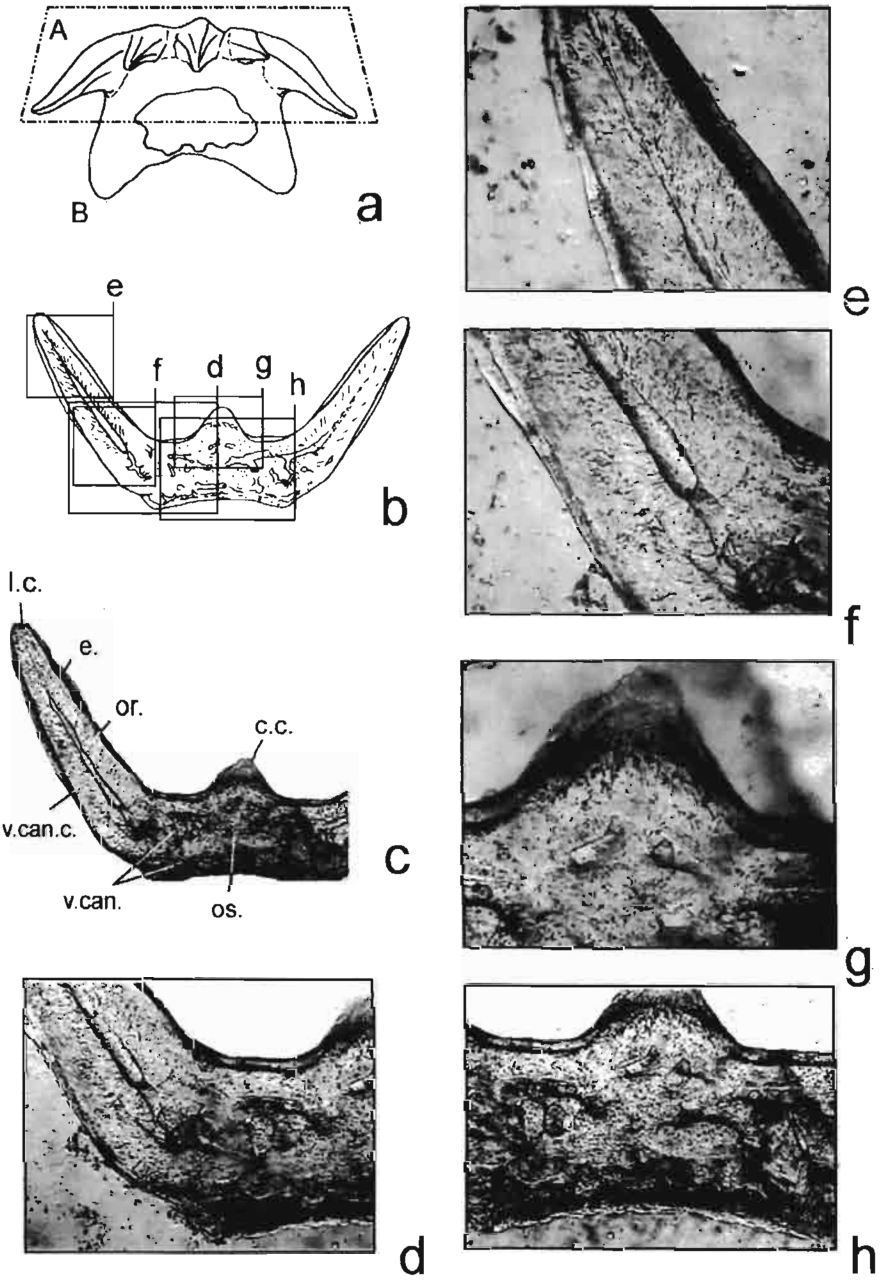

Fig. 4. - Histological structure of a tooth of *Phoebodus bifurcatus* Ginter & Ivanov. **a**: Position of cross sections A and B; **b-h**: Oblique longitudinal section A; **b**: Position of illustration of some details (**d-h**); **c**: General view, x35; **d**: Left lateral part of base: osteodentine, x70; **e**: Enameloid and orthodentine in the top of central cusp, x110; **f**: Lower part of lateral cusp with orthodentine, x120; **g**: Lower part of central cusp with orthodentine and enameloid, x100; **h**: Central part of base: osteodentine and position of vascular canals, x70.

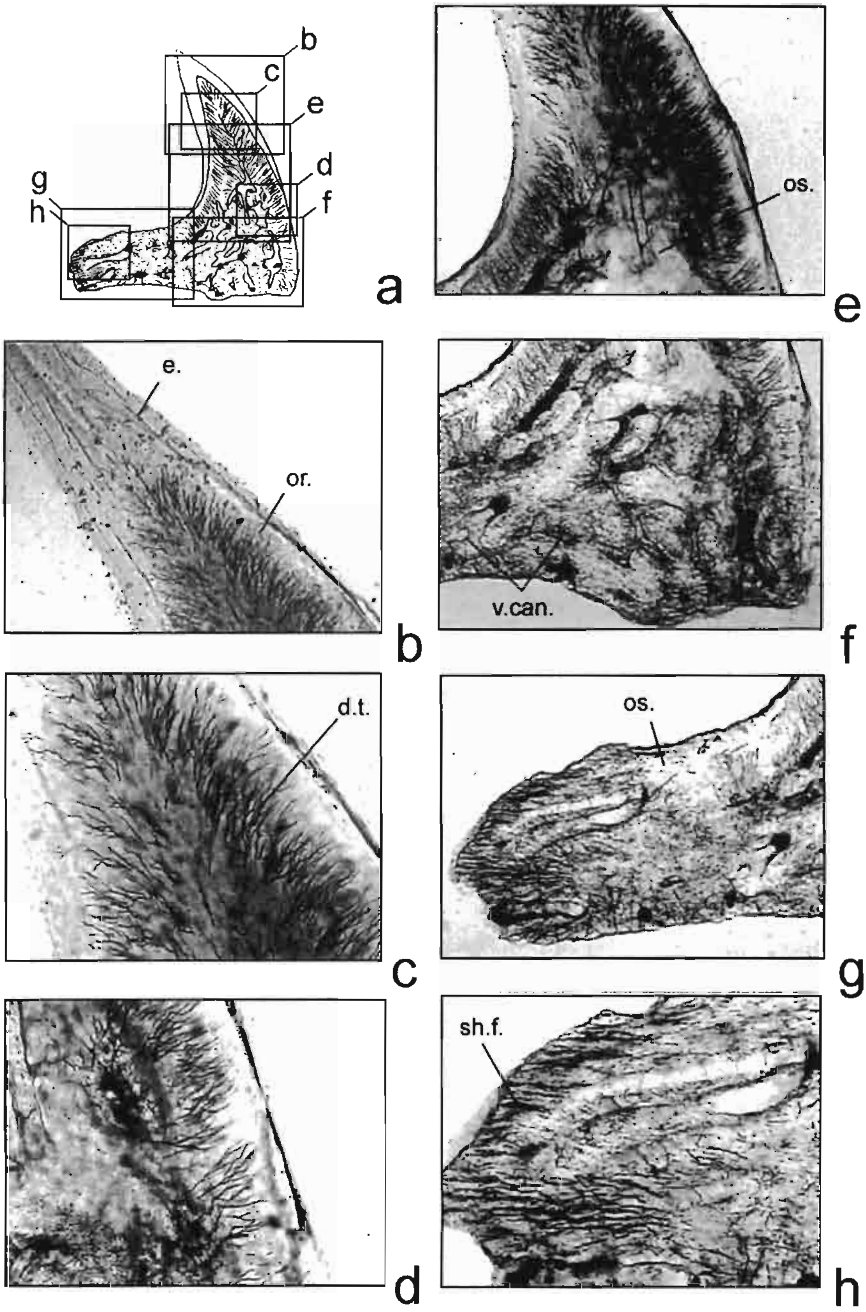

Fig. 5. - Histological structure of a tooth of *Phoebodus bifurcatus* Ginter & Ivanov, oblique transverse section B. **a**: Position of illustration of some details (b-h); **b**: Enameloid and orthodentine in the top of the central cusp, x90; **c**: Dentine tubules of orthodentine, x150; **d**: Contact between the orthodentine and osteodentine, x150; **e**: Middle part of central cusp with orthodentine and osteodentine, x75; **f**: Crown part of base: osteodentine, x75; **g**: Lingual part of base: osteodentine, x85; **h**: Sharpey's fibers in the lingual part, x140.

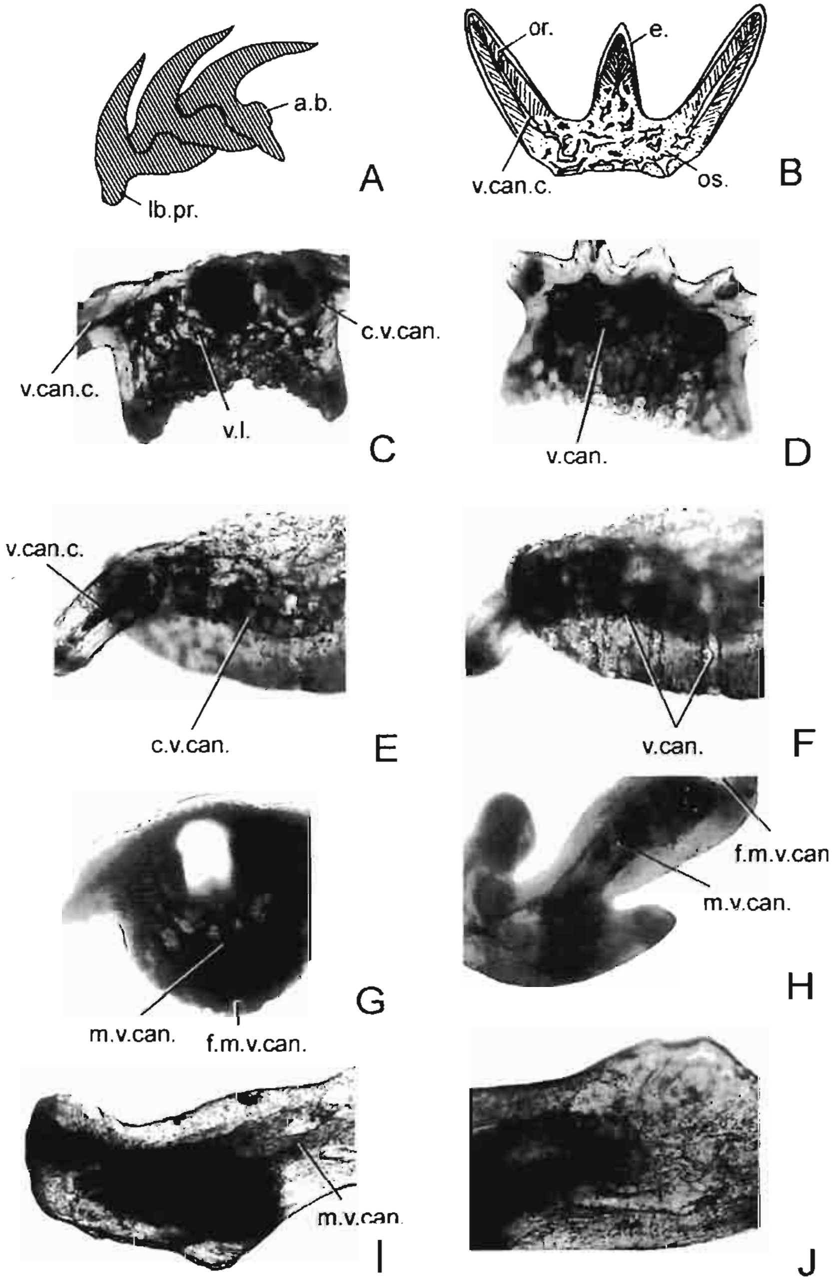

Fig. 6. - **A**: Reconstruction of the articulation in the tooth row of *Phoebodus*; **B**: Histological structure of a tooth of *Phoebodus bifurcatus* Ginter & Ivanov, longitudinal section; **C-J**: Vascularization system, teeth immersed in aniseed oil; **C**: *Phoebodus bifurcatus* Ginter & Ivanov, x20; **D**: *Phoebodus latus* Ginter & Ivanov, x30; **E-F**: *Phoebodus limpidus* Ginter, x50; **H-J**: *Thrinacodus* sp.; **H**: x60; **I**: x80; **J**: x130; **C-H**: occlusal views; **I-J**: oblique views.

The same histological structure and similar vascularization are characteristic of another species of this genus, *Phoebodus sophiae* (Middle Devonian, Givetian) and *P. latus* (Upper Devonian, Frasnian). The teeth of that group of species, including *P. bifurcatus*, have a thick base with large button which occupies most of the occlusal surface of the base and is surrounded and perforated by numerous foramina of vascular canals. The small round button in the juvenile teeth of this group appears in the central part of the base; during tooth growth the number of surrounding foramina increases, and the button occupies the most occlusal surface of the base (Fig. 2D-F). The vascular canals are accumulated under the button. The vascular canals have almost the same size of cross section. Much of the lower part of the central cusp is formed from osteodentine.

The teeth of another Givetian species *P. fastigatus* bear a small central foramen for the main vascular canals between the lingual rim and apical button on the occlusal side of the base, as well as numerous secondary foramina around the button. A corresponding position of the foramen on the occlusal surface, and one or two foramina on the centre of concavity on the basal surface, are observed in most of the Famennian species of *Phoebodus*: *P. typicus*, *P. turnerae* and *P. gothicus* (Fig. 2). The branching network of vascular canals in these Famennian species is evenly distributed into all base. The network is represented by the main and large primary canals and secondary small canals, their ramifications, which connect the large canals (Fig. 6G). The main vascular canal runs from the lingual rim, across the base, and opens on the basal side of the tooth. The same arrangement was described by Gross (1973, Abb. 29C) for *P. gothicus* (*P. politus* in the original paper). Some large primary canals branch off from the main canal at each side, near the lingual rim, and reach for the crown. They connect the canal of cusps with other network. Osteodentine is present in the base and the lower part of central cusp, whereas the orthodentine occurs in the lateral cusps and the upper part of central one (Gross, 1973, Abb. 29D, 29E, 31A). Gross (1973, Abb. 29C) illustrated the accumulation of Sharpey's fibers in the lingual part of the base, between the main canal and lingual rim.

Thus, the tooth histological structure of this group of Famennian species resembles that of Givetian - Frasnian representatives of *Phoebodus*, but the osteodentine in their teeth forms a smaller part of the central cusp. The vascularization system of those Famennian species considerably differs from that of the oldest species in the presence of the main vascular canal and large primary canals in the network and its equable distribution into the base.

The teeth of the Famennian species *P. limpidus* have a simply composed vascularization system which consists of a few primary vascular canals. Two or three large parallel canals run perpendicularly to the longitudinal axis of the tooth, from the lingual rim to the crown (Fig. 6F). The circular canal connects the canals of cusps with those parallel canals (Fig. 6E). There is no equivalent of the numerous secondary vascular canals and their ramifications seen in above mentioned species of *Phoebodus*.

The teeth of *Thrinacodus* from the Famennian - Lower Carboniferous contain orthodentine exclusively in all cusps (Turner, 1982, *Harpago* in the original paper) and osteodentine in the base. The dentine tubules of the orthodentine are not considerably ramified. The orthodentine is subdivided into several layers. There are two or three main foramina on the twisted asymmetrical base. The vascularization system of teeth with the wide and considerably twisted base is constructed of a main wide canal and two or three almost parallel canals which are connected by very wide and short lateral ramifications (Fig. 6J). The vascular canals occupy the almost inner part of the base. A single wide main vascular canal occurs in teeth with a long and narrow base (Fig. 6H). It branches near the crown into two or three canals according to the number of cusps. The Sharpey's fibers are concentrated in the distal lingual part of the base.

DISCUSSION

The teeth of all *Phoebodus* species have orthodentine covered by enameloid in the lateral and intermediate cusps and in the upper part of central cusp, and osteodentine in the base and the lower part of central cusp. The histological structure in the different species is similar and differs in the degree of distribution of osteodentine in the central cusp and degree of development of dentine tubules in the cusps.

The teeth of *Thrinacodus* exhibit the presence of orthodentine in the crown exclusively and osteodentine in the base. The accumulation of Sharpey's fibers in the lingual part of the base is observed both in *Phoebodus* and *Thrinacodus.*

However, some distinct groups of *Phoebodus* species can be established on the basis of the structure of the vascularization system. The first comprises *P. sophiae - latus - bifurcatus*. They are characterised by the presence of a network of similar, moderately sized vascular canals, which is concentrated under the apical button. Usually the latter occupies most of the occlusal side of the base, and is perforated by numerous foramina.

The second group is represented by *P. fastigatus*, *P. typicus*, *P. turnerae* and *P. gothicus.* Their teeth have a vascularization system consisting of the main and large primary canals and secondary canals and their ramifications, and a dense, compact button. The main canal opens on the linguo-basal face of the base, as well as on the concavity of its basal side. The tooth of *P. limpidus* shows the simplified type of vascularization system including a few large canals.

The similar type of vascularization system of first group also occurs in some xenacanthids (Hampe, 1993, fig. 4b) and symmoriids (Mertiniene, 1995), where all canals are almost equal in cross section. But the teeth of those xenacanthids contain a network of canals which occupies the whole base. The vascular canals in the mentioned symmoriid teeth rise up to the top of main central cusp.

Thus, the teeth of Givetian-Frasnian phoebodont sharks exhibit the general features of internal morphology for the first elasmobranchs. A specialised character of the vascularization system, the development of a main vascular canal, appears in the younger taxa of this group. The latest phoebodontid, *Thrinacodus*, has teeth with a very different histological structure and vascularization system. Probably, this is related to another type of articulation in the tooth row: without apical button and labio-basal projection.

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DERMAL DENTICLE MORPHOLOGY WITHIN BATOID RAYS: A REVIEW

by

Pascal DEYNAT (1)

ABSTRACT. - The dermal covering of chondrichthyan fishes is constituted by numerous dermo-epidermic structures called dermal denticles. These micrometric elements cover most of the body and the buccopharyngeal cavity in almost all extant species. Important morphological variations of the denticles brought some authors to consider the use of the dermal structures as impossible in species identification. However, study of the denticles among sharks and rays shows that the morphology and distribution of these structures are linked to mode of life and ecology of the species. By studying the morphological variations of the crown, peduncle and basal plate, it is often possible to identify, and to locate, isolated denticles. Examples among Batoids are given to demonstrate their interest in Systematics.

RÉSUMÉ. – Morphologie des denticules cutanés chez les raies Batoïdes: une revue.

Le revêtement cutané des Chondrichtyens est constitué de nombreuses structures dermo-épidermiques appelées denticules cutanés. Ces éléments micrométriques recouvrent la plus grande partie du corps et de la cavité bucco-pharyngienne chez la plupart des espèces actuelles. Les variations morphologiques importantes de ces structures ont amené certains auteurs à considérer comme impossible leur utilisation dans l'identification taxinomique au niveau spécifique. L'étude des denticules cutanés des requins et des raies montre cependant que leur morphologie et leur mode de distribution peuvent être liés à l'écologie et au mode de vie des espèces. Par l'étude des variations morphologiques de la couronne, de la plaque basale et du pédoncule, il est alors possible, dans la plupart des cas, d'identifier et de localiser les denticules cutanés isolés. De nouvelles caractéristiques morphologiques sont ici utilisées afin de démontrer l'intérêt de ces structures dans la systématique des Batoïdes.

Key words. - Pristiformes - Rajiformes - Dermal denticles - Systematics.

Since the important works of Hertwig (1874) and Steinhardt (1903), the study of the dermal covering of chondrichthyan fishes has essentially been focused on sharks. The variations in shape and arrangement of dermal denticles, tubercles, thorns, stings and bucklers, have been mainly discussed from a descriptive point of view and the morphological variations of the dermal denticles on a same specimen have been considered too important to be a good taxonomic tool (Radcliffe, 1917). This subject has been poorly debated with regard to batoid fishes (Hubbs and Ishiyama, 1968; Stehmann and Bürkel, 1984a, 1984b; Leible, 1988; Deynat and Brito, 1994; Deynat and Séret, 1996; McEachran and Konstantinou, 1996). The study of skates and rays brought new data about the

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taxonomic value of these structures, especially in the orders Pristiformes and Rajiformes (Deynat, 1996).

MATERIAL AND METHODS

The morphological study and intra- and interspecific comparisons of the dermal covering have been carried out on 153 species of Pristiformes and Rajiformes *sensu* Compagno (1973), McEachran and Miyake (1990a), Nishida (1990) and Yearsley and Last (1992) (see Annex 1 in Deynat and Séret, 1996 for the list of species).

The study of the dermal covering, from juveniles to adults, was conducted according to Hubbs and Ishiyama (1968), Stehmann and Bürkel (1984a), Leible (1988), Deynat and Séret (1996) and Deynat (1996, 1998). Samples of skin have been removed from the area of the right scapula (Dingerkus and Koestler, 1986). However, important variations in shape or arrangement of the dermal structures have required examination of other skin samples from different parts of the body, including the bucco-pharyngeal cavity. Preparation of skin samples has been conducted following Dingerkus and Koestler (1986) and Deynat (1996). Observations have been conducted with a Jeol 840 SEM. Inter- and intraspecific comparisons of the dermal denticles and tubercles are based on Deynat (1996, 1998).

RESULTS

Arrangement of the dermal denticles

Among the studied species, Pristiformes and Rhinobatoids present both dorsal and ventral sides of the body, including fins, skin of the eyelids and bucco-pharyngeal cavity, completely covered by numerous close-set denticles, except for *Zapteryx exasperata* (Jordan & Gilbert, 1880) (Rhinobatidae) and *Anoxypristis cuspidata* (Latham, 1794) (Pristidae) (Deynat and Séret, 1996; Deynat, 1996).

The progressive disappearance of the dermal covering, or feeble density of the denticles on the inner part of the pectoral fins in adult Rajoids, is a character linked to sexual dimorphism and degree of development, shared by a number of Rajidae (Table I). Absence of dermal denticles is extreme within Anacanthobatidae and *Irolita*. In Rajoids, the covering is poorly distributed on the ventral side of the body, except in some species of *Raja* (e.g., *R. clavata*) (Deynat, 1996) and is only limited to the anterior edges of the disc in most of the species.

Denticles are always deeply imbricated and arranged as a mosaic on the front edge of the disc, rostrum (saw in Pristiformes) and fins within Pristiformes and Rhinobatoids. The Rajoids are completely devoided of such denticles.

Bucco-pharyngeal denticles are present in Pristiformes (except *Anoxypristis*) and Rhinobatoids, and absent in all developmental stages in Rajoids (except *Sympterygia brevicaudata* and perhaps *Rhinoraja longicauda* (Dolganov, 1982)) (Deynat and Séret, 1996). They are minute and closed-set, and their morphology varies among the different species and between juveniles and adults. In most cases, the shape of the crown is based on the general pattern of the denticles of the dorsal side of the body, with or without ridges and furrows.

Table I. - Main characteristics of the dermal covering among Pristiformes and Rajiformes. Buc. phar. Dent.: buccopharyngeal denticles.

Family	Genera	Buc.-phar. Dent.	Corono-peduncular relief	Bucklers	Rostral teeth	Malar thorns	Alar thorns
Pristidae	*Anoxypristis*	absent	absent (no tubercle)	absent	present	absent	absent
	Pristis	present	absent (no tubercle)	absent	present	absent	absent
Rhinidae	*Rhina*	present	absent	absent	absent	absent	absent
Rhynchobatidae	*Rhynchobatus*	present	absent	absent	absent	absent	absent
Rhinobatidae	*Aptychotrema*	present	present	absent	absent	absent	absent
	Rhinobatos	present	present	absent	absent	absent	absent
	Trygonorrhina	present	present	absent	absent	absent	absent
	Zapteryx	present	present	absent	absent	? present	absent
Platyrhinidae	*Platyrhina*	present	present	absent	absent	absent	absent
	Platyrhinoidis	present	present	absent	absent	absent	absent
	Zanobatus	present	present	absent	absent	absent	absent
Anacanthobatidae	*Anacanthobatis*	absent	?	absent	absent	absent	present
Arhynchobatidae	*Arhynchobatis*	?	absent	absent	absent	present	present
Pseudorajidae	*Pseudoraja*	absent	absent	absent	absent	absent	? absent
Rajidae	*Bathyraja*	absent	absent	absent	absent	absent	present
	Breviraja	absent	absent	absent	absent	variable	present
	Cruriraja	absent	absent	absent	absent	variable	present
	Dactylobatus	absent	absent	absent	absent	absent	present
	Gurgesiella	absent	absent	absent	absent	absent	present
	Irolita	?	absent	absent	absent	absent	present
	Malacoraja	absent	absent	absent	absent	present	present
	Neoraja	absent	absent	absent	absent	present	present
	Notoraja	absent	absent	absent	absent	absent	present
	Pavoraja	absent	absent	absent	absent	variable	present
	Psammobatis	absent	absent	absent	absent	absent	present
	Raja	absent	absent	*R. clavata*	absent	variable	present
	Rhinoraja	? *R. longicauda*	absent	absent	absent	absent	present
	Sympterygia	*S. brevicaudata*	absent	*S. bonapartei*	absent	absent	present

Table I. – (continued).

		Dorsal side			Ventral side		
Family	**Genera**	**Crown**	**Covering**	**Arrangement**	**Crown**	**Covering**	**Arrangement**
Pristidae	*Anoxypristis*	flat, tricuspidate	partial	poorly imbricated	flat, enlarged and smooth	partial	poorly imbricated
	Pristis	flat, monocuspidate	complete	deeply imbricated	flat, enlarged and smooth	complete	deeply imbricated
Rhinidae	*Rhina*	cruciformes	complete	poorly imbricated	cruciformes	complete	poorly imbricated
Rhynchobatidae	*Rhynchobatus*	flat, monocuspidate	complete	deeply imbricated	flat, enlarged and smooth	complete	deeply imbricated
Rhinobatidae	*Aptychotrema*	flat, monocuspidate	complete	deeply imbricated	flat, enlarged and smooth	complete	deeply imbricated
	Rhinobatos	variable	complete	deeply imbricated	flat, enlarged and smooth	complete	deeply imbricated
	Trygonorrhina	tricuspidate	complete	deeply imbricated	flat, enlarged and smooth	complete	deeply imbricated
	Zapteryx	variable	variable	deeply imbricated	variable	variable	deeply imbricated
Platyrhinidae	*Platyrhina*	flat, monocuspidate	complete	deeply imbricated	flat, enlarged and smooth	complete	deeply imbricated
	Platyrhinoidis	flat, monocuspidate	complete	deeply imbricated	flat, enlarged and smooth	complete	deeply imbricated
	Zanobatus	flat, monocuspidate	complete	deeply imbricated	flat, enlarged and smooth	complete	deeply imbricated
Anacanthobatidae	*Anacanthobatis*	absent	absent	absent	absent	absent	absent
Arhynchobatidae	*Arhynchobatis*	slender, pointed tip	complete	no imbricated	absent	absent	absent
Pseudorajidae	*Pseudoraja*	slender, pointed tip	complete	no imbricated	spiny	partial (tail)	no imbricated
Rajidae	*Bathyraja*	slender, pointed tip	partial	no imbricated	spiny	variable	no imbricated
	Breviraja	slender, pointed tip	partial	no imbricated	absent	absent	absent
	Cruriraja	slender, pointed tip	variable	no imbricated	spiny	variable	?no imbricated
	Dactylobatus	blunt tip	complete	no imbricated	absent	absent	absent
	Gurgesiella	variable	partial	no imbricated	spiny	partial	no imbricated
	Irolita	absent	absent	absent	absent	absent	absent
	Malacoraja	slender, pointed tip	complete	no imbricated	spiny	variable	no imbricated
	Neoraja	slender, pointed tip	partial	no imbricated	spiny	partial (tail)	no imbricated
	Notoraja	slender, pointed tip	partial	no imbricated	spiny	partial (tail)	no imbricated
	Pavoraja	slender, pointed tip	variable	no imbricated	spiny	variable	no imbricated
	Psammobatis	slender, pointed tip	partial	no imbricated	absent	absent	absent
	Raja	variable	variable	no imbricated	spiny	variable	no imbricated
	Rhinoraja	slender, pointed tip	partial	no imbricated	absent	absent	absent
	Sympterygia	slender, pointed tip	partial	no imbricated	spiny	variable	no imbricated

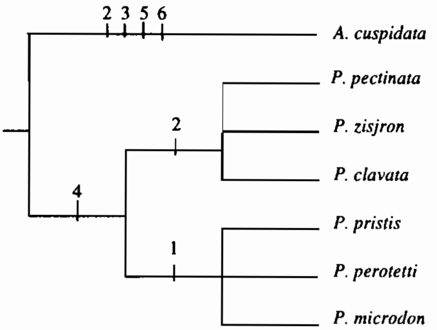

Fig. 1. - Comparison diagram proposed for the Pristiformes by the characteristics of the dermal denticles (Deynat, 1996). This diagram does not represent a phylogeny, but only a character distribution. Characters: 1 - well differentiated ridges on the anterior edge of the denticles of both dorsal and ventral sides of the body; 2 - absence of crown ridges on the denticles; 3 - three well differentiated cuspids at the posterior edge of the dermal denticles of both ventral and dorsal sides of the body; 4 - single well differentiated cuspid at the posterior edge of the denticles; 5 - absence of bucco-pharyngeal denticles; 6 - uncomplete covering of both sides of the body in all stages of growth.

Morphology of the dermal denticles

Within chondrichthyan fishes, dermal denticles present a common pattern (Fig. 3). A classical dermal denticle is constituted by three parts: the basal plate (Pb), anchoring the denticle to the dermis, the peduncle (Pe) and the crown (Co). A superficial relief of the crown is sometimes represented within some Rhinobatoids and Pristiformes by crown ridges (Cac) and furrows (Si). The honeycomb relief cited among sharks by several authors (Hertwig, 1874; Muñoz-Chapuli, 1985; Reif, 1985a; Rashi and Elsom, 1986) never exists in Batoids. Morphology of the dermal denticles of Batoids presents important variations in shape among the different taxa.

Within Pristiformes, the morphology of the dermal denticles can also be used to separate *Pristis* and *Anoxypristis* (Fig. 1). Adult specimens of *Anoxypristis* are partially covered by dermal denticles over most part of the rostrum and on the front edge of the fins, without any bucco-pharyngeal denticles. The denticles of *Anoxypristis* have a flat crown, without any relief or furrow, and with three posterior cusps. *Pristis* species present a homogenous covering on both sides of the body since the early developmental stages. Bucco-pharyngeal denticles are always present. Among the different species of *Pristis*, a first group is characterised by dermal denticles presenting ridges on the anterior part of the denticles of both sides of the body and the tail (*P. pristis*, *P. microdon* and *P. perotetti*). The second group, including *P. pectinata*, *P. zijsron* and *P. clavata* never possesses such ridges during any developmental stage.

Rajiformes are divided into two major suborders: Rhinobatoids and Rajoids (Rajids *sensu* McEachran and Dunn, 1998). As with Pristiformes, dermal denticles of Rhinobatoids are mainly formed by a flat or lanceolate crown with a well-differentiated peduncle. Presence of furrows, ridges or diverse reliefs has been mainly observed on the denticles of the dorsal side of the body. Morphological variations, due to the location of the denticles on the body, are typical of guitarfishes. However, the comparative morphology of the dermal denticles of both sides of the body can establish a separation between the genera in which dermal denticles of the ventral side present no relief (*Rhynchobatus*, *Aptychorema*, *Rhinobatos*, *Trygonorrhina*, *Zapteryx*, *Zanobatus*, *Platyrhina*, *Platyrhinoidis*) and those in which denticles of the ventral side have a cruciform relief (*Rhina*) (Deynat, 1996).

Denticles of the dorsal side show always furrows and ridges among Rhinobatoids, except for *Rhinobatos blochii*, *Platyrhina*, *Platyrhinoidis* and *Zanobatus schoenleinii*.

Among Rajoids, dermal denticles present generally a slender and erected crown on a star-shaped basal plate with no well differentiated peduncle. The more significant variations are pointed on the anterior relief of the denticle crown on the dorsal side of the body (myrmecoid denticles *sensu* Deynat, 1996) and on the regression of the crown (denticles with atrophied crowns (some *Raja* species) or blunt tip (*Dactylobatus*)) (Deynat, 1996). Dermal denticles of the Rajoids, in most of the species, present a similar morphological pattern on both sides of the body, except for the species with myrmecoid denticles and denticles with atrophied crowns (Deynat and Séret, 1996). In most cases, due to a benthic mode of life, denticles of the ventral side of the disc show a flat crown.

Tubercles, thorns and bucklers

Within the Batoids, the tubercles appear only in Rajiformes and Myliobatiformes (Figs 4-5). Morphological characteristics of the tubercles and thorns, and their mode of arrangement (Fig. 2), can be used to separate Rhinobatoids and Rajoids. Most of the guitarfishes possess spiny tubercles characterised by corono-peduncular ridges (Deynat, 1998). This peculiar relief appears only in the genera *Rhinobatos*, *Aptychotrema*, *Trygonorrhina*, *Zapteryx* and *Zanobatus*. Among these taxa, the morphology of the tubercles separates the genera *Rhinobatos* and *Aptychotrema*, with well-differentiated basal plate and peduncle, and the genera *Zanobatus*, *Trygonorrhina* and *Zapteryx*, showing only the outer part of the tubercle, the rest being completely covered by dermal denticles.

Thorns of Rajoids and dermal tubercles of *Platyrhina*, *Platyrhinoidis*, Rhinidae and Rhynchobatidae never show this kind of relief. Variations are mainly linked to the relative size of the thorns, their arrangement and the thickness of the crown. Alar and malar thorns are typical of Rajoids (Fig. 5), except for *Zapteryx brevirostris* in which malar tubercles have been reported (Deynat, 1996, 1998). Bucklers appear only in *Raja clavata* and *Sympterygia bonapartei*: bucklers of *Raja clavata* are more globulous, with a sharper and more elongated crown than those of *S. bonapartei* (Fig. 5).

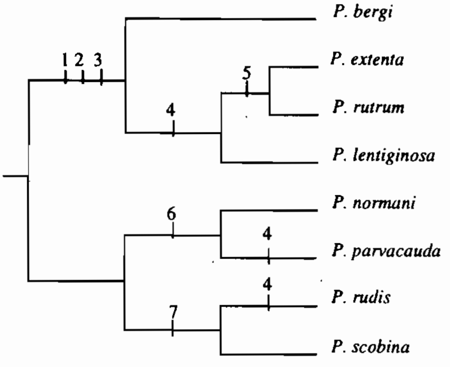

Fig. 2. - Comparison diagram proposed for *Psammobatis* by the characteristics of the dermal covering (Deynat, 1996). Characters: 1 - nucho-scapular patch; 2 - truncal middorsal series present in juveniles; 3 - parallel series; 4 - postero-inner thorns; 5 - interdor-sal series developed in juveniles; 6 - parallel series absent in all development stages; 7 - parallel series poorly developed.

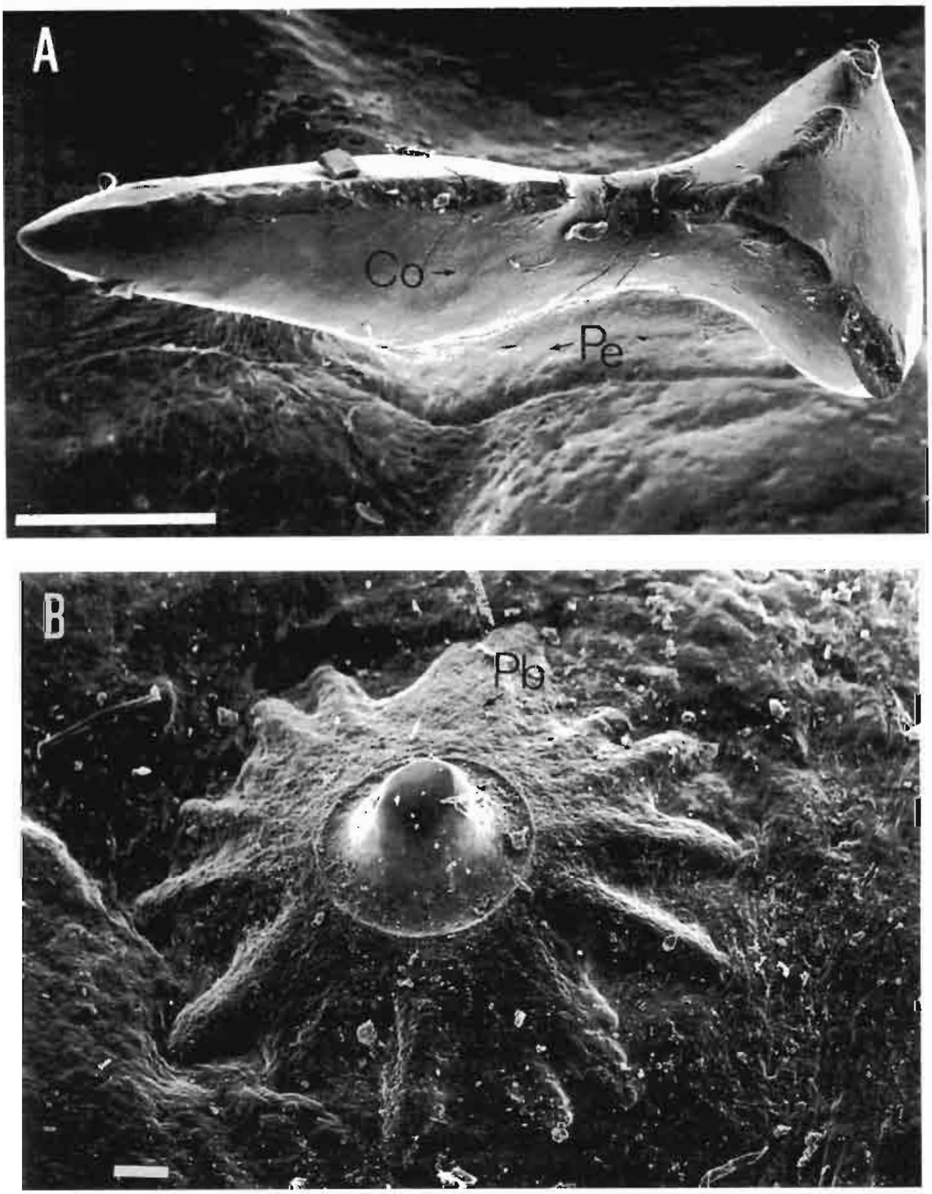

Fig. 3. - Dermal denticles in Batoids (I). **A**: Myrmecoid denticle of *Raja (Raja) clavata* (juvenile male, 425 mm TW, coll. P. Deynat); **B**: Atrophied denticle of *Raja (Atlantoraja) castelnaui* MNHN A-8007 (female, 425 mm TW, Brazil). Pb: basal plate; Pe: peduncle; Co: crown. Scale bars = 100 µm.

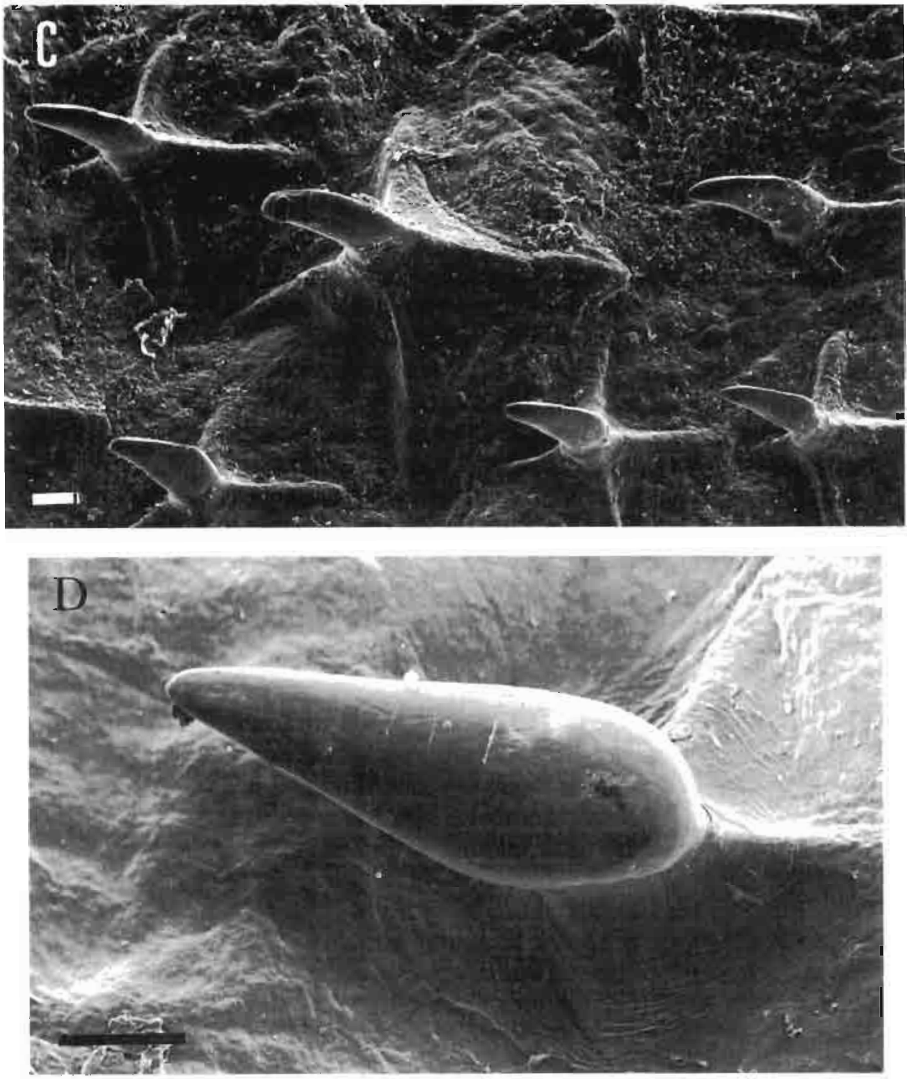

Fig. 3. - (Continued). . C: Typical spiny denticle of *Raja (Leucoraja) fullonica* MNHN 1974-0276 (female, 325 mm TW, South Ireland); D: Flat spiny denticle of the ventral side of the body in *Raja (Raja) clavata* (juvenile male, 425 mm TW, coll. P. Deynat). Scale bars = 100 µm.

CONCLUSION

Even if the dermal structures are always replaced during growth of the specimen, they maintain a typical pattern that does not change with sex and degree of maturity. Hence, it is possible to identify Batoids by comparisons of the morphological changes depending on the location of the denticles on the body. Potential functions have been

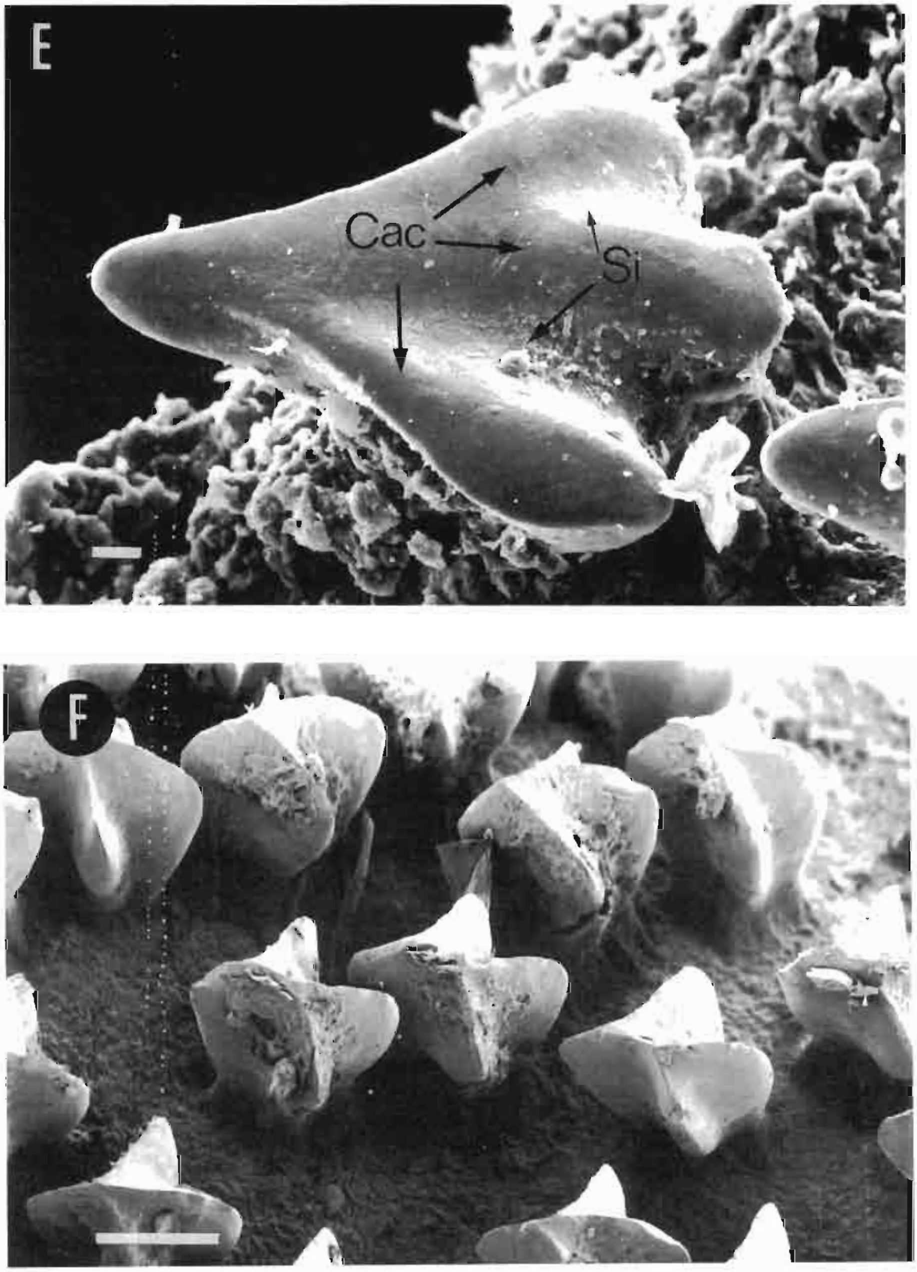

Fig. 3. – (Continued). E: Sagittate denticle of *Rhinobatos rhinobatos* MNHN 1907-0249 (immature male, 405 mm TL, Senegal); F: Typical cruciform denticle in *Rhina ancylostoma* BMNH 1925.7.20.615 (juvenile female, 450 mm TL, Gulf of Aden). Cac: crown ridges, Si: furrows. Scale bars: E = 10 µm, F = 100 µm.

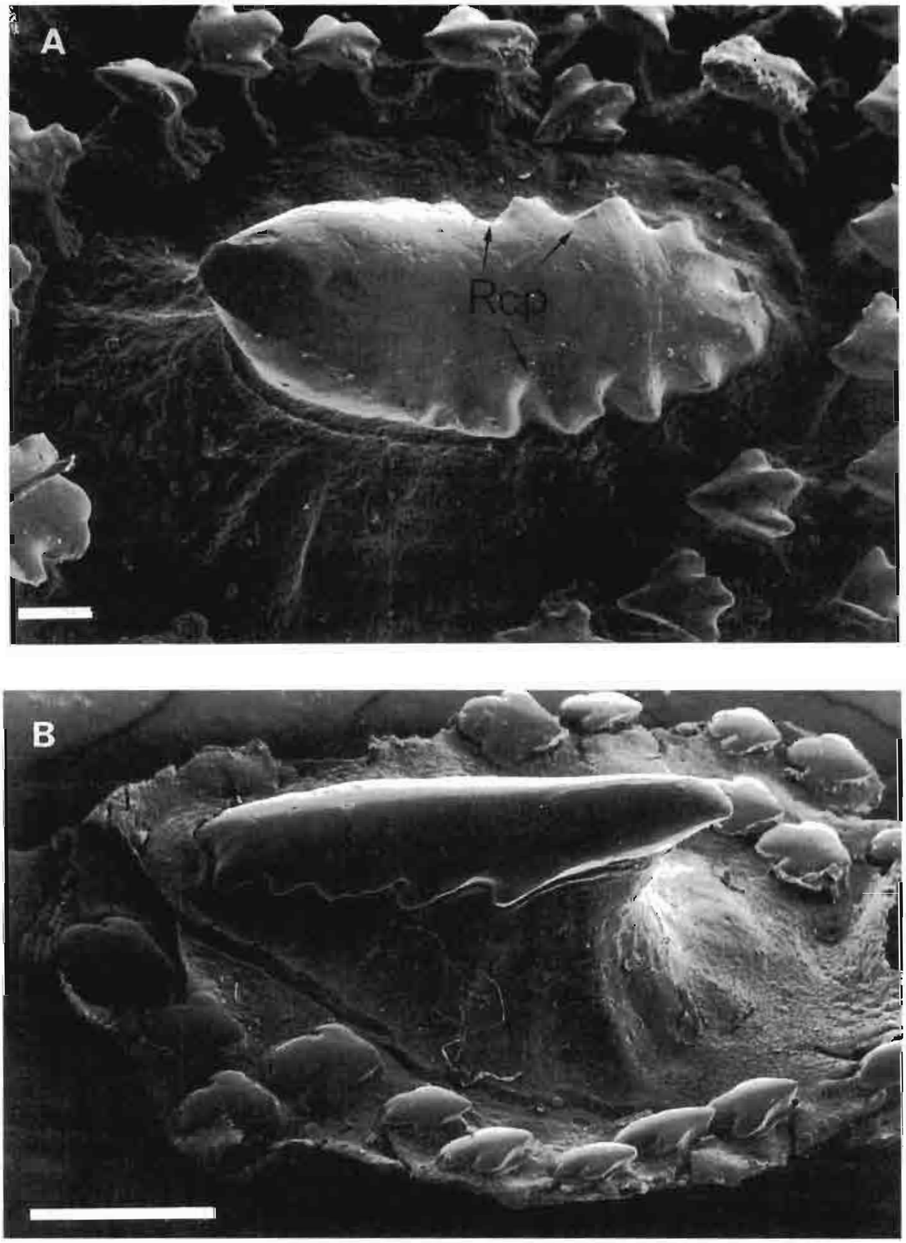

Fig. 4. - Tubercles. **A**: Middorsal tubercle of *Rhinobatos percellens* MNHN 1259 (male, 550 mm TL, Brazil) showing the corono-peduncular relief; **B**: Middorsal tubercle of *Rhinobatos cemiculus* MNHN 1989-1988 (female, 360 mm TL, Congo-Gabon). Rcp: corono-peduncular relief. Scale bars: A = 100 µm, B = 1 mm.

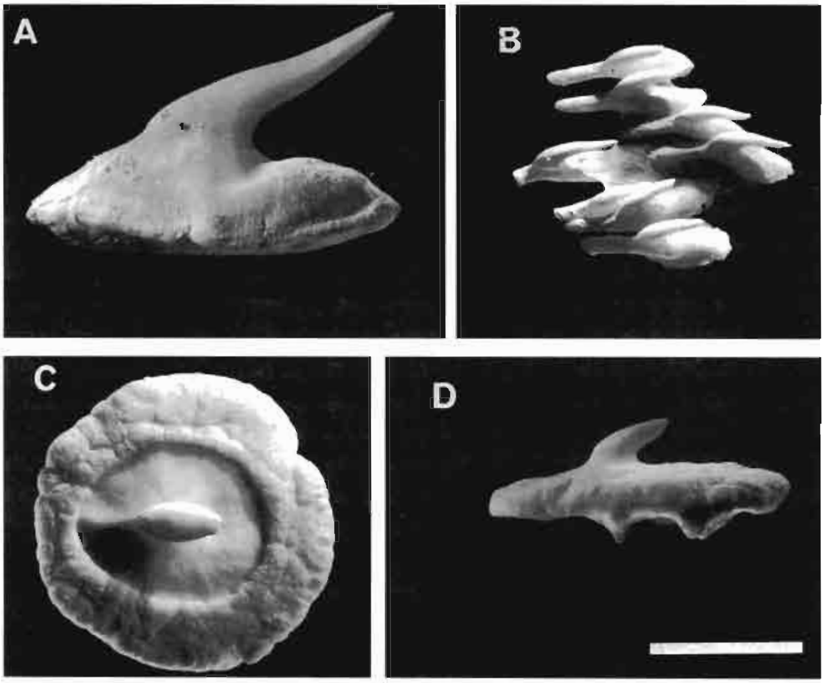

Fig. 5. - Thorns and bucklers. **A**: Lateral view of a thorn of the lateral series in *Raja (Raja) clavata* (juvenile male, 425 mm TW, coll. P. Deynat); **B**: General view of the alar thorns in *Sympterygia bonapartei* MNHN 1984-0018 (male, 387 mm TW, Brazil); **C**: Isolated ventral buckler of the same specimen in lateral view; **D**: Upper view of the same sample. Scale bar = 1 cm.

supposed by Burdak (1986), Reif (1985a, 1985b) and Rashi and Tabit (1992) in sharks, between morphology and arrangement of the denticles and ecology of the species. Skates and rays being less active than sharks, a regression of the hydrodynamic-type dermal structures is observed, marked by the disappearance of ridges and furrows of the crown, loss of imbrication and erected and sharp denticles. Even if the possibility of identifying rays by their denticles can bring new data for archeozoologists or palaeontologists, it is now necessary to build a valid database that could bring valuable information for each specialist of fossil or extant microrests of chondrichthyan fishes.

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OBSERVATIONS OF CHONDRICHTHYAN FISHES (SHARKS, RAYS AND CHIMAERAS) IN THE BAY OF BISCAY (NORTH-EASTERN ATLANTIC) FROM SUBMERSIBLES

by

Pascal LORANCE (1), Daniel LATROUITE (2) & Bernard SÉRET (3)

ABSTRACT. - Forty one manned submersible dives were carried out during 2 cruises in the Bay of Biscay covering a range of depth from about 100 to 2100 m. Chondrichthyan species were observed in most of the dives, some of them were easily identified and their behaviour could be studied. Twenty-two chondrichthyan species (9 sharks, 8 rays and 5 chimaeras) were recorded. Shark species were always seen active except *Scyliorhinus canicula* and *Galeus melastomus*. Some representatives were found motionless on the bottom, sometimes forming groups for the first species. Chimaeras appeared to strongly react to the presence of the submersible. The density of chondrichtyes and their relative frequency in the total fish assemblage were estimated, the results are globally consistent with former knowledge and the differences with results from trawl surveys are discussed. The observations presented here suggest peak of *Chimaera monstrosa* abundance at upper slope depth (200-500 m) that was not documented formerly for that area.

RÉSUMÉ. - Observations de Chondrichtyens (requins, raies et chimères) dans le Golfe de Gascogne (Atlantique Nord-Est), à partir de submersibles.

Quarante et une plongées en submersible habité ont été effectuées lors de 2 campagnes dans le Golfe de Gascogne par des profondeurs de 100 à 2100 m environ. Des Chondrichtyens ont été observés au cours de la plupart des plongées, 22 espèces (9 requins, 8 raies et 5 chimères) ont été identifiées et leurs comportements ont pu être étudiés. Les requins étaient toujours actifs sauf *Scyliorhinus canicula* et *Galeus melastomus* dont certains représentants ont été trouvés immobiles sur le fond, parfois en groupe pour la première espèce. Les chimères se sont montrées très réactives à la présence du submersible. Les densités et fréquences relatives pour l'ensemble des Chondrichtyens ont été estimées, les résultats sont globalement cohérents avec les estimations antérieures; les différences avec les estimations issues de chalutages sont discutées. Les observations présentées ici suggèrent qu'il existe un pic d'abondance de *Chimaera monstrosa* à la profondeur de la pente supérieure (200-500 m). Ce pic n'avait pas été observé précédemment dans cette zone.

Key words. - Chondrichthyans - ANE - Bay of Biscay - Deep-Sea - Submersible.

The chondrichthyan fauna of the Bay of Biscay included about 60 species: 33 sharks, 23 rays and 5 chimaeras (Whitehead *et al.*, 1984), with about 40 on the continental slope. In term of fisheries, chondrichthyan fishes are mainly by-catches of trawl fisheries (Quéro and

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Vayne, 1998; Carpentier, 1999, unpubl. data) and some are target species of longline fisheries. Several fisheries operate in the Bay of Biscay. Some large chondrichthyan fishes are considered as endangered by fishery exploitation in the Bay of Biscay (Quéro and Cendredo, 1996). Due to the extension of fishing activity towards the slope, commercial trawlers exploit the deep-sea sharks of the North-eastern Atlantic for about 10 years. In France, they are marketed skinned under the name "siki" which include several species mainly *Centrophorus squamosus*, *Centroscymnus coelolepis* and *Dalatias licha*, mainly caught off western British Isles. From null in 1993, the landings of "siki" reached about 2400 tons in 1995 (i.e., about 10% of the total catch of chondrichthyan fishes in France), and about 2000 tons in 1997; the evolution of this fishery seems to fit with the "boom and bust" model generally observed for shark fisheries, and the collapse of deep-sea shark fisheries may even be quicker as their populations are limited (Ponroy and Séret, in press).

Beebe (1933) was the first biologist who used a submersible device, the bathysphere, to explore the deep-sea fauna off Bermuda. He observed numerous meso- and bathypelagic fishes but only two sharks. Clarke (1973) made some observations with a submersible off Hawaii, but the seven chondrichthyan species he recorded during the survey were caught in nets and traps. Isaacs and Schwartzlose (1975) used automatic baited cameras to make some observations on deep-sea fishes, including some sharks.

Gilat and Gelman (1984) carried out a photographic survey of deep-sea sharks of the eastern Mediterranean, with "free-fall camera" set between 280 and 1490 m depth off Haifa (Israel) and Cyprus (eastern Mediterranean). They recorded 12 species of sharks and a ray, and they observed the behaviour of three shark species: *Centrophorus granulosus, Etmopterus spinax* and *Hexanchus griseus*. They found that gulper shark (*C. granulosus*) made up the bulk of the shark population and that there was good correlation between the estimates made with photographs and those resulting from catches with long lines. The largest biomass, about 89 kg/m^2, was found at 880 m depth.

Clark and Kristof (1990a, 1990b) reported on the results of 71 dives done with seven submersibles between 300 and 4000 m depth off Bermuda, Bahamas, Grand Cayman, California, Suruga Bay (Japan) between 1986 and 1990, in the frame of the Beebe Project. They identified 13 shark species, the most common being the six-gill shark (*Hexanchus griseus*) with about 90 specimens observed, and they found four species of gulper sharks (genus *Centrophorus*). The deepest shark observed during this project was the Pacific sleeper shark (*Somniosus pacificus*) by 1630 m depth. Rays were also observed during this project: two skates and two electric rays.

Séret (1994) analysed the videos taken by the diving saucer "CYANA" during the "CALSUB" cruise carried out off New Caledonia down to 3000 m depth. He recorded six chondrichthyan fishes, five sharks, mainly the kitefin shark *Dalatias licha*, and a skate.

This short account illustrates that direct visual observations of marine ecosystems below the depths accessible to scuba diving have rarely been carried out. No doubt this is related to the technical difficulties and costs to operate submersibles as well as to the worldwide limited availability of such vehicles. Fisheries research commonly relies on three kinds of data: (i) fishery dependant data - catch and effort of the fisheries, biological sampling of the catch, (ii) scientific surveys operating fishing gears or sampling gears derived from fishing gears, and (iii) surveys targeting a particular biological stage of one or a few species in order to estimate population densities and biomass (e.g., egg and larval surveys, acoustics surveys). Although extremely valuable, these investigation methods have their own technical limits. Knowledge about the natural history of species, their behaviour and small-scale species interactions cannot be acquired using these traditional methods of investigation.

Table I. - Number of dives carried out by cruise and objectives (*: dives combined with bottom radials).

Main objectives		Number of dives		Details
		1996	1998	
1	**Bottom habitat**	14 *	9	Transects over the bottom to count all fixed and mobile organisms
2	**Mid-water habitat**	0	2	Transects in the water column to evaluate the density and the vertical stratification of pelagic fish
3	**Fishing gear technology**	2	5	Observations of: the effects of trawls on the bottom, the setting of pots and nets lines and the possible lost catch when hauling in of static gears
4	**Scientific gear trial**	2	6	Attempts to tag some deep water bony fishes with a chemical dye in order to analyse growth increments deposited while they are kept alive in cages on the bottom
	Invalid dive	1		

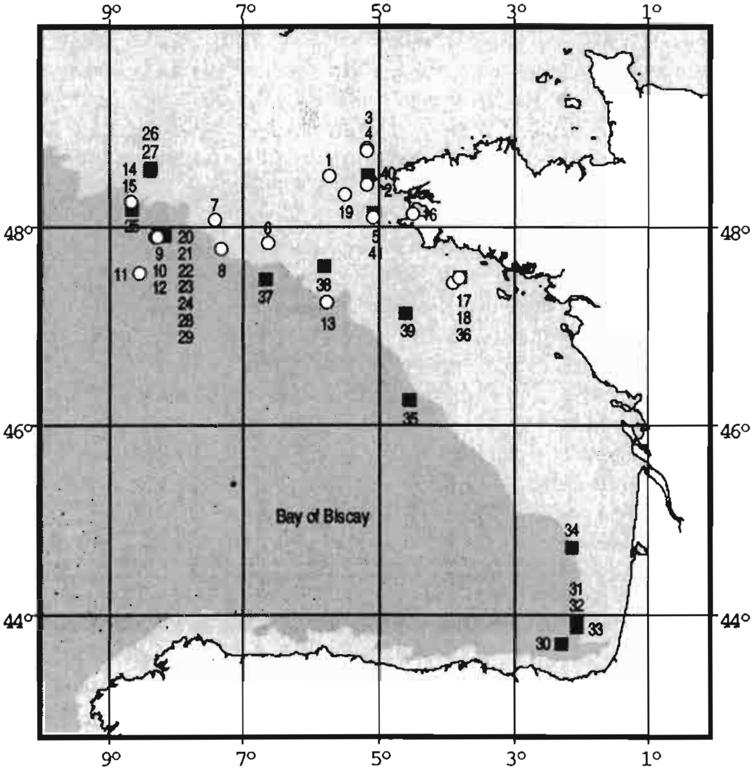

Fig. 1. - Map showing the dive stations in the Bay of Biscay (N.E. Atlantic). O: "OBSERVHAL96" (dives 1 to 19); ■: "OBSERVHAL98" (dives 20 to 41).

In order to assess the possible contribution of submersible observations to fishery science two submersible cruises were carried out in the Bay of Biscay (north west Atlantic). Several objectives were pursued (Table I) the main one being the observation and censusing of all fishes along bottom transects. However, results for chondrichtyes only will be presented here.

Sharks, rays and chimaeras were seen in most of the dives. Some species were easily identified and some behaviour features could be observed. The present paper is an attempt to compare the apparent densities observed to those from trawl surveys and to discuss the possible contribution of submersible observations to the knowledge of chondrichthyan species in terms of distribution, densities, behaviour, which ultimately might lead to improved management of these species.

MATERIAL AND METHOD

The surveys were carried out from 5 to 26 August 1996 with the submersible "CYANA" (OBSERVHAL96) and from 13 May to 7 June 1998 with the submersible "NAUTILE" (OBSERVHAL98).

A total of 40 valid dives could be completed (Table I). Most dives took place to the west of Brittany and some took place in the southern Bay of Biscay when spring tide did not allow operating submersible elsewhere (Fig. 1). The overall depth range of the dives extended from 80 to 2100 m (Tables II, III). It covered continental shelf and slope depth and a variety of types of seabeds.

The duration of a dive was limited to about 5 hours on the bottom by the capacity of the batteries (Latrouite *et al.*, 1999). The locations of the dives were defined in advance. However, the actual route on the bottom depended upon the seabed topography and unpredictable conditions like current strength and direction on the bottom. The speed of the submersible was generally about 1 knot (30 m/min) along transects but several stops occurred for video recording, sampling (stones or organisms) or other operations. The altitude of the submersible above the bottom varied according to the visibility, which depended on turbidity and plankton density. To allow easy observation of benthic megafauna and demersal fishes it was generally between 0.5 and 5 m. The width of the visual scope for the two observers (pilot + scientist) was estimated by the pilot of the submersible. Although the scope within which fish can be seen depends also upon the size and the species of the observed animal (mimetic species, like flatfishes, are less visible than active demersal species), the visual scopes used here apply to all species as no device to estimate distances from the submersible to the fishes observed was available. The swept area per dive was estimated by multiplying the distance travelled with the visual scope. The lengths of the transects were calculated from the navigation system of the support "R/V Suroît" (OBSERVHAL96) or of the submersible "NAUTILE" (OBSERVHAL98); in both cases, the reliability was rather low. Although no confidence interval can be computed, the distance calculated may be wrong of up to 30% for some dives.

The data were analysed in a quantitative way. Maximum and minimum depth of occurrence of species were recorded, apparent relative densities per taxonomic group (sharks, rays and chimaeras) were calculated based upon observations during all the time on bottom. The relative frequencies of chondrichthyan individuals among all demersal fish were calculated. Pelagic, mesopelagic and small and gregarious species (namely *Trachurus trachurus*, *Scomber scombrus*, *Argentina* sp., *Gadiculus argentatus*, *Micromesistius poutassou*, *Trisopterus minutus*, *Capros aper*), which were encountered sometimes in high numbers, were ignored in these calculations. Depending on the reliability of fish counts, dives devoted to other objectives (Table I) were treated similarly (for example, dive 38, over a pot string, was treated here as a bottom radial) or only short transects carried out during spare time were used. These estimated densities and frequencies were compared to trawl survey data.

In 1998, six dives were carried out at one single location at mid-slope depth (1200 m) for chemical tagging purposes (Latrouite *et al.*, 1999). During these dives fish individuals encountered were recorded, however, as a lot of moves to and from were done the same individual was possibly seen more than once. Furthermore the census cannot be related to a swept area. Hence, the observations from these 6 dives were summed up to provide relative fish frequencies at this location, but no density was calculated.

During 3 dives (1300 m, 1200 m and 1000 m), attempts were made to attract sharks to the submersible using bait. In the first attempt the bait was sepion, in the second tuna and squids and in the third fresh pelagic fish (*Scomber scombrus* and *Trachurus trachurus*). In each case the bait was laid on the ground near the submersible that remained immobile with lights switched off for 30 to 45 min.

RESULTS

Species identification and depth range

In the course of the bottom transects Chondrichthyes were observed during 23 dives among 29 (Tables II, III) and 22 species (9 sharks, 8 rays and 5 chimaeras) were identified (Table IV). Some species were easily identified from their colour patterns. This was the case for most of the rays, *Leucoraja naevus* (Fig. 2A), *L. circularis*, *Raja brachyura*, *R. montagui*, *Neoraja caerulea*, *Torpedo nobiliana*, and for two species of Scyliorhinidae, *Scyliorhinus canicula* and *Galeus melastomus*. The shape of their snout allowed adding the Rhinochimaeridae, *Hariotta raleighana* and *Rhinochimaera atlantica*, to this list of easily identifiable species. Similarly, the single dorsal fin of *Hexanchus griseus*, the concave angle of the anterior margin of the disk in *Dipturus oxyrhinchus* (distinction from *D. nidarosiensis* which could share the same habitat) appeared as typical characteristics usable for visual identification.

Some other species, whose characteristics were less evident, were identified only when individuals could be approached and observed for some time. This was the case for the Chimaeridae family where the colour pattern was of little help. The genus *Chimaera* and *Hydrolagus* could be distinguished from the characteristic separation (*Chimaera*) or continuity (*Hydrolagus*) of anal and caudal fins. Within the genera *Hydrolagus*, species identification was more difficult and could only rely on the long caudal filament of *H. mirabilis*, absent in *H. affinis*. Only one individual of each *Hydrolagus* species was identified with certitude. The deep-water squalids also required a longer examination, and many individuals seen were only identified as sharks. However, some individuals of *Deania calcea* (long snout and characteristic shape), *Dalatias licha* (shape of snout and caudal fin) and *Centroscymnus coelolepis* (combination of a massive body, small dorsal fins and caudal fin with lobes moderately differentiated), were identified. Lastly, some deep-water Scyliorhinidae were also seen, due to the frequency of these species in trawl they should mainly belong to the genus *Apristurus*. As the species of this genus are hard to identify when caught, it is not realistic to identify them from the submersible. However, it is likely that at least two species were encountered as dark and clearer individuals were recorded. According to the area and depth range studied, the black individuals may be *A. microps* and the clearer ones may belong to *A. laurussoni* or to *A. aphyodes*. Another small deep-water Scyliorhinidae had a well visible darker colour at the

Table II. - Chondrichthyan fishes observed during bottom dives, during the cruise "OBSERVHAL96". (*: Some time during transect was spent stopped for video recording or observations; **: Several numbers are minimum as some groups of fishes revealed impossible to count exhaustively).

Dive N°	**1**	**2**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**17**	**18**	**19**
Objective (see table I)	1	1	1	1	1	1	1	4 & 1	4 & 1	1	1	1 & 3	1 & 3	1 & 3	1 & 3	1
Latitude North (median point)	48°30'	48°25'	48°06'	47°51'	48°04'	47°47'	47°55'	47°55'	47°33'	47°54'	47°15'	48°15'	48°15'	47°27'	47°30'	48°20'
Longitude West (median point)	05°44'	09°50'	05°07'	06°38'	07°25'	07°19'	08°17'	08°19'	08°33'	08°17'	05°46'	08°40'	08°38'	03°54'	03°49'	05°30'
Duration on bottom (hh:mm) *	2:22	2:16	4:18	0:52	2:32	4:47	5:39	4:59	4:02	4:22	4:45	2:03	2:46	2:03	2:46	1:58
Minimum depth (m)	119	90	83	83	185	171	1170	1210	2095	1200	172	176	175	95	93	118
Maximum depth (m)	122	94	96	96	186	182	1430	1240	2105	1550	397	184	179	97	97	118
Distance (m)	2 900	2 400	3 700	2 200	1 800	3 800	3 000	2 400	900	4 000	1 200	4 600	5 300	1 500	1 600	1 400
visual scope (m)	6	6	6	4	8	8	15	15	15	10	8	10	10	4	4	6
Swept area (m^2)	17 400	14 400	22 200	8 800	14 400	30 400	45 000	36 000	13 500	40 000	9 600	46 000	53 000	6 000	6 400	8 400
Number observed																
Sharks	32	0	42	1	0	5	2	2	1	20	6	20	18	0	0	6
Rays	0	0	2	0	4	4	0	4	1	1	2	4	8	0	0	1
Chimaeras	0	0	0	0	0	0	8	2	0	7	1	0	0	0	0	0
Demersal bony fishes **	48	> 53	> 84	29	67	> 218	142	90	33	301	> 20	237	> 206	9	68	83
Densities (number per 10 000 m^2)																
Sharks	18.4	0	18.9	1.1	0	1.6	0.4	0.6	0.7	5.0	6.3	4.3	3.4	0	0	7.1
Rays	0	0	0.9	0	2.8	1.3	0	1.1	0.7	0.3	2.1	0.9	1.5	0	0	1.2
Chimaeras	0	0	0	0	0	0	1.8	0.6	0	1.8	1.0	0	0	0	0	0
Demersal bony fishes	27.6	36.8	37.8	33.0	46.5	71.7	31.6	25.0	24.4	75.3	20.8	51.5	38.9	15.0	106.3	98.8
Relative frequencies of Chondrichthyes in the fish assemblage (%)																
Sharks	40.0	0	33	3.3	0	2.2	1.3	2.0	2.9	6.1	20.7	7.7	7.8	0	0	6.7
Rays	0	0	1.6	0	5.6	1.8	0	4.1	2.9	0.3	6.9	1.5	3.4	0	0	1.1
Chimaeras	0	0	0	0	0	0	5.3	2.0	0	2.1	3.4	0	0	0	0	0
Total	40.0	0	34.4	3.3	5.6	4.0	6.6	8.2	5.7	8.5	31.0	9.2	11.2	0	0	7.8

Table III. - Chondrichthyan fishes observed during near bottom dives during the cruise "OBSERVHAL98". (*: Addition of 2 short bottom transects at the beginning of dives devoted to mid-water observations; **: Route too tortuous).

Dive N°	22	25	26	30	31/32 *	33	34	35	36	37	38	39	41
Theme (see table I)	1	1	3	1	2	1	1	1	1	1	3	3	1
Latitude North (median point)	47°54'	48°10'	48°04'	43°41'	43°55'	43°51"	44°43"	46°15'	47°30'	47°28'	47°36'	47°08'	48°08'
Longitude West (median point)	08°11'	08°17'	07°25'	02°20'	02°05'	02°04'	02°09'	04°34'	03°50'	06°41'	05°50'	04°37'	05°05'
Time in transect (hh : mm)	4 : 18	5 : 12	1 : 52	4 : 18	1 : 22	5 : 25	4 : 45	4 : 51	3 : 49	4 : 06	3 : 08	0 : 19	2 : 46
Minimum depth (m)	932	245	168	1365	180	200	710	1110	109	434	156	143	100
Maximum depth (m)	1227	408	172	1855	180	496	1580	1560	109	522	158	148	105
Distance (m)	4 800	4 500	3 160	6 070	1 000	6 580	3.750	6 350	**	5 270	4 050	200	4 110
visual scope (m)	15	12	10	10	10	10	20	20	5	15	10	5	10
Swept area (m²)	72 000	54 000	31 600	60 700	10 000	65 800	75 000	127 000	-	79 100	40 500	1 000	41 100
Number observed													
Sharks	8	0	1	10	0	323	6	62	0	40	21	0	27
Rays	3	0	1	0	0	0	0	11	0	0	0	0	0
Chimaeras	13	3	0	28	0	0	6	13	0	81	0	0	0
Demersal bony fishes	769	62	38	1030	207	119	750	1256	177	316	50	11	38
Densities (number per 10 000 m²)													
Sharks	1.1	0	0.3	1.6	0	49.1	0.8	4.9	-	5.1	5.2	0	6.6
Rays	0.4	0	0.3	0	0	0	0	0.9	-	0	0	0	0
Chimaeras	1.8	0.6	0	4.6	0	0	0.8	1.0	-	10.2	0	0	0
Demersal bony fishes	106.8	11.5	12.0	169.7	207.0	18.1	100.0	98.9	-	39.9	12.3	110.0	9.2
Relative frequencies of Chondrichthyes in the fish assemblage (%)													
Sharks	1.0	0	2.5	0.9	0	73.1	0.8	4.6	0	9.2	29.6	0	41.5
Rays	0.4	0	2.5	0	0	0	0	0.8	0	0	0	0	0
Chimaerids	1.6	4.6	0	2.6	0	0	0.8	1.0	0	18.5	0	0	0
Total	3.0	4.6	5.0	3.6	0	73.1	1.6	6.4	0	27.7	29.6	0	41.5

Table IV. - List of chondichthyan species, with observed depth ranges compared to literature data.

Family	**Species**	**Depth range (m) observed**		**Depth range (m). Data from literature**		**Observed in dives N°**	
		Minimum	**Maximum**	**Minimum**	**Maximum**	**1996**	**1998**
Scyliorhinidae	*Galeus melastomus* Rafinesque, 1810	276	820	55	1200	-	33, 34, 37
	Galeus murinus	1300	1300	380	1200	12	-
	Scyliorhinus canicula (Linnaeus, 1758)	120	295	0	400	1,5,6,8,13-15,17-19	26, 33, 38, 40, 41
	Apristurus sp.	1286	1490			9, 12	-
Triakidae	*Mustelus asterias* Cloquet, 1821	130	130	0	150	-	40
Hexanchidae	*Hexanchus griseus* (Bonnaterre, 1788)	265	265	0	1875	-	33
Squalidae	*Centroscymnus coelolepis* Bocage & Capello, 1864	945	2100	270	3675	11, 12	-
	Dalatias licha (Bonnaterre, 1788)	932	1140	37	1800	-	22, 28, 34
	Deania calcea (Lowe, 1839)	939	1200	73	1450	-	22, 34
Rajidae	*Dipturus oxyrinchus* (Linnaeus, 1758)	1230	1230	90	900	10	-
	Leucoraja circularis (Couch, 1838)	388	388	70	275	13	-
	Leucoraja naevus (Müller & Henle, 1841)	110	190	20	250	3, 4, 7, 8, 14, 15	-
	Neoraja caerulea (Stehmann, 1976)	1220	1540	600	1260	10	35
	Raja brachyura Lafont, 1873	118	118	0	100	19	-
	Raja montagui Fowler, 1910	90	110	0	100	3, 4, 5	-
	Rajella bigelowi (Stehmann, 1978)	2100	2100	-	-	11	-
Torpedinidae	*Torpedo* sp. cf *nobiliana* Bonaparte, 1835	120	120	10	350	-	40
Chimaeridae	*Chimaera monstrosa* Linnaeus, 1758	395	1380	300	500	9, 10, 12, 13	22, 37
	Hydrolagus affinis (Capello, 1867)	1480	1480	300	2400	12	-
	Hydrolagus mirabilis (Collett, 1904)	1070	1070	450	1200	-	22
Rhinochimaeridae	*Hariotta raleighana* Goode & Bean, 1895	1560	1848	360	2600	-	30, 34
	Rhinochimaera atlantica Holt & Byrne, 1909	1580	1849	500	1500	-	30, 34

tips of dorsal fins, which is probably a characteristic of *Galeus murinus*, but all this will remain unconfirmed.

Lastly, it is likely that more species could be recognised by a trained observer. It appeared also that, thanks to their external organs, sexing chondrichthyes seen from submersibles is possible.

Habitats

The depth range observed (or the depth at which one single specimen was seen) is most often within the known depth range of the species. The Portuguese shark, *Centroscymnus coelolepis*, observed at 945 and 2100 m depths during "OBSERVHAL" cruises, is the deepest shark, with a bathymetric range of 300-3675 m (Compagno, 1984). The six-gill shark, *Hexanchus griseus*, is mainly a deep-water species, however it occasionally comes to surface, apparently during night without moon light, according to Mediterranean fishermen; during our dives, it was observed at 265 m depth. Several species (*Galeus murinus, Dipturus oxyrinchus, Neoraja caerulea, Chimaera monstrosa* and *Rhinochimaera atlantica*) were observed at greater depths than their known depths ranges (Table IV). However, for these slope species, a lot of new data and records have been collected recently and these depths should not be exceptional for these species.

Densities and relative frequencies

The highest total density of Chondrichthyes was observed at upper slope depths, 200-500 m (about 50 individuals/10 000 m^2, dive 33, see Table III). This figure is due to the large number of lesser spotted catsharks (*Scyliorhinus canicula*) seen during that dive. Other high figures in Chondrichthyes densities were due to the same species on the shelf (dives 1 and 5, see Table II), to the closely related *Galeus melastomus* and to *Chimaera monstrosa* on the upper slope (dive 37, see Table III). Deeper, Chondrichthyes were seen in all dives at densities from 0.8 to 7.0 individuals per 10 000 m^2. Excluding dives 1 and 5, the total density of Chondrichthyes on the shelf ranged from 0 to 8.3 individual per 10 000 m^2, chimaeras being absent (Tables II, III).

In terms of relative frequency of Chondrichthyes in the fish assemblage, the highest proportion was also seen at upper slope depth with a maximum of 71% in dive 33. At greater depths, the proportion varied from 1% to 9%. On the shelf the proportion was more variable from 0 to 34%. At mid-slope (about 1200 m), where more observations were available, the relative frequency was 6% (Table V).

Table V. - Chondrichthyan fishes observed during dives for age validation operations during the cruise "OBSERVHAL98".

Dive N°	**20**	**21**	**23**	**24**	**28**	**29**	**Overall**
Maximum depth	1100	1150	1165	1150	1125	1150	1100
Minimum depth	1220	1190	1190	1190	1195	1190	1220
Sharks	4	0	2	1	1	1	9
Rays	1	1	0	0	5	0	7
Chimaeras	11	5	0	4	6	2	28
Demersal bony fishes	152	84	32	61	244	73	646

Relative frequencies of Chondichthyes in the fish assemblage							
Sharks	2.4	0.0	5.9	1.5	0.4	1.3	1.3
Rays	0.6	1.1	0.0	0.0	2.0	0.0	1.0
Chimaeras	6.5	5.6	0.0	6.1	2.3	2.6	4.1
Total	9.5	6.7	5.9	7.6	4.7	3.9	6.4

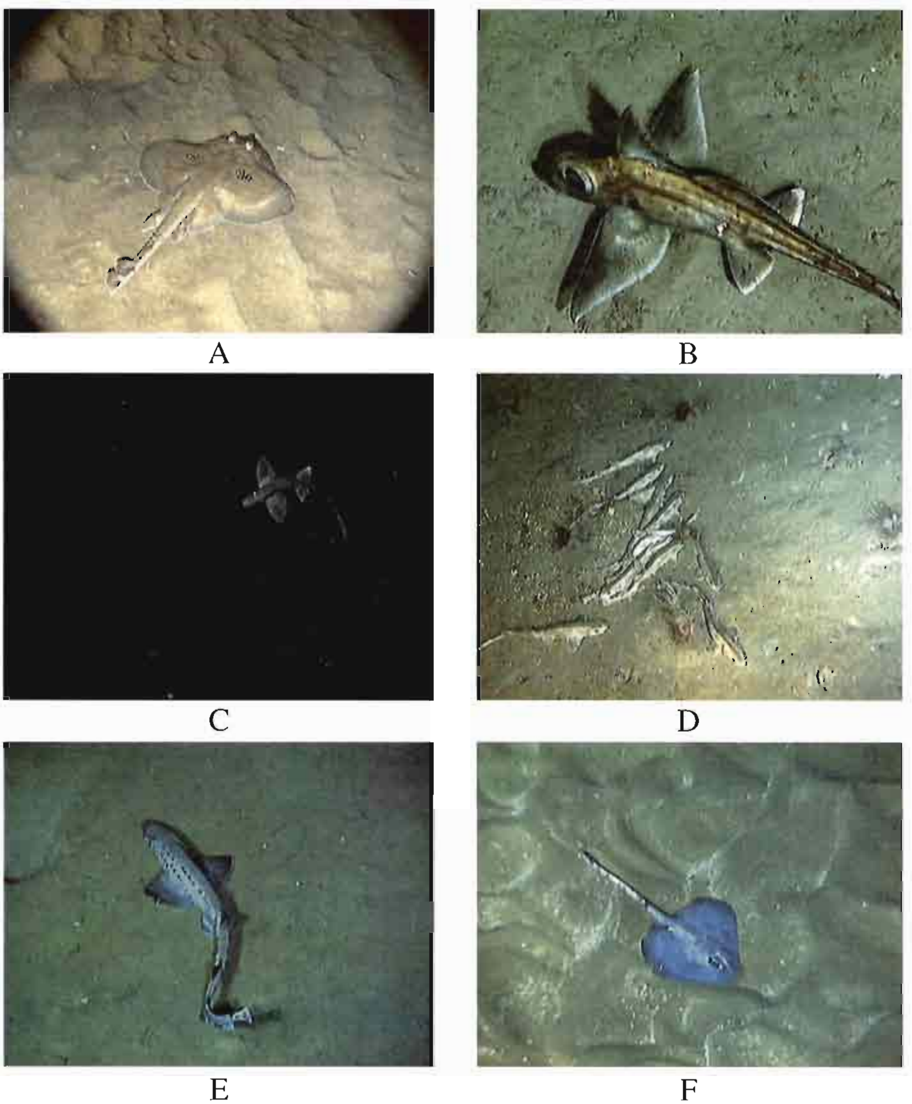

Fig. 2. - Some chondrichthyan fishes observed during the "OBSERVHAL 96" and "OBSERVHAL 98" cruises in the Bay of Biscay (N.E. Atlantic). **A**: Cuckoo ray, *Leucoraja naevus*; **B**: Wounded rabbitfish, *Chimaera monstrosa*; **C**: Rabbitfish looping the loop; **D**: Group of lesser spotted catshark, *Scyliorhinus canicula*; **E**: Blackmouth catshark, *Galeus melastomus*; **F**: Blue ray, *Neoraja caerulea*.

Attraction by bait

None of the three trials carried out attracted any chondrichthyan fish.

Wounded animal

Along the slope, some wounded bony fishes, in particular macrourids having lost their tails, were seen (Latrouite *et al.*, 1999). Amongst Chondrichthyes, several wounded chimaeras were observed (Fig. 2B). These anecdotal observations illustrate the severe predation that prevails at these depths, and from which some chondrichthyan species do not escape.

Behaviour

Chimaeras were always seen very active. Some individuals swam away from the submersible, other went up into the water column, moving actively, sometimes looping the loop (Fig. 2C). Some individuals were also seen knocking against the bottom (probably blinded by the submersible lights). All these behaviours illustrate strong reaction to the submersible.

Sharks did not display such hypersensitive behaviour. They were mainly seen slowly swimming. However, they could not be approached enough to be touched by the submersible arm like some bony fishes. Rays were seen motionless on the bottom, some reacted to the arrival of the submersible.

Scyliorhinus canicula were often seen lying on the bottom; several groups of immobile animals were seen. Up to 12 individuals almost side by side were counted (Fig. 2D). These animals did not react at all to the arrival of the submersible. No other chondrichthyan species was seen forming group.

Galeus melastomus was seen slowly swimming a few centimetres above the bottom or motionless on the bottom as *S. canicula* but not in groups. This swimming behaviour suggested exploitation of ground effect (Fig. 2E). Similarly when they swam away from the submersible all the rays moved just over the bottom. The swimming movements of sharks are different between species, *Galeus melastomus* advances with wide undulations while deep-sea squalids advance by movements restricted to their tail.

One case of possible attraction of *Neoraja caerulea* was observed at dive 35: the ray appeared in the field of vision and approached up to a few meters while the submersible was stopped for topography video recording (Fig. 2F).

At different occasions, over fine sediments, encounter of a chondrichthyan fish was preceded by observation of a sediment perturbation revealing a short running away of the animal, which then stayed in the field of vision.

DISCUSSION

Behaviour

To our knowledge, the literature about the behaviour of chondrichthyan fishes in the open sea is limited, especially for deep-water species. Although this was not the aim of the dives, some observations were collected and may be of interest beyond the scope of animal behaviour.

It is worth noting that deep-water squalids were always seen active while at mid-slope depths several bony fish species were seen lying on the bottom (for example: *Hoplostethus atlanticus*, *Trachyscorpia cristulata echinata*, *Bathypterois* sp.) or static (small macrourids, morids). However, it can be difficult to discriminate the usual behaviour of species from their reaction to the submersible, for example rays seen swimming were thought to be reacting to the submersible.

Attraction by baits

In the light of former experiments, carried out in the Bay of Biscay, it is not astonishing that no chondrichthyan species were attracted by baits during "OBSERVHAL" surveys because the stops done were probably shorter than the time required for sharks to arrive on a bait (Isaacs and Schwartzlose, 1975; Mahaut *et al.*, 1990).

Behaviour in relation to the submersible

In the Bay of Biscay, Mahaut *et al.* (1990) studied fish behaviour and population densities. In particular, estimates of fish densities were derived from one transect at 2100 m depth of the unmanned submersible "EPAULARD" which travels at an average 3.5 m above the bottom and takes photos straight down beneath itself. No shark or chimaera was observed in that transect while, during the same series of cruises they were successfully attracted by baited cameras and observed around baits from the submersible "CYANA". As Chondrichthyes attracted by baits were seen swimming close to the bottom and were not frightened by "CYANA", Mahaut *et al.* (1990) thought it unlikely that they would have escaped the field of vision of "EPAULARD" and they concluded that their absence « must have an ethological explanation ». During "OBSERVHAL" cruises, sharks and chimaeras were encountered in all dives along the slope, including at depths similar to that prospected by Mahaut *et al.* (1990). The difference is ascribed to the observation method. The behaviour of chimaeras and deep water sharks, which kept clear enough from the submersible and never stayed beneath it, suggests that they did escape the field of vision of "EPAULARD" during former observations.

Wounded animals, predation, competition

Our observations are very limited and no former analysis of frequency of wounded animal has been found. However, the encounter of a wounded animal is striking and may be useful in terms of predation and competition assessment. This can probably not be done from trawl sampling, as what can be a sign of ethological interactions is lost due to injuries caused by trawling. Censusing of wounded animal over areas where differences in predation/competition intensities are expected to occur (for example in similar ecosystems on unexploited areas and where fishery may have relaxed species interactions) might throw light on this subject as yet very speculative.

Swimming and energy

The suspected use of the ground effect by *G. melastomus* could be an illustration of a strategy for energy saving of dispersed deep-sea fishes as these species live in energetically poor environments. Adaptations for energy conservation of slope fish have often been conjectured, however they remain to be confirmed (Merrett and Haedrich, 1997). Submersible observations may be helpful in the validation of this theory.

Submersibles and assessment of fishery effect

All chondrichthyan species dealt with here are now exploited commercially. Shelf rays and sharks are long-standing components of the catches in the Bay of Biscay and elsewhere (Quéro and Vayne, 1998). Chondrichthyes on the continental slope are of more recent exploitation. Depending on their palatability and market they are either targets, by-catch or discard species (Blasdale and Newton, 1998; Dupouy *et al.*, 1998; Lorance and

Table VI. - Average and ranges of densities and frequencies of chondrichthyan fishes by depth range during "OBSERVHAL" cruises.

	Shelf	Upper slope	Slope
Depth range (m)	**83 - 186**	**172 - 522**	**710 - 2105**
Densities (number per 10 000 m²)			
Sharks	4.2 (0 - 18.9)	15.1 (0 - 49.1)	1.9 (0.4 - 5.0)
Rays	0.6 (0 - 2.8)	0.5 (0 - 2.1)	0.4 (0 - 1.1)
Chimaeras	0	3.0 (0 - 10.2)	1.5 (0 - 4.6)
Total	4.5 (0 - 19.8)	18.6 (0.6 - 49.1)	3.9 (1.5 - 7.0)
Relative frequencies of Chondrichthyes in the fish assemblage (%)			
Sharks	10.2 (0 - 41.5)	25.7 (0 - 73.1)	2.5 (0.8 - 6.1)
Rays	1.0 (0 - 5.6)	1.7 (0 - 6.9)	1.1 (0 - 4.1)
Chimaeras	0	6.6 (0 - 18.5)	1.9 (0 - 5.3)
Total	11.3 (0 - 41.5)	34.1 (4.6 - 73.1)	5.4 (1.6 - 8.5)

Dupouy, 1998) In the Bay of Biscay, they are mainly caught by longliners (Piñeiro *et al.*, 1998). Although the French landings as "siki", which reached 2400 t in 1995 (Ponroy and Séret, in press) are mainly caught in the west of the British Isles and not in the Bay of Biscay, they show that these species are of interest for high sea trawlers and may be object of increasing fishing effort in the Bay of Biscay. However, the distribution and total abundance of these species in the Bay of Biscay are not known with sufficient precision for stock assessment.

Table VII. - Densities and relative frequencies of chondichthyan fishes species in the shelf and upper slope demersal fish assemblages of the Bay of Biscay observed from yearly trawl surveys. Shelf corresponds to depths from 60 to 200 m; upper slope to depths from 200 to 500 m. Average densities and frequencies observed over 7 surveys are given together with minimum and maximum annual values. Ratios between mean densities and frequencies from submersible and trawl surveys are calculated.

	Assemblage			
	Shelf (60 - 200 m)		**Upper slope (200 - 500 m)**	
	Density (number per 10 000 m²)	**Ratio sub./trawl**	**Density (number per 10 000 m²)**	**Ratio sub./trawl**
Sharks	0.8 (0.3 – 1.4)	5	2.6 (0.8 – 6.1)	6
Rays	0.2 (0.1 - 0.3)	3	0.3 (0.1 – 0.7)	1
Chimaeras	> 0 (0 - > 0)	-	0.3 (0.1 – 0.7)	10
Total	1.0 (0.6 – 1.7)	5	3.2 (1.2 – 7.5)	6
	Relative frequency (%)	**Ratio sub./trawl**	**Relative frequency (%)**	**Ratio sub./trawl**
Sharks	2.3 (1.3 - 3.7)	4	19.0 (9.0 - 28.2)	1
Rays	0.7 (0.3 - 1.3)	1	2.3 (0.9 - 3.4)	1
Chimaeras	> 0 (0 - > 0)	-	2.0 (0.7 - 4.2)	3
Total	3.0 (1.5 - 4.6)	4	23.3 (13.9 - 34.7)	1

Table VIII. - Range of relative frequencies (%) of chondrichthyan fishes species in the fish assemblage to the west of Scotland between 54° and 57° N (data from different types of trawl from SAMS surveys from 1975 to 1987 and IFREMER cruise in 1996).

	Bathymetric zone (m)						
	250	**500**	**750**	**1000**	**1250**	**1500**	**1750**
Sharks	4	1 - 10	0 < - 8	0 < - 4	0 < - 4	0 < - 2	0 < - 4
Rays	0 <	0 <	0 <	0 <	0 <	0	0<
Chimaeras	1	2 - 35	0 < - 9	2 - 5	1 - 3	0 < - 2	0 < - 4
Total	5	4 - 45	1 - 18	5 - 8	1 - 8	1 - 3	1 - 8

Chondrichthyes and, in particular, shark species, are recognised to be sensitive to fishery exploitation due to their k-selected life history strategy. Even species that support major fisheries may only be able to undergo low exploitation rates (Cortés, 1998; Márquez-Farias and Castillo-Geniz, 1998; Rago *et al.*, 1998). Inclusion of some species in the list of internationally protected species is considered (Daves and Nammack, 1998). In the Bay of Biscay, some large species have been depleted due to fishing (Quéro and Cendredo, 1996), suggesting that appropriate fishery management is required for these species. Beyond the continental shelf, the jagged topography restricts the use of trawl sampling to some small terraces. Then, the possibility to estimate population densities from submersibles (or remote operated vehicles) may prove very useful for these species probably susceptible to overfishing.

The mean densities and relative frequencies of Chondrichthyes observed from the submersible in different habitat types (Table VI) can be compared to those estimated from trawl surveys. In the Bay of Biscay, estimates of fish densities, on the shelf and upper slope, were available from a seven years series of trawl surveys, which sampling gear was a 36/47 GOV trawl (Anonyme, 1992). The results are given for two assemblages (shelf and upper slope) which were identified from catch composition analysis (Table VII) and correspond roughly to depths from 60 to 200 m and > 200 m (Poulard, pers. comm.), the deepest tows sampled in these surveys were around 500 m.

For the continental slope, less data were available. The most comprehensive studies of the ecology and biology of slope species, in the North-eastern Atlantic, have been carried out to the west of Scotland from the 70s (Gordon and Duncan, 1985; Gordon, 1986; Gordon and Bergstad, 1992; Gordon *et al.*, 1996, and literature herein). These cruises were carried out with different trawls including large commercial trawls and smaller trawls designed for scientific sampling at great depths. It was shown that the image of the slope fish assemblage from trawl cruises depends upon the kind of trawl used for sampling (Gordon and Duncan, 1985; Gordon, 1986; Merrett *et al.*, 1991; Gordon *et al.*, 1996). A more recent survey was carried out with a larger commercial trawl (Lorance, 1998). The range of relative frequencies of chondrichthyan fishes in the catches from these surveys (Table VIII) was compared to the frequencies derived from submersible observations. The bathymetric zones used in former analysis (Gordon and Bergstad, 1992) were kept.

Comparing these data, it should be kept in mind that the aims of the trawl surveys were different to those of "OBSERVHAL" cruises, resulting in differences in depth ranges covered, geographical distributions and intensity of sampling effort. In other words, comparisons are carried out within a very heterogeneous data set.

The relative frequency of chondrichthyan species along the slope off the west coast of Scotland are comparable to those calculated from "OBSERVHAL" cruises and peak frequencies of sharks and chimaeras at upper slope depths are seen in both (Tables VI, VIII).

Within the Bay of Biscay, the densities of Chondrichthyes calculated from submersible cruises were higher than those calculated from trawling, the relative frequencies of Chondrichthyes in the demersal fish assemblage were more similar (Tables VI, VII).

The higher densities calculated from "OBSERVHAL" may suggest that swept areas were underestimated. Indeed, no device to estimate the visual scope was available on the submersible, so that the field of vision within which these large animals were visible may have been underestimated. The better consistency of the relative frequencies makes this underestimation of the visual scopes probable. However, the higher densities of Chondrichthyes obtained from "OBSERVHAL" may also come from their behaviour and/or the geographical distribution of dives (several dives were carried out over not trawlable grounds or areas of relatively low fishing intensity, where the density of large predators like Chondrichthyes could be higher).

It is worth noting that chimaeras reacted strongest to the submersible, which could mean that they avoid trawls. Along the slope the relative frequency of chimaeras estimated from submersible is 3 times higher than the estimate obtained from trawling while the frequencies of sharks and rays are similar from the submersible and in trawl catches (Table VII). However, the trawlable grounds in the Bay of Biscay are restricted, which means that the sampling of the fish density from trawl may be biased, in particular the depth distribution of the trawl hauls within the depth range 200 to 500 m during trawling cruises may be uneven.

The higher density of chimaeras observed at upper slope depth is due to one species: *Chimaera monstrosa*, other chimaeras have a deeper distribution. This peak of abundance was also found to the west of British Isles from 50° to 60° North (Bridger, 1978; Ehrich, 1983; Gordon and Duncan, 1985; Gordon and Bergstad, 1992) but it seemed less marked further south at Porcupine Seabight - to the south west of Ireland - (Gordon *et al.*, 1996). In the Bay of Biscay area, Ehrich (1983), indicated that *C. monstrosa* was present from 200 to 1200 m at low densities and interpreted the difference with the west of the British Isles as due to hydrological conditions.

On the shelf, the ability of the submersible to sample not trawlable bottom may also explain that densities and frequencies of sharks higher than those derived from trawl surveys were estimated. Most of the sharks seen were *Scyliorhinus canicula*, which motionless attitude suggests a greater vulnerability to trawling than for chimaeras. However, on the shelf, the estimates derived from trawling surveys are based upon a much larger number of stations.

CONCLUSION

The frequency of Chondrichthyes in the slope fishes assemblage from the present study are consistent with trawl data from the west coast of Scotland. In shallower waters, on the upper slope and on the shelf, there are differences between trawl and submersible estimates. These could be due to bias in estimates, species behaviour and the geographical distribution of the sampling stations. No single sampling method is suited to estimate densities and frequencies of all species. There is currently no reason to believe that densities or frequencies derived from trawl sampling are more realistic than those from submersibles. The range of the densities of Chondrichthyes obtained from yearly trawl surveys illustrate that they do not provide very accurate estimates for these species and underwater visual observation may become a useful complement to collect data on these species. Trawl sampling allows identifying all specimens to species level while from the submersible this identification proved difficult for some chondrichthyan species. On the other hand, the submersible provides observations from not trawlable grounds like most of the continental slope of the Bay of Biscay where some shark species are exploited by longliners. This also includes rough bottom with blocs, steep areas as well as sea floor with fine sediment where trawl gear quickly bury with not chance of recovery. Moreover, the submersible allows not destructive studies.

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GEOGRAPHICAL DISTRIBUTION AND BIOLOGICAL INFORMATION ON THE BASKING SHARK, *CETORHINUS MAXIMUS* IN THE TYRRHENIAN AND LIGURIAN SEAS

by

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ABSTRACT. - The occurrence of the basking shark (*Cetorhinus maximus*) along the Tuscan and Ligurian coasts (north-western Mediterranean Sea) was analysed from data collected during the "Large Elasmobranchs Monitoring Program", and from the literature. Basically, the basking shark is incidentally caught in trammel and gill nets. Young individuals are mainly caught in shallow waters during spring. Sub-adults and adults are also present in the area; a mature male (7.3 m TL) was recently caught. The occurrence of the basking shark off the coasts of Tuscany and Liguria in spring, mainly in May, is probably due to the concentrations of zooplankton during this period, in this area. An appropriate measure for the conservation of the species would be to limit the trammel and gill nets fishery in time and space to reduce its impact on this vulnerable species.

RÉSUMÉ. - Distribution géographique et données biologiques sur le requin-pèlerin, *Cetorhinus maximus*, dans les mers Tyrrhénienne et Ligure.

La présence du requin-pèlerin, *Cetorhinus maximus*, sur les côtes toscane et ligure (nord-ouest de la Méditerranée) est analysée à partir de données provenant du "Programme de Surveillance des grands Élasmobranches" et de la littérature. Les requins-pèlerins sont pris accidentellement dans les filets maillants qui capturent surtout des jeunes individus, notamment au printemps, dans les eaux peu profondes. Des pré-adultes et des adultes sont aussi présents dans la zone; récemment, un mâle adulte (7,3 m LT) a été capturé. La présence du requin-pèlerin sur les côtes toscane et ligure, au printemps et principalement en mai, est probablement due aux concentrations de zooplancton dans cette zone, à cette période. Une mesure conservatoire appropriée serait de limiter, dans le temps et dans l'espace, la pêche au filet maillant de façon à réduire son incidence sur cette espèce vulnérable.

Key words. - *Cetorhinus maximus* - Basking shark - MED - Tyrrhenian and Ligurian seas - Distribution - Conservation.

The basking shark (*Cetorhinus maximus* (Günnerus, 1765)) fisheries of the past suggest that the species is vulnerable to overfishing (Castro *et al.*, 1999). While neither in the studied area nor in other Mediterranean countries a fishery targeted to basking shark did exist, this happened in other colder marine regions where this species has been widely exploited for a long time. Fisheries for basking shark were of some importance in the UK during the 40's

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mainly on the West Coast of Scotland (Kunzlik, 1988). In Western Ireland, the fishery for basking shark began in 1947 with a peak in the early 50's and a decline after 1955. In Norway, probably by employing the most important fleet of Northern Europe as regards to number of boats and tonnage, the basking shark fishery started in the 16th century for the usage of dried flesh for food. Stimulated by the increasing demand for liver oil, the fishery had a major expansion in the 70's of the last century. More recently, the fins were exported to the Orient market. Successively Norwegian basking shark fishery has suffered a real collapse, with total catches plummeting from 11,335 t in 1979 to 352 t (a 97% decrease) in 1987 (Bonfil, 1994). It is likely to connect this collapse with the dynamic of the Norwegian elasmobranch fisheries, which seems strongly influenced by economic and social factors (Myklevoll, 1989), but also by the erratic nature of basking sharks and their seasonal appearances (Kunzlik, 1988). Fluctuations in abundance of basking shark in California were attributed to abnormally warm years and to El Niño perturbations (Squire, 1990).

There are not evident reasons to link, in European waters, the decline of the basking shark fisheries with overexploitation, even if Parker and Stott (1965), describing the fishery of the West Coast of Ireland during the 50's, attributed the mentioned decline to overfishing. Since 1998 the basking shark has been considered a protected species in the British Isles and Germany. Some other eastern Atlantic countries are now considering the adoption of this status (Vas, 1995).

Considering the drastic fluctuations in abundance observed in many areas, that could depend on both, environmental causes and fishing pressure, the species has been included in the Annex II (Endangered or Threatened Species) of the Barcelona Convention for the Protection of the Mediterranean Sea (1976) in the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean, and signed in Barcelona on 10 June 1995. Moreover, the basking shark Mediterranean population was added to Appendix II (strictly protected species) of the Bern Convention on Conservation of European Wildlife and Natural Habitats in December 1997.

The basking shark is probably one of the species that most requires measures of protection, considering its reproductive strategy. Aasen (1966) suggests a gestation period of 18 months, while Parker and Stott (1965) report a period of 3.5 years, even if it is based upon their postulated age-length relationship. However, Holden (1974) undertook a length-frequency analysis of their data and found a period of just over one-year. This time period is in agreement with the findings of Stott (1984).

It has been observed in sharks a relative constancy of the ratio between length at birth/maximum length (Holden, 1974; Garrick, 1982). Holden (1974) proposed an empirical equation for the estimation of the parameter K of the VBGF that use data on gestation period, size at birth and maximum attained size. This method can be an indirect way to estimate the gestation period. With an assumed gestation period of one year, K values are in a range 0.1-0.2. These values are quite higher than those estimated with a non-linear regression of 31 length records of basking shark (Pauly, in press). In fact, with a gestation period of 2.6 years, that he assumed equal to t_0, Pauly obtained a value for K of 0.062 that fits well with the K value obtained with the analysis of the above mentioned size records.

The basking shark is the largest elasmobranch in the Mediterranean Sea and with the giant devilray (*Mobula mobular*) are the only filter feeders among the cartilaginous fish living in the region. The presence of the basking shark in the north-western part of the Mediterranean basin (Northern Tyrrhenian and Ligurian Seas) is here analysed. Records of this fish are not numerous, but its presence can be considered frequent mainly in spring and early summer, while sightings during the winter period are rare.

In addition to the few sightings made in the open sea, the presence of this shark is mainly evidenced by incidental catches in the trammel nets, which are frequently used in the coastal waters of Liguria and Tuscany. Fortunately, there is no direct fishery for this species in the Mediterranean Sea, thus preventing a further threat to the population survival.

MATERIAL AND METHODS

A survey of the greater cartilaginous fishes, called LEM (Large Elasmobranchs Monitoring) has been carried out since 1985 in this area (northern Tyrrhenian and Ligurian Seas), under the co-ordination of ICRAM and ARPAT-GEA (Serena and Vacchi, 1997). This program has allowed the acquisition of valuable miscellaneous information, including several records of captures and sightings of the zooplanktivorous large shark *C. maximus* (Fig. 1). A review of the literature on this species has also allowed us to develop a broad picture of the recorded catches starting from 1871 (Pavesi, 1877; Parona, 1908; Ariola, 1913; Senna, 1913; Vinciguerra, 1923; Tortonese, 1956; Torchio, 1960; Boero and Carli, 1979). Furthermore, museum collections of the Tuscan and Ligurian universities, as well as the logbooks where catches of the tuna trap fisheries and small-scale tuna traps were recorded, provided other useful sources of information. This type of information is not available from more recent years because the above mentioned fisheries have practically disappeared. A major contribution was provided by the information network created during the LEM activity, mainly through the collaboration with military authorities (Coast Guard) and with professional and recreational fishermen (offshore anglers). This network has allowed the acquisition in real time of relevant information that otherwise would have been lost as it has often happened in the past.

A data record form (MOD.SQ1), conceived in a way to make its completion accessible to non-specialists, was distributed to the groups participating to this information network. This form allows the classification (at least to order or family level) of the examined shark. Space in the form is provided for the inclusion of information concerning the date, place, species, if determined, and morphometric characteristics of the specimen. A second, more complex sheet (MOD.SQ2) allowed the recording of up to 102 morphometric data as suggested by Compagno (1984). Other ancillary information is recorded in the sheet like stomach contents, parasites, etc.

Data acquired directly in the field or from bibliography or other sources have been included in an ACCESS database file, complemented by special software (WINGIS) (Burczynski *et al.*, in press) enabling the plotting of georeferenced catches on a map. This file also contains data relative to basking sharks caught along the Campanian, Sardinian, Spanish and French coasts. In the data analysis, especially in the case of records found in the literature, length (TL) and sex data could not be included for all specimens when omitted in the sources.

RESULTS

Along the fourteen years of activity of the LEM program, 120 specimens of basking shark have been recorded. The geographical distribution of the mentioned findings is represented in figure 1. Many of these records are lacking in ancillary information on size, sex, weight, etc. Only data of 46 individuals for which information was more complete are reported in table I. The analysis of the seasonal frequency of the findings was performed with the 67 available data (47 of which proceed from literature). Figure 2 highlight late spring as

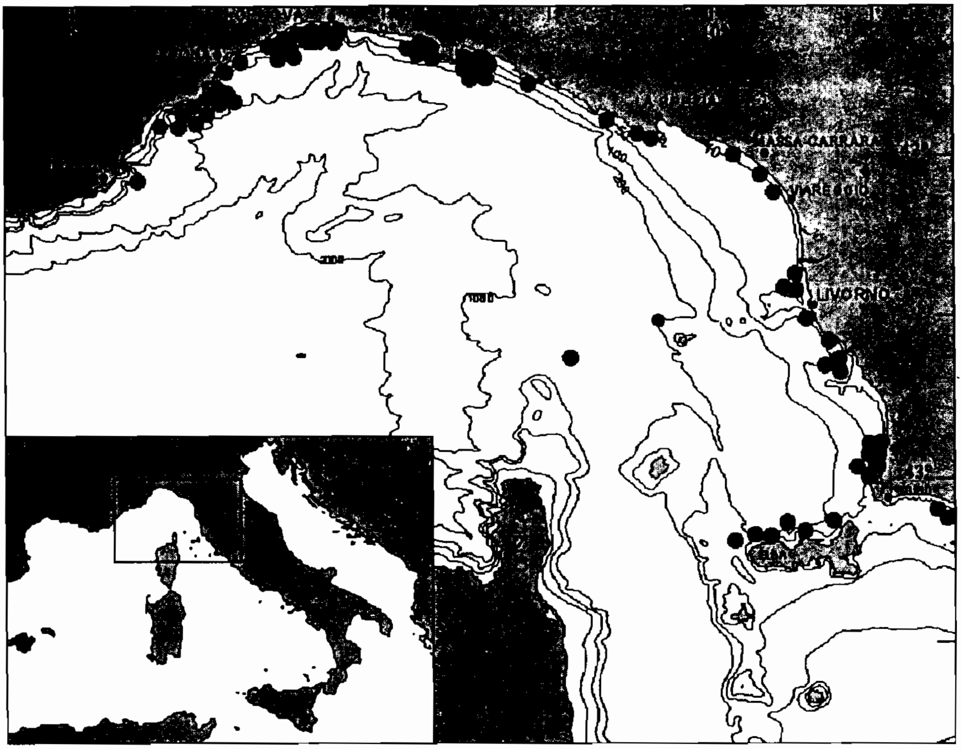

Fig. 1. - Geographical distribution of findings of basking shark in the Ligurian and North Tyrrhenian seas since 1870.

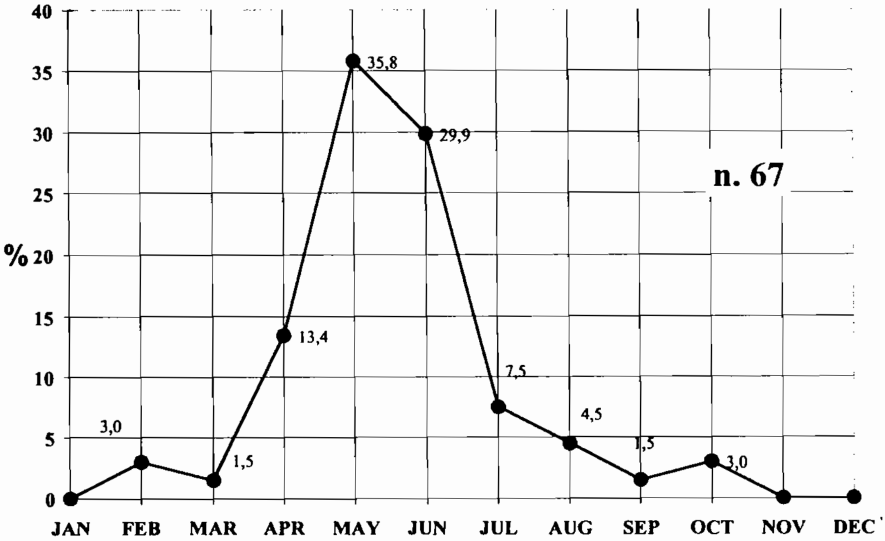

Fig. 2. - Frequency of incidental catches of basking shark by month (1870-1999).

Table I. - List of selected records for which information on date and place of finding, total length (TL), weight, sex, depth of capture and fishing gear are available.

Date	Locality	TL (m)	Weight (kg)	Sex	Depth (m)	Fishing gear
25 Avr 1871	Lerici (La Spezia)	2.95		M		Other
25 Avr 1871	Lerici (La Spezia)	8.95		M		Mullet gillnet
10 Jun 1877	Vado Ligure (Savona)	3.25	150	M		Mullet gillnet
16 Jun 1887	Vado Ligure (Savona)	6.00	160	M		Mullet gillnet
10 Jun 1913	Vado Ligure (Savona)	2.85		M		Other
19 Jun 1913	Vado Ligure (Savona)	3.25		M		Other
24 Jul 1913	Portofino (Genova)	2.50				Other
10 Avr 1942	Varazze (Genova)		500		10	Other
10 Avr 1960	Donoratico (Livorno)	6.00				Small-meshed gillnet
10 May 1962	San Vincenzo (Livorno)	4.00	400		10	Other artisanal gear
10 Avr 1964	San Vincenzo (Livorno)	6.00	600			Small-meshed gillnet
10 May 1964	San Vincenzo (Livorno)	5.00				Small-meshed gillnet
10 Jun 1970	Donoratico (Livorno)	8.00			12	Small-meshed gillnet
10 Jun 1984	Secca delle Vedove	5.50		F		Other
10 Avr 1986	Marciana M. (Livorno)					Trammel net
28 Feb 1987	Capo Mele (Imperia)	8.00	1500	F		Other artisanal
15 Jun 1987	Isola di Capraia (Livorno)	2.35				Other
10 Mar 1989	Piombino (Livorno)	4.00	600		10	Trammel net
27 May 1989	Portoferraio (Livorno)	7.20	2000	F	70	Lobster gillnet
29 May 1989	Secca delle Vedove	8.00	200	M	200	Lobster gillnet
10 Jun 1989	Baratti (Livorno)	7.30	2500	F		Large-meshed gillnet
10 Jun 1989	Portofino (Genova)		550		30	Other artisanal
03 Oct 1989	Viareggio (Lucca)	3.24	1015	F		Stranded
01 Feb 1990	Isola di Sardegna	6.80	150			Other
24 Avr 1990	Baratti (Livorno)	6.30		F	20	Large-meshed gillnet
26 Avr 1990	P.S.Stefano (Grosseto)	5.95		M		Trammel net
04 May 1990	Castiglione P. (Grosseto)	5.76	100	F	20	Trammel net
20 May 1990	Pomonte (Livorno)	5.60	120	F	10	Large-meshed gillnet
29 Aug 1990	San Vincenzo (Livorno)	4.00	400	F	90	Lobster gillnet
09 May 1991	Genova				70	Trammel net
13 May 1992	Varazze (Genova)	8.50	200		2	Trammel net
19 May 1992	Cogoleto (Genova)	8.00	120		6	Trammel net
30 May 1992	Arenzano (Genova)		70		25	Trammel net
23 Jun 1992	Finale Ligure (Savona)		200		20	Trammel net
04 May 1993	Secca della Meloria	4.17	250	F		Large-meshed gillnet
08 May 1993	Piombino (Livorno)	7.68	100	F		Large-meshed gillnet
10 Avr 1994	Marciana M. (Livorno)	6.00	2000	F		Other
07 May 1994	Cavo (Livorno)	5.95	4000	M	20	Small-meshed gillnet
22 Jun 1994	Isola di Gorgona	6.56	2000	F		Lobster gillnet
30 Sep 1997	Versilia (Lucca)		150			Trawl net
01 May 1998	Noli (Savona)		250			Other
24 Jul 1998	Santateresa (La Spezia)					Other
28 Feb 1999	Baratti (Livorno)	6.50			0	Sighting
28 Feb 1999	Baratti (Livorno)	5.00			0	Sighting
06 May 1999	Marina di Carrara (Massa)	7.30	2500	M	0	Stranded
07 May 1999	Noli (Savona)	7.00	2000	F		Other artisanal
06 May 1999	Varazze (Genova)	2.80	110	M	4	Trammel net

the time in which catches for this species are higher. It is important to remark that the frequency of use of the fishing gears responsible of the incidental captures is almost constant along the year. The 36% of the total recorded catches of basking sharks have occurred in May according to Berrow and Heardman (1994), Barrul and Mate (1999) and Stephane *et al.* (pers. comm. and abstract, this issue). The analysis of the annual frequency of findings was made using 105 available records. Three peaks were found probably explained by the increased scientific interest regarding to this species that occurred in these particular periods (Fig. 3). Only 59 records contain information on size. As shown in figure 4, young individuals in the size range 2-4 m TL constitute a half of the catches. According to Parker and Boeseman (1954) the mentioned individuals are in their first year of life. However, also subadults and adults exceeding 7 m TL are present in the database. The latter were never found to be sexually mature except for one male recently caught (May 1999) near the Carrara harbour (Tuscany). Such individual had the duct deferens full of spermatophores, the diameter of which was 1.5-3 cm. Although no definitive assessment of the sex ratio was possible due to the small number of specimens for which sex data were available, there is no apparent departure from the 1 to 1 ($\chi^2 = 0.334$, $p = 0.56$).

The specimen described by Pavesi (1874), only 1.5 m TL, was the smallest recorded basking shark. As far as the LEM program is concerned, the smallest specimen recorded was a young (2.35 m TL), caught in 1987 in the waters of Capraia Island. These two records do not show the morphological characteristic of the snout of a young basking shark specimen (2.6 m TL) described by Izawa and Shibata (1993) from Japanese Seas.

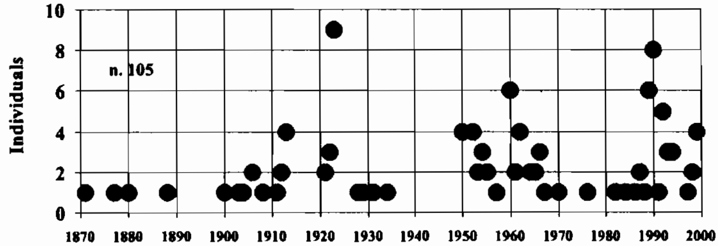

Fig. 3. - Frequency of incidental catches of basking shark by year (1870-1999).

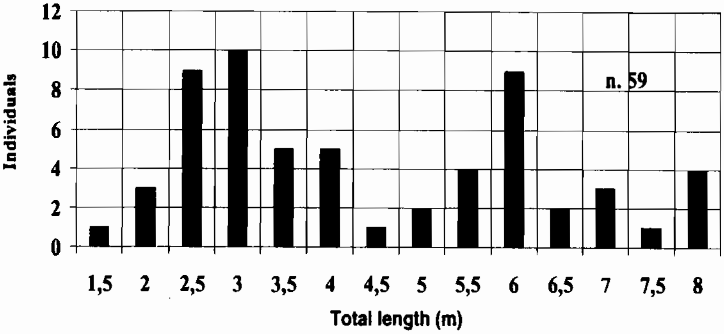

Fig. 4. - Length frequency distribution of individuals of basking shark for which information on total size is available.

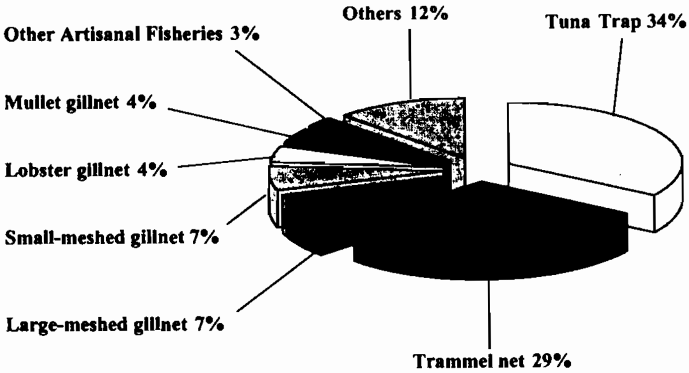

Fig. 5. - Incidental catches of basking shark split by fishing gear.

Most of the catches of basking shark occurred up to 30 m of depth, therefore close to the coastal line (Fig. 1). As an example, higher catches were recorded in the Sea Compartments of the Ligurian and of southern Tuscany characterised by a narrow shelf. Vice versa, where the shelf is wider, basking shark catches become rarer, as is the case for the Versilian coasts.

DISCUSSION

Regarding to the frequency of the findings it could be hypothesised that the higher catches in the areas with narrower continental shelf should be linked with the closeness to the bathyal zones where upwelling phenomena are more likely to occur. In wider shelf zones of the studied area, the artisanal fisheries activity (that constitutes the main source of information on basking sharks) is less important and this may be an alternative explanation of the reduced capture of individuals.

The presence of *Cetorhinus maximus* can be correlated with the movement of large water masses around the coasts of the Tuscany and Liguria. The species' appearance follows a winter period interpreted by Matthews (1962) as hibernation even if the validity of this hypothesis is now put in discussion (Weihs, 1999). A recent paper (Sims, 1999) describes the foraging behaviour of basking shark assuming that migratory phenomena should explain the less frequent findings of the species during winter. In this season, a reduction of the intensity of the temperate current coming from the Tyrrhenian Basin (south of Elba Island) does occur. In spring the colder waters of the Liguria Basin influence the waters of the Archipelago of Tuscany; this situation continues until the end of summer (Astraldi *et al.*, 1993). In spring the water layers of different density are mixed, consequently waters enriched with nutrients rise to the surface promoting an increase in primary production (Innamorati *et al.*, 1993). In May and June a relative maximum of the zooplanktonic biomass occurs (Pérès and Devèze, 1963), which coincides with the greatest occurrence of basking sharks in our records. In fact, the diet of this shark is rich in crustacean copepods of the genus *Calanus*, decapods and shellfishes larvae, fish eggs, etc. (Matthews and Parker, 1950). More recent information, specially regarding to the zooplankton assemblages that constitute the food of basking shark is included in Sims and Merrett (1997). Furthermore, some specimens analysed by us had their stomachs full of relatively recently eaten food, with similar species composition to the others previously described.

At this moment, a population estimate of the basking sharks inhabiting the north-western Mediterranean basin is not possible because the available information is not sufficient. Such lack of information is caused by the absence of specific basking shark targeted fisheries in the Mediterranean Sea. Therefore at the moment the only possible information derives from occasional sightings and the recording of incidental catches. Unexpected higher frequencies of sightings/catches, could be explained by a particularly careful scientific monitoring of incidental captures and sightings of the basking shark at the corresponding times. With the exception of the tuna traps, that presently are practically disappeared, which can also capture basking sharks, the gear mainly responsible (29%) for catching this species is the trammel net (Fig. 5). The trammel net fishery is directed fundamentally to bony fishes such as red mullets, sparids, octopuses, cuttlefish, lobsters, etc. Nets are hauled in the early morning, after soaking all night. Unfortunately, when basking sharks get entangled in one of these gears, they invariably die. Although the basking shark flesh has sometimes been used for the production of fish flour or as canned pets food, its scarce commercial value makes it an undesirable capture for local fishermen because it produces severe damages, or the total loss of the fishing gear, without revenue.

Concerning incidental catches, fishermen often create difficulties for the recovery and landing of the entangled specimens as this implies time-consuming efforts. This frequently induces fishermen to discard the carcasses at sea as soon as possible, as confirmed by the findings in the open sea of floating shark carcasses, sometimes in an advanced state of decomposition.

The available data and recorded literature do not enable us to hypothesise the presence, in the north-western Mediterranean, of a population of *C. maximus* separated from the population occurring in the near north-eastern Atlantic Ocean. Specific studies based on genetic analyses in this case should be needed. The abundance of basking sharks in the Mediterranean is probably less important than in the north-eastern Atlantic. Data recorded during the activity of the LEM program suggest that the northern Tyrrhenian and Ligurian Seas are a suitable habitat for the Mediterranean basking shark population. These seas seem to constitute nursery areas for this species, where in late spring 1-4 year-old individuals concentrate inshore apparently to feed. Therefore, we argue that the Mediterranean Sea could be also an important reproductive area for basking sharks. To confirm our hypotheses and to improve the knowledge on the biology and population ecology of this species, new and more systematic research should be undertaken and extended to other Mediterranean areas. Tagging as many individuals as possible could be useful for a better understanding of their migratory behaviour and ecology, especially during the winter period.

It would be very important that Italy aligned itself with other countries of the European Union to consider the basking shark as a protected species. It would be necessary to go beyond by the monitoring and limitation of the fishing activities along the coastal zone in the periods when abundance of this shark is higher. It would be possible to establish a biological fishing ban that could apply to certain areas and periods. This management action should minimise the impact of the fishing activities in agreement with the recent Barcelona Convention Protocol.

Unfortunately, at the eleventh CITES Conference, held in Nairobi in April 2000, is failed for the second time the inclusion of basking shark, white shark and whale shark in the list.

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DISTRIBUTIONAL NOTE ON THE DUSKY SHARK, *CARCHARHINUS OBSCURUS*, FROM THE MEDITERRANEAN SEA, WITH A FIRST RECORD FROM THE MALTESE ISLANDS

by

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ABSTRACT. - The occurrences of most requiem sharks (Carcharhinidae) are poorly documented in the Mediterranean Sea. The largest carcharhinid in the region is the dusky shark *Carcharhinus obscurus*, which can be considered an occasional transient species within the Mediterranean marine ichthyofauna. This paper reviews the known and suspected distribution of this species within the Mediterranean Sea. Based on capture data, most occurrences appear confined to more southerly parts of the western basin of the Mediterranean, and the Sicily and Malta Channels. New distributional records, however, indicate that it may occupy a wider regional range than previously supposed. The authors describe an adult male specimen taken off Malta in 1995, which represents an addition to the Maltese fauna and easterly range extension for this species in the Mediterranean Sea. Photographic evidence further indicated its occurrence off northern Sardinia. The presence of the very similar Galapagos shark *Carcharhinus galapagensis* within the Mediterranean cannot be discounted, based upon interpretation of literature records.

RÉSUMÉ. - Note sur la distribution du requin sombre, *Carcharhinus obscurus* en Méditerranée, et premier signalement dans les eaux de Malte.

La présence des requins requiem (Carcharhinidae) en Méditerranée est peu documentée. En Méditerranée, le plus grand de ces requins est le requin sombre, *Carcharhinus obscurus*, qui peut être considéré comme un visiteur occasionnel de l'ichtyofaune méditerranéenne. Le présent article est une analyse critique de la distribution connue et supposée de cette espèce en Méditerranée. Les données de captures semblent montrer que ce requin est confiné dans les parties méridionales du bassin occidental de la Méditerranée, aux détroits de Sicile et de Malte. Cependant, de nouveaux signalements indiquent qu'il est probablement présent dans une zone bien plus grande que celle qui était supposée. Les auteurs décrivent un mâle adulte capturé à Malte en 1995, ce qui représente le premier signalement pour la faune de Malte et une extension vers l'Est de la distribution géographique de cette espèce. Des photographies confirment sa présence au nord de la Sardaigne. En se basant sur les signalements publiés, il n'a pas été possible d'infirmer la présence en Méditerranée d'une espèce voisine, *Carcharhinus galapagensis*.

Key words. - Carcharhinidae - *Carcharhinus obscurus* - MED - Distribution.

Requiem or 'whaler' sharks of the family Carcharhinidae are presently represented in the Mediterranean Sea by nine species: the bignose shark, *Carcharhinus altimus* (Springer,

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1950), the bronze whaler, *C. brachyurus* (Günther, 1870), the spinner shark *C. brevipinna* (Müller & Henle, 1839), the silky shark, *C. falciformis* (Bibron, 1839), the blacktip shark, *C. limbatus* (Valenciennes, 1839), the dusky shark, *C. obscurus* (Lesueur, 1818), the sandbar shark, *C. plumbeus* (Nardo, 1827), the blue shark, *Prionace glauca* (Linnaeus, 1758) and the milk shark *Rhizoprionodon acutus* (Rüppell, 1837). The blacktip reef shark, *C. melanopterus* (Quoy & Gaimard, 1824), is also listed as an eastern Mediterranean inhabitant through Lessepsian migration by some authors including Branstetter (1984), Compagno (1984), Bauchot (1987) and Fergusson (1994a), although records of this species are considered uncertain by Fredj and Maurin (1987) and Tortonese (1987), through misidentification with *C. limbatus* and *C. brevipinna.* Thus, its inclusion within regional ichthyofaunal lists needs to be resolved.

The regional status of most of these species, with the generalised exclusion of *P. glauca* and (at least partially) *C. plumbeus*, are essentially sketchily-known. Literature works concerning Mediterranean carcharhinids include Tortonese (1950, 1951) and Moreno (1982) as regional overviews, and the more dedicated studies by Tortonese (1953) for *C. melanopterus*, Capapé *et al.* (1979) and Vacchi and Serena (1997) for *C. obscurus*, Moreno and Hoyos (1983a, 1983b) for *C. altimus* and *C. brachyurus* (the latter as *C. acarenatus*, a junior synonym according to Compagno, 1984); Cigala Fulgosi (1983) and Vacchi *et al.* (1996), also both for *C. brachyurus*, and Pastore and Tortonese (1984) for *Rhizoprionodon acutus*.

Additionally, local research by F. Hemida of the Laboratoire Halieutique, ISN-USTHB, in Algiers (pers. comm.), confirms that *C. altimus* is not exceptional as by catch within Algeria's pelagic longline fishery operating from ports in the east of the country. Thus, although its regional status remains uncertain and rather poorly documented, this species is certainly a more frequent inhabitant of at least the southwestern Mediterranean Sea than has been previously supposed.

A key local problem in collecting data on these sharks is the collective grouping and lack of interspecific discrimination between carcharhinids (with the exception of *P. glauca*, which is readily identifiable) by the commercial fisheries that catch them, particularly those operating within the Sicilian and Malta Channel, and along the north African coast. For this reason, discussion with fishermen often fails to yield definitive information on their identification (such as discriminating between captures of the 'black-tipped' species *C. limbatus*, *C. brevipinna* or *C. melanopterus*) and photographs, preserved jaws or individual teeth are rarely available to allow identification. This is further compounded by the wide colloquial use of the name 'grey shark' in describing sympatric carcharhinids in Italian waters and indeed some other (dissimilar) sharks; e.g., 'Kelb griz' in Malta, and 'Squalo grigio' in Italy, may variably refer to a variety of *Carcharhinus* spp., or even sporadically to the bluntnose sixgill shark *Hexanchus griseus* (Bonnaterre, 1788). A further index of this type of linguistic complication can be envisaged by the fact that within Maltese fisheries, the tope shark *Galeorhinus galeus* (Linnaeus, 1758) often shares the vernacular name 'Kelb il-bahar' with the white shark, *Carcharodon carcharias* (Linnaeus, 1758).

In this paper, we discuss the status of dusky sharks within the Mediterranean and describe a male specimen from the island of Malta, increasing the known easterly range of this shark in the region. We give further information to confirm its occurrence off northern Sardinia.

METHODS

One of us (IKF) has recorded captures of large coastal sharks in central Mediterranean waters since 1993, enlarging upon a dedicated regional study directed more specifically at the great white shark *Carcharodon carcharias* (Fergusson, 1994, 1996; Fergusson *et al.*, 2000). Improved collaborative effort towards this work, which provided further useful records, was developed by IKF during 1998 by way of data exchange formulated between the Shark Trust and Italy's central marine research organisation, ICRAM.

As a consequence of visits by IKF to the island of Malta in September 1994 and May 1995, the assistance of a local commercial fisherman, A. Cutajar, was sought in reporting captures of sharks within his artisanal set-line fishery operating from Wied-iz-Zurrieq on the south coast of the island. A. Cutajar had previously caught a number of large sharks and pelagic batoids in his solo operation, including some adult examples of *Isurus oxyrinchus, Prionace glauca, Hexanchus griseus, Alopias vulpinus, Carcharodon carcharias, Lamna nasus, Odontaspis ferox* and *Mobula mobular*. Rare or unusual specimens caught by him were notified to a local enthusiast, J. Abela, who subsequently forwarded any available data to IKF for assimilation, identification and computer logging.

RESULTS

First record of *C. obscurus* from Malta

On 7 December 1995, A. Cutajar notified J. Abela of a shark he had caught earlier that day. The specimen had been transferred to freezer rooms at the central Valletta fishmarket, where an examination was made at around 04.00 hrs the following morning. Some measurements were taken, which as best we can ascertain largely followed the methodology and protocol of Compagno (1984), in keeping with instructions given earlier to J. Abela during previous discussions with him.

The specimen was taken by a set line baited with chub mackerel, *Scomber japonicus*, set approximately 4 km to the east-south-east of Filfla islet (Fig. 1), at approximately 35°46'N, 14°26'E, over a rock and sand bottom 250 m deep. The line was secured in position by a concrete seabed anchor and marked at the surface by a large float fashioned from white

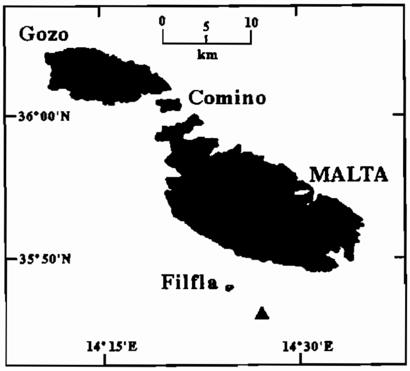

Fig. 1. - Map of Malta showing the capture-location (▲) of *Carcharhinus obscurus*, December 1995, near the islet of Filfla.

polystyrene blocks and sealed empty water containers. The bait was suspended from this at a depth of 4 m. The locale, although coastal, is typified by exceptionally clear blue water and subsurface visibility can be expected to have exceeded 30 m at the time of capture. Sea surface temperature (SST) was likely 17°C based on measured monthly mean values from contemporary remote satellite imagery (SATMER charts). Other sharks caught at the same site and by the same method were six adult specimens of *Hexanchus griseus*, the largest measuring approximately 360 cm TL. All the sharks were likely hooked during the hours of darkness.

The shark was examined early the following morning in Valetta by J. Abela, accompanied by the captor. Photographs were taken at this time and later used by us for identification. The stomach was reportedly empty of any identifiable contents but not everted.

Identification

The shark was a conspicuously large, dark grey-blue carcharhinid measured as 311 cm TL (Fig. 2) by J. Abela, with an interdorsal ridge clearly present in one of the various photographs taken by him and forwarded to us. Based upon the morphometrical descriptions of carcharhinid sharks presented by Bass *et al.* (1973), Cadenat and Blache (1981), Garrick (1982), and Compagno (1984, 1989), this feature can thus only include *C. altimus*, *C. brachyurus*, *C. obscurus* and *C. plumbeus* in the currently-described Mediterranean carcharhinoid fauna (Moreno, 1982; Fergusson, 1994b). The anterior upper-jaw teeth were broadly triangular and bladelike, which thus excludes the narrower and oblique distinctive

Fig. 2. - Anteroventral view of *Carcharhinus obscurus*, male, 311 cm TL, photographed at the Valletta fishmarket. (Photo: J. Abela).

Measurement	Value (mm)	%TL	Literature comparisons
TL (TOT)	3110	(100)	
P1A	559	17.97	17 - 22% (1); 16.8-23% (2)
P1L	305	9.81	
CDM	686	22.06	
CPV	229	7.36	
D1L	356	11.44	
D1H	267	8.58	5.8 - 10.4% (2)
CLO	305	9.81	
CLI	229	7.36	

Table I. - Meristics of adult male *Carcharhinus obscurus* captured off Malta, December 1995. The measurements were taken by J. Abela and on the basis of his descriptive notes were matched by the authors to follow the protocol and terminology of Compagno (1984) as closely as possible. An additional non-standard measurement is D1 apex to D2 apex: 864 mm. Comparative literature sources are (1) Compagno (1984) and (2) Garrick (1982). Abbreviations: TL(TOT) = Total length; P1A = Pectoral anterior margin; P1L = Pectoral length; CDM = Dorsal caudal margin; CPV = Preventral caudal margin; D1L = First dorsal fin length; D1H = First dorsal fin height; CLO = Clasper outer length; CLI = Clasper inner length.

upper cusps of *C. brachyurus*. The first dorsal fin origin was nearer to the pectoral free tips rather than the pectoral insertion, excluding both *C. altimus* and *C. plumbeus* in this respect and moreover by virtue of other morphometrical features. The posterior margins of the pectoral fins were notably falcate. In all respects, the specimen fitted closely the descriptions of *Carcharhinus obscurus* given by previous authors including Bigelow and Schroeder (1948), Bass *et al.* (1973), Garrick (1982), Moreno (1982), Compagno (1984, 1989) and Last and Stevens (1994). Morphometrical values obtained by J. Abela, and later matched by us to the measurement methodology of Compagno (1984), fell within described ranges as proportionate percentages of total length (Table I).

Possible occurrence off northern Sardinia

Photographic evidence also suggests that this species may occur to the north of Sicily, at least to northern Sardinia and perhaps further northward into the Ligurian Sea.

Following a recent (summer 1998) trip to Sardinian coastal fisheries, a Rome-based marine environmental journalist, E. de Sabata, contacted us and provided copies of a photograph showing a shark caught off the north coast of Sardinia, possibly in the mid to late 1970's. Taken in a net set for bluefin tuna *Thunnus thynnus*, the capture location was within the nearshore waters off Capo Testa, on the Straits of Bonifacio that separate Sardinia from Corsica. The photograph showed a freshly-caught carcharhinid and from our scrutiny of the image, we were able to note some aspects of its morphology. Dorsal colour was very dark grey, and the ventrum was white. This ruled-out *C. brachyurus*, which tends to retain its golden-brown to brown-grey dorsal pigmentation even for a protracted period after death (authors, pers. obs. from South Africa). The snout was noticeably broad, without any conspicuous nasal flaps as would be found with *C. altimus*. The eyes were small. Based on the known carcharhinoid fauna of the western Mediterranean, we suspect this to be a specimen of *C. obscurus*, representing a likely northerly range extension in Mediterranean waters.

DISCUSSION

Validity of *C. galapagensis* in the Mediterranean ichthyofauna

In his description of *C. obscurus*, Moreno (1982) cited Lozano y Rey (1928), who described a species of carcharhinid taken off Alicante (Costa Blanca) and elsewhere on Spanish coasts as *Carcharhinus commersoni*. However, Garrick (1982) suggested that this specimen may have been *Carcharhinus galapagensis*, commenting: « Finally, it is worth noting that

Rey's (1928) account of a ridge-backed shark, under the name *commersoni*, as part of the Iberian fauna could well be interpreted as being of *galapagensis* ».

Crucially, Garrick had examined Atlantic material of *C. galapagensis* from Bermuda, the Virgin Islands, Madeira, Great Salvage Isl. (presumably the Portuguese Selvagens, near Madeira), and St. Helena Island in the South Atlantic. Conversely however, it is unclear if Lozano y Rey (1928) had comparative specimens of *C. galapagensis* and *C. obscurus* available to him whilst preparing his work. Lozano y Rey's (1928) illustrative work is of a high quality, with particular attention paid to morphometric details and considering this point, his depictions of *C. commersoni* lateral view (p. 342) and dentition (p. 343) do look more like *C. galapagensis* rather than *C. obscurus*. The pectoral fins of his illustrated specimen are much less falcate than that in *C. obscurus*; the dorsal fin is noticeably high, as in *C. galapagensis*; similarly the second dorsal fin is also depicted as taller than we would expect with *C. obscurus*. Although less compelling, the dentition shown by Lozano y Rey (1928) also bears more similarities to that of *C. galapagensis* as opposed to *C. obscurus*; e.g., compare with the respective illustrations contained on p. 474 and p. 490 of Compagno (1984), with the upper jaw anterolateral teeth being slightly more oblique than in *C. obscurus*. Thus we concur with Garrick (1982) that Lozano y Rey (1928) may have described *C. galapagensis* and that subsequent inclusion of his record under *C. obscurus* (e.g., by Moreno, 1982) may, in fact, be erroneous. We emphasise that this is a problematic case to resolve in any definitive fashion, but the possibility that *C. galapagensis* is included within the Mediterranean ichthyofauna cannot be discounted and may account for some other (misidentified) specimens previously cited as *C. obscurus*.

Distribution of *C. obscurus*

The areal distribution of *C. obscurus* within the eastern North Atlantic Ocean and western Mediterranean Sea was reviewed in detail by Moreno (1982), based upon literature records and a number of specimens examined by that author. He described further examples from the Alboran Sea, caught predominantly off the north African coast in the Golfe di Chafarinas (Morocco), noting that the species was not uncommon in that area. This bias of records towards the extreme western Mediterranean was again reflected by Bauchot *et al.* (1987) in a regional review.

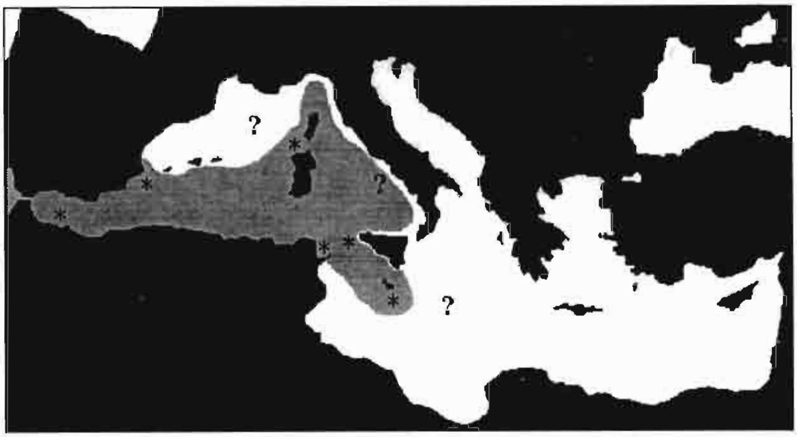

Fig. 3. - Known and suspected distribution of *Carcharhinus obscurus* within the Mediterranean Sea. Stars indicate confirmed capture sites; shaded areas represent likely distribution with question marks denoting zones where further range extensions can be anticipated.

Further east, within the central Mediterranean, previous published records of *Carcharhinus obscurus* have been limited to three works: firstly that of Capapé *et al.* (1979), who reported a pregnant female taken 3 km offshore at Sidi Daoud, northwest Cape Bon, Tunisia; secondly a citation by Cigala Fulgosi (1983) based upon an example seen by him at the fish-market of Mazara del Vallo (TP, Sicily); and thirdly a recent work by Vacchi and Serena (1997), who describe a specimen estimated at 250 cm TL taken by drifting surface longline on 27 July 1984 within the Sicilian Channel and landed at Mazara del Vallo. F. Cigala Fulgosi (pers. comm.) also reports a further three large examples from Mazara del Vallo, all adult females, taken in the summer of 1983: 330 cm TL on 23 July, 339 cm on 25 July and 349 cm on 6 August. Thus although most Mediterranean records are from the Sicilian Channel and environs, the capture of this species off Malta indicates that it probably ranges further eastwards at least to the Ionian Sea and quite possibly beyond, even into the eastern basin of the Mediterranean. However, we have no data to indicate that this species enters the Adriatic Sea. A revised areal distribution for this species within the Mediterranean is given in figure 3.

Given the presence (albeit perhaps sporadic) of these sharks as far north as the Straits of Bonifacio, it seems quite possible that their range, in at least the western Mediterranean waters is much more cosmopolitan than current capture records infer. G. Notarbartolo di Sciara (pers. comm.) described a large (> 300 cm TL) dark grey carcharhinid, quite unlike any other requiem shark typically sighted in those waters (i.e., *Prionace glauca*) that he observed swimming near the surface during an offshore cetacean study in pelagic waters northwest of Corsica during early 1992. Sea surface temperature at the time of his observation was extremely high, ranging 27° to 29°C, due to an exceptionally prolonged period of calm weather (the precise location and details of this research are described by Forcada *et al.*, 1995). The shark may conceivably have been a *C. obscurus* although various other carcharhinids, including *C. falciformis*, which occurs in the southwestern Mediterranean, also have maximal sizes around 300 cm.

Dusky sharks taken in the Mediterranean have almost certainly arrived as North Atlantic transients following immigration through the Straits of Gibraltar, but we cannot presently assess if a proportion of these animals remain essentially resident once having passed into the Mediterranean. The capture of the Maltese specimen in December 1995, when coupled to previous regional records which have a strong July-August bias, suggests that dusky sharks might frequent central Mediterranean waters throughout the annual cycle albeit peaking during the high summer. Given that various pelagic and coastal fisheries capable of landing large sharks operate all year in this area, we suspect that the July-August peak in captures is not merely a phenomenon biased by seasonal shifts in fishery pressure, location and methodology but more probably a reliable index of this species spatiotemporal distribution within at least the Sicilian Channel and its environs.

Pregnant female sharks within the families Carcharhinidae, Sphyrnidae, Alopiidae and Lamnidae have previously been recorded from the Sicilian Channel; e.g., *C. plumbeus* (see Capapé, 1984, for reproductive data from Tunisian waters), *Alopias vulpinus* (IKF, unpubl. data), smooth hammerhead *Sphyrna zygaena* (IKF, unpubl. data) and *Carcharodon carcharias* (Cigala Fulgosi, 1990; Fergusson, 1996, unpubl. data). The predominance of adult female *C. obscurus* amongst locally-caught specimens, plus the earlier capture of a pregnant specimen containing full-term foetuses (Capapé *et al.*, 1979), offers circumstantial indications that reproductive activity might be a motivation for their occurrence during summer in the Sicilian Channel. Conversely however and crucially, we are not aware of any neonatal *C. obscurus* taken anywhere within the Mediterranean Sea, so further evidence to support this hypothesis is presently lacking. As previously noted, small (including neonatal) specimens of dusky shark could be easily misidentified or go unrecorded, having been grouped amongst catches of other sympatric carcharhinids of very similar appearance.

More detailed monitoring and better interspecific discrimination within fisheries is required to further assess all aspects of carcharhinid status and autecology within the Mediterranean Sea. Stomach content data would be additionally useful, as the regional feeding ecology of most of these sharks (even including common species such as blue and sandbar sharks) is still largely unknown.

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A NEW OBSERVED PRE-COPULATORY BEHAVIOUR OF THE LESSER-SPOTTED DOGFISH, *SCYLIORHINUS CANICULA*, IN CAPTIVITY

by

Nadège DOMI (1), Pascal PONCIN (2) & Jacques VOSS (1)

ABSTRACT. - The lesser-spotted dogfish, *Scyliorhinus canicula*, exhibits four pre-copulatory behaviours: nosing, tailing, biting and a newly described one, herein named rubbing, observed on specimens kept in captivity.

RÉSUMÉ. - Un nouveau comportement pré-copulatoire observé chez la petite roussette, *Scyliorhinus canicula*, en captivité.

La petite roussette, *Scyliorhinus canicula*, montre quatre comportements précopulatoires: "nosing" (test), "tailing" (poursuite), "biting" (saisie) et un nouveau comportement, dénommé "rubbing" (frôlement) décrit à partir d'observations faites sur des spécimens maintenus en captivité.

Key words. - *Scyliorhinus canicula* - Pre-copulatory behaviour - Captivity.

The literature on the reproductive biology of the lesser-spotted dogfish, *Scyliorhinus canicula* (Linnaeus, 1758), was approached only from one anatomical and physiological point of view (Ford, 1921; Craik, 1978; Sumpter and Dodd, 1979; Mellinger, 1983, 1994; Capapé *et al.*, 1991; Ellis and Shackley, 1997). Currently, information is available on its reproductive behaviour (Houziaux and Voss, 1997). This is also the case for other sharks species (Myrberg and Gruber, 1974; Klimley, 1980; Tricas and Feuvre, 1985; Bres, 1993; Gordon, 1993). Very few observations have been made on these animals. This is mainly due to the difficulty to observe them in their natural environment (Nelson, 1977). Also, the lesser-spotted dogfish, an oviparous benthic shark, is an excellent biological model for ethological study because of its small size, its abundance in European inshore waters and its easy acclimatisation in tank.

This paper reviews the principal pre-copulatory behaviours of the lesser-spotted dogfish observed in captive conditions and describes for the first time a new observed behaviour.

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MATERIALS AND METHODS

Our observations were based on four mature lesser-spotted dogfishes: two males of respectively 62 and 66 cm long and two females of 58 and 63 cm. These individuals were maintained in a 5 m^3 tank at the constant temperature of 14°C, at the aquarium of the University of Liège (Belgium). They were individually marked on the first dorsal fin using different colours strips in order to assist recognitism them during observations. They were fed every two days with pieces of fish, shellfishes, and molluscs. Ten 24-h observation cycles were carried out from February to July 1998. Individuals were observed during fifteen minutes every hour. These periods of observations (60 hours) were recorded with a video camera system controlled from an adjacent room. The most frequently observed pre-copulatory behaviours were described and quantified.

RESULTS AND DISCUSSION

Three matings were observed and filmed from 30 March to 13 April 1998. During this reproduction period, the individuals were very active in the experimental tank. The observations highlighted the high frequency of four pre-copulatory behaviours: nosing, tailing and biting behaviours, already described in the lesser-spotted dogfish (Houziaux and Voss, 1997), and a newly observed behaviour never described, herein named "rubbing". Males exclusively initiate these behaviours. While the 60 h of observation, we quantified 67 biting, 357 tailing, 229 nosing and 109 rubbing (Fig. 1).

Biting (Fig. 2A) has been observed in other sharks species: the sandtiger shark *Carcharias taurus* (Gordon, 1993), the reef white-tip shark *Triaenodon obesus* (Tricas and Le Feuvre, 1985), the nurse shark *Ginglymostoma cirratum* (Klimley, 1980), the chain

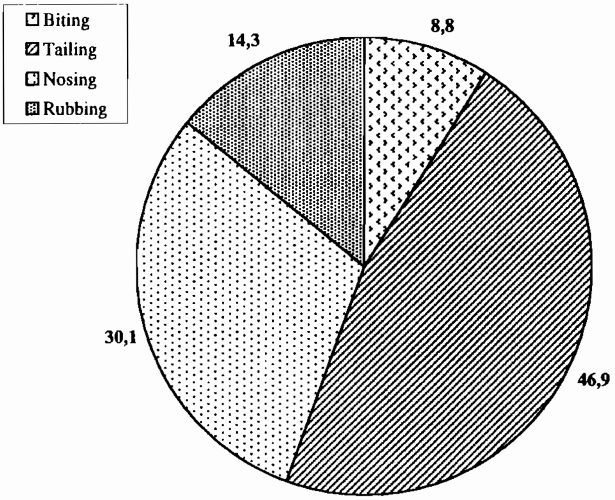

Fig. 1. - Percentages of pre-copulatory behaviours (nosing, rubbing, tailing and biting) exhibited by specimens of lesser-spotted dogfish, *Scyliorhinus canicula*, observed during ten 24 h-cycles at the aquarium of the University of Liège (Belgium).

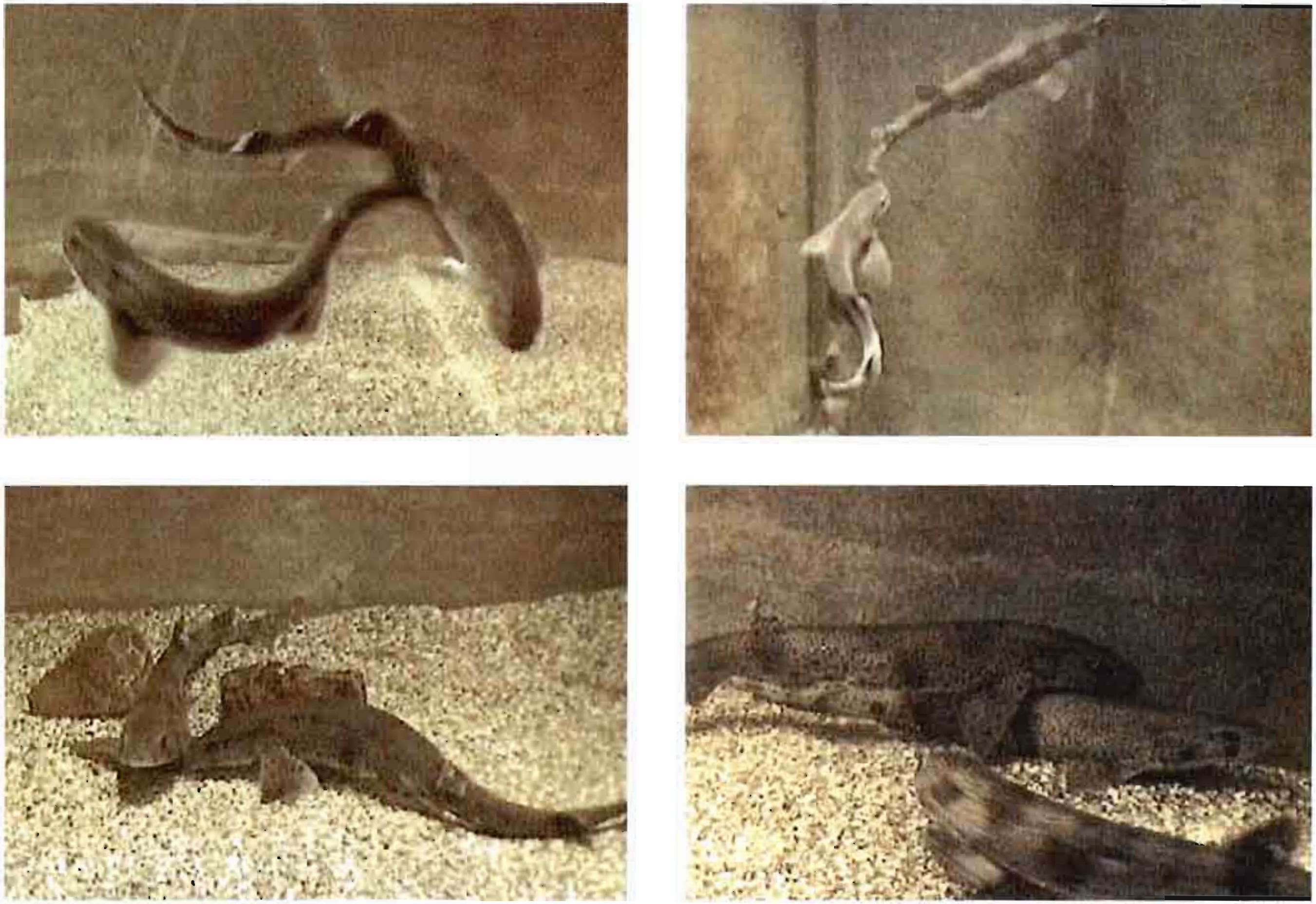

Fig. 2. - Pre-copulatory behaviours observed on specimens of lesser-spotted dogfish, *Scyliorhinus canicula*, kept in captivity in the aquarium of the University of Liège (Belgium). Top left: Biting. Top right: Tailing. Bottom left: Nosing. Bottom right: Rubbing.

dogfish *Scyliorhinus retifer* (Castro *et al.*, 1988) and the blue shark *Prionace glauca* (Stevens, 1974). Males often bite females on the pectoral or caudal fins. Biting behaviour may act as a premating releaser that stimulates females to mate. It also seems to hold the partners together to facilitate the insertion of the clasper during copulation. During tailing behaviour, males follow very closely females and carry out the same changes of direction, with snouts less than 30 cm from the lead shark's tail. This is the most frequent behaviour. Nosing behaviour (Fig. 2C) consists in a slow approach of a male from behind and underneath the female whilst at rest or swimming. The male's snout is slightly moved back and forth on the female's side, often just below the cloaca. Tailing and nosing suggested many hypothesis of the possible existence of a chemical stimulant like pheromones released by females in order to induce the males' reproductive behaviour. These pheromones could be important for males to be informed of the females' reproductive stage (Johnson and Nelson, 1978; Gordon, 1993; Houziaux and Voss, 1997).

The new behaviour, rubbing (Fig. 2D), is generally carried out right before nosing. Males remain close to females and carry out many passages on the back or on the side of females. The male can be posed on the back of the female maintaining its pectoral fins in a very low position. The involved female can show three behaviours in response to rubbing: either it stays totally inactive or goes away to another place or goes up to the surface when solicitations of the male are too intrusive. When many males carry out rubbing on the same female, it often leads to tailing. The consequence of tailing is a great competition between males for mating. Rubbing induces a tactile stimulation on females, which would encourage it to reproduce. Similar to tailing and nosing, it could also be a response of males to the release of pheromones by females. We also think that males would exert a pressure on the abdomen of females in order to encourage it to lay.

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ATTAQUES DE REQUINS À L'ÎLE DE LA RÉUNION (SUD-OUEST DE L'OCÉAN INDIEN)

par

Géry VAN GREVELYNGHE (1)

RÉSUMÉ. - Les attaques de requins sont des événements rares, extrêmement médiatiques. Néanmoins, dans certains pays (Afrique du Sud, Australie, États-Unis) ces phénomènes surviennent régulièrement, constituant un réel danger pour les usagers de la mer et pour l'économie touristique, au point que les gouvernements ont investi considérablement dans des programmes de recherche et de prévention. Dans les îles francophones du sud-ouest de l'Océan Indien, et surtout à l'île de La Réunion, des accidents se produisent également depuis le développement des sports nautiques et subaquatiques. À partir des 22 cas d'attaques recensés à La Réunion entre 1980 et 1999, une analyse des facteurs relatifs à la victime et à l'environnement est donnée, et des mesures de protection sont proposées.

Abstracts. - Shark attacks in La Reunion Island (southwestern Indian Ocean).

Shark attacks are rare yet extremely mediatized events. Nevertheless, in some countries like the South Africa, Australia and USA, these phenomena occur regularly, representing a real danger for sea user and the tourist industry in general. To cope with this threat, the governments have considerably invested in research and prevention programs. In the French Isles in the Southwest Indian Ocean, particularly in Reunion Island, such accidents have occurred since the development of water and underwater sports. The study of the 22 cases reported from the Reunion Island between 1980 and 1999, allowed to determine the main factors related to the victims and to the environment, and to suggest some measures of protection.

Key words. - Shark attacks - ISW - La Réunion Island.

L'île de La Réunion, située au sein de l'archipel des Mascareignes, dans le secteur sud-ouest de l'Océan Indien, fut dans le passé relativement préservée des attaques de requins. Cependant, depuis une vingtaine d'années, la survenue quasi-annuelle d'attaques de requins a fait naître une grande inquiétude pour l'économie touristique de l'île. Un recensement des cas historiques et une analyse des cas actuels ont été entrepris dans le cadre d'une thèse de médecine (Van Grevelynghe, 1994). Le présent article est une analyse synthétique des cas survenus à La Réunion depuis 1980.

MÉTHODES

Pour le recensement des attaques, la définition suivante a été adoptée: une attaque est un accident au cours duquel un contact physique agressif a été formellement établi entre un (ou des) requin(s) et une (ou des) victime(s) humaine(s) vivante(s); ce contact ayant

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entraîné des blessures ou le décès de la (ou des) victime(s), ou encore une détérioration importante de son (leurs) équipement(s), comme les morsures de planches de surf, les arrachages de palmes, etc. Cette définition permet d'exclure du recensement les attaques sans blessure, ni dégradation matérielle (cas par exemple des plongeurs chargés par des requins, mais qui ont pu sortir de l'eau sains et saufs), les attaques d'embarcations sans dommage, et surtout les prédations posthumes (i.e., les cadavres de noyés dévorés secondairement).

RÉSULTATS

Depuis 1913, on a recensé 27 cas d'attaques de requins à La Réunion, 5 de 1913 à 1979, et 22 de 1980 à 1999. L'analyse des 22 cas recensés en détail durant la période 1980-1999 a permis de déterminer les principaux facteurs influençant ces attaques.

Activité de la victime (Tableau I)

Les attaques de nageurs, surfeurs ou véliplanchistes

Elles sont les plus fréquentes et les plus graves. Depuis 1988, 13 attaques de ce type ont provoqué la mort de neuf personnes et l'invalidité sévère permanente d'une dixième. La victime paraît directement visée dans un but alimentaire (confusion avec la silhouette d'une proie habituelle). Les espèces impliquées sont souvent de grande taille, les victimes ne voient pas venir l'agresseur et n'ont aucune parade possible lors de l'accident, en dehors d'une fuite incertaine.

Les attaques de pêcheurs sous-marins

Elles se caractérisent par des morsures souvent peu graves, l'objectif initial du requin étant plutôt les poissons blessés ou tués que le chasseur lui-même. La motivation de l'attaque est parfois simplement territoriale. Les espèces impliquées sont souvent de petite taille, la victime peut souvent faire face au danger.

Les attaques de plongeurs en scaphandre autonome

Elles sont rares: 2 cas sans blessure (arrachement et section d'une palme) sont recensés à La Réunion.

Tableau I. - Nombres et pourcentages des attaques de requins à La Réunion en fonction de l'activité de la victime. *[Number and percentage of shark attacks at the Reunion Island in function of the activity of the victim].*

Catégories	Nombre de cas	%
Baigneurs, nageurs avec palmes-masque-tuba, pêcheurs à pieds, embarqués, tombés à l'eau	11	40,0
Surfistes, véliplanchistes	8	30,0
Chasseurs sous-marins	6	22,5
Plongeurs avec scaphandre	2	7,5
Total	27	

Lieu de l'attaque (Fig. 1)

À La Réunion, les accidents se produisent à une distance d'environ 35 m du rivage. Environ 80% des accidents (18 sur 22) sont survenus en surface; la profondeur maximale d'une attaque est 26 m, la profondeur moyenne de 5 m. Les victimes sont presque toujours isolées par rapport aux témoins, ou bien elles sont accompagnées d'une seule personne dans un rayon d'une vingtaine de mètres. Les attaques surviennent de manière homogène autour de l'île, principalement dans des zones peu fréquentées.

Proximité d'une embouchure, d'un port, d'une décharge publique

Environ 60% des accidents (13 sur 22) enregistrés après 1980 sont survenus à proximité immédiate de l'embouchure d'une rivière, de la sortie d'un port ou d'une décharge publique, certains sites pouvant réunir ces critères. Les cas non concernés par cette proximité correspondent majoritairement à des chasseurs sous-marins ayant tué ou blessé un ou plusieurs poissons.

Visibilité

Environ 80% des accidents (18 sur 22) sont survenus en eaux troubles. La turbidité des eaux est un facteur de risque important car la confusion entre les proies est possible et parce que les zones estuariennes, riches en matières organiques et en poissons, sont fréquentées par des espèces potentiellement dangereuses, comme le requin-bouledogue et le requin-tigre.

Distribution horaire (Figs 2, 3)

Il existe un lien significatif entre l'heure du jour et la fréquence des attaques. L'heure modale des accidents est 16h00 pour l'après-midi et 08h15 pour la matinée; 50% des attaques sont survenues entre 16h00 et 20h00, 25% de 06h00 à 10h00 et 25% de 13h00 à 16h00.

Distribution saisonnière (Fig. 4)

Aucune saisonnalité n'a été observée: les accidents sont répartis équitablement durant l'année. Les légères variations peuvent être liées aux fluctuations du nombre de sujets exposés au risque (variant selon leur activité), mais non aux mœurs des requins présents.

DISCUSSION

À La Réunion, le risque d'être attaqué par un requin est relativement réduit par rapport à d'autres risques. Ainsi, depuis 1988, on dénombre une attaque de requin par an pour 25 noyades; en Australie (Coppleson, 1958; Gilbert, 1990), le rapport est d'une attaque pour 50 noyades; en Afrique du Sud (Gilbert, 1990), le rapport est d'une attaque pour 600 noyades et une attaque pour 1000 noyades aux USA (Gilbert, 1990). En comparaison, on dénombre annuellement 550 décès d'origine cardio-vasculaire et 100 morts sur les routes à La Réunion (*Infostat*, Bull. d'info. statistiques de la DRASS Réunion, N° 4, décembre 1998).

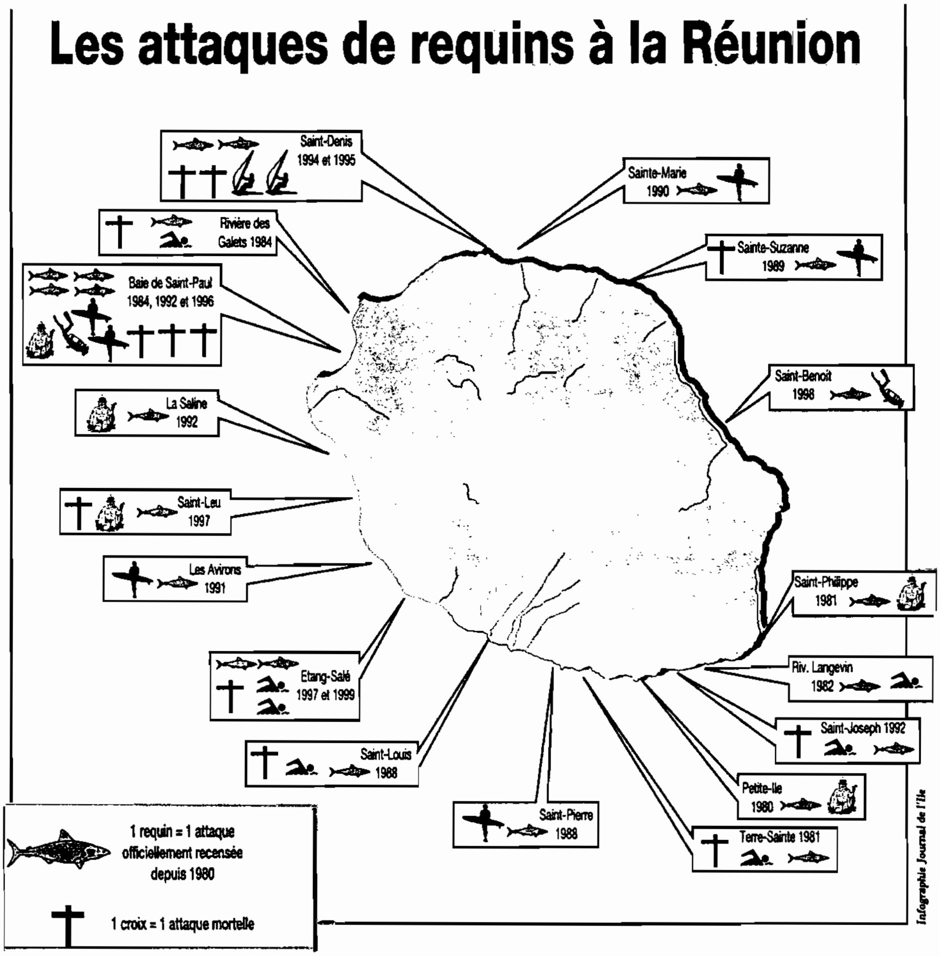

Fig. 1. - Carte des attaques de requins à La Réunion (extraite du *Journal de l'île*). *[Map of shark attacks at the Réunion Island (courtesy of* Journal de l'île *].*

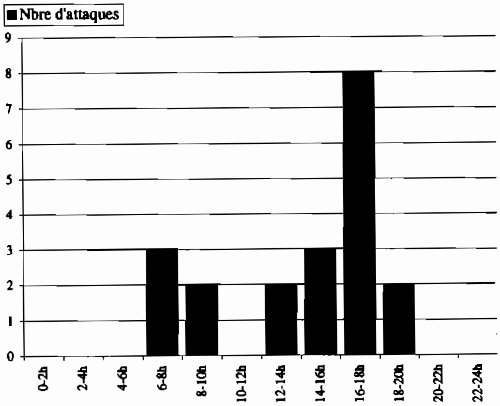

Fig. 2. - Répartition horaire des attaques de requins à La Réunion. *[Time distribution of shark attacks at the Réunion Island].*

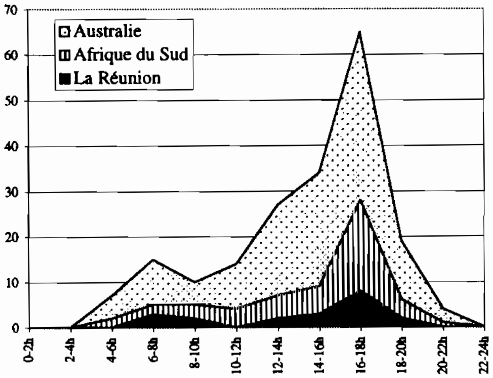

Fig. 3. - Graphique illustrant les répartitions horaires des attaques de requins à La Réunion, en Afrique du Sud et en Australie; données d'après West (1992), Cliff (1991) et Van Grevelynghe (1999). *[Graph showing the time distribution of shark attacks at the Réunion Island, South Africa and Australia; data from West (1992), Cliff (1991) and Van Grevelynghe (1999)].*

À La Réunion, 22 attaques de requins sont recensées entre 1980 et 1999, pour une population de 700 000 habitants et un périmètre littoral de 207 km. Les taux d'attaques sont donc de 3,1 pour 100 000 habitants, et 10,6 pour 100 km de côte. Comparés aux taux observés dans d'autres pays, les taux réunionnais sont plus élevés: les taux en Australie (West, 1991), Floride (Burgess, 1991; Guidera *et al.*, 1991; Howard et Burgess, 1993; Chen *et al.*, 1995), Californie (Miller et Collier, 1981), Afrique du Sud (Cliff, 1991), et Japon (Nakaya, 1993), étant inférieur à 0,5 attaque pour 100 000 habitants et de 2 attaques pour 100 km de côtes. Seul l'archipel des îles Hawaii dont les aspects généraux rappellent ceux de l'île de La Réunion (îles de petite taille, assez peuplées, mais où les sports nautiques sont plus développés), a des taux comparables mais inférieurs (Borg, 1993). Au Brésil, on a récemment relaté une série d'attaques avec un taux géographique ponctuellement supérieur (Hazin, comm. pers.).

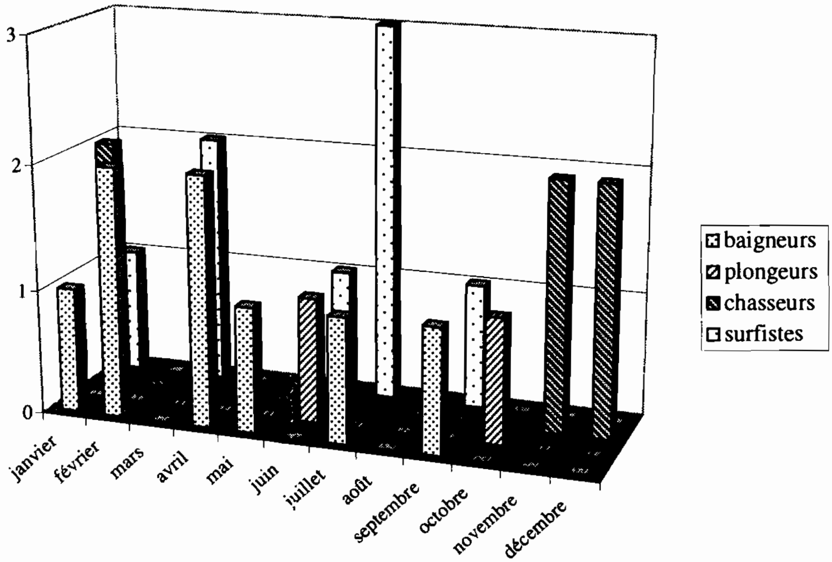

Fig. 4. - Distribution saisonnière des attaques de requins à La Réunion. *[Seasonal distribution of shark attacks at the Réunion Island].*

La gravité des blessures dépend de la localisation et de la profondeur des morsures: la fréquence des morsures aux membres inférieurs (65% dans la série réunionnaise), atteignant l'artère fémorale est la cause principale de la forte mortalité des attaques. Il est difficile d'affirmer que cet aspect est dû uniquement à la position des victimes (jambes immergées au moment de l'assaut), ou s'il existe une volonté délibérée de la part de l'assaillant d'atteindre une partie vitale chez la victime (technique de chasse). Le pronostic est donc étroitement lié aux effractions vasculaires et à la rapidité des premiers secours. La classification établie par Feindberg (Davies et Campbell, 1962) permet d'évoquer un pronostic selon les atteintes artérielles: l'issue est fatale pour les blessures de "grade 1" dans lesquelles une ou les deux artères fémorales sont atteintes dans leur tiers supérieur; le pronostic est réservé pour les blessures de "grade 2" dans lesquelles une artère fémorale est atteinte dans sa partie inférieure (ou en cas d'atteinte humérale, ou des 2 tibiales postérieures, ou d'une plaie abdominale péritonéale); le pronostic est favorable pour les blessures de "grade 3" dans lesquelles l'artère tibiale ou une artère des avant-bras est atteinte. Dans certains pays (Afrique du Sud, Australie, Floride), la formation spécifique des sauveteurs et l'équipement des plages (trousses de secours adaptées: "Feindberg pack") ont considérablement amélioré le pronostic (Burgess, 1991; Cliff, 1991).

Sur les 27 cas recensés à La Réunion, 15 furent mortels et une attaque engendra une invalidité permanente de la victime, soit un taux de mortalité d'environ 55%. Ce taux est supérieur à celui des séries étrangères (Coppleson, 1958; Davies et Campbell, 1962; Bagnis, 1968; Lagraulet *et al.*, 1972; Balbridge, 1973; Miller et Collier, 1981; Paux, 1981; Paul, 1987; Burgess, 1991; Cliff, 1991; West 1991; Borg, 1993; Howard et Burgess, 1993; Nakaya, 1993; Chen *et al.*, 1995; Hazin, comm. pers.) qui varient de 10 à 50%. Le taux de mortalité varie aussi avec l'activité de la victime au moment de l'attaque: lorsque celle-ci peut "faire face" à l'agresseur, c'est-à-dire lorsqu'elle est consciente de l'attaque imminente, la vulnérabilité est moindre (Tableau II).

L'identification de l'espèce responsable d'une attaque est rarement certaine. En dehors des plongeurs, qui parfois voient leur agresseur et dans certains cas le reconnaissent, la majorité des victimes est incapable d'en fournir une description précise. Quant aux témoins oculaires, leurs descriptions sont souvent divergentes, et leur imaginaire peut prendre le pas sur la réalité. Néanmoins, il est parfois possible de déterminer l'identité de l'agresseur en ayant une bonne connaissance des espèces fréquentant la zone incriminée, et en analysant minutieusement les circonstances de l'accident et les blessures. Des spécialistes de divers instituts de recherche sont également susceptibles d'aider à l'identification des espèces (ce fut le cas pour cette analyse). À la Réunion, l'espèce a pu être identifiée dans 17 cas sur 22 (Tableau III).

À La Réunion, les attaques de requins constituent d'importants "faits divers", du fait de leur fréquence et de leur gravité. En plus du drame humain résultant de la survenue d'un événement de cette nature, une intense émotion touche alors l'opinion publique, relayée et amplifiée par les médias. Cet aspect engendre un effet des plus néfastes au regard des prétentions touristiques de cette région. En se basant sur l'expérience des pays étrangers confrontés de longue date à la gestion du "risque requin", il apparaît que la mise en œuvre d'une stratégie de prévention efficace peut s'articuler autour de deux axes principaux

Tableau II. - Taux de mortalité des attaques de requins à La Réunion. *[Mortality rates of shark attacks at the Réunion Island].*

Catégories	**Nombre de cas**	**Nombre de décès**	**%**
Baigneurs, nageurs avec palmes-masque-tuba, pêcheurs à pieds, embarqués, tombés à l'eau	11	8	73,0
Surfistes, véliplanchistes	8	5	62,5
Chasseurs sous-marins	6	2	33,0
Plongeurs avec scaphandre	2	0	0
Total	27	15	

Tableau III. - Espèces de requins impliquées dans les attaques à La Réunion à partir de 1980, et nombre de cas mortels par espèces. *[Shark species involved in shark attacks at the Réunion Island since 1980, and number of fatal cases for each species].*

Catégories	**Espèces**	**Nombre de cas**	**%**	**Nombre de cas mortels**
Requin-bouledogue	*Carcharhinus leucas*	6	27,5	5
Requin -tigre	*Galeocerdo cuvier*	5	22,5	4
Autres requins	*Carcharhinus* spp.	6	27,5	1
	Negaprion acutidens	-	-	-
	Isurus oxyrhinchus	-	-	-
Requins indéterminés		5	22,5	2
Total		22		

et complémentaires:
- la création de barrières physiques: les filets anti-requins et la pose de palangres, sont des techniques éprouvées depuis plusieurs dizaines d'années en Australie et en Afrique du Sud. Ces procédés pourraient être envisagés pour sécuriser des zones particulières de baignade, ou à vocation touristique. Néanmoins l'ampleur de l'impact écologique et des contraintes financières sont des aspects incontournables à prendre en considération;
- les actions de responsabilisation basées sur la communication auprès des usagers: un effort particulier peut être accompli pour l'élaboration d'une prévention primaire, visant à diminuer le nombre d'accidents. Sa mise en place rapide serait possible, car peu coûteuse et fondée sur la communication auprès des usagers (diffusion d'informations pratiques: mœurs des requins, habitats, heures à éviter; ainsi qu'une signalisation des sites à risques). Un volet complémentaire de prévention secondaire peut aussi être envisagé en développant la formation des secouristes et des usagers exposés, la mise à disposition des surveillants de baignades formés, de matériels d'urgence adaptés (trousses de secours type "Feindberg pack", jet-skis pour raccourcir les délais d'intervention). De telles mesures ont permis dans certains pays de diviser par 3 à 5 le taux de mortalité.

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ABSTRACTS

Note. - The abstracts of the communications (oral and posters) that were either not submitted as papers by the authors or not accepted by the referees are published here below. The address of the first author is given and the name of the presenter is underlined.

ORAL COMMUNICATIONS

Development of elasmobranch transport techniques

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An overview of techniques utilised to transport elasmobranchs to the Oceanário de Lisboa was undertaken. Specifically, techniques to capture, restrain and transport elasmobranchs were examined. In addition, anaesthetic regimes and profilactic protocols were reviewed. The efficacy of different techniques were discussed.

The role of Oceanário de Lisboa in elasmobranch husbandry

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An overview of elasmobranchs within the zoological collection at the Oceanário de Lisboa was given. Distinctive features of each species were discussed, and specifically, ecological requirements, compatibility and educational value. Medical procedures and husbandry challenges were also examined.

From laboratory to public: An exhibit on shark presented in Oceanopolis

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The aquarium and education centre, Oceanopolis, in Brest (Brittany) is under extension to include two new sections devoted to the tropics and to the polar regions, completing the existing temperate section. In the tropical section, sharks will represent a large part with a giant aquarium, several tanks and an educational exhibit aiming to modify the negative image of the sharks. For that purpose, Oceanopolis has been collaborating with the French scientific institute, IRD. The authors will present how to use the scientific information to make it available and understandable to public. In this process, a number of experts are involved such as ichthyologists specialised in sharks, museologists, communication specialists, etc.

Chemical restraint of sharks for translocation

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On December 1998, the NAUSICAA Aquarium had to remove their sharks from a tank to fix it : 4 nurse sharks (*Gynglymostoma cirratum*), 2 mature adult sand tiger sharks (*Carcharias taurus*) and 7 sandbar sharks (*Carcharhinus plumbeus*). For the last two species, injectable chemical restraint was chosen. Preliminary anaesthetic studies were performed on small but unrelated species. The sharks were darted with Xylazine/Ketamin combination, captured by divers, and partially reversed. Different kind of dosages and manual restraints were used. Among the 13 sharks removed, three died in the following weeks.

On a large specimen of bigeye thresher shark, *Alopias superciliosus* (Lowe, 1839) (Chondrichthyes: Alopiidae) stranded in Tavolara Island (Eastern Sardinia, Mediterranean)

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In November 1994, the fishermen of Tavolara Island (Eastern Sardinia) found the carcass of a very large shark stranded in locality Spiaggia di Spalmatore. The shark seems just dead and because its freshness, was retrieved and then used for human consumption. Some members of the local diving witnessed to the landing and they collected accurate information and several photographs of the specimen. The shark was an adult big-eye thresher shark (*Alopias superciliosus*) measuring 400 cm in total length. The fishermen referred that this species was unknown and never caught before. A mortal wound in the intra-orbital area of the head's shark was noted. A 15 cm-long apical fragment of the rostrum of a sword fish (*Xiphias gladius*) was extracted from the wound. The specimen was a gravid female with two embryos measuring 40 cm in total length; furthermore, 6 large ova were found. The finding of Tavolara Island is one of the few documented records of the presence of *Alopias superciliosus* in the Mediterranean Sea; moreover, it gives evidence of a sword-fish fatal attack on a large shark.

Basking shark (*Cetorhinus maximus*) apparent abundance off French coasts in 1997 and 1998

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Within the framework of a national census campaign carried out by a French association (APECS), sightings of basking shark (*Cetorhinus maximus*) were reported within a range of 20 nautical miles off the French coasts in 1997 (n = 59) and 1998 (n = 56). Positions, states (alive, stranded or captured) as well as sizes of individuals were reported. An effective presence of the species was noticed in each of the 19 pre-determined sectors of coast. However the 8 Atlantic sectors are highly prevalent with respectively 95% and 89% of the total number of sightings listed in 1997 and 1998. These results didn't allow us to deduce an absolute abundance of the basking shark along the French coasts (methodological bias due to spreading of the inquiry, weather conditions as well as frequentation of each sector). Nevertheless, they offer the unique French estimate of the apparent abundance of this species. Sightings occurred all along the two years of the census campaign. Each year showed a maximum of sightings during spring and a peak of occurrence in May (42% of the total number of observations in 1997 and 36% in 1998). In 1998, 44 individuals were measured, highlighting 3 size groups. Basking sharks of 3-6 m are preponderant (68% of the measured individuals); they were observed during 8 months of the year between March and October. The assumed young-of-the-year (1.5-3 m) account for 23% of the measured individuals and were visible from May to August. Only 4 individuals measuring more than 6 m were punctually observed in May, January and October. Temporal shift between sightings period of the different size groups could be explained by biological characteristics of the species, particularly the reproductive cycle almost entirely unknown. According to this study, a discrete presence of basking shark throughout the year can be expected and would tend to confirm the assumption of an "in-depth" winter migration.

Space-time variations of the distribution of four skates (*Raja clavata, R. montagui, R. radiata* and *R. naevus*) in the North Sea, from 1992 to 1996

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Every year, fishery research cruises are carried out in the North Sea by IFREMER under the international co-ordination of CIEM (IBTS Program) in order to evaluate the resources exploited by the European fisheries in this area. During these cruises, a lot of scientific observations were also recorded on the abundance and the biology of the accessory species as the skates. During five year, from 1992 to 1996, these IBTS cruises were performed with the R.V. Thalassa in winter (January-February) and in summer (September). As for the other fishery resources sampled with bottom trawls, the abundance indices (in number and in weight per hour of trawling) were calculated for four species of skates (*Raja clavata, R. montagui, R. radiata* and *R. naevus*) caught during the ten cruises. The results are presented as maps for every species and for every cruise. They show the seasonal and annual variations of the geographical distribution of these four species. These variations are correlated to the bottom temperatures data recorded during the ten cruises.

The neuroendocrine system in the gastrointestinal tract of cartilaginous fishes

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The neuroendocrine system (NES) of the gastro-intestinal tract of cartilaginous fish is relatively well known, even if a few species have been studied until today, and only few reports deal with the early differentiation and further development of this system. The NES of the cartilaginous fish gut is composed of endocrine cells and nerve elements containing a large variety of regulatory peptides. These substances play different roles in regulating gastrointestinal motility, metabolism, secretion, and controlling cell proliferation and differentiation. The endocrine cells can be found, as single elements, within the epithelial component of the gut. They lie on the basement membrane and frequently have a cytoplasmic process extending to the lumen; their basal cytoplasm shows numerous secretory granules with various ultrastructural features. Numerous regulatory substances were immuno-histochemically demonstrated in the gastrointestinal endocrine cells: serotonin-, gastrin/CCK-, PP-, somatostatin-, glucagon-, substance P-, PHI-, VIP, NPY- and bombesin. Interspecific variability in the number, distribution, and localisation of cells engaged in secretion of NES regulatory substances were observed. The peptide secreting nerve elements, both neuron somata and nerve fibres, belonging to the peripheral nervous system, are distributed throughout the gastrointestinal wall. No anatomical boundaries are present between the endocrine and the nerve compartment, often sharing identical, or nearly identical, bioactive substances. Some molecules, such as VIP, PHI, bombesin and serotonin, are localised in both endocrine cells and nerve elements, while others, such as glucagon and PP, are localised only in the endocrine compartment. The bioactive substances released by the nervous and the endocrine compartments may function either as neurotransmitters and/or neuromodulators, or they may diffuse to the blood and act as hormones, or they can also diffuse locally, acting as paracrine messengers on target neighbouring cells. Data on the ontogeny of the NES were collected on the dogfish *Scyliorhinus stellaris*. The early histological gut differentiation in *S. stellaris* is paralleled by the precocious appearance of immunoreactivity in endocrine cells and nerves; however, the pattern of distribution of such peptides in embryos is different from that found in adult specimens and immunoreactivity of nerve elements can be detected later than that of endocrine cells.

Patterns of distribution of Lorenzini ampullae in sharks of the genus *Apristurus*

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Lorenzini ampullae in elasmobranchs allow detection and location of electrical potentials from living prey. These electroreceptors are restricted to cephalic regions of the body and are also grouped in clusters. Different clusters of ampullae near the mouth were observed in some species of the genus *Apristurus*, depth sharks of the family Scyliorhinidae. Principal Component Analysis (PCA) in all of available specimens shows that species with dissimilar clusters of ampullae also differ by significant distinct morphometric and meristic characters. Therefore, the Lorenzini ampullae distribution near the mouth can be considered as a good systematic character. As a real physiological and behavioural adaptation, this character could be studied for other species, belonging to other families, keeping their biology in consideration.

Could elasmobranch teeth recapitulate phylogeny? A preliminary approach by cladistic method on guitarfishes

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Because elasmobranch teeth have well-mineralised tissues, they are abundant in sedimentary formations from the Devonian to the present days. Numerous taxa are based only on isolated teeth. These fossils are considered as good biostratigraphical indicators. Gradualist phylogenies have also been elaborated from only teeth. To test the phylogenetic signal of elasmobranch teeth, we have chosen the cladistic method. A matrix of 33 dental characters and 13 Recent terminal taxa of the "rhinobatoid" polyphyletic group (*Anoxypristis, Aptychotrema, Platyrhina, Platyrhinoidis, Pristis, Rhina, Rhinobatos, Rhynchobatus, Trygonorrhina, Zanobatus, Zapteryx*) and of the Rajidae (*Pavoraja, Raja*) have been performed. The most parsimonious tree was compared with batoid phylogenic trees using varied anato-mical characters (skull, pectoral and pelvic girdles, etc.). Our tree topology is not very congruent with the aforementioned trees. However, some branches were resolved (i.e., *Rhina/Rhynchobatus* or *Raja/Pavoraja*). Moreover, the grouping of clades seems aberrant. *Anoxypristis* therefore takes a basal position, but *Pristis* is not its sister-genus. Another important incongruency, is that *Zanobatus* is just after *Anoxypristis*, the lowest basal taxon of the topology. Concerning these batoids, we can conclude that the characters that were used for dental morphology for some of them are homoplastic and they scramble the phylogenetical signal. Phylogenies based solely on the structure of "rhinobatoid" teeth must therefore be considered with suspicion.

Man/sharks relationships in Oceania: A social and religious question. Some illustrations

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With few icons representing sharks in two or three dimensions, belonging to Oceanian artefact collections, the author will show the very special relationship between those micro-insular societies and sharks. Living in symbiosis with oceanic environment since very young, familiar with a mythology, which identify man as a shark walking on the land, Oceanian people see the shark as a god or as a justice man. Sharing anthropological and biological data lets hope a channel between man and natural sciences. A hole in the wall between both reflections may bring an improvement in both disciplines.

POSTERS

“Squali: dalla parte dei cattivi”. An exhibit on sharks and a campaign for the protection of thresher and blue shark in the Adriatic sea

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During 1997 and 1998 an exhibition on sharks has been held at the Delphinarium Riccione. The exhibition was subdivided in 11 sections facing all the topics: reproductive biology, ecology, strategies and dangers that threaten sharks' survival. The exhibition primary aim was to discredit too many commonplaces, more fabulous that real, and false information that very often circulate on these fascinating animals. An entire section was dedicated to the most common species of sharks living in the Adriatic Sea and to the problems of their conservation, due to the importance of the nursery-areas of the thresher shark and the blue shark in the Northern Adriatic Sea. During the exhibition, an initiative connected to sharks conservation was held: signatures (more than 10,000) were collected, addressed to the Minister for the Agricultural Politics, asking the introduction of rules regulating the sport fishery to the thresher and the blue shark. The exhibition has been organized by the Fondazione Cetacea - a non-profit organisation based at the Riccione Delphinarium - in co-operation with "Uno squalo per amico" (see poster) a non-profit organisation based in San Marino Republic. It was visited approximately by 400,000 persons. Furthermore nearly 1,000 school-classes have visited the exhibition; among these ones, almost 250 have chosen to carry out also a deeper visit guided by an expert of the Fondazione Cetacea.

“Uno Squalo per amico”. A shark as a friend

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“Uno squalo per amico” is a non-profit organisation based in San Marino, founded in 1997 for various reasons. 1- One of our aims is to explain that all the animals deserve respect, not just the nice, tender and agreeable ones, but also the "misunderstood" ones, like sharks. So we organise exhibitions or lectures, and write articles or booklets. 2- Our main aim is not just to talk - or write- about sharks, being "friends of the sharks". We want to demonstrate that, talking about sharks, we can be "friend of the people" - through sharks. How? Because in facts we are volunteers that provide professional services and employ our rewards for the benefit of the poor. 3- With our activity we show that we can combine our passion for marine biology and our respect for sharks with our needs to help unfortunate, poor, ill, hungry, neglected people. We explain that it's correct to study sharks even in a troubled world. We show to common people that it's not true that biologists studying sharks "should think to more serious human problems". Past activity: “Uno squalo per amico” has collaborated with the City Aquarium in Milan, with the Delphinarium in Riccione (Italy) and with other organisations to prepare exhibitions on sharks (see poster of the Fondazione Cetacea), to write texts on sharks and on general marine biology, and to speak about sharks in lessons and lectures. Our rewards in 1997/98 have been assigned to the “Fondazione Marcello Candia” that works in Brazil in support of the poor, the leper and the meniños de rua. In 1998/99 our rewards are assigned to "Médecins sans frontières", the association operating all over the world in support of wounded, hungry, old and young people left by the wars. Future activity: as in the past and the present, we are organising activities about sharks like shows, lectures, courses, books: the funds so raised will be assigned to humanitarian organisations.

Behavioural study of the lesser spotted dogfish, *Scyliorhinus canicula*

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Few behavioural studies have been devoted to shark species. It is very difficult to observe them. So, the lesser spotted dogfish, *Scyliorhinus canicula* (L.), is used as a model for sharks because of its abundance in European inshore water, its well acclimatisation in captivity and its production of voluminous eggs. In this study, we described the reproductive behaviour of the lesser spotted dogfish. Our observations are based on four tagged lesser spotted dogfish, two males and two females, maintained in a 5 m^3 tank at a constant temperature of 14°C. Many 24 hours-activity cycles were carried out where fishes were observed 15 minutes a hour. The spawning behaviour and mating sequences were recorded with a video camera system and were also photographed. Three behavioural classes were determined. The key behaviours include the most frequently behaviours observed: the nosing, the chase, the seizing and a newly described behaviour, the rubbing. All these behaviours have been quantified. Supplementary interaction behaviours are less numerous and can be represented by the voluntary meeting, the circling, the hit. Other behaviours like gill-puff or hunching act are very rare and not very easy to interpret. The matings we have observed lasted each roughly 30 minutes. All these data complete the summary knowledge in reproductive behaviours of sharks.

Exploitation and distribution of the lesser spotted dogfish (*Scyliorhinus canicula*) in the eastern Channel

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The lesser-spotted dogfish is the first elasmobranch species in the landings from the eastern Channel. This species is almost exclusively caught in bottom trawls. Evolution of the catch per year from 1993 to 1997 is shown together with seasonal variations and the main ports where the species is landed. The geographical distribution of the lesser-spotted dogfish in the eastern Channel is shown from a yearly bottom trawl survey carried out in October since 1988.

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ElasmoFrance

Société Française d'Ichtyologie
ElasmoFrance

Le groupe **ElasmoFrance** a été créé au sein de la Société Française d'Ichtyologie (SFI) pour réunir toutes les personnes s'intéressant aux élasmobranches (requins et raies). Les buts sont de promouvoir les recherches sur ces poissons longtemps ignorés, d'encourager les initiatives de gestion et de conservation des populations de requins et de raies, et de diffuser les informations résultant de ces recherches et actions.

Si nos connaissances sur les requins et les raies ont notablement augmenté ces dernières décennies, nous sommes seulement au début de la "requinologie", et de nombreuses questions demeurent sans réponse. Par exemple, combien existe-t-il d'espèces de requins et de raies dans les mers et les océans du monde ? Quelle est la taille de leurs populations ? La biologie de la plupart des espèces est largement inconnue, etc.

Le groupe ElasmoFrance est le correspondant officiel de l'European Elasmobranch Association (EEA) qui est une structure fédérative créée en 1996 des associations nationales en Europe (voir la préface de ce livre).

Depuis 1997, chaque année l'EEA organise une réunion plénière suivie d'un séminaire. En 1999, la troisième réunion s'est tenue à Boulogne-sur-Mer (dans les locaux de l'aquarium Nausicaa), et les actes de ce séminaire paraissent dans ce numéro spécial de *Cybium*, la revue de la SFI.

Adhésion : La cotisation à ElasmoFrance pour l'année 2000 est de 180 FF (120 FF pour la SFI et 60 FF pour l'EEA). Les membres reçoivent: SFI Info (bulletin de liaison de la SFI), ElasmoScope (bulletin de liaison du groupe ElasmoFrance) et SharkFocus (bulletin de l'European Elasmobranch Association, en anglais).

Payable par virement postal (CCP 7050-20G Paris), par chèque bancaire à l'ordre de la Société Française d'Ichtyologie, ou par virement bancaire au compte n°042-8010-19 (Banque National de Paris).

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