

# *Géominpal Belgica*

*Découvertes géologiques, minéralogiques et paléontologiques  
en Belgique*

4

**Observations concerning the Evolution and the Parasytematic  
of all the living and fossil Scyliorhiniformes and Carcharhiniformes  
and suggestions concerning the possible origins of the Batoidei.**

2012

By

Herman Jacques<sup>1</sup> & Hilde Van Waes<sup>1</sup>

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**Extern side of one lower anterior tooth of *Pteroscylidium* sp. on its matrix.**

Uppermost phosphatic level (Cm1g) of the *Trivières Chalk* at Obourg, C.B.R. Quarry 4 (Province of Hainaut).

Codification of the Belgian Geological Archives: 140 E 481. Collection Jacques Boel - Photo Pieter De Schutter

**HERMAN Jacques Editor**

**H**

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**December 2012**

**Editeur responsable: Docteur Jacques Herman. I.S.S.N. : 2033 - 6365**

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## **Dedication**

**This work is dedicated to:**

**Dr. Prof. Max Poll**

**U.L.B. (Brussels, Belgium),**

**whom initiated his student to the arcanes of the**

**Zoological Systematic**

**Respectfully,**

**at Beigem**

**24 December 2012**

*Jacques Herman*

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# 1. Summary – Résumé – Samenvatting– Kurzfassung

## Summary

Between Mid-June and Mid-July 2012, a Tetralogy concerning the largest part of the other Elasmobranchii\* was electronically published. In November 2012, the revision of the Heterodontiformes\*\* was proposed. This Publication has for proposal the completion of this Parasytematic Series.

This Publication regroups one revision of the former Order Scyliorhiniformes, one important completion to the revision of the former Order Carcharhiniformes and some suggestions concerning the origins of the Batoidei.

\*References: HERMAN, J. & VAN WAES H. 2012: *Géominpal Belgica 2*, *Géominpal Belgica 2* (Supplement), *Géominpal Belgica 2* (End) and *Géominpal Belgica 2* (Erratum). \*\* *Géominpal Belgica 3*.

**Key-words:** Elasmobranchii, Systematic, Parasytematic, Scyliorhinomorphii, Scyliorhiniformes, Atelomycteriformes, Halaeluriformes, Pentanchiformes, Triaenodoniformes, Carcharhiniformes, Scyliorhinidae, Paleoscylliidae, Atelomycteridae, Schroederichthyidae, Halaeluridae, Pentanchidae, Triaenodonidae, Proscylliidae, Carcharhinidae, Hemipristidae, Sphyrnidae, Loxodonidae, Plates Tectonic, Magnetic field inversions.

## Résumé

Entre la mi-juin et la mi-juillet 2012, fut publiée électroniquement une Tétralogie concernant la plupart des autres taxa d'Elasmobranchii\*. En Novembre 2012, la révision des Hétérodontiformes\*\* a été proposée. Cette Publication a pour but l'achèvement de cette Série Parasystématique.

\*Références: HERMAN, J. & VAN WAES H. 2012: *Géominpal Belgica 2*, *Géominpal Belgica 2* (Supplement), *Géominpal Belgica 2* (End) et *Géominpal Belgica 2* (Erratum). \*\* *Géominpal Belgica 3*.

Cette Publication regroupe une révision parasystématique de l'ancien Ordre des Scyliorhiniformes, un important apport à la révision des Carcharhiniformes et quelques suggestions concernant les origines des Batoidei.

**Mots-Clés:** Elasmobranchii, Systématique, Parasystématique, Scyliorhinomorphii, Scyliorhiniformes, Atelomycteriformes, Halaeluriformes, Pentanchiformes, Triaenodoniformes, Carcharhiniformes, Scyliorhinidae, Paleoscylliidae, Atelomycteridae, Schroederichthyidae, Halaeluridae, Pentanchidae, Triaenodonidae, Proscylliidae, Carcharhinidae, Hemipristidae, Sphyrnidae, Loxodonidae, Tectonique des plaques, Inversions du champ magnétique.

## Samenvatting

Tussen midden juni en midden juli, werd een Tetralogie betreffende het grootste deel van de andere Elasmobranchii\* elektronisch gepubliceerd. In november 2012, werd de revisie van de Heterodontiformes\*\* voorgesteld. Deze Publicatie beoogt het verrijken van deze Parasytematische Reeks.

\*Referenties: HERMAN, J. & VAN WAES H. 2012: *Géominpal Belgica 2*, *Géominpal Belgica 2* (Supplement), *Géominpal Belgica 2* (End) en *Géominpal Belgica 2* (Erratum). \*\* *Géominpal Belgica 3*.

Deze pulicatie groepeert één revisie van de Orde Scyliorhiniformes, één belangrijke additie aan de revisie van de Orde Carcharhiniformes en enkele suggesties over de mogelijke oorsprongen van de Batoidei.

**Sleutelwoorden:** Elasmobranchii, Systematiek, Parasytematiek, Scyliorhinomorphii, Scyliorhiniformes, Atelomycteriformes, Halaeluriformes, Pentanchiformes, Triaenodoniformes, Carcharhiniformes, Scyliorhinidae, Paleoscylliidae, Atelomycteridae, Schroederichthyidae, Halaeluridae, Pentanchidae, Triaenodonidae, Proscylliidae, Carcharhinidae, Hemipristidae, Sphyrnidae, Loxodonidae, Platen Tectonik, Magnetische veld inversies.

## Kurzfassung

Zwischen halb June und halb Julie, wurde eine Tetralogie betreffs der grösser Teil von der andren Elasmobranchii\* elektronische herausgegeben. In November 2012, wurde der Revision der Heterodontiformes\*\* elektronische herausgegeben. Heute Publikation hat für Ziel heute Parasystematische Reihe zu ergänzen.

\*Beziehungen: HERMAN, J. & VAN WAES H. 2012: *Géominpal Belgica 2*, *Géominpal Belgica 2* (Supplement), *Géominpal Belgica 2* (End) und *Géominpal Belgica 2* (Erratum). \*\* *Géominpal Belgica 3*.

Diese Publikation gruppiert eine Revision der Order Scyliorhiniformes, ein belangreiche Addition an der Revision der Order Carcharhiniformes und einzige Vorstellungen für der Origin der Batoidei.

**Schlüsselworten:** Elasmobranchii, Systematik, Parasystematik, Scyliorhinomorphii, Scyliorhiniformes, Atelomycteriformes, Halaeluriformes, Pentanchiformes, Triaenodoniformes, Carcharhiniformes, Scyliorhinidae, Paleoscylliidae, Atelomycteridae, Schroederichthyidae, Halaeluridae, Pentanchidae, Triaenodonidae, Proscylliidae, Carcharhinidae, Hemipristidae, Sphyrnidae, Loxodonidae, Platen Tectonik, Magnetik Feld Stromwendungen.

## 2. Introduction

In July 2012, one, apparently, insignificant observation surprised the senior-author of this Paper, namely that the majority of the living taxa of the Order Scyliorhiniformes are oviparous animals.

All the primitive fossil taxa of the Order Scyliorhiniformes were in possession of fine and elongated teeth, which suggests that they had very supple and rapid moving ancestors.

The Super Order Scyliorhinomorphii, new taxon, here proposed, allows regrouping all the fossil and living taxa included in the five Orders, presently proposed: the Order Scyliorhiniformes, the Order Atelomycteriformes, the Order Halaeluriformes, the Order Pentanchiformes and the Order Triaenodoniformes.

All the fossil species of these five taxa have suddenly lost their dorsal spines, decreased the thickness and the imbrication of the elements of their dermic protection, made their vertebral column progressively suppler and preserved a relatively flat chondrocranium.

Scyliorhinomorphii have a stratigraphic distribution covering, at least, the Lower Cretaceous to the Holocene.

All the actual and fossil generic and specific taxa of the former Order Scyliorhiniformes and of the Family Proscylliidae (sensu Compagno 1984) are re-examined.

Diverse fundamental tectonic data may help to better understand the Natural History of the new Super-Order Scyliorhinomorphii here proposed.

## 3. Introduction

En Juillet 2012, une observation, apparemment insignifiante, surprit le senior-auteur de cette Note: La majorité des taxa vivants de l'Ordre des Scyliorhiniformes est constituée d'animaux ovipares.

Tous les taxa fossiles primitifs de l'Ordre des Scyliorhiniformes étaient en possession de dents fines et étirées, ce qui suggère qu'ils avaient des ancêtres très souples et rapides.

Le Super Ordre des Scyliorhinomorphii, nouveau taxon ici proposé, permet le regroupement de tous les taxa fossiles et actuels inclus dans les cinq nouveaux Ordres proposés: l'Ordre des Scyliorhiniformes, l'Ordre des Atelomycteriformes, l'Ordre des Halaeruriformes, l'Ordre des Pentanchiformes et l'Ordre des Triaenodoniformes.

Toutes les espèces fossiles de ces cinq taxa ont soudainement perdu leurs épines dorsales, réduit l'épaisseur et l'imbrication des éléments de leur protection dermique, rendu progressivement plus souple leur colonne vertébrale et conservé un chondrocranium, relativement peu élevé.

Les Scyliorhinomorphii ont une distribution stratigraphique recouvrant, au moins, le Crétacé inférieur à l'Holocène.

Tous les taxa génériques et spécifiques actuels de l'ancien Ordre des Scyliorhiniformes et de la Famille des Proscylliidae (sensu Compagno 1984) sont réexaminés.

Diverses données tectoniques fondamentales peuvent aider à mieux comprendre l'Histoire Naturelle du nouveau Super Ordre des Scyliorhinomorphii ici proposé.

## **4. Introductie**

In juli 2012, werd de senior-auteur van deze Publicatie getroffen door één observatie die blijkbaar onbeduidend scheen, namelijk dat de meerderheid van de levende taxa van de Scyliorhiniformes ovipare dieren zijn.

Al de fossiele taxa van de Scyliorhiniformes waren in het bezit van fijne en spitsige tanden, wat suggereert dat hun voorouders zeer soepele en snelle dieren waren.

Het nieuwe taxon, de Super Orde Scyliorhinomorphii, hier voorgesteld, integreert al de fossiele en levende taxa, inbegrepen in de vijf nieuwe voorgestelde Orden: Orde Scyliorhiniformes, Orde Atelomycteriformes, Orde Halaeluriformes, Orde Pentanchiformes en Orde Triaenodoniformes.

Al de fossiele soorten van deze vijf taxa hebben, in een extra korte tijd, hun dorsale vin-stekels verloren, de dikte en de insertie van hun dermische beschermende elementen gereduceerd, hun vertebrale kolom langzaam plooibaarder gemaakt, en een relatief plat chondrocranium bewaard.

De Scyliorhinomorphii hebben een stratigrafische distributie die ten minste, het Onder Krijt tot het Holoceen bestrijkt.

Al de levende en fossiele generieke en specifieke taxa van de voormalige Orde Scyliorhiniformes en van de Familie Proscylliidae (sensu Compagno 1984) worden opnieuw geëxamineerd.

Diverse fundamentele tektonische data kunnen helpen om de Natuurlijke Geschiedenis van de nieuwe Super-Orde Scyliorhinomorphii beter te begrijpen.

## **5. The former Order Scyliorhiniformes and the Scyliorhinomorphii nov. Sup. Ord.**

### **5.1. The living Scyliorhinidae**

#### **Generalities concerning their living representatives**

##### **Senior-author's conception of one species**

The Senior-author considers that one living species of Chondrichthyes is an amalgam of, more or less scattered, different populations having a majority of genetic and anatomic common points, but presenting eventually some differentiation tendencies which, if their isolation increases, may finish by producing sterile descendants when crossed.

Some morpho-anatomical differences make it possible to immediately identify bones of the different human races. Many biologists and palaeontologists are so eager to create new taxa that they will surely propose different species for the European, Asiatic and Semitic populations and, why not, a distinct Genus for the African one.

The apparition of a distinct species is, geologically speaking, a sudden event: e.g.: the transition\* from the dental morphology of *Pseudocorax laevis* to the dental morphology of *Pseudocorax affinis*, or the transition\*\* from the dental morphology of *Otodus obliquus* to the dental morphology of *Carcharocles subserratus*, or the transition\*\*\* from

the dental morphology of *Cosmopolitodus hastalis* to the dental morphology of *Carcharodon carcharias*, marked by the apparition of a single delicate serrulation on the anterior and posterior cutting edges of their teeth, always accompanies important tectonic events, marking geological chronostratigraphic units.

\*Worldwide transition Lower Campanian-Upper Campanian. \*\* Worldwide transition Palaeocene-Eocene. \*\*\* Worldwide transition Miocene-Pliocene.

But these, apparently, insignificant changes of crown dental morphology are the result of a genetic perturbation induced by astrophysical causes.

The huge faults resulting from the plates tectonic have always separated different populations of Scyliorhinomorphii inducing separate evolutions.

## 5.2. Taxa mentioned

All these taxa\* of living species, recognized by all biologists, must be accepted by a palaeontologist. He may only try to add and insert the existing fossil taxa in their right evolutionary place.

\*Except for two taxa, which are subject to multiple controversies.

All the biological criteria are consequently sufficient to define these Genera. Herman, Hovestadt and Euler-Hovestadt have carefully described and illustrated the different constituents of their dentition (See Bibliography: HERMAN, HOVESTADT & EULER-HOVESTADT, 1990). It remains strange that no biologist made reference to this work or manifested any interest in the cladographic phylogenetic schema proposed.

## 5.3. Size of the specimens

Concerning the total length of one specimen, museum biologists insist on precisising this data millimetrically, which is, of course, a *non-sensus*. All the researchers, who were once at sea, remember the very characteristic short sound produced by the dislocation of the vertebral colon of a Chondrichthyes when caught or *manipulated*.

The latter ones are amply satisfied with half-centimetric data for specimens smaller than two meters and with centimetric data for the larger specimens.

## 5.4. Genera examined

The sixteen living Genera\* of this Family are: *Apristurus* GARMAN 1913, *Asymbolus* WHITLEY 1939, *Atelomycterus* GARMAN 1913, *Cephaloscyllium* GILL 1862, *Cephalurus* BIGELOW & SCHROEDER 1941, *Figaro* WHITLEY 1928, *Galeus* RAFINESQUE 1810, *Halaelurus* GILL 1862, *Haploblepharus* GARMAN 1913, *Holohalaelurus* FOWLER 1934, *Parmaturus* GARMAN 1906, *Pentanchus* SMITH & RADCLIFFE in SMITH 1912, *Poroderma* SMITH 1838, *Proscyllium* HILGENDORF, 1904, *Schroederichthys* SMITH 1838 and *Scyliorhinus* de BLAINVILLE 1816.

\*The Genus *Proscyllium* HILGENDORF, 1904 was proposed as generotype of the Family Proscylliidae, for a Family regrouping the Genus *Proscyllium* with two other Genera\*, odontologically absolutely characteristic of Triakidae. (See Bibliography: COMPAGNO, 1984). The re-examination of the Family Proscylliidae is, of course, integrated in this Publication.

\*The Genera *Ctenacis* COMPAGNO, 1973 en *Eridaenis* SMITH, 1913.

## 5.5. Number of taxa of the Scyliorhinidae, their geographical distribution and their depth range

The Family Scyliorhinidae of the Order Scyliorhiniformes regroups more than hundred-fifty living species of ground sharks. Their principal characteristics are their high velocity and their suppleness allowing snake-like movements.

They are generally known as *cat-sharks*, while many species are also called *swell-sharks*, and others *dog-fishes*. The living Scyliorhinidae inhabit temperate and tropical seas worldwide, ranging from very shallow intertidal waters to depths of 2000 meters or more.

The living Scyliorhinidae may be distinguished from the other neoselachian sharks by their elongated eyes and their two small dorsal fins set far back. The majority of its species are relatively small, growing no longer than 80 cm, but some attain 150 cm.

They are worldwide scattered, from cold temperate to equatorial zones and the different Genera occupy littoral zones to hadal zones.

### **5.6. Diversity of their reproduction mode**

The majority of the Genera and species included in this Family have preserved the most primitive mode of reproduction: oviparity.

But some Genera regroup oviparous and ovoviviparous species, which means the existence of an important anatomical intrageneric evolution. They must be considered as more evolved than the Scyliorhiniformes *sensu stricto*.

Some other Genera regroup ovoviviparous species and aplacental viviparous species. This last evolutionary step represents, of course, the most evolved step of the new Super-Order Scyliorhinomorphii, here proposed. Some important systematic uncertainties subsist.

### **5.7. Generalities concerning their fossil representatives**

Fossil Scyliorhinomorphii are represented by many species, Genera and Families making together a good series of evolutionary links with their living representatives, but the insufficient knowledge of the dentition of their living representatives makes many palaeontologists enumerate them purely and simply by alphabetic order.

The last attempt to produce a Handbook, based only on their fossil teeth, is the better example for this uncertainty and of these hesitations.

The odontological characteristics of all these fossil generic taxa will also be re-examined and compared with those of the living ones.

### **5.8. Remaining problem**

#### **(A lineage comprising only huge Upper Cretaceous predators)**

The Scyliorhinomorphii, originally represented by small Upper Jurassic well-known taxa\*, seem (according to Cappetta 2006 and Cappetta 2012) to turn progressively into large predators such as *Protoscyliorhinus bettrechiensis* HERMAN, 1977, during the Lower Cretaceous.

\*Genus *Palaeoscyllium* WAGNER, 1857, with its four species.

The attribution of the two huge specific taxa *lamaudi*\* LANDEMAINE, 1991 and *magnus*\*\* BIDDLE & LANDEMAINE, 1988 to the Genus *Protoscyliorhinus* is more than dubious.

\*From the Upper Barremian (Aube Department, France), and\*\*from the Lower Cenomanian (Indre-et-Loire Department, France).

These attributions suggest that the Scyliorhinomorphii populations were suddenly affected, after a short period of gigantism, by a kind of nanism.

Nanism is relatively frequent for isolated vertebrate continental groups (e.g.: the dwarf-crocodile and the dwarf-hippopotamus), but has never been signalized for vertebrates living in oceanic basins.

If considering some additional odontological singularities\*, the senior-author is not convinced that these two last species: *P. lamaudi* and *P. magnus* are *Protoscyliorhinus* species.

\*Odontological singularities: pronounced holaulacorhizy, elongated radicular lobes and intense intern crown striations.

Some, such as *Scyliorhinus stellaris* can reach 160 cm in length. Most of the species have a patterned appearance, ranging from stripes to patches to spots. They feed on invertebrates and smaller fish.

All the species of the Genus *Cephaloscyllium* have the curious ability to fill their stomachs with water when threatened, increasing their girth by a factor of 2 or 3.

## 5.9. Recent systematic controversies

The Sub-Genus *Bythaelurus* of the Genus *Halaelurus*, with its unique living representative, *Bythaelurus incanus* species invalidated, is not admitted by I.T.I.S. The Genus *Bythaelurus* proposed, without diagnosis, by Hovestadt and Euler-Hovestadt is, of course, refused. The taxa that regrouped the *Bythaelurus* taxon return consequently to the Genus *Halaelurus*.

The Genus *Figaro* is also rejected by I.T.I.S., but not by other International Systematic Authorities, which represents an incomprehensible problem for honest biologists and palaeontologists.

Such problems do not concern our parasystematic proposal. To be as complete as possible, the main biological data of the species included in these two I.T.I.S. rejected taxa - but formerly everywhere accepted - are re-examined in this publication.

## 5.10. Principal biological data of the living Scyliorhiniformes

For the first\* step of this present research, only the following data were retained: the length record, the area of distribution, the depth range and the reproduction mode.

\*The second step will consist of a re-examination of the vascularisation mode of their dental root and of the ornamentation of their dental crown.

When existing, additional personal data (provided by diverse fishermen and diver friends) are mentioned and the principal bibliographic references are given.

### Genus *Apristurus* GARMAN, 1913

(Synonym: *Parapristurus* FOWLER, 1932)

The holotype of this Genus is: *Scyliorhinus indicus* BRAUER, 1906. This Genus regroups the following 38 living species: *Apristurus albisoma* NAKAYA & SERET, 1999, *Apristurus ampliceps* SASHARA, SATO & NAKAYA, 2008, *Apristurus aphyodes* NAKAYA & STEHMANN, 1998, *Apristurus australis* SATO, NAKAYA & YOROZU, 2008, *Apristurus brunneus* (GILBERT, 1892), *Apristurus bucephalus* WHITE, LAST & POGONOSKY, 2008, *Apristurus canutus* SPRINGER & HEEMSTRA, 1979, *Apristurus exsanguis* KATO & STEWART, 1999, *Apristurus fedorovi* DOLGANOV, 1985, *Apristurus gibbosus* CHU, MENG & LI, 1985, *Apristurus herklotsi* (FOWLER, 1934), *Apristurus indicus* (BRAUER, 1906), *Apristurus internatus* DENG, XIONG & ZHAN, 1988, *Apristurus investigatoris* (MISRA, 1962), *Apristurus Iaponicas* NAKAYA, 1975, *Apristurus kampae* TAYLOR, 1972, *Apristurus laurussonii* (SAEMUNDSON, 1922), *Apristurus longicephalus* NAKAYA, 1975, *Apristurus madeirensis* CADENAT & MAUL, 1966, *Apristurus manis* TAYLOR, 1972, *Apristurus macrorhynchus* (TANAKA, 1909), *Apristurus macrostomus* (SPRINGER, 1979), *Apristurus melanoasper* IGLESIAS, NAKAYA & STEHMANN, 2004, *Apristurus microps* (GILCHRIST, 1922), *Apristurus manis* SPRINGER, 1979, *Apristurus micropterygeus* MENG, CHU & LI, 1986, *Apristurus nasutus* de BUEN, 1959, *Apristurus parvipinnis* SPRINGER & HEEMSTRA, 1979, *Apristurus pinguis* DENG, XIONG & ZHAN, 1983, *Apristurus platyrhynchus* (TANAKA, 1909), *Apristurus profundorum* (GOODE & BEAN, 1896), *Apristurus riveri* BIGELOW & SCHROEDER, 1944, *Apristurus saldanha* (BARNARD, 1925), *Apristurus sibogae* (WEBER, 1913), *Apristurus sinensis* CHU & HU, 1981, *Apristurus spongiceps* (GILBERT, 1905), *Apristurus stenseni* (SPRINGER, 1979) and *Apristurus verweyi* (FOWLER, 1934).

The numerous undescribed taxa are not mentioned and do not enter in this enumeration.

***Apristurus albisoma* NAKAYA & SERET, 1999**

This species seems to have a restricted area of distribution, limited to continental slopes of the islands of New Caledonia and some adjacent sea mounts. Its catches are comprised between 935 meters and 1564 meters depth.

The senior author did not discover other interesting data concerning this species of doubtful validity. (See Bibliography: NAKAYA & SERET, 1999).

***Apristurus ambliceps* SASHARA, SATO & NAKAYA, 2008**

The size record of *Apristurus ambliceps*, called the *Roughskin cat-shark*, is 78 centimeters of total length. It is caught off Australian western coasts and off New Zealand coasts. Its mode of reproduction is oviparity.

The senior author did not discover other interesting data concerning this species of doubtful validity. (See Bibliography: SASHARA, SATO & NAKAYA, 2008).

***Apristurus aphyodes* NAKAYA & STEHMANN, 1998**

It is called the *white ghost cat-shark*, reaches a maximum of 54 cm total length, its geographical distribution area is the deep waters of the northeastern Atlantic Ocean, between the Northern Bay of Biscay and Porcupine Seabight to Lousy Bank. Its mode of reproduction is oviparity.

The senior-author *caught* himself eight specimens on the Lousy Bank in April 1978. Its depth range varies between 875 meters (J. Herman data) to 1800 meters (M. Stehmann data).

It seems that the collected information is insufficient to assess this species to a precise taxon. (See Bibliography: FROESE, & PAULY Eds. 2006 in FishBase and NAKAYA & STEHMANN, 1998).

**Additional recent references**

ICES. 2009: Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009. Copenhagen. Denmark. ICES CM 2009/ACOM:16: 424 pp.

VOLLEN, T. 2009: World distribution of chondrichthyan species in Norwegian deep-sea waters. Working document presented to ICES WGEF. 15 pp.

***Apristurus australis* SATO, NAKAYA & YOROZU, 2008**

This little cat-shark is called the *Pinnocchio cat-shark*. It lives in the open seas of the Australian and New-Zealand waters, absolute record size is not given. It is caught between 590 to 1000 metres (according to the sole Australian data). SATO, NAKAYA & YOROZU, 2008: *Its reproduction mode seems to be aplacental viviparity*, a sentence difficult to understand if this taxon is really an *Apristurus*. (See Bibliography: LAST & STEVENS, 1994 and SATO, NAKAYA & YOROZU, 2008).

***Apristurus brunneus* (GILBERT, 1892)**

*Apristurus brunneus*, (*Catulus brunneus* GILBERT, 1892) is commonly called *brown cat-shark*. Its size record is 68 centimeters of total length. Its distribution range is very discontinued.

Its larger distribution area extends from the northern U.S.A. Pacific coasts to the southern Mexican Californian coasts

It is absent in the Sea of Cortez, and represented by two small isolated populations, one off Central America and the

other off the Ecuadorian and Peruvian coasts.

The disparity of this population is the consequence of the Plate Tectonic having affected a primarily continuous distribution area, during the Andes surrection and the subduction of the Coco's and Nazca's Plates. This event is anterior to the opening of the Sea of Cortez, which seems to occur at the beginning of the Miocene.

The catches of *A.brunneus* are comprised between 30 meters to 650 meters depth. The animals live on muddy and sandy bottoms. They reach a maximum size of 68 cm in total length.

Such as most other sharks, including other members of the family Scyliorhinidae, it is believed that they have a well-developed sense of smell, and that they are highly electroreceptive, which allows them to detect electricity emitted by other animals\*, and may also allow them to detect magnetic fields\*\*, which is a useful tool in the depths of the eastern part of the Pacific Ocean.

\*Such as electricity produced by bioluminescence. \*\*Apparently, one of the first mentionings by biologists.

If so, such abilities allowed their owners to cross the eastern half of the Pacific Ocean, to cross the Andean zone before its complete surrection and to cross the North Atlantic Ocean without the help of the Gulf Stream.

The different species of *Apristurus* feed on many bottom-dwelling species, including different Crustacea such as small shrimps and euphausiids, or small Cephalopoda such as squids and small Teleostei fishes.

The reproduction mode of the living *Apristurus* is oviparity, with a single egg per oviduct, and their eggcapsels generally measure between 6.5 centimeters of length and 2.5, or a little more, centimeters of width.

The eggcapsels are, more or less, transparent and have long tendrils that are probably used to attach them to hard structures. (See Bibliography: GILBERT, 1892, COMPAGNO, 1984 and NAKAYA & SATO, 1999 ).

#### ***Apristurus bucephalus* WHITE, LAST & POGONOSKY, 2008**

Data concerning *A. bucephalus*, commonly called the *hoary catshark*, are the following. Its size record is 67.5 centimeters length (females), its distribution area is off western Australia, its depth record is comprised between 1030 and 1140 meters and its reproduction mode is oviparity. (See Bibliography: GARMAN, 1913, COMPAGNO, 1984, LAST & STEVENS, 1994, COMPAGNO & NIEM, 1998, WHITE, LAST & POGONOSKY, 2008).

#### ***Apristurus canutus* SPRINGER & HEEMSTRA, 1979**

*Apristurus canutus*, commonly called *hoary cat-shark*, presents the following characteristics. Its size record is 43 centimeters of total length, its distribution range is comprised between 18°N to 13°N, in the Carribean Sea, from off Yucatan coasts to off the Little Antillas Islands.

It is a bathydemersal fish with a depth range comprised between 500 to 1000 meters depth. Its reproduction mode is oviparity. (See Bibliography: SPRINGER & HEEMSTRA, 1979 and COMPAGNO, 1988).

#### ***Apristurus exsanguis* KATO & STEWART, 1999**

*Apristurus exsanguis*, commonly called the *flaccid cat-shark*, presents the following characteristics. Size record: *circa* 91 centimeters of total length, with a common range of 65 to 70 centimeters.

Its distribution range is limited to a little part of the Southwest Pacific, off the coasts of New Zealand, the depth records of this bathydemersal shark range from 560 meters to 1200 meters, its reproduction mode is oviparity, data confirmed by local collectors of sharks eggs. (See Bibliography: KATO & STEWART, 1999, SATO, NAKAYA, & STEWART, 1999).

#### ***Apristurus fedorovi* DOLGANOV, 1985**

*Apristurus fedorovi*, commonly called *Fedorov cat-shark* presents the following biological characteristics. Its size

record is *circa* 68 centimeters of total length (one male), its very restricted distribution area is off the Tohoku Slope in Japan, it is caught between 100 meters to 1500 meters depth and its reproduction mode is oviparity.

(See Bibliography: DOLGANOV, 1985, NAKAYA & SERET, 1999).

***Apristurus gibbosus* CHU, MENG & LI, 1985**

(Selected synonym: *Pentanchus herklotsi* FOWLER, 1934)

This synonym is selected because it was Fowler who proposed to assign this species to the Genus *Pentanchus* SMITH & RADCLIFFE, 1912, and not to the Genus *Apristurus* GARMAN, 1913.

*Apristurus gibbosus*, commonly called the *humpback cat-shark* presents the following biological characteristics. Its size record is 42 centimeters of total length, its distribution range seems to be restricted to off southern Taiwan, its catches are localised between 750 to 950 meters depth (personal communication), its reproduction mode is oviparity. (See Bibliography: CHU, MENG & LI, 1985 and COMPAGNO, 1984).

***Apristurus herklotsi* (FOWLER, 1934)**

*Apristurus herklotsi*, called the *longfin cat-shark*, presents the following biological characteristics. Its size record is 54 centimeters of total length, its distribution range is very elongated, from the Jolo Sea, the South of China Sea to Shikoku Island and the Kyushu-Palau Ridge, its depth records vary between 520 to 900 meters depth, its reproduction mode is oviparity. (See Bibliography: FOWLER, 1934, CHU, MENG & LI, 1985 and COMPAGNO, 1984).

***Apristurus indicus* (BRAUER, 1906)**

The size record of this species, commonly called *smallbelly cat-shark*, is 34 centimeters (immature specimen) of total length, its distribution range: western Indian Ocean, from off Somalian coasts, off the Gulf of Aden coasts and off the Oman coasts, its catches records are comprised between 1300 and 1840 meters depth, and its reproduction mode is oviparity. (See Bibliography: BRAUER, 1906 and COMPAGNO, 1988).

***Apristurus internatus* DENG, XIONG & ZHAN, 1988**

The size record of this species called the *short-nose demon* is *circa* 40.5 centimeters of total length, its distribution range comprises, at least, the eastern part of the China Sea, its reproduction mode is oviparity. (See Bibliography: DENG, XIONG, & ZHAN, 1988).

***Apristurus investigatoris* (MISRA, 1962)**

The size record of this species called the *broad-nose cat-shark* is *circa* 44 centimeters of total length (personal communication), its distribution range comprises, at least, the eastern part of the China Sea, and between 16°N to 10°N, its depth of catches are comprised between 900 and 1250 meters depth (personal communication), its reproduction mode is oviparity. (See Bibliography: MISRA, 1962, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus japonicus* NAKAYA, 1975**

The size record of this species called the *Japanese cat-shark* is *circa* 74 centimeters of total length (personal communication), its distribution range comprises the northwest Pacific from off the Chiba Prefecture, Honshu, Japan, between the latitudes 36°N and 34°N, its depth catches are comprised between 850 and 1050 meters depth (personal communication), its reproduction mode is oviparity. (See Bibliography: NAKAYA, 1962, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus kampae* TAYLOR, 1972**

The size record of this species called the *long-nose cat-shark* is *circa* 59 centimeters of total length (personal communication), its distribution range comprises the eastern central Pacific, from off the central and southern coasts of

California and the Sea of Cortez, between 38°N and 23°N, its depth catches are comprised between 840 to 1920 meters depth (personal communication), its reproduction mode is oviparity. (See Bibliography: TAYLOR, 1972, COMPAGNO, 1984 and COMPAGNO, 1988).

This species has penetrated the Sea of Cortez. Its apparition is consequently posterior to the birth of the San Andrea's Fault, which means, at least, 20 millions years ago.

Its ancestors may have been the larger distributed population of *Apristurus bruneus*, living along the North American Pacific coast, just before the apparition\* of the first populations of *Apristurus kampa* in the recently formed Sea of Cortez .

\*Eddy Rickettes mentioned in his correspondence with Perry Gilbert, to have observed a strange *Apristurus* in the catches of the Japanese trawlers operating, not only for fisheries' purposes but surely also for military purposes, in the Sea of Cortez in the beginning of 1941.

#### ***Apristurus laurussonii* (SAEMUNDSON, 1922)**

The size record of this species called the *Iceland cat-shark* is about 85 centimeters of total length (Observation of the senior-author), its geographical distribution concerns the western Atlantic, from Massachussets, the northern part of the Gulf of Mexico and the eastern Atlantic, from Iceland, the southwest of Ireland, the Canary and Madeira Islands, South Africa, between 67°N and 11°S.

Its depth catches are comprised between 840 to 1920 meters depth (personal communication), its reproduction mode is oviparity. (See Bibliography: SAEMUNDSON, 1922., BIGELOW & SCHROEDER, 1948, COMPAGNO, 1984 and COMPAGNO, 1988).

*Apristurus laurussonii* feed on little Teleostei, Cephalopods, Polychaeta and Crustacea, principally deep water Crangonidae and Galatheidae (Observations valid for the North-East Atlantic populations).

#### ***Apristurus longicephalus* NAKAYA, 1975**

The size record of this species called the *long head cat-shark* is 60 centimeters of total length, its geographical distribution concerns the Seychelles Islands, Japan, the Oriental part of the China Sea, the Philippines Islands and Australia. It was recently signalised off western New Caledonia and off Mozambique. Its catches are comprised between 650 meters and 1235 meters depth. See Bibliography: NAKAYA, 1975, COMPAGNO, 1984 and COMPAGNO, 1988).

#### ***Apristurus madeirensis* CADENAT & MAUL, 1966**

The size record of this species called the *Madeira cat-shark* is 69 centimeters, its geographical distribution seems to extend from Madeira Island to southern Iceland. Its diverse populations occupy the areas comprised between the SSW-NNN oriented ridges of the two North Atlantic Plates between these two extremities\*. Numerous catches were mentioned on the slopes of the Lousy, Bill Bailey and Porcupine Banks.

\*30°N to 60°N of latitudes but, with a zone of absence comprised between 55° to 35°N of latitudes.

This phenomenon is explainable by the diverse transversal faults having affected this sector when the Biscaye Gulf opened\* and enlarged, at least since the Lower Cretaceous, which means *circa* 135 million years, and much later, *circa* 6 million years ago, when the Gibraltar Strait appeared\*\*.

\* Reference: SIBUET, 1974: Histoire tectonique du Golfe de Gascogne. Collection COB. **115(137)**: 136 à 180.

\*\*Reference: ROBINSON, RICHARD & MALANOTTE-RIZZOLI, 1994: *Ocean Processes in Climate Dynamics: Global and Mediterranean Examples*. Springer Verlag. Pp. 307-308.

But, if the separation between the northern Icelandese populations and the southern Madeira populations persisted so long, it is difficult to believe that they had preserved an identical D.N.A. sequence.

If so, it is of course, the population of the Madeira island which has the priority for the *Apristurus madeirensis* designation, and it is its definition given by Cadenat and Maul, in 1966, which is the valid one. (See Bibliography: CADENAT & MAUL, 1966, COMPAGNO, 1984 and COMPAGNO, 1988).

And, following the same logic, in such case, it is all the northern populations which request a deep re-examination before being assigned to other existing taxa or attributed to one new taxon or more different new taxa. This does not concern a palaeontologist.

***Apristurus macrorhynchus* (TANAKA, 1909)**

The size record of this species called the *flathead cat-shark* is 68 centimeters of total length, its geographical distribution area concerns the southern coasts of Honshu (Japan) and the China Sea between China and Formosa. Its catches were realised between 435 to 840 meters depth\*, between 22°N and 35°N, its reproduction mode is oviparity. (See Bibliography: TANAKA, 1909, COMPAGNO, 1984 and COMPAGNO, 1988).

\*Japanese colleagues' information, 1994.

***Apristurus manis* TAYLOR, 1972**

The size record of this species called the *ghost cat-shark* is 88 centimeters\* of total length, its geographical distribution concerns the northwestern Atlantic, off the Massachussets coasts, North of the U.S.A., the southern continental slopes of the Rockall Shelf\*, central Atlantic, the Lousy Bank\*, the South of Iceland and the Porcupine Bank and the West of Ireland. Its catches are comprised between 585\* to 1740 meters depth, between 38°N and 61°N, its reproduction mode is oviparity. (See Bibliography: TAYLOR, 1972, COMPAGNO, 1984 and COMPAGNO, 1988).

\*Personal data of the senior-author who collected himself some specimens of this species. It was the captain Pierre Gueguen (Lorient, Bretagne, France) who pointed out some differences existing with *A. laurussonii* populations caught during other trawling tests.

***Apristurus macrostomus* (SPRINGER, 1979)**

The size record of this species called the *broadnose cat-shark* reach 41\* centimeters of total length, its catches\* are localised off the southern coasts of China from depths comprised between 850 and 1020 meters depth. Its reproduction mode is oviparity. (See Bibliography: SPRINGER, 1979).

\*Personal information.

***Apristurus melanoasper* IGLESIAS, NAKAYA & STEHMANN, 2004**

The size record of this species, called the *black roughnose cat-shark*, is *circa* 78 centimeters of total length. Its huge geographical distribution covers, apparently all the North Atlantic slopes. Its catches are mentioned from off of French coasts, off of the Irish coasts and off of the Orkney and Hebridean Islands. Its depth range is comprised between 420 meters and 1520 meters depths. Its mode of reproduction is oviparity.

***Apristurus microps* (GILCHRIST, 1922)**

The maximal size record of this species called the *smalleye cat-shark* may reach 54 centimeters of total length, its complete disrupted geographical distribution (if the assignments of the reference specimens are correct) concerns a small area off the southern coasts of Namibia, and two small areas in the North Atlantic, one off the coasts of Terra Nova (western Atlantic) and the other one, off the northern coasts of Ireland.

It should be very interesting to compare the D.N.A. of these three populations for which it is, geologically speaking, impossible that they have any biological relations.

(See Bibliography: GILCHRIST, 1922, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus marnkalha* JACOBSEN & BENNETT, 1830**

The validity of this species is also highly contested by different biologists. The I.T.I.S. list does not mention this taxon, but it is listed in FishBase.

***Apristurus manis* SPRINGER, 1979**

The size record of this species called the *ghost cat-shark* reaches 83 centimeters of total length, its geographical distribution concerns two small very distinct areas, the first one off the northeastern U.S.A. coasts\*, between 38°N and 45°N of latitudes and the second one off the northwestern Irish coasts, between 55°N and 60°N of latitudes.

\*Origin of the holotype described in 1979 by Steward Springer, ignoring, apparently, the abundance of the numerous *Apristurus* populations in the second sector, where intensive European commercial deep water trawlings started only after 1984.

Both populations are composed of bottom dwelling animals caught between 580 and 1740 meters depth, and both are oviparous.

Once more, the controversial discussions concerning this taxon outnumber precise data, or data concerning the histology and the ornamentation of their teeth. (See Bibliography: SPRINGER, 1979, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus micropterygeus* MENG, CHU & LI, 1986**

The size record of this species called the *shortfinned cat-shark* reaches 37.5 centimeters of total length. Its geographical distribution seems restricted to off the coasts of the China Sea. (See Bibliography: MENG, CHU & LI, 1986, DUFFY & HUNENEERS, 2004: *Apristurus micropterygeus*, Red List of endangered species of the UICN 2010. 4).

The validity of this taxon seems not to be contested, but data concerning the histology and the ornamentation of their teeth remains unknown. (See Bibliography: SPRINGER, 1979, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus nasutus* de BUEN, 1959**

The maximal size record of this species called the *largenose cat-shark* may reach 59 centimeters of total length, its complete disrupted geographical distribution concerns two small areas (in the eastern Pacific) located off the southern coast of Panama and the Ecuador coasts, another, much more southern, along the northern Chilean coasts and one off the southern Moroccan coasts (in the western Atlantic), its reproduction mode is oviparity. (See Bibliography: de BUEN, 1959, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus parvipinnis* SPRINGER & HEEMSTRA, 1979**

The size record of this species called the *smallfin cat-shark* reaches 52 centimeters of total length. Its reproduction mode is oviparity.

Its geographical distribution is discontinuous, but all its discovered populations are known from off the central coasts of the Gulf of Mexico (four sectors) and off the three Guyanas\* coasts (Compagno 1988). They inhabit the costal bottom slopes up to 1115 meters (Compagno 1988) depth.

\*Presence off the Suriname coasts was confirmed by fishermen friends.

The dispersion of its populations may easily be explained by the complex structural geology of the Caribbean Sea. Logically, the earlier ones must be their ancestors (or, geological supposition: Miocene age) living off the Panamean coasts.

From this stock, later diverged two groups of populations, one having colonised the Yucatan zone and the western Florida zone, and the other having colonised the Colombian and the Guyanas zones. (See Bibliography: SPRINGER & HEEMSTRA, 1979, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus pinguis* DENG, XIONG & ZHAN, 1983**

The size record of this species, called the *fat cat-shark* by its inventors, is 55.5 centimeters of total length. It was known (in 1983) by nine specimens caught off the East China Sea. Other specimens caught (1998 to 2004) in the same area confirm its oviparity and enlarged lightly its depth range, presently\*, from 180 meters to 1150 meters depth. (See Bibliography: DENG, XIONG & ZHAN, 1983, COMPAGNO, 1984 and COMPAGNO, 1988 and FROESE, RAINER & PAULY, 2011).

\*Formosan fishermen personal communication.

***Apristurus platyrhynchus* (TANAKA, 1909)**

The size record of this *Apristurus platyrhynchus*, commonly called the *spatulanose cat-shark*, is 80 centimeters of total length, its geographical distribution concerned, originally, only the southern and the central zones of off the coasts of the Honshu Island (Japan). Later, populations of this species were also recognized from off different Philippines Islands, off different Borneo coasts, and off the southern and eastern China Sea\*. Its reproduction mode is oviparity.

Its catches were realised between the concerned continental slopes to approximately 1450 meters depth\*\*. (See Bibliography: TANAKA, 1909, SPRINGER, 1979, COMPAGNO, 1984 and COMPAGNO, 1988).

\*The senior author had always considered the two China Seas more as a political problem than a biological problem.

\*\*Information from fishermen killed during the last Vietnam war.

***Apristurus profundorum* (GOODE & BEAN, 1896)**

The size record of this species, called the *deep water cat-shark* is 58 centimeters of total length, its geographical distribution concerns its type origin, off the coasts of the northern country of the U.S.A., between 36°N and 42°N of latitudes, at 1492 meters depth. One other population of *Apristurus*, caught off the Mauritanian and the northern Senegalese coasts is attributed to the same taxon.

Other authors consider this African population as a population of *Apristurus manis* SPRINGER, 1979. The reproduction mode of *Apristurus profundorum* (*sensu stricto*) is oviparity. (See Bibliography: GOODE & BEAN, 1896, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus riveri* BIGELOW & SCHROEDER, 1944**

The size record of this species called, the *broadgill cat-shark*, is 51 centimeters of total length. The geographical distribution of its populations is divided in two longitudinally relatively large northern Atlantic areas.

One of these distribution zones covers the continental slope off the Panamean and the northern Columbian coasts, between 76°W to 84°W of longitudes.

The second one, much larger, includes the southern continental slopes of the USA, including the western Florida continental slope and the northern Cubanese continental slopes, between 72°W and 94°W of longitudes. Its catches were realised between 860 to 1098 meters depth. The reproduction mode of these two communities is oviparity. (See Bibliography: BIGELOW & SCHROEDER, 1944, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus saldanha* (BARNARD, 1925)**

The size record of this species, called the *Saldanha cat-shark* is 84 centimeters of total length. Its geographical distribution is restricted to the continental slopes of South Africa, between 14°W and 23°W of longitudes and 386 and 1080 meters depth. Its reproduction mode is oviparity.

(See Bibliography: BARNARD, 1925, BIGELOW & SCHROEDER, 1944, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus sibogae* (WEBER, 1913)**

The size record of this species, called the *pale cat-shark*, represented by a single immature specimen is 21 centimeters of total length. Its discovering place is the Makassar Strait slope between Borneo and Sulawesi (Indonesia), at 635 meters depth. Its mode of reproduction is unknown. (See Bibliography: WEBER, 1913, BIGELOW & SCHROEDER, 1944, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus sinensis* CHU & HU, 1981**

The size record of the holotype, and unique specimen known of this species, called the *South China cat-shark* is 42 centimeters of total length. It was caught at 537 meters depth in the South China Sea. Its reproduction mode is unknown. (See Bibliography: CHU & HU, 1981, BIGELOW & SCHROEDER 1944, COMPAGNO, 1984 and COMPAGNO, 1988).

***Apristurus spongiceps* (GILBERT, 1905)**

The size record of this species called, the *spongehead cat-shark*, is 50 centimeters of total length. This species is only known by two populations: one living off Bird Island (Hawaii Islands) and a second one living off the coasts of Sulawesi in the Banda Sea.

Both populations inhabit the continental slopes between 570 and 1482 meters depth, and certainly on the Northampton Seamount off the northwestern Hawaiian Islands. Its reproduction mode is oviparity. (See Bibliography: GILBERT, 1905 and ITIS compilation data).

***Apristurus stenseni* (SPRINGER, 1979)**

The size record of this species, called the *Panama cat-shark*, reaches 23 centimeters of total length, This species is represented by only one population living from off the southern coasts of Panama to off the western coasts of Columbia, between 915 and 975 meters depth. Its reproduction mode is oviparity. (See Bibliography: SPRINGER, 1979 and ITIS compilation data).

***Apristurus verweyi* (FOWLER, 1934)**

The size of the holotype, an immature specimen, of *Apristurus verweyi*, called the *Borneo cat-shark* was 23 centimeters of total length, its size record is (2006\*) 36 centimeters of total length, its geographical distribution concerns the depth around the Sipadan Island in the Celebes Archipelago. Its catches were realised between 745 to 1240 meters depth\*. The complete isolation of the Celebes Archipelago during millions of years, and consequently of this population is a geological argument for the defense of its validity\*\*. (See Bibliography: FOWLER, 1934, FOWLER, 1941 and SPRINGER, 1979).

\*Personal information from Phillipinese fishermen.

\*\*Very restricted human communities are maybe not the best example, but demonstrate the survival potential of restricted vertebrates communities. Suggested reading: FRAIN Irène, 2009: *Les naufragés de l'île Tromelin*. Eds. Michel Laffont. Neuilly-sur-Seine. 375p., 3 cartes. ISBN: 978 – 2 – 286 – 05156 - 3

**Conclusions concerning the Genus *Apristurus***

The Series called *Contribution to the study of the comparative morphology of teeth and other relevant ichthyolodurites in supraspecific taxa of Chondrichthyan fishes*, was initiated in 1987 and finished in 2000.

From then onwards the curiosity of the senior-author was to try to understand the intraspecific variations of some taxa of Neoselachii.

That was the origin of the three last Papers published between 2002 and 2004 (See Bibliography: HERMAN, EULER-HOVESTADT & HOVESTADT 2002, HERMAN, EULER-HOVESTADT & HOVESTADT 2003 and HERMAN, EULER-HOVESTADT & HOVESTADT 2004).

But another attempt was initiated with the *Apristurus* living taxa. It was evident that the division of this Genus in specific taxa was completely inconsistent and that was the reason for ending this new Series, waiting for the neontologist taxonomists to find some agreements.

The very high number of species of this Genus allows us to have some doubts concerning their global validity. Often the specific criteria were reduced to their colour patterns.

Morphologically, only the form of the head and the body of the six following species allow an immediate recognition: *A. brunneus*, *A. kampae*, *A. longicephalus*, *A. manis*, *A. spongiceps* and *A. verweyi*. All the other taxa seem to be: *Variations on the same theme*.

For palaeontologists, it is also regrettable that the elements of the dentition of the huge majority of these taxa were not described, nor illustrated by S.E.M. photographs.

This lack of objective odontological information made it impossible to detect the existence of their fossil ancestors.

The most relevant points are that they are all called *cat-shark*, a clear reference to their very supple mobility and the rapidity of their attack, that many species seem to have a very restricted area of distribution, that different species attain a considerable depth of more than 1650 meters and that the large majority of their species is oviparous.

A very important, but strange, data is this given by Nakaya and Sato, in 1999: *One of the three populations\** of *Apristurus brunneus* is ovoviparous.

\*The signification of the use of this qualification: *One of the three populations of Apristurus brunneus* is not explained. If they are so easily distinguishable, why not propose three species or sub-species?

What interests a geologist-palaeontologist-biologist, is to try to explain that the complete worldwide migration of the Scyliorhiniformes realized from their birthplaces across all the Seas and the Oceans was not only the result of their extraordinary abilities of adaptation to extreme environments, but also the result of complex interferences with successive tectonic events.

With a good understanding of these Plates Tectonic Events, it is possible to precise the phylogenetic relations having existed between their numerous populations and to initiate a fundamental revision of the evolutive systematic of this Order, and in particular of the Genus *Apristurus*.

### **Genus *Asymbolus* WHITLEY, 1939**

(Synonym: *Juncrus* WHITLEY, 1939)

Its type species is: *Scyllium anale* OGILBY, 1885. The Genus *Asymbolus* regroups the nine following living species: *Asymbolus analis* (OGILBY, 1885), *Asymbolus funebris* COMPAGNO, STEVENS & LAST, 1999, *Asymbolus galacticus* SERET & LAST, 2008, *Asymbolus occiduus* LAST, GOMON & GLEDHILL, 1999, *Asymbolus pallidus* LAST, GOMON & GLEDHILL, 1999, *Asymbolus parvus* COMPAGNO, STEVENS & LAST, 1999, *Asymbolus rubiginosus* LAST, GOMON & GLEDHILL, 1999, *Asymbolus submaculatus* COMPAGNO, STEVENS & LAST, 1999 and *Asymbolus vincenti* (ZIETZ, 1908).

#### ***Asymbolus analis* (OGILBY, 1885)**

It is a relatively common species of which the distribution area is limited to the south-eastern coasts of Australia, living between 10 and 180 meters depth. It is oviparous. (See Bibliography: OGILBY, 1885, KUITER, 1993 and WHITLEY, 1939).

#### ***Asymbolus funebris* COMPAGNO, STEVENS & LAST, 1999**

No accessible data. For unknown reasons, only the original drawings of this recently described species were accessible\*.

Some fishermen friends said to have caught specimen of this species in its type zone.

***Asymbolus galacticus* SERET & LAST, 2008**

No accessible data. For unknown reasons, only the original drawings of this recently described species were accessible\*.

***Asymbolus occiduus* LAST, GOMON & GLEDHILL, 1999**

No accessible data. For unknown reasons, only the original drawings of this recently described species were accessible\*.

***Asymbolus pallidus* LAST, GOMON & GLEDHILL, 1999**

No data. For unknown reasons, only the original drawings of this recently described species were accessible\*.

\*This suggests a deep discord between Last and his co-authors. Consequently, these phantomatic taxa are mentioned but, valid or not, they could not have any influence in the conclusions proposed.

***Asymbolus parvus* COMPAGNO, STEVENS & LAST, 1999**

Its size record is 35 cm length, its depth range varies between 160 to 260 meters, its distribution area is restricted to a limited part of the north-western coasts of Australia and its mode of reproduction is oviparity. (See Bibliography: WHITLEY, 1939, COMPAGNO, STEVENS & LAST, 1999, DULVY & REYNOLDS, 1997 and LAST & STEVENS, 1994).

***Asymbolus rubiginosus* LAST, GOMON & GLEDHILL, 1999**

Its size record is 39 cm length, its distribution area is restricted to the south-eastern coasts of Australia and its mode of reproduction is oviparity. (See Bibliography: WHITLEY, 1939, LAST, GOMON & GLEDHILL, 1999 and DULVY & REYNOLDS, 1997).

***Asymbolus submaculatus* COMPAGNO, STEVENS & LAST, 1999**

Its distribution area comprises the coastal shelf waters of New South Wales and Occidental Australia, between 30 to 200 meters depth, its record size is 41 cm length and its mode of reproduction is oviparity. (See Bibliography: WHITLEY, 1939, DULVY & REYNOLDS, 1997 and COMPAGNO, STEVENS & LAST, 1999).

***Asymbolus vincenti* (ZIETZ, 1908)**

Its distribution area comprises all the south Australian coasts, between 27 to 650 meters depth, its record size is 61 cm length and its mode of reproduction is oviparity.

See Bibliography: ZIETZ, 1908, COMPAGNO, 1984, KUITER, 1993 and LAST & STEVENS, 1994

**Conclusions concerning the Genus *Asymbolus***

Important biological remarks and observations are that all these scyliorhinid species are called *cat-sharks* and that many of these have very restricted distribution areas.

The large majority of the *Asymbolus* species are inhabitants of the continental shelf but also of the continental slope to a depth of 650 meters. All the species, completely described, included in this Genus are oviparous.

**Genus *Atelomycterus* GARMAN, 1913**

Its type-species is: *Scyllium marmoratum* Anonymous, supposed BENNETT, 1830. This Genus comprises five living species.: *Atelomycterus baliensis* WHITE, LAST & DHARMADI, 2005, *Atelomycterus fasciatus* COMPAGNO & STEVENS, 1993, *Atelomycterus macleayi* WHITLEY, 1939, *Atelomycterus marmoratus* (Anonymous, referred to BENNETT, 1830) and *Atelomycterus marnkalha* JACOBSEN & BENNETT, 1830.

***Atelomycterus baliensis* WHITE, LAST & DHARMADI, 2005**

This species of cat-shark is known only from southern Bali. It seems to be a reef-dwelling species, endemic to Bali. This species is known only from off Jimbaran Bay in southern Bali, and has, apparently, a very restricted distribution area.

Its biology and habitat are unknown. It is presumed to be a reef-dwelling little shark inhabiting holes and crevices on reefs. Its record size attains a maximum of 52 cm of total length, and it is presumed to be oviparous. Its feeding sources are unknown, as well as its depth range. (See Bibliography: WHITE, LAST & DHARMADI, 2005)

***Atelomycterus fasciatus* COMPAGNO & STEVENS, 1993**

Very few reliable data are available concerning this species, but Australian diver friends confirmed to the senior-author its distribution area and its coastal presence. They do not know which depth it may attain, but at least 40 meters. They have observed some specimens eating little decapoda (including small Stomatopoda). (See Bibliography: COMPAGNO & STEVENS, 1993).

***Atelomycterus macleayi* WHITLEY, 1939**

This species, the validity of which is seriously contested, has theoretically a very large distribution area covering all the north Australian coasts.

This huge distribution area is abnormal for an *Atelomycterus* species and consequently it is the principal source of controversies. (See Bibliography: WHITLEY, 1939, COMPAGNO & STEVENS, 1993).

***Atelomycterus marmoratus* (Anonymous, referred to BENNETT, 1830)**

*Atelomycterus marmoratus* is commonly called: *the coral cat-shark*. It is common on shallow coral reefs across the Indo-West Pacific, from Pakistan to New Guinea. It reaches 70 cm in length. It is oviparous: females lay purse-shaped egg capsules two at a time on the bottom, and the young hatch after 4 to 6 months.

Part of the original description: *It can be identified by the numerous black and white spots on its back, sides, and fins, which often merge to form horizontal bars. Furthermore, adult males have distinctively long and thin claspers.* All criteria which palaeontologists are unable to use.

Reclusive and inactive during the day, at dusk and at night the coral cat-shark actively forages for small, bottom-living invertebrates and bony fishes. Its slender form allows it to access tight spaces on the reef.

This species feeds on small benthic invertebrates and bony fishes, captive specimens have been observed lying still and lunging at a prey that comes into range.

**Conclusions concerning the Genus *Atelomycterus***

The most relevant point is that their common vernacular is *cat-sharks*, a clear reference to their very supple mobility and the rapidity of their attack and that, if known, the reproduction mode is oviparity.

Its type species, *Atelomycterus marmoratus*, is oviparous. Precise data concerning the reproduction system of the other species were not found.

**Sub-Genus *Bythaelurus* COMPAGNO, 1988**

*Bythaelurus* is one sub-Genus of the Genus *Halaaelurus*. Its type-species was *Bythaelurus incanus* LAST & STEVENS, 2008, and as long as it was admitted it regrouped the nine following living\*species. As Genus *Bythaelurus* is presently rejected by I.T.I.S.

\*One fossil species, from the Boom Clay Member (Middle Belgian marine Oligocene) was proposed: *Bythaelurus steurbauti* by HOVESTADT & EULER-HOVESTADT in 1995.

*Bythaelurus* regrouped the nine living following species: *Bythaelurus alcockii* (GARMAN, 1913), *Bythaelurus canescens* (GÜNTHER, 1878), *Bythaelurus clevai* (SERET, 1987), *Bythaelurus dawsoni* (SPRINGER, 1971), *Bythaelurus giddingsi* McCOSKER, LONG & BALDWIN, 2012, *Bythaelurus hispidus* (ALCOCK, 1891), *Bythaelurus immaculatus* (CHU & MENG, 1982), *Bythaelurus incanus* LAST & STEVENS, 2008 and *Bythaelurus lutarius* (SPRINGER & D'AUBREY, 1972).

***Bythaelurus alcockii* (GARMAN, 1913)**

The maximal size record of this species called the *Arabian cat-shark* is only known by its lost holotype which seemed immature and measured 30 centimeters of total length. It was caught between 1134 and 1262 meters depth in the Arabian Sea. (See Bibliography: (GARMAN 1913, SPRINGER, 1979, COMPAGNO, 1984 and COMPAGNO, 1988).

***Bythaelurus canescens* (GÜNTHER, 1878)**

The size record of *Bythaelurus canescens*, also called the *dusky cat-shark*, is 70 centimeters of total length and is, more or less regularly caught between 250 and 700 meters depth. It lives on the continental slopes of the Peruvian, Chilean and Magelanian coasts (See Bibliography: GÜNTHER, 1878, COMPAGNO, 1988, CHIRICHIGNO, 1974 and PEQUEGNO, 1989).

***Bythaelurus clevai* (SERET, 1987)**

*B. clevai* is only known by its holotype, a single specimen caught off Madagascar between 425 and 500 meters depth. Its habitat and biology are unknown. (See Bibliography: SERET, 1987).

***Bythaelurus dawsoni* (SPRINGER, 1971)**

The original designation of *B. dawsoni* was *Halaelurus dawsoni*. Its vernacular names are *Dawson's cat-shark* or *New-Zealand cat-shark*. This species is based on nine specimens caught off southern New Zealand. *B. dawsoni* is oviparous.

Their catch place, mentioned as 44°32.5' S, 166°41' E was supposed to be incorrect because, apparently, too deep (several thousands meters of depth) and then, it was, without argumentation, supposed to be 46°32.5' S, 166°41' E.

The senior-author having frequently accompanied fishermen crews on sea would be surprised that the captain of such high-sea trawlers could be wrong, and he supposes that the original data are the correct ones, which makes a great difference.

The source of confusion was surely a dilemma between law applications and the truth. He is convinced that the real catch places were the Chatham Rise and the Campbell Plateau.

Theoretically, *this species occurs between 50 and 790 meters depth, on sea bottoms of soft sediments, however it is possible that this species also occurs above foul, untrawlable seabeds.*

What is sure is that its feeding source consists of small decapoda\*. Its size record is circa 42 centimeters of total length. The smallest free-living specimen observed was 11.3 cm length. (See Bibliography: SPRINGER, 1971).

\*If preserved, these decapoda could immediately precise the depth of their catch places.

***Bythaelurus giddingsi* McCOSKER, LONG & BALDWIN, 2012**

*Bythaelurus giddingsi*, commonly called the *Galapagos cat-shark* is a cat-shark from the Galapagos Islands. Its size record is about 30 centimeters of total length. It is coloured brown with light spots. Its mode of reproduction is oviparity, it is known only from waters around several of the Galapagos Islands. It has been found at depths ranging from 428 to 562 meters (See Bibliography: McCOSKER, LONG, & BALDWIN, 2012).

### ***Bythaelurus hispidus* (ALCOCK, 1891)**

*Bythaelurus hispidus*, commonly called the *bristly catshark*, is a cat shark found from southeastern India and the Andaman Islands between latitudes 15° N and 5° N, at depths comprised between 200 and 300 m. Its length is up to 29 cm. Its mode of reproduction is oviparity. (See Bibliography: ALCOCK, 1891, COMPAGNO, 1984 and COMPAGNO, 1988).

### ***Bythaelurus immaculatus* (CHU & MENG, 1982)**

*Bythaelurus immaculatus*, also called the *spotless cat-shark*, is a cat shark occurring in the South China Sea at depths of between 535 and 1020 m on the continental slope. Its length may rise up to 71 centimetres. Its reproduction mode is oviparity. (See Bibliography: CHU, & MENG, 1982, COMPAGNO, 1984 and COMPAGNO, 1988).

Once more, it is a taxon based, principally, on its coloration, or, better said, on its distinctive lack of coloration.

### ***Bythaelurus incanus* LAST & STEVENS, 2008**

*Bythaelurus incanus* is commonly called the *sombre cat-shark*. Its record size is circa 45.5 centimeters of total length, its depth catches vary between 900 to 1000 meters, its reproduction mode is oviparity. It is only known from off Australian coasts. (See Bibliography: LAST & STEVENS, 1994, COMPAGNO, 1984, COMPAGNO & NIEM, 1998 and NELSON, 2006).

### ***Bythaelurus lutarius* (SPRINGER & D'AUBREY, 1972)**

*Bythaelurus lutarius*, commonly named the *brown cat-shark*, is found in Mozambique and Somalia. Its natural habitat is open seas of the western Indian Ocean from Mozambique and Somalia between latitudes 13° N and 29° S, at depths comprised between 340 and 765 m. It grows up to 34 centimetres of total length. Its reproduction mode is oviparity. (See Bibliography: SPRINGER & D'AUBREY, 1972, COMPAGNO, 1984, COMPAGNO & NIEM, 1998 and NELSON, 2006).

The invalidation of the sub-generic taxon *Bythaelurus incanus* LAST & STEVENS, 2008 allows to suppose that the eight other taxa re-integrate the Genus *Halaelurus*\*, but the senior-author has not found confirmation of this supposition.

\*The Genus *Bythaelurus* was proposed, without diagnosis, in 1995 by Dirk and Maria Hovestadt for a Belgian Oligocene taxon\*, and rejected by lack of any generic diagnosis.

\**Scyliorhinus steurbauti* nov. sp. HOVESTADT & EULER-HOVESTADT, 1995.

### **Conclusions concerning the sub-Genus *Bythaelurus***

All the taxa, valid or questionable, assigned to this sub-Genus are oviparous and inhabit waters comprised between 50 meters depth (*B. dawsoni* from New Zealand) and 1262 meters depth (*B. alcocki* from the Arabian Sea).

The dentition of some species included in this rejected taxon seems to have more affinities with the dentition of the Genus *Parmaturus* than with the one of the Genus *Halaelurus*.

The few teeth of *Scyliorhinus steurbauti* discovered in the Middle Oligocene of Belgium, and previously assigned to the taxon *Bythaelurus* as *Bythaelurus steurbauti* nov. genus, nov. sp. (HOVESTADT & EULER-HOVESTADT, 1995) present more odontological similarities with the teeth of the Genus *Parmaturus*, which is represented by additional teeth discovered in the same Formation.

### **Genus *Cephaloscyllium* GILL, 1862**

The Genus *Cephaloscyllium* has for type species *Scyllium laticeps* DUMERIL, 1853 and includes the following 19 living species: *Cephaloscyllium albipinnum* LAST, MOTOMURA & WHITE, 2008, *Cephaloscyllium circulopullum* YANO, AHMAD & GAMBANG, 2005, *Cephaloscyllium cooki* LAST, SERET & WHITE, 2008, *Cephaloscyllium fasciatum* CHAN, 1966, *Cephaloscyllium hiscosellum* WHITE & EBERT, 2008, *Cephaloscyllium isabellum* (BONNATERRE, 1788), *Cephaloscyllium laticeps* (DUMERIL, 1853), *Cephaloscyllium maculatum* SCHAAF-DA-SILVA & EBERT, 2008, *Cephaloscyllium pardelotum* SCHAAF-DA-SILVA & EBERT, 2008, *Cephaloscyllium pictum* LAST, SERET & WHITE, 2008, *Cephaloscyllium sarawakensis* YANO, AHMAD, GAMBANG, HAMID, RAZAK & ZAINAL, 2005, *Cephaloscyllium*

*signourum* LAST, SERET & WHITE, 2008, *Cephaloscyllium silasi* (TALWAR, 1974), *Cephaloscyllium speccum* LAST, SERET & WHITE, 2008, *Cephaloscyllium stevensi* CLARK & RANDALL, 2011, *Cephaloscyllium sufflans* (REGAN, 1921), *Cephaloscyllium umbratile* JORDAN & FOWLER, 1903, *Cephaloscyllium variegatum* (LAST & WHITE, 2008) and *Cephaloscyllium ventriosum* (GARMAN, 1880).

*Cephaloscyllium* is a Genus of the Family Scyliorhinidae commonly called *swell sharks* because of their ability to inflate their bodies with water as a defense against predators. These sluggish, bottom-dwelling sharks are found widely in the tropical and temperate coastal waters of the Indian and Pacific Oceans.

The largest members of this Genus may attain more than 1 m in length. The different species of *swell sharks* prey on a variety of fishes and invertebrates, and are oviparous with females producing paired egg capsules.

After examining all the species included in this Genus and extensive reading, the following observations may give a better knowledge of the ecological data of the different species included in this Genus.

#### ***Cephaloscyllium albipinnum* LAST, MOTOMURA & WHITE, 2008**

Its length record is 101 centimeters. Its depth range records vary between 126 to 554 meters. Its reproduction mode is oviparity. (See Bibliography: GILL, 1862, LAST, MOTOMURA & WHITE, 2008, WHITE & POGONORSKI. Eds. 2011, GOMON, GLOVER & KUITER. Eds. 1994 and LAST & STEVENS, 1994).

#### ***Cephaloscyllium circulopullum* YANO, AHMED, GAMBANG, IDRIS, RAZEL & RAZNAN 2005**

This species is called the *circle-blotch pygmy swell shark* in Malaysia and Brunei (Darussalam), in the western Pacific Ocean. It can grow to a maximum length of 38 centimeters. Its reproduction mode is unknown. (See Bibliography: YANO, AHMED, GAMBANG, IDRIS, RAZEL & AZNAN, 2005).

#### ***Cephaloscyllium cooki* LAST, SERET & WHITE, 2008**

The *Cook's swellshark* is a small (to 30 cm total length), poorly known deepwater cat-shark, with a restricted distribution off northern Australia and eastern Indonesia. This species occurs on the upper continental slope at depths of 225–300 m. Nothing is known of its biology or capture in fisheries.

Cook's Swellshark is restricted to a small area of the Arafura Sea off northern Australia and off Tanimbar Island in eastern Indonesia (Last and Stevens 2009).

It is a deepwater benthic *cat-shark*. It has been recorded from the upper continental slope at depths of 225 to 300 meters (Last and Stevens 2009). Maximum size of this small species is at least 30 cm total length (Last and Stevens 2009). Nothing else is known about the biology of this species.

#### ***Cephaloscyllium fasciatum* CHAN, 1966**

It is a little species of *cat-shark*, living off the southern coasts of Hainan to the northern west coasts off Australia. Its length record is 42 centimeters. Its known depth range is supposed to be between 220 meters and 450 meters. Its reproduction mode is unknown. (See Bibliography: CHAN, 1966, COMPAGNO, 1984, LAST & STEVENS, 1994, HUANG, 2001).

#### ***Cephaloscyllium isabellum* (BONNATERRE, 1788)**

The two following names are considered as junior-synonyms of this species: *Scyllium lima* RICHARSON, 1843 and *Cephaloscyllium formosanum* TENG, 1962. Its vernacular name is *draughtsboard* shark.

Occurring down to a depth of 673 meters, *Cephaloscyllium isabellum* frequents rocky reefs during the day and sandy bottoms at night. Its diet consists of fishes and invertebrates. When threatened by a predator, it can take water or air into its body to inflate it. This species is oviparous.

*C. isabellum* is found only in the coastal waters around New Zealand, including the Snares Islands, the Chatham Islands and the Stewart Island, where it is particularly common.

*C. isabellum* consumes a wide variety of fishes and invertebrates, including spiny dogfish, cod, sand perch, blennies, octopus, squids, gastropods, innkeeper worms, krill, hermit crabs, crabs, spiny lobsters.

Like other *Cephaloscyllium* species, *C. isabellum* has the ability to inflate its body dramatically in response to a predator. While it usually inflates with water, when captured by humans and brought to the surface it may inflate with air instead.

This rapid inflation and deflation possibility is surely the anatomo-physical process which allowed the ancestors of its Genus to initiate a rapid and efficient solution to control the problems of the phenomenal pressures existing in the deepest parts of the Oceans.

This species is oviparous, with females laying two eggs at a time. The smooth egg cases are 12 cm long.

#### ***Cephaloscyllium hiscosellum* WHITE & EBERT, 2008**

This species was considered by Last and Stevens (1994) to be conspecific with *C. fasciatum* CHAN, 1966. White and Ebert (2008), however, described it as a distinct species. (See Bibliography: WHITE & EBERT, 2008).

#### ***Cephaloscyllium laticeps* (DUMERIL, 1853)**

*Cephaloscyllium laticeps*, commonly called the *Australian swell-shark* is an inhabitant of the Australian coasts (from New South Wales to South-East Australia, caught between 32°S and 44°S of latitudes (actually temperate climate), its size record is 150 centimetres of total length, it is caught between 2 to 220 meters depth (personal information from divers and trawlers). It is an oviparous animal, able to inflate its stomach with air and, or, water. (See Bibliography: DUMERIL 1853, COMPAGNO, 1984, COMPAGNO, 1988 and LAST & STEVENS, 2005).

#### ***Cephaloscyllium maculatum* SCHAAF-DA SILVA, & EBERT 2008**

*Cephaloscyllium maculatum* is known by only one juvenile male specimen of nearly 19 centimetres of total length, which was caught off the southern coast of Taiwan. It is also able to inflate its stomach with air and, or, water. (See Bibliography: SCHAAF-DA SILVA & EBERT 2008). Its mode of reproduction is unknown.

#### ***Cephaloscyllium pardelotum* SCHAAF-DA SILVA, & EBERT 2008**

*Cephaloscyllium pardelotum*, called the *leopard swell-shark* is known by only one juvenile male specimen\* of nearly 20 centimetres of total length, which was caught off the southern coast of Taiwan. It is also able to inflate its stomach with air and water. (See Bibliography: SCHAAF-DA SILVA & EBERT 2008).

\*Without D.N.A. analysis or without comparison with S.E.M. photographs of their teeth, it remains difficult to admit the validity of the specific rank of two juvenile males caught in the same sector.

The precise number of valid species existing in the Indo-Pacific Oceans has relatively little importance for a palaeontologist, but this number could give a better conception of the variability of the diverse populations of this Genus in its double\* continuous expansion during the period which shortly precedes the complete submersion of one very long central pacific Archipelago and the formation of the Andes.

\*One expansion is oriented towards the eastern direction to colonise more and more coastal areas, and another consists in colonising, progressively, deeper and deeper waters. (See Bibliography: SCHAAF-DA SILVA & EBERT 2008).

#### ***Cephaloscyllium pictum* LAST, SERET & WHITE, 2008**

*Cephaloscyllium pictum*, is commonly called the *painted swell-shark*. Its holotype came from the Lombok market (Bali). It is an inhabitant of the costal zones of Bali too, maybe, at 250 meters depth (fishermen's communications). Its

size record is 72 centimetres of total length. It is an oviparous\* animal, able to inflate its stomach with air and, or, water. (See Bibliography: LAST, SERET & WHITE, 2008)

\*Some fishermen, friends of Dr. Boeseman (R.M.N.H., Leiden, NL).

***Cephaloscyllium sarawakensis* YANO, AHMAD, GAMBANG, HAMID, RAZAK & ZAINAL, 2006**

*Cephaloscyllium sarawakensis*, commonly called the *Sarawak pygmy well-shark* is an inhabitant off the Malaysian and Brunnei (Darussalam) coasts caught from 118 to 165 meters depth. Its size record is 40 centimetres of total length. It has also the possibility to inflate its stomach with air and, or, with water. Its mode of reproduction is oviparity. (See Bibliography: YANO, AHMAD, GAMBANG, HAMID, RAZAK & ZAINAL, 2006).

\*Except for its very small dimensions, this new taxon presents no other important distinctive criteria, such as genome analysis, and its teeth are not illustrated by S.E.M. photographs.

This taxon is a good example of what a palaeontologist calls: *Taxon of uncertain validity*.

***Cephaloscyllium signorum* LAST, SERET & WHITE, 2008**

*Cephaloscyllium signorum* is an inhabitant of the South East coasts of Australia, its size record is 74 centimetres of total length, it is caught between 480 and 700 meters depth. Its mode of reproduction is oviparity. (See Bibliography: LAST, SERET & WHITE, 2008).

***Cephaloscyllium silasi* (TALWAR, 1974)**

*Cephaloscyllium silasi*: Its size record is 36 cm length, its depth distribution is coastal to 300 meters, its distribution area are the southwestern Indian coasts. It is capable of rapidly inflating its body. Its reproduction mode is oviparity. (See Bibliography: TALWAR, 1974, COMPAGNO, 1984 and COMPAGNO, 1988).

***Cephaloscyllium speccum* LAST, SERET & WHITE, 2008**

*Cephaloscyllium speccum*: Its maximal size nears 70 cm length, its depth range is 150 to 455 meters, its is an endemic species of the northwestern Australian coasts, its reproduction mode is not precised (See Bibliography: LAST, SERET & WHITE, 2008 and LAST & WHITE, 1994).

***Cephaloscyllium stevensi* CLARK & RANDALL, 2011**

*Cephaloscyllium stevensi*: Its dispersion area are the southern coasts of New Guinea (See Bibliography: Clark & Randall, 2011), and the northwestern coast of Australia (Divers personal communication), and its depth range is coastal to 70 meters (Divers personal communication). Its reproduction mode is oviparity. (See Bibliography: CLARK & RANDALL, 2011).

***Cephaloscyllium sufflans* (REGAN, 1921)**

*Cephaloscyllium sufflans*, commonly called the *balloon shark* has a depth range comprised between 40 meters and 600 meters. Its size record is 106 cm of total length, it is a common inhabitant of the Natal coast, but may be encountered to the southern Mozambic coasts. Its reproduction mode is oviparity. These animals seem insensitive to the pressure exerced by the mass of fishes surrounding them when captured. Its reproduction mode is oviparity. (See Bibliography: REGAN, 1921, FOWLER, 1941, BASS, d'AUBREY & KITSANAMY, 1975, COMPAGNO, 1984 and COMPAGNO, 1988).

***Cephaloscyllium umbratile* JORDAN & FOWLER, 1903**

*Cephaloscyllium umbratile* is also capable of rapidly inflating its body as a defense against predators. Its record size is 145 centimeters of total length, its depth range is comprised between 90 and 200 meters. Its reproduction mode is oviparity. (See Bibliography: JORDAN & FOWLER, 1903, COMPAGNO, 1984 and COMPAGNO, 1988).

Some fishermen friends confirmed to the senior-author its presence in its type zone.

### ***Cephaloscyllium variegatum* (LAST & WHITE, 2008)**

*Cephaloscyllium umbratile*, commonly called the *saddle swell-shark*, is capable of rapidly inflating its body as a defense against predators. Its size record is 72 centimeters of total length, its depth range is comprised between 114 and 605 meters. Its reproduction mode is oviparity. (See Bibliography: LAST & WHITE, 2008).

### ***Cephaloscyllium ventriosum* GARMAN, 1880**

*Cephaloscyllium ventriosum*, commonly called the *Californian swell-shark* is also capable of rapidly inflating its body as a defense against predators. Its record size is 112 centimeters (personal information) of total length. Its depth range is coastal to 480 meters. Its reproduction mode is oviparity. (See Bibliography: GARMAN, 1880, COMPAGNO, 1984 and COMPAGNO, 1988).

*Cephaloscyllium ventriosum* has developed a bioelectric-mediated technique to precise the position of its preys in aphotic depths (See Bibliography: TRICAS, 1979).

### **Conclusions concerning the Genus *Cephaloscyllium***

The depth range of this Genus seems to be coastal (for *C. silasi*, from South West India) to 700 meters (for *C. signoroum*, from southeastern Australia). All the species represented by females specimens are oviparous.

They seem resistant to high pressures and they present the possibility to increase their volume considerably by absorbing a large quantity of water and, or, air in their stomachs. The possibility to stock important quantities of air, mixed with water, is a very important, if not decisive, evolutive step for the colonisation of the deepest parts of the Oceans.

Curiously, if the validity of none of the old taxa assigned to this Genus seems questionable, all these proposed after 2005 are subjects of endless controversies.

### **Genus *Cephalurus* BIGELOW & SCHROEDER, 1941**

The Genus *Cephalurus* includes only one living species, its type-species: *Cephalurus cephalus* (GILBERT, 1892), also called the *lollipop cat-shark*.

The *lollipop catshark*, *Cephalurus cephalus*, is a little-known species of deep sea cat-shark, and the only described member of its Genus. A diminutive, bottom-dwelling shark of the outer continental shelf and upper continental slope, this species can be rapidly identified by its tadpole-like shape with a greatly expanded, rounded head and a narrow body.

The large head houses expanded gills, which are thought to be an adaptation for hypoxic conditions. This shark preys on crustaceans and fishes. Its reproduction mode is aplacental viviparous, with females retaining egg cases internally, two at a time, until they hatch.

### **Conclusions concerning the Genus *Cephalurus***

#### **1. Taxonomy and phylogeny**

The lollipop cat-shark was based on a 24 cm long adult male caught from a depth of 841 m off the Clarion Island in the Revillagigedo Islands.

One or more species of *Cephalurus*, not yet described, appear to exist off Panama, Peru, and Chile, which differ slightly from *C. cephalus* in appearance and size.

Based on morphological and molecular phylogenetic evidence, *Cephalurus* is thought to have a more closely relation with the Genera *Asymbolus*, *Parmaturus*, *Galeus*, and *Apristurus*.

However, different authors disagree on the interrelationships within this group. Molecular data support *Cephalurus* and *Parmaturus* as sister groups.

The senior author suggests that, at least, one ancestor of the living Genus *Cephalurus*, may be a fossil population of the Genus *Triaenodon*, presently considered as the ancestor of this enigmatic Genus *Cephalurus*.

## **2.Distribution and habitat**

The range of the *lollipop cat-shark* extends from the Gulf of California to off the southern Baja Peninsula. This benthic species occurs around the outer continental shelf and upper continental slope at depths of 155 to 937 meter, where it is reported to be abundant.

## **3.Description**

The *lollipop cat-shark* is so named because of its peculiar tadpole-like shape, with an enormously expanded head and branchial region (containing the gills) coupled with a slender, cylindrical body tapering towards the tail.

The head is wide, flattened, and rounded, comprising a third of the total length in adults. The snout is very short and blunt, with widely spaced nostrils flanked by moderately developed flaps of skin. The mouth has a pair of furrows at the corners that curl around from the upper to the lower jaw.

The widely spaced teeth have a large central cuspid flanked by one to three lateral cuspids on both sides. The upper teeth are straight while the lower teeth are curved somewhat outward. The five pairs of gill slits are distinctive, being strongly arched forward.

The skin is delicate and sparsely covered by thorn-like dermal denticles interspersed with narrower hair-like denticles that become more numerous on the back. Adults typically attain a length of 24 cm but may grow up to 28 cm long.

## **4.Biology and ecology**

The enlarged gill region and expanded gill filaments of the *lollipop cat-shark* suggest that it has adapted to living in deep-sea basins with very low levels of dissolved oxygen and perhaps also high temperatures and salinity. This shark feeds mainly on crustaceans, followed by fishes.

The mode of reproduction of *Cephalurus cephalus* is aplacental viviparous, with birthing apparently taking place in early summer. Females have two functional ovaries and retain pairs of thin-shelled egg cases (one within each oviduct) within their bodies until they hatch.

## **Sub-Genus *Figaro* WHITLEY, 1928**

The type species of this Sub Genus was *Figaro boardmani* WHITLEY, 1928. This Sub Genus included only two species: *Figaro boardmani* WHITLEY, 1928 and *Figaro striatus* GLEDHILL, LAST & WHITE, 2008.

These two species are found off Australia, inhabiting deep, offshore waters on, or near, the bottom. *Figaro* contains small, slender, firm-bodied sharks that bear distinctive crests of enlarged, spiny dermal denticles along the dorsal and ventral edges of their short caudal fins.

## ***Figaro boardmani* WHITLEY, 1928**

*F. boardmani* is a predator of fishes, crustaceans, and cephalopods. Its mode of reproduction is aplacental viviparous, which is the most evolved mode of reproduction for the Neoselachii.

Its size record is 61 centimeters of total length. It is a bathydemersal fish, living between 128 and 823 meters depth, in southern Australia and the western Indo-Pacific, remaining in the temperate climate zone\*.

\*Which, presently, means nothing, at more than 800 meters depth, but certainly did in far geological periods.

### **The other living Genera and species of the Family Scyliorhinidae**

After passing in review, species per species, some plethospecific\* Genera and some of the most disputed Genera of this Family, the senior author decided to restrict his investigation to the generic level, hoping that the chondrichthyan neontologists will find some solutions.

\*It is impossible to give an opinion concerning the validity of the majority of the new specific taxa recently published, without having access to the references of the specimens, or at least, having seen photographs of their teeth, which remain very superficially described as *little and numerous* and, which are eventually only schematically drawn, without any significant crown morphological details. The structure of their root is never mentioned.

### **Genus *Figaro* WHITLEY, 1928**

#### **Distribution and habitat**

*Figaro* is a Genus of the Family Scyliorhinidae, which was considered as a subgenus of *Galeus* by some biologists or of *Halaelurus* by some other biologists.

The two living species attributed to this taxon were caught off the Australian coasts in deep offshore waters, or resting on the sea bottom. *F. boardmani* off the southern coasts of Australia and *F. striatus* off the northern coasts of Australia which suggests a very old scission of their ancestral populations, or a simple diphyletism, invalidating this taxon definitely.

*Figaro boardmani* WHITLEY, 1928 feeds on mollusks (principally cephalopods), diverse crustaceans (principally small decapods) and little fishes (principally juvenile macrourids). Its mode of reproduction is the most primitive one: oviparity. The ecology of *Figaro striatus* GLEDHILL, LAST & WHITE, 2008 is virtually unknown.

### **Conclusions concerning the Genus *Figaro* WHITLEY, 1928**

The coherence of this taxon is highly contestable. The most evident observation is that the Genus *Figaro* seems to be a diphyletic taxon.

### **Genus *Galeus* RAFINESQUE, 1810**

**(Synonym: *Pristiurus* BONAPARTE, 1834)**

Its type species is *Galeus melastomus* RAFINESQUE, 1810. This Genus regroups the seventeen following species: *Galeus antillensis* SPRINGER, 1979, *Galeus arae* (NICHOLS, 1927), *Galeus atlanticus* (VAILLANT, 1888), *Galeus cadenati* SPRINGER, 1966, *Galeus eastmani* (JORDAN & SNYDER, 1904), *Galeus gracilis* COMPAGNO & STEVENS, 1993, *Galeus longirostris* TACHIKAWA & TANIUCHI, 1987, *Galeus melastomus* RAFINESQUE, 1810, *Galeus mincaronei* de SOTO 2001, *Galeus murinus* (COLLETT, 1904), *Galeus nipponensis* NAKAYA, 1975, *Galeus piperatus* SPRINGER & WAGNER, 1966, *Galeus polli* CADENAT, 1959, *Galeus priapus* SERET & LAST, 2008, *Galeus sauteri* (JORDAN & RICHARDSON, 1909), *Galeus schultzi* SPRINGER, 1979 and *Galeus springeri* KONSTANTINOU & COZZI, 1998

### **Conclusions concerning the Genus *Galeus***

They are found in the Atlantic, the western and central Pacific, and the Gulf of California, inhabiting deep waters close to the bottom.

All the species of the Genus *Galeus* feed on various invertebrates and fishes, and may be either egg-laying (oviparous) or live-bearing. In such case, their mode of reproduction is ovoviviparous, or even, aplacental viviparous.

It is this Genus which was the first to have concretised the three modes of reproduction mode of the Neoselachii.

During their long evolution they have colonised all the seas of the world. Actually they were caught between 35 meters depth (*G. melastomus*, from the Mediterranean Sea and the eastern Atlantic between 65°N and 15°N of latitudes) to, at least, 1350 meters depth (*G. piperatus*, from Baja California and the Sea of Cortez).

The biological habits of the majority\* of the different species of the Genus *Galeus* indicate that after the females have reached maturity, a sexual segregation is the dominant rule.

\*In this case, 13 species out of the 19 enumerated.

The senior-author remembers that, in one single trawling of four hours, 24 males of *Galeus murinus* were caught together when trawling from the greater depth (e.g. 650 meters depth) to the lower depth (e.g. 720 meters depth). And that, a week later, operating in the other direction, 36 females were caught together, without eggs. (Observations realised in the Porcupine Bay, in 1977, 1978 and 1981).

Logically, after copulation at around 600-620 meters depth, on fine sandy bottom, the females swam in the direction of less deep waters to release their young in aphotic corallian areas far more rich in feeding sources for them, and the males return before the females to their normal living depths.

Such a phenomenon may explain that the populations having a balanced proportion of both sexes during their crossing, via the last submarine straits or passes of the Andes Chain area, had a real possibility to colonise the Gulf of Mexico, the Carribean Sea, the coasts of the Bahamas and the western North Atlantic.

\*This observation is valid for the species for which sufficient catching data seem reliable, in this case 13 species out of the 19 enumerated.

All the species of this Genus live close to the bottom in deep water. The centres of biodiversity for *Galeus* are the North Atlantic (eight species) and the northwestern Pacific (four species).

A few outlying species are found in the South Atlantic (*G. mincaronei* and *G. polli*), Oceania (*G. gracilis* and *G. priapus*), and the Gulf of California (*G. piperatus*). In the western Indian Ocean, this genus appears to be replaced by the ecologically similar genus *Holohalaelurus*.

Reproductive modes within the Genus are notably diverse: while most species are oviparous and lay eggcapsels on the sea floor, there is a single aplacental viviparous species (*G. polli*) that retains eggs internally and gives live birth.

Among the oviparous species, most (e.g. *G. murinus* and *G. nipponensis*) exhibit single oviparity, in which only a single egg matures within each of the female's oviducts at a time.

In contrast, a few species such as *G. atlanticus* and *G. melastomus* exhibit multiple oviparity, in which several eggs can mature within each oviduct simultaneously.

Single oviparity is considered to be the basal condition, while multiple oviparity and aplacental viviparity are thought to be more derived.

As conclusion, the Genus *Galeus* seems to have been the departing point of the three reproduction modes: oviparity, multiple oviparity and aplacental viviparity.

#### **Publications consulted for the redaction of this paragraph**

**See the original and complete references in the final Bibliography**

#### **Part 1. References concerning living taxa.**

ALCOCK, 1899, BASS, D'AUBREY & KISTNASAMY, 1975, BIGELOW & SCHROEDER, 1948, BIGELOW, SCHROEDER & SPRINGER, 1955, BLEEKER, 1852, BREDER & ROSEN, 1966, BUEN, (de) 1959, BULLIS, Jr.

1967, CADENAT, 1959, COMPAGNO, 1984, COMPAGNO, 1988, DULVY & REYNOLDS, 1997, FROESE & PAULY, Edits. 2011, GARMAN, 1906, HERMAN, HOVESTADT-EULER & HOVESTADT, 1990, HORIE & TANAKA, 2000, IGLESIAS, du BUIT & NAKAYA, 2002, KONSTANTINOOU & COZZI, 1998, ORKIN, 1952, SPRINGER, 1979, SPRINGER & D' AUBREY, 1972 and SPRINGER & WAGNER, 1966.

### **Genus *Halaelurus* GILL, 1862**

The generotype of the Genus *Halaelurus* is *Scyllium buergeri* MÜLLER & HENLE, 1841. This Genus includes the eight following living species: *Halaelurus alcocki* GARMAN, 1913, *Halaelurus boesemani* SPRINGER & D'AUBREY, 1972, *Halaelurus buergeri* (MÜLLER & HENLE, 1838), *Halaelurus lineatus* BASS, D'AUBREY & KISTNASAMY, 1975, *Halaelurus maculosus* WHITE, LAST & STEVENS, 2007, *Halaelurus natalensis* (REGAN, 1904), *Halaelurus quagga* (ALCOCK, 1899) and *Halaelurus sellus* WHITE, LAST & STEVENS, 2007.

### **Conclusions concerning the Genus *Halaelurus***

Their common vernacular name is always followed by *cat-shark*. During their long evolution they have, progressively, colonised the Gulf of Aden, in Somalia, the Arabian Sea, Mozambique, southern Africa, northern India, southern India, the Andaman Islands, western Australia, the Amboina Islands, the Philippines Islands, Vietnam, Korea, Taiwan, China, New Zealand, the Auckland Islands, Peru, Chile, and in the Magellan Straits.

Their size record varies between 25 centimeters (for *H. hispidus*) of total length (for *H. immaculatus*) to 76 centimeters of total length. All the species of the Genus *Halaelurus* feed on various invertebrates, mainly crustacean decapods and little squids and diverse teleostean fishes including deep water species of the Family Macruridae.

The different species of the Genus *Halaelurus* are oviparous or ovoviviparous, aplacental viviparity is not mentioned but the mode of reproduction of two of them remains unknown. Actually they were caught between coastal waters (*H. natalensis* from eastern South Africa), between 35°S and circa 25°N of latitudes) to, at least, 1300 meters depth (*H. alcocki*, from the Arabian Sea).

### **Publications consulted for the redaction of this paragraph**

**See the original and complete references in the final Bibliography**

#### **Part 1. References concerning living taxa.**

ALCOCK, 1899, BASS, D'AUBREY & KISTNASAMY, 1975, BIGELOW & SCHROEDER, 1948, BIGELOW, SCHROEDER & SPRINGER, 1955, COMPAGNO, 1984, COMPAGNO, 1988, GARMAN, 1913, MÜLLER & HENLE, 1838, MÜLLER & HENLE, 1841, REGAN, 1904, SPRINGER & D'AUBREY, 1972 and WHITE, LAST & STEVENS, 2007.

### **Genus *Haploblepharus* GARMAN, 1913**

*Haploblepharus* is a Genus of cat-sharks, of which the species are commonly called *shy-sharks*. It regroups the four following species: *Haploblepharus edwardsii* (SCHINZ, 1822), *Haploblepharus fuscus* SMITH, 1950, *Haploblepharus kistnasamyi* HUMAN & COMPAGNO, 2006 and *Haploblepharus pictus* (MÜLLER & HENLE, 1838).

Their common name comes from a distinctive defensive behaviour in which the shark curls into a circle and covers its eyes with its tail, which demonstrates the extraordinary suppleness of its vertebral column. The Genus is endemic to southern Africa, and inhabits shallow coastal waters to a maximum of 130 m depth.

Shysharks are bottom-dwelling predators of bony fishes and invertebrates. The four species of *Haploblepharus* are oviparous.

### **Conclusions concerning the Genus *Haploblepharus***

All the *Haploblepharus*, or *shy-sharks* are bottom-dwelling predators of bony fishes and invertebrates. The four living species of the Genus *Haploblepharus* are endemic to the southern tip of Africa. Three of them are found only off South Africa, while the range of the dark shyshark extends to southern Namibia. They are bottom-dwelling in nature and usually found in shallow, coastal waters over sandy or rocky bottoms. The record of depth catch is 165 meters (Durban's fishermen information). The four species are small, exceeding rarely 60 cm of total length and they are oviparous.

During their long evolution they have, progressively, colonised the coasts of South Africa, Mozambique and southern Tanzania. Actually they were caught between coastal waters to 160 meters depth (Durban's and Cape-Town's fishermen information) and between 5°S and 35°S of latitudes.

#### **Publications consulted for the redaction of this paragraph**

**See the original and complete references in the final Bibliography**

#### **Part 1. References concerning living taxa.**

See Bibliography : COMPAGNO, 1984, COMPAGNO, 1988, GARMAN, 1913, HUMAN & COMPAGNO, 2006, SCHINZ, 1822, SERET, 1990, SMITH, 1950 and WAITE, 1905.

#### **Genus *Holohalaelurus* FOWLER, 1934**

**(Synonym: *Catulus* WAITE, 1905)**

The type species of this Genus is: *Holohalaelurus labiosus* (WAITE, 1905). This Genus is represented only by two living species: *Holohalaelurus labiosus* (WAITE, 1905) and *Holohalaelurus kanakorum* SERET, 1990. *Holohalaelurus* is a Genus commonly known as *Izak cat-sharks* or *hallelujah sharks*.

Its type species is: *Scyliorhinus regani* GILCHRIST, 1922. The Genus regroups five living species: *Holohalaelurus favus* HUMAN, 2006, *Holohalaelurus grennian* HUMAN, 2006, *Holohalaelurus melanostigma* (NORMAN, 1939), *Holohalaelurus punctatus* (GILCHRIST, 1914) and *Holohalaelurus regani* (GILCHRIST, 1922).

### **Conclusions concerning the Genus *Holohalaelurus***

During their evolution they have colonised, progressively the southwestern coast of South Africa and, practically, all the eastern coasts of Africa to the Indian coasts of Somalia. They did not enter the Red Sea because this part of the Great African Rift did not yet exist. Actually, they were caught between coastal waters to 160 meters depth (*H. punctatus*) and between 15°N and 35°S of latitudes.

All the species of the Genus *Halaelurus* feed on various invertebrates, mainly, nudibranches and cephalopods mollusks and little coastal to upper continental slopes teleostean fishes.

#### **Publications consulted for the redaction of this paragraph**

**See the original and complete references in the final Bibliography**

#### **Part 1. References concerning living taxa.**

COMPAGNO, 1984, COMPAGNO, 1988, FOWLER, 1934, GILCHRIST, 1914, HUMAN, 2006, NORMAN, 1939 and WAITE, 1905.

#### **Genus *Parmaturus* GARMAN, 1906**

Its generotype is: *Parmaturus pilosus* GARMAN, 1906. This Genus regroups the nine\* following living species: *Parmaturus albimarginatus* SERET & LAST, 2007, *Parmaturus albipennis* SERET & LAST, 2007, *Parmaturus bigus* SERET & LAST, 2007, *Parmaturus campechiensis* SPRINGER, 1979, *Parmaturus lanatus* SERET & LAST, 2007, *Parmaturus macmillani* HARDY, 1985, *Parmaturus melanobranchus* (CHAN, 1966), *Parmaturus pilosus* GARMAN, 1906 and *Parmaturus xaniurus* (GILBERT, 1892).

\*LAST & SERET, 2007 suggested to add three other, recently discovered, species but numerous ichthyologists contested and still contest their validity. In absence of a detailed description and a modern illustration of their teeth, it is impossible for any palaeoichthyologist to give an argued opinion.

*P. albimarginatus*, called by their inventors the *white-tip cat-shark*, *P. albipennis*, called by their inventors the *white-caspir cat-shark* and *P. bigus*, called by their inventors the *beige cat-shark* remain three species of highly controversial validity. They are mentioned with the intention to make our inventory as complete as possible.

Valid or not, these taxa have no signification in the global natural history of the Genus *Parmaturus*. Their validation may just add some details to its local diversification.

Séret and Last (2007) furnished the following data concerning their new taxa: *P. albipennis*: no additional data, but oviparity was confirmed, *P. albimarginatus* is a deep-water shark in the Western Pacific waters near New Caledonia and *P. bigus*: its first recorded specimen was a female recorded off the coast of Queensland, Australia around Lord Howe Island. Its total length is 72 cm, and they signalled that: *Recently, a number of specimens both male and female (unpublished data) were captured in New Zealand waters at the edge of the E.E.Z. (exclusive economic zone).*

To date, very little is known about the ecology of *Parmaturus bigus*. Some scientists are currently studying the sensory systems of this cat-shark in order to reveal information about its ecology and ultimate behaviour. The most important data is that its reproduction mode is oviparity.

*P. lanatus*, called by its inventors, the *velvet cat-shark*, is a deep-water bathydemersal shark living in the Western Pacific waters near Indonesia and has been seen at depths of 840-855m. Once more, the validity of this taxon is contested by diverse other neontologists.

*P. macmillani* is known from two specimens caught off of the North Island of New-Zealand and and three specimens caught off southeastern Africa between 1000 and 1500 meters depth. Its record size is 45 centimeters.

Considering the four remaining taxa for which the validity seems also assured, Compagno (1988) pointed out the following singularities.

*P. campechiensis* is only known by its holotype, an immature specimen of 19 cm of total length, caught at 1097 meters depth on the continental slope of the Gulf of Campeche (Mexico).

*P. melanobranchus*, the *blackgill cat-shark*, was caught in the southern part of the continental slope off southern China, in the China Sea, living on mud bottoms at depths comprised between 549 meters and 810 meters. Its size record is 85 centimeters of total length.

*P. pilosus*, the *salamander cat-shark*, only known (in 1988) by its holotype caught at 786 meters depth off the southern coast of Honshu Island (Japan), and later by some other specimens of which the size record was 64 centimeters in length.

*P. xaniurus* is known from off the central coast of California (U.S.A.) and in the southern part of the Sea of Cortez (California del Sur, Mexico). It was, possibly\* seen in the catches of Japanese high-sea fishship by Ed. Ricketts and Stefan Spielberg during their expedition\*\* in the Sea of Cortez.

\*\*SPIELBERG, S. 1941: *The Log from the Sea of Cortez*. R. Matas Ed. Journal. La Paz, California del Sur, Mexico. One French translation was published in 1979 by Les Editions maritimes et d'outre-mer. Legal deposit: 08/79. Printer Number 1717.

\*Eddy Ricketts had furnished many marine specimens to Dr. Perry Gilbert, the inventor of *Parmaturus xaniurus* and published, with Jack Calvin, a very interesting popular book: *Between Pacific Tides*. Stanford University Press. 365p., 125 fig., 56 pl.

### **Conclusions concerning the Genus *Parmaturus***

During their evolution they have colonised, progressively the southwestern coasts of South Africa and, practically, all the eastern coasts of Africa to the Indian coasts of Somalia. They did not enter the Red Sea because this part of the Great African Rift did not exist at this moment.

Actually, they were caught between coastal waters to 160 meters depth (*H. punctatus*), and between 15°N and 35°S of latitudes.

The seismic activities of the Great African Rift began with the Miocene, which means, approximately, 23 million years ago. It is the instability of the sea bottoms which was responsible for the isolation of some populations of miocene Scyliorhinidae, inducing their singularisation.

All the species of the Genus *Parmaturus* feed on various invertebrates, mainly, nudibranches and cephalopods mollusks and little coastal to upper continental slopes teleostean fishes.

#### **Publications consulted for the redaction of this paragraph**

**See the original and complete references in the final Bibliography**

#### **Part 1. References concerning living taxa.**

CHAN, 1966, COMPAGNO, 1984, COMPAGNO, 1988, GARMAN, 1906, GILBERT, 1892,  
HARDY, 1985, SERET & LAST, 2007, SPRINGER, 1979 and WAITE, 1905.

### **Genus *Pentanchus* SMITH & RADCLIFFE *in* SMITH, 1912**

*Pentanchus profundicolus*, also called the *onefin cat-shark*, is the only member of this Genus. The singularity of the possession of a unique dorsal fin may be a simple abnormality.

### **Conclusions concerning the Genus *Pentanchus***

This very poorly represented Genus, and sometimes contested Genus, lives off on the continental slopes of the islands of the Mindanao Sea. The unique species of the Genus *Pentanchus* seems to feed on various invertebrates and small fishes. The total length of its unique specimen is 50.5 centimeters. It has no natural history. If validated, it may be just a variation of one proximal *Apristurus* population.

#### **Publications consulted for the redaction of this paragraph**

**See the original and complete references in the final Bibliography**

#### **Part 1. References concerning living taxa.**

COMPAGNO, 1984, COMPAGNO, 1988 and SMITH & RADCLIFFE *in* SMITH, 1912.

### **Genus *Poroderma* SMITH, 1838**

Its type species is *Poroderma africanum* (GMELIN, 1789). This Genus comprises only 2 living species: *Poroderma africanum* (GMELIN, 1789) and *Poroderma pantherinum* (MÜLLER & HENLE, 1838).

They are found in South Africa and are nocturnal. They live preferably in shore areas, close to the bottom, to depths of 100 meters or more (supposition concerning *Poroderma pantherinum*, based on recent information). They prefer small caves and crevices.

Their diet usually consists of crustaceans, but they also feed on small fish. The average size is between 60 and 80 cm, with a maximum total length of about 100 cm. Their birth size is about 15 cm. The two living species are oviparous.

### **Conclusions concerning the Genus *Poroderma***

The most important data is that the three living species of the Genus *Poroderma* are oviparous. The fact that they are endemic to South Africa indicates us that their ancestors arrived from the Red Sea, but that the tectonic perturbations\* resulting from the increase of the seismic activities of the southern part of the Great African Rift, have made that they did not remain along the southern Somalian and the northern Mozambique coasts.

\*Which they are able to detect via their very high electro-magnetic perception.

These coasts were too unstable sea bottoms to guarantee the maturation of their eggcapsels. This phenomenon explains their isolated evolution and their multiple distinctions (genetic and odontologic singularities).

### **Publications consulted for the redaction of this paragraph**

**See the original and complete references in the final Bibliography**

#### **Part 1. References concerning living taxa.**

COMPAGNO, 1984, COMPAGNO, 1988, GMELIN, 1789, MÜLLER & HENLE, 1838 and SMITH, 1838

#### **Genus *Schroederichthys* SMITH, 1838**

The type species of this Genus is: *Halaelurus chilensis* GUICHENOT, 1847. This Genus regroups 5 living species: *Schroederichthys bivius* (MÜLLER & HENLE, 1838), *Schroederichthys chilensis* (GUICHENOT, 1848), *Schroederichthys maculatus* SPRINGER, 1966, *Schroederichthys saurisqualus* de SOTO, 2001 and *Schroederichthys tenuis* SPRINGER, 1966. The five living species of this Genus are oviparous. It has no fossil records.

#### **Conclusions concerning the Genus *Schroederichthys***

The most important data is its ovoviviparous mode of reproduction. The histology and the morphology of the dental crown of its teeth were, apparently without utility, described and illustrated by Herman, Euler-Hovestadt et Hovestadt in 1990. (See Bibliography: SMITH, 1838, COMPAGNO, 1984, and HERMAN, EULER-HOVESTADT & HOVESTADT, 1990).

#### **Genus *Scyliorhinus* de BLAINVILLE, 1816**

Its type-species is *Squalus canicula* LINNAEUS, 1758. Its English vernacular name: *Cat-sharks* is very relevant: a cat sleeps, but is also incredibly rapid, supple and it undulates between delicate objects. The Genus had and has a worldwide distribution. It inhabited or inhabits all the costal, and some intertidal, and continental slopes of the equatorial to cold temperate waters of the world.

*Scyliorhinus* is a Genus of the Family Scyliorhinidae, comprising 15 living species: *Scyliorhinus besnardi* SPRINGER & SADOWSKY, 1970, *Scyliorhinus boa* GOODE & BEAN, 1896, *Scyliorhinus canicula* (LINNAEUS, 1758), *Scyliorhinus capensis* (MÜLLER & HENLE, 1838), *Scyliorhinus cervigoni* MAURIN & BONET, 1970, *Scyliorhinus comoroensis* COMPAGNO, 1988, *Scyliorhinus garmani* (FOWLER, 1934), *Scyliorhinus haeckelii* (MIRANDA-RIBEIRO, 1907), *Scyliorhinus hesperius* SPRINGER, 1966, *Scyliorhinus meadi* SPRINGER, 1966, *Scyliorhinus retifer* (GARMAN, 1881), *Scyliorhinus stellaris* (LINNAEUS, 1758), *Scyliorhinus tokubee* SHIRAI, HAGIWARA & NAKAYA, 1992, *Scyliorhinus torazame* (TANAKA, 1908) and *Scyliorhinus torrei* HOWELL-RIVERO, 1936.

#### **Conclusions concerning the Genus *Scyliorhinus***

All *Scyliorhinus stellaris* the living species of the Genus *Scyliorhinus* are oviparous. The Genus itself seems to exist since the lower part of the Upper Cretaceous. Its older known ancestor is *Paleoscyllium formosum* WAGNER, 1857 from the Tithonian of Solnhofen (Bavaria, Germany).

Its two more recent species are *Scyliorhinus canicula* (LINNAEUS, 1758) and *Scyliorhinus stellaris* (LINNAEUS, 1758). Logically the *Scyliorhinus* populations, such as *Scyliorhinus retifer* (GARMAN, 1881) living in the Caribbean Sea and the Bahamas Islands must be a little older.

The *Scyliorhinus* species living, actually, along the Pacific coasts of America are their ancestors. Older ancestral population stocks are difficult to precise, but their descendants live in the central Pacific, according to a reverse movement of their 140 million years of eastern colonisation direction.

### **Part 1. References concerning living taxa.**

**See the original and complete references in the final Bibliography**

**(Selected List)**

BLAINVILLE, (de), 1816, COMPAGNO, 1984, COMPAGNO, 1988, FOWLER, 1934, GOODE & BEAN, 1896, HERMAN, EULER-HOVESTADT & HOVESTADT, 1990, GARMAN, 1881, HILGENDORF, 1904, LAST & VONGPANICH, 2004, HOWELL-RIVERO, 1936, LINNAEUS, 1758, MAURIN & BONET, 1970, MIRANDA-RIBEIRO, 1907, MÜLLER & HENLE, 1838, SHIRAI, HAGIWARA & NAKAYA, 1992, SMITH, 1957, SPRINGER, 1968, SPRINGER & SADOWSKY, 1970 and TANAKA, 1912.

### **5.11. Conclusions concerning the former Order Scyliorhiniformes and the Family Scyliorhinidae**

The number, the diversity and the adaptations of the ancestral and all the living populations of the former Order Scyliorhiniformes is amazing, but real.

One of the last problems was the correct assignation of the Family Triaenodontidae and its two species: the living *Triaenodon obesus* RÜPPEL, 1837 and its, recently identified, Eocene ancestor, *Triaenodon willei* HERMAN & VAN DEN EECKAUT, 2010.

*Triaenodon willei* is the unique fossil species, erroneously considered as a Carcharhinidae, of which the crown of the teeth are not serrulated and the two lateral cusplets of the teeth are flat and divergent.

The conclusion seems evident. One population of *Triaenodon willei* HERMAN & VAN DEN EECKAUT, 2010 is the ancestor of the Genus *Cephalurus*.

Because of diverse anatomical aspects and its singular dentition, the Genus *Cephalurus* may be considered as a traumatic taxon.

## **6. Order Carcharhiniformes COMPAGNO, 1977 Ord. rev.**

### **6.1. Family Proscylliidae COMPAGNO, 1984**

This Family regroups the three following living Genera: *Proscyllium* HILGENDORF, 1904, *Ctenacis* COMPAGNO, 1973 and *Eridacnis* SMITH, 1913. The re-examination of its living species has for unique reason their ancient integration in the Family Scyliorhinidae.

#### **Genus *Proscyllium* HILGENDORF, 1904**

**(Synonym: *Calliscyllium* TANAKA, 1913)**

This Genus includes the three following living species: *Proscyllium habereri*, HILGENDORF, 1904, *Proscyllium magnificentum* LAST & VONGPANICH, 2004 and *Proscyllium venustum* (TANAKA, 1912).

### ***Proscyllium habereri* HILGENDORF, 1904**

The size record of *P. habereri*, also called the *graceful cat-shark*, is 65 centimeters of total length. It is an inhabitant of tropical and warm-temperate continental and insular shelves, descending at a depth corresponding precisely with the sea level of the last ice-time\*. Its depth catches are comprised between 50 and 100 meters depth. The distribution area of its diverse populations comprises two distinct zones.

\*Which means from 108°W to 142°W of longitudes and 18°N to 38°N of latitudes.

The first and larger covers a relatively continuous area extending from\* the North Vietnam coasts to the northern Chinese coasts and from the North Korean coasts to the South Japanese coasts, including the coasts of the Kyushu Archipelago. This large area is divided in two sub-zones by the Japanese Sea.

The coastal populations of *P. habereri* were, with all the coastal forms of life, the first to be confronted with nuclear devastation at the end of the second World War, by one dictatorship and two democracies. A little stock of normal individuals seems to have been reconstituted in the beginning of the 1950s.

The second population is much more concentrated in an area comprising only the northwestern coasts of Java.

If the validity of the Genus itself was never contested, the specific determination of the diverse southern populations of *Proscyllium haberi* was, and remains hardly controversial. (See Bibliography: HILGENDORF, 1904, COMPAGNO, 1984, COMPAGNO, 1988 and FROESE, RAINER & PAULY. Eds. 2011).

### ***Proscyllium magnificum* LAST & VONGPANICH, 2004**

The size record of *P. magnificum*, also called the *magnificent cat-shark*, is 49 centimeters of total length. Only five specimens were caught in the northern part of the Andaman Sea, between 141 and 144 meters depth. (See Bibliography: LAST & VONGPANICH, 2004, COMPAGNO, 1984 and FROESE, RAINER & PAULY. Eds 2011).

### ***Proscyllium venustum* (TANAKA, 1912)**

The size record of *P. venustum*, also called the *finback cat-shark*, is 64 centimeters of total length. Its catches are localised in temperate waters, between 50 and 120 meters depth in the Okinawa Strait (Japan). (See Bibliography: TANAKA, 1912 and FROESE, RAINER & PAULY. Eds. 2006).

### **Conclusions concerning the Genus *Proscyllium***

The senior-author, as well as diverse palaeontologists and neontologists, is also certain that the Genus *Proscyllium* is not a member of the Family Scyliorhinidae.

If for the biologists, the most important anatomical data is the relative position of their fins\*, for all the palaeontologists, the histology, the vascularisation and, particularly, the ornamentation of the crown of all the teeth of one fossil or living *Proscyllium* specimen are those of all the typical members of the Family Triakidae *sensu* HERMAN & VAN DEN EECKHAUT, 2010.

\*Data undetectable on isolated teeth.

The three living species, considered as valid taxa, of the Genus *Proscyllium*, called *small fin-back cat-sharks*, are: *Proscyllium habereri* HILGENDORF, 1904, *Proscyllium magnificum* LAST & VONGPANICH, 2004 and *Proscyllium venustum* TANAKA, 1912.

The most important data, demonstrating the primitivity and the age of this Genus is that its three living representatives are oviparous. The validity of the Genus *Proscyllium* was never contested by biologists or palaeontologists.

Its size record is 65 centimeters of total length, its depth range is comprised between 50 and 120 meters. It is a demersal fish of the northwestern Pacific, particularly common along the Japanese coasts.

The principal obvious characteristics are the morphology and the histology of the dentition of its three living representatives. After the histology of their teeth, it is the dental morphology of their dental crown which demonstrates their strong affinities with the different Genera of the Family Triakidae, considered, since 2010, as a distinct Family of one distinct Order (See Bibliography: HERMAN, EULER-HOVESTADT & HOVESTADT, 1988, HERMAN, & VAN DEN EECKHAUT, 2010).

### **Genus *Ctenacis* COMPAGNO, 1973**

This Genus comprises only one species: *Ctenacis fehlmanni* (SPRINGER, 1968).

#### ***Ctenacis fehlmanni* (SPRINGER, 1968)**

The record size of *C. fehlmanni*, also called the *harlequin cat-shark*, is 48 centimeters of total length. It was caught off the coasts of Somalia. Its type locality is Southwest of Cape Guardafui, Somalia (Springer, 1968). Its mode of reproduction seems to be ovoviviparity, according to the original description by Springer (1968).

*Ctenacis fehlmanni* is an outer shelf dwelling shark, known only from 60 meters to 170 m depth off Somalia. Little is known about the biology or ecology of this species. (See Bibliography: SPRINGER, 1968 and COMPAGNO, 1984).

### **Genus *Eridacnis* SMITH, 1913**

This Genus comprises the three following species: *Eridacnis barboursi* BIGELOW & SCHROEDER, 1944, *Eridacnis radcliffei* SMITH, 1913 and *Eridacnis sinuans* (SMITH, 1957).

#### ***Eridacnis barboursi* BIGELOW & SCHROEDER, 1944**

The size record of *Eridacnis barboursi*, also called the *Cuban ribbontail cat-shark*, is 34 centimeters of total length. It is a subtropical bottom shark of the upper continental and insular slopes. Its catches are comprised between 430 and 613 meters. Its mode of reproduction is ovoviviparity. (See Bibliography: BIGELOW & SCHROEDER, 1944).

#### ***Eridacnis radcliffei* SMITH, 1913**

The record size of *Eridacnis radcliffei*, also called the *pygmy ribbontail cat-shark*, is 24 cm of total length\*. Its Range of depth is comprised between 50 and 840\* meters depth. Its presumed mode of reproduction is ovoviviparity.

\*Indian fishermen's information.

The distribution area of its dispersed populations zone are the Indian Ocean and the western Pacific Ocean. (See Bibliography: (See Bibliography: SMITH, 1913 and COMPAGNO, 1984)

#### ***Eridacnis sinuans* (SMITH, 1957)**

The size record of *E. sinuans*, also called the *African ribbontail cat-shark*, is 23 centimeters of total length. Its catches are comprised between 180 to 480 meters depth. Its mode of reproduction is ovoviviparity.

Its distribution zone covers a long band off the western coasts of Africa, from 29°S to 5°S of latitudes, with an absence between 18°S and 11°S of latitudes, corresponding with a zone of water high turbulences, not clearly explained, but in relation with the northeastern derive of the plate supporting Madagascar. (See Bibliography: SMITH, 1957 and COMPAGNO, 1984).

### **Conclusions concerning the Genus *Eridacnis***

#### **Publications consulted for the redaction of this paragraph**

**See the complete references in Bibliography Part 1.**

BIGELOW & SCHROEDER, 1944, COMPAGNO, 1973, COMPAGNO, 1984, SMITH, 1913, SMITH, 1957 and SPRINGER, 1968.

## 6.2. Phylogeny and evolution of the Family Scyliorhinidae

Their English vernacular name designating all the living species of the Scyliorhinidae: *Cat-sharks* is very relevant. Remember: A cat may sleep, but is also incredibly rapid, supple and it undulates between delicate objects.

Many taxonomic studies have concluded that deep relations could exist between the taxa designed as *Galeus*, *Apristurus*, *Asymbolus* and even with *Cephalurus*.

It is very important to realise that *Apristurus* species (38 species), *Asymbolus* species (9 species) and *Parmaturus* species (9 species) have conserved the more primitive reproduction mode, i.e. oviparity, and that, in fact, it is not these Genera which need re-examination, but on the contrary the melting taxon called *Galeus* with its 17 taxa presenting oviparity or aplacental viviparity, but none of them, ovoviviparity.

Even for a palaeontologist, it is difficult to believe that the scientific conception of this taxon is normal. Researchers having carefully examined the histology and the crown ornamentation of some different taxa of '*Galeus*' were surprised by their high, if not incompatible, intrageneric variations.

Leonard Compagno has placed *Galeus* with *Apristurus*, *Bythaelurus*, *Cephalurus*, *Parmaturus*, and *Pentanchus* in the tribe Pentanchini of the subfamily Pentanchinae, based on morphological\* characters.

*Galeus* was suggested to be the sister group of *Apristurus* in a 2005 phylogenetic study based on mitochondrial and nuclear D.N.A. gene sequences \* (See Bibliography: IGLESIAS et alii).

The affinity between *Galeus* and *Apristurus* was also emphasised after a 2006 phylogenetic analysis based on three mitochondrial D.N.A. genes\* (See Bibliography: HUMAN et alii).

\*All these data are undetectable on fossil material, and remain purely hypothetical suggestions for palaeontologists.

The positive point is that isolated fossil teeth attributed to the 'Genus *Galeus*' (group including the generotype), dating to the Burdigalian (20.43 to 15.97 Ma) and Langhian (15.97 to 13.65 Ma) stages of the early Miocene, have been discovered in France.

## 6.3. Problems encountered during the long evolution of the different Scyliorhiniformes

### 6.3.1. Thermo-regulation problems

These problems will limit their northern and southern territorial expansions, but not their progressive invasion of deep to hadal waters.

The senior-author has never found, in the abundant literature he consulted, a satisfying explanation for the biological solution these fishes used to resolve the enormous calorific loss they were confronted with.

### 6.3.2. Oxygen deficiency

Below the photic zone, oxygen became rarer and rarer. Between the diverse anatomical innovations they tested, the increasing of the exchange surfaces of their branchiae and the ability to inflate and deflate their stomachs very quickly by water, by water and oxygen, or by pure oxygen\*, which seems to have been a, or one, solution posed by this problem.

\*Which means that they have inaugurated with success a biological type of *depressor* millions of years before the principle Cousteau-Gagnan, which allows the mechanical depressurisation to 80 meters, or a little more, but not to 2500 meters depth.

(Interesting reading: AUGUSTO, Louis. 2009 : *Mistral, le détenteur de légende*. Les Presses du Midi. Toulon. I.S.B.N.: 281270067X.

### **6.3.3. Pressure problems**

The senior-author has never read a biological explanation for the discovery of one, or more, solution(s) to compensate the huge pressure difference existing between the pressure in deep to hadal waters and the intern organic pressure of Elasmobranchii.

But it is a fact: The living or fossil Chlamydoselachimorphii, the majority of the living or fossil Squalomorphii and the majority of the living or fossil Scyliorhinomorphii have resolved this problem.

Additionally, some living species of Squalomorphii, such as the three species of the Genus *Isistius*, are able to go near the water surface at night, which means they have the ability to realise an ascension of 300 meters to 800 meters in some minutes, which is a performance only approached by bathyscaphs.

### **6.3.4. Feeding problems**

Except around the deep hot-vents, the majority of the living animal groups are poorly diversified and quantitatively very poorly represented.

Some enormous colonies of sea cucumbers, such as the Elaspoda\* exist, but other preys, such as little Teleostei or Crustacea are rare and scattered.

\*See Bibliography: LE DANOIS, 1958, THEES 1882 and GEBRUK 1983.

At least, one ancestor of the living Genus *Cephaloscyllium* has developed a bioelectric-mediated technique to localise its preys in an aphotic environment (See further: Comments on the living Genus *Cephaloscyllium*).

## **7. Obstacles to the continuous progression of the Scyliorhiniformes in the eastern direction**

### **(The Natural History of the Scyliorhiniformes)**

#### **7.1. Geographical obstacles**

The first obstacle was the formation of the Mount Lebanon, some 80 to 90 millions years ago, and the most important, when they approached the eastern Pacific coasts, some 40 millions years ago, was the formation of the Andes.

The Scyliorhinidae easily resolved the first topographic problem evoked by contouring the emerging Mount Lebanon *via* a southern way and following the northern branch of the African Rift, the Red Sea.

This way allowed them to colonise all the tropical and equatorial southern coasts of Africa, and to initiate their colonisation of all the coasts of the Indian Ocean, the China Sea and a part of the Japanese coasts.

The following step was easy, they just needed to jump from one island to the next one to arrive at the extremity of the Insulida.

How they crossed the last 5000 kilometers before the central American coasts was a biological enigma, presently, resolved by the numerous and continuously more abundant geological information furnished by the knowledge of the Plates Tectonic Events.

Having progressively resolved the survival problems of the colonisation of the hadal plains and, sometimes, using the alternance of the remaining terrestrial field, the Scyliorhinidae were ready for the last part of their more than 30,000 kilometers long migration in the sunrise direction\*.

\*This direction is the terrestrial moving of its daily rotation on itself.

This huge distance, separating Bavaria, or Lebanon, to the eastern extremity of the Mediterranean Sea *via* a continuous eastern direction was effectuated, between the Lower Jurassic (Tithonian) to the present days, which means between *plus-minus* 150 and 144 million years, at a rhythm of approximately 50 kilometers per month\* and a going down to the abyssal zones of *circa* 12 meters per month.

\*This rhythm allows an ideal spatio-temporal interval between their eggs laying places.

This approach helps to define which living species of Scyliorhinidae seems older than one, or more, others still existing in the same area. It is, of course, impossible to occupy new marine territories before their existence (e.g.: the Red Sea or the Sea of Cortez)

It is in this enlarged, four-dimensional, conception that all the fossil taxa discovered must be inserted. This will be the interest of the last part of this Publication, resulting from an intense forty years of co-operation between very clever fishermen friends, numerous field friends and some foreign and Belgian scientific colleagues.

Additionally, two approaches of the odontological conception of all the living supra-specific proposed taxa, one concerning the Family Scyliorhinidae and one concerning the Family Triakidae were published by HERMAN, EULER-HOVESTADT & HOVESTADT in the years 1988 and 1990 (See Bibliography).

These two publications also gave the first complete palaeontological phylogenetic reinterpretation of these two Families.

## 7.2. Impact of the climatic changes on their Evolution

Contrarily, the climatic changes have absolutely no signification or influence for all their populations living in aphotic zones. Only the populations living in coastal areas were affected by climatic variations.

## 8. Interpretations of these new data for a phylogenetic and systematic revision of this Order

With the indispensable help of a dense net of high-sea fishermen friends, it is possible to increase the data concerning all the Fishes groups needing revision. Their esteem and their trust are not easy to obtain, but once obtained, it is for a lifetime.

## 9. The systematic of the fishes proposed by Karl von Linné

While Karl von Linnaeus imposed the binominal nomenclature and developed a complex first serious attempt to the classification of the Plantae\*, he had a poor understanding of the complex systematic of the Animalia. He regrouped, in 1758, all the neoselachians in one single Genus: Genus *Squalus* LINNAEUS, 1758 and all the batomorphii in some Genera such as the Genus *Raja* LINNAEUS, 1758.

It seems that Pierre Artedi, officially, *accidentally dead drunk* died by hydrocution, had a far better conception of the diversity of the Animalia, which von Linné could not admit.

\*Because he was an extraordinary botanist.

It was a real surprise to discover the possible double personality of the world-famous Mister L. His *good friend*, Pierre Artedi, had more advanced conceptions concerning the classification of the Living Fishes than Linnaeus himself. A tragic night in September 1735, Pierre Artedi, seriously drunk, left the tavern he was in with Linnaeus and fell into the icy waters of a small single of Amsterdam. Justice concluded that it was a stupid accident\*, but during the rest of his life

Linnaeus repeated constantly his deep grief, which in fact allowed him to be the sole author of the magistral *Systema Naturae*.

\*Interesting reading: PIETSCH Théodore 2010: *The curious death of Pierre Artedi*. Scott and Nix Eds. London. 222p. ISBN: 978 – 0 – 9825102 – 8 – 5.

## **10. The relative scarcity of fossil Scyliorhiniformes taxa in the Belgian strata**

The huge majority of the living Genera of the, formerly called, Order Scyliorhiniformes lives in depths which are not compatible with the sedimentologic conditions of the totality of the Belgian Mesozoic and Cenozoic geological strata, which never surpassed a depth of some fifty to sixty meters.

It is for this reason that only some species of the three following Genera: *Pteroscyllium* CAPPETTA, 1980, *Megascyliorhinus* CAPPETTA & WARD, 1977, *Premontreia* CAPPETTA, 1992 and *Scyliorhinus* de BLAINVILLE, 1816, , 1906 were discovered in the Belgian marine deposits.

In the Lower Oligocene of Belgium, one extremely rare species of the Genus *Parmaturus* GARMAN, 1906 was discovered in the Ruisbroek Sands Formation.

## **11. Frequencies of the fossil Scyliorhiniformes teeth in these Belgian strata**

The taxa living in tropical to temperate coastal waters are, of course, represented by thousands of teeth in all the Belgian recent\* private Collections. In proportion\*\*, their teeth represent 2% to 4% of the collected teeth from the different Cretaceous Belgian strata, 3% to 4% of the collected teeth from the Paleocene\*\*\* Belgian strata, 4% to 5% of the collected teeth from the Eocene strata, only 0.01% of the collected teeth from the Oligocene strata, 1% to 1.5% of the collected teeth from the Miocene strata and 1.5% to 2% of the collected teeth from the Pliocene strata.

\*Posterior to 1969, year of the introduction of the use of sifts with meshes inferior to 2.5 millimeters. The first collector to use one sift with 0.8mm mesh was Michel Crochard, one of the first collaborators of the Belgian Geological Survey. He was surprised by his discoveries, as well as the senior-author.

\*\*Percentages concerning their frequency in comparison with the other Neoselachii taxa. The Batoidei teeth do not enter in count in these data.

\*\*\* A short isolation of the Belgian Basin, during the Lower Paleocene (Sands of Orp-le-Grand Formation), induced a complete lack of Scyliorhiniformes. This could mean that none of their populations had already adapted to living in relatively cool waters.

The two Belgian North Sea living species of the Family Scyliorhinidae, *Scyliorhinus canicula* (LINNAEUS, 1758) and *Scyliorhinus stellaris* (LINNAEUS, 1758) are the most abundant Elasmobranchii of the Belgian coast. Sampling of different Holocene strata demonstrate that they represent 100% of the Scyliorhiniformes teeth.

## **12. Geological explanations for the palaeodistribution of some Elasmobranchii taxa**

### **12.1. Convictions of the senior-author**

Convictions are, of course, non-objective considerations, but if their possible origins are repetitively observed, these convictions may help to propose new audacious conceptions, completely different from the ancient slow and long intraspecific transforming evolutionary process.

The Chondrichthyes are the unique group of marine vertebrates presenting three reproduction modes, the most primitive: the oviparity step, the intermediary: ovoviviparity and the most evolved: aplacental viviparity.

The vascularisation types of the root of the living and fossil species of the Scyliorhiniformes present two clear types, a pronounced hemiaulacorhizy and an evident secondary anaulacorhizy, but also different steps and modalities between these two extremes, which posed problems to the simplest conception of the four basic steps well defined:

anaulacorhizy, hemiaulacorhizy, holaulacorhizy and secondary anaulacorhizy. This last structure is characterized by the presence of one single small foramen on the top of the medio-intern root protuberance.

The dental root of the different living and fossil species of the Family Scyliorhinidae presents a very large range of possible transitions between pure holaulacorhizy and a definitely well formed secondary anaulacorhizy, which suggests the intervention of external factors.

The senior-author is convinced that the passage between these steps is, in both cases, the consequence of a deep genetic perturbation of worldwide significance, consequence of an intense biospheric change which implies a long time effect of a terrestrial magnetic field inversion.

This suggestion is corroborated by diverse geological data confirming the chronological succession of these three reproduction steps.

Ovoviviparous taxa appeared at different places in the Oceans but did not suppress the survival of oviparous taxa. And when aplacental viviparous taxa appeared at different places and depths in the Oceans, other taxa remained oviparous or ovoviviparous.

The apparition of populations sufficiently dense, and eventually diversified, correspond with different major plates tectonic events. These events offer new colonisation areas such as the Red Sea or the Sea of Cortez, immediately colonised by some populations of the geographically proximate species. Such phenomena do not request a terrestrial magnetic field inversion.

## 12.2. Generalities

The Parasystematic Revision, proposed and electronically published in 2012\* allows to suggest that it was the formation\*\* of the Andes which was responsible for the beginning of the separation of, at least, one small population of *Heterodontus* from the multiple other *Heterodontus* Indo-Pacific populations (species).

\* See Bibliography : HERMAN & VAN WAES, 2012: *Géominpal Belgica* 1 (revised), The tetralogy *Géominpal Belgica* 2, *Géominpal Belgica* 2 (Supplement), *Géominpal Belgica* 2 (End), *Géominpal Belgica* 2 (Erratum), *Géominpal Belgica* 3.

\*\*Sufficiently developed at the beginning of the Lower Cretaceous (approximately 79 million years ago).

This isolated population evolved separately during a sufficient time to form a distinct Oligocene species: *Heterodontus janefirdae* CASE, 1970.

The only logical suggestible explanation for the presence of one very scarce population of this species in the Belgian Lower Oligocene strata is that it has used a branch of the Gulf Stream.

It seems that the same geological event could be responsible for the existence of one living species of the Genus *Parmaturus* GARMAN, 1906: *Parmaturus campechiensis* SPRINGER, 1979, in the central deepest part of the Gulf of Mexico.

This species has an ancestor in the Belgian Lower Oligocene strata: *Parmaturus steurbauti* HOVESTADT & EULER-HOVESTADT, 1995, which is as scarce as *Heterodontus janefirdae* CASE, 1970.

Once more, the only logical suggestible explanation for the presence of one very scarce population of this species in the Belgian Lower Oligocene strata is that it has utilised a branch of the Gulf Stream.

It seems that the same phenomenon has also introduced in the western European Oligocene to Pliocene one *Pristiophorus* species: *Pristiophorus rupeliensis* STEURBAUT & HERMAN, 1978.

This species is extremely rare in the Belgian Lower Oligocene deposits, but proliferates exponentially during the Miocene period in the Breda Formation at Liessel (Province of Noord Brabant, NL).

It seems that the same geological event has also isolated one population of the Genus *Pristiophorus* MÜLLER & HENLE, 1837, one population of the Genus *Heterodontus* de BLAINVILLE, 1816 and one population of the Genus *Hexanchus* RAFINESQUE, 1810 from their relatives of the Indo-Pacific Ocean. These three Genera have all one living species in the Caribbean Sea or along the Bahamas Islands.

## 13. Cappetta's comments

### 13.1. Cappetta's 2006 comments concerning the fossil Scyliorhinidae taxa

Cappetta 2006 (p.: 404) added the 19 following fossil Genera: *Bavariscyllium* THIES 2005, *Casieria* NOUBHANI & CAPETTA 1997, *Cretascyliorhinus* UNDERWOOD & MITCHELL 1999, *Eypea* UNDERWOOD & WARD 2004, *Foumtizia*\* NOUBHANI & CAPETTA 1997, *Megascyliorhinus* CAPETTA & WARD 1977, *Microscyliorhinus* CASE 1994, *Palaeoscyllium* WAGNER 1857, *Parasymbolus* CANDONI 1993, *Porodermoides* NOUBHANI & CAPETTA 1997, *Pachyscyllium* REINCKE, MOTHS, GRANT & BREITKREUZ 2005, *Platyrhizoscyllium* ADNET 2000, *Premontreia* (Sub-Genera: *Premontreia* and *Oxyscyllium*) CAPETTA 1992, *Protoscyliorhinus* HERMAN 1977, *Pseudoscyliorhinus* MÜLLER & DIEDRICH 1991, *Pteroscyllium* CAPETTA 1980, *Scylliodus* AGASSIZ 1843, *Stenoscyllium* NOUBHANI & CAPETTA 1997 and *Thyellina* MÜNSTER in AGASSIZ 1843.

\*The Genus *Foumtizia* NOUBHANI & CAPETTA 1997 is no more considered as one Scyliorhinidae and was incorporated in the Family Triakidae GRAY, 1851 (See Bibliography: HERMAN & VAN WAES 2012, p.: 29).

*Bavariscyllium* THIES 2005: The type and unique species of this Genus is *Bavariscyllium tischlingeri* THIES 2005, based on one skeleton discovered in the Malm deposits of Bayern (D).

*Palaeoscyllium* WAGNER 1857: The type species of this Genus is *Palaeoscyllium formosum* WAGNER 1857, based on one skeleton. It was considered as an Orectolobiformes by Cappetta in 1987, but reconsidered, by himself, as a Scyliorhinidae in 2006. This skeleton was discovered in the Lower Jurassic of Bayern (D).

This Genus had a larger distribution and comprises three other species: *P. octevillensis* CANDONI 1993 (F), *P. reticularis* UNDERWOOD & MITCHELL 1999 (GB) and *P. tenuidens* UNDERWOOD & WARD 2004 (GB).

*Parasymbolus* CANDONI 1993: The type species of this Genus is *Parasymbolus octevillensis* CANDONI 1993 from the Kimmeridgian of the Seine-Maritime (F).

Cappetta (2006, p.: 352) admits that this Genus must be considered as synonymous of *Palaeoscyllium* WAGNER 1857, respecting the advice of LEIDNER & THIES 1999, UNDERWOOD 2000 and KRIWET & KLUG 2004.

*Pachyscyllium* REINCKE, MOTHS, GRANT & BREITKREUZ 2005: Is based on isolated teeth of *Pachyscyllium albigensis* REINCKE, MOTHS, GRANT & BREITKREUZ 2005, discovered in the Chattium of Northern Germany (D).

This taxon is, without explanations, considered as a junior synonym of *Premontreia* by CAPETTA 2012.

*Platyrhizoscyllium* ADNET 2005: Is based on isolated teeth of *Platyrhizoscyllium jaegeri* ADNET 2000 discovered in the Lutetian (Angoumé) of Aquitaine (F). Comment and sentence: *Thèse non publiée*\*: *Nomen nudum* (Cappetta, 2006: p. : 355).

\*This argument is logical, because intern document, not purchasable or electronically consultable by other scientists. See Remarks preceding Bibliography.

*Platyrhizoscyllium* ADNET 2006: finally accepted by Cappetta because published in a scientific review.

*Pseudoscyliorhinus* MÜLLER & DIEDRICH 1991: is based on isolated teeth of *Pseudoscyliorhinus schwarzhansi* MÜLLER & DIEDRICH 1991 discovered in the Cenomanian of northern Germany (D) is also, without explanations, considered as a synonym of *Scyliorhinus*.

*Scylliodus* AGASSIZ, 1843: *Scylliodus antiquus* AGASSIZ, 1843, based on one skeleton discovered in the Turonian of Kent (GB) is considered as a synonym of the living Genus *Scyliorhinus* de BLAINVILLE 1816.

*Thyellina* MÜNSTER in AGASSIZ 1843: *Thyellina angusta* MÜNSTER in AGASSIZ 1843 is based on one skeleton, discovered in the Campanian of northern Germany (D) is, also, considered as a synonym of the living Genus *Scyliorhinus* de BLAINVILLE 1816.

It was said that one of the last problems was to find the correct systematic re-insertion of the Family Triænodonidae HERMAN & VAN DEN EECKHAUT, 2010. It seems that this problem is resolved. This Family may be considered as the basal taxon of a new Order: the Order Triænodoniformes.

### **13.2. Cappetta's 2012 comments concerning the fossil Scyliorhinidae taxa**

Except the wonderful quality of the illustrations of this reviewed and enlarged edition of 1987, this huge work causes, in fact, more confusions than it offers precious indications.

The author regroups all the living and fossil species of the Carcharhiniformes (*sensu stricto*) and all the former living and fossil species of the former Family Scyliorhinidae in the same Order he persists on calling Order Carcharhiniformes COMPAGNO, 1973, based on the Genus *Carcharhinus* de BLAINVILLE, 1816.

All the anterior and posterior cutting edges of the teeth of the living or fossil taxa of the Carcharhiniformes (*sensu stricto*) are serrulated. This ornamentation is their principal odontologic characteristic, never present on any teeth of the five new Orders here proposed.

According to Compagno's 1988 opinions, Cappetta suggested in 2012, without dental argumentation, that, considering the narrow phyletic relations existing between the following taxa: *All the species of the three living Genera Aulohalaelurus, Atelomyxerus and Schroederichthys could be regrouped in one sub-Family, all the species of the three Genera Scyliorhinus (Upper Cretaceous to Recent), Premontreia (fossil), Megascyliorhinus (fossil), could be regrouped in one other sub-Family and all the species of the three living Genera Holohalaelurus, Halaelurus and Galeus could be regrouped in one third sub-Family.*

These suggestions may be partially, corroborated by the re-examination of recent and fossil materials (a detailed list is furnished in another paragraph).

### **13.3. Cappetta's conclusions concerning the living and fossil taxa**

Following Cappetta 2006, the living Genus *Scyliorhinus* exists since the Campanian. Some complete or nearly complete skeletons\* are, without explanation, considered as skeletons of the living Genus *Scyliorhinus* de BLAINVILLE 1816.

The Genus *Scyliorhinus* is definitely the most polymorphic Genus known. But it remains possible, with some isolated teeth, to distinct 18 other fossil Genera. It is logical that such affirmation leaves biologists very suspicious.

\*Which is the case for the three Genera: *Thyellina* MÜNSTER in AGASSIZ 1843, *Palaeoscyllium* WAGNER 1857 and *Bavariscyllum* THIES 2005.

Even in possession of one fossil skeleton, it remains difficult to be sure if this skeleton is one of a juvenile or one of an adult. Another problem is that the ontogeny of one skeleton may be very complex.

In Belgium, only the teeth of the five following Genera: *Protoscyliorhinus* (in the Upper Cretaceous: Turonian-Coniacian), *Pteroscyllium* (in the Upper Cretaceous: in the Campanian), *Premontreia* (in the Ypresian and the Lutetian), *Megascyliorhinus* (in three different Eocene Formations\*), *Parmaturus* (in the Lower Oligocene) and *Scyliorhinus* (in the Pliocene) were, presently discovered, described or mentioned.

\*Discoveries not yet published.

## **14. Super Order Scyliomorphii nov. Sup. Ord.**

### **14.1. Taxonomic subdivisions of the Scyliorhinomorphii nov. Sup. Ord**

## 14.2. Generalities

The different living species of the Family Scyliorhinidae, with over 150 known species, are generally called *cat-sharks*. Scyliorhinidae occur in temperate and tropical seas worldwide, ranging from very shallow intertidal waters to depths of 2000 meters or more, depending on the species.

## 14.3. Additional data

Marinus Boeseman (R.M.N.H. Leiden – NL) gave me the possibility to consult the original diaries of Max Karl Wilhelm Weber, and most interesting for a palaeontologist, the diary of his wife: Anna Weber-van Bosse concerning the Algae she had collected.

The data consigned in these diaries concerning the Vertebrata collected on the same sea bottom where one new Scyliorhinidae was discovered, detailed very precisely the possible food resources of *Apristurus sibogae* WEBER, 1913.

## 14.4. Recent material examined

After the redaction of the publication concerning the odontology of the living Scyliorhinidae (See Bibliography: HERMAN, HOVESTADT & EULER- HOVESTADT, 1990), the senior-author had the possibility to examine additional jaws or eggs of the following species:

*Apristurus kempae*: 14 jaws (8 males, 6 females) and 3 eggs, *Apristurus atlanticus*: 13 jaws (9 females, 4 males) and 2 eggs, *Atelomycterus marmoratus*: 6 jaws (4 males, 2 females) and 3 eggs, *Aulohalaelurus labiosus*: 5 jaws (4 females, 1 male) and 2 eggs, *Cephaloscyllium isabellum*: 2 jaws (2 females) and 4 eggs, *Galeus arae*: 6 jaws (4 females, 2 males) and 2 eggs, *Galeus murinus*: 8 jaws (4 males, 4 females) and 2 eggs, *Halaelurus boesemani*: 4 jaws (2 females, 2 males) and 2 eggs, *Haploblepharus edwardsii*: 6 jaws (4 females, 2 males) and 1 egg, *Haploblepharus pictus* 3 jaws (3 females) and 2 eggs, *Holohalaelurus buergeri*: 4 jaws (4 males), *Parmaturus xaniurus*: 1 jaw (1 male), *Pentanchus profundicolus*: 4 jaws (2 females, 2 males), *Poroderma pantherinum*: 8 jaws (5 females, 3 males) and 6 eggs, *Schroederichthys bivius*: 2 jaws (2 females) and 3 eggs, *Scyliorhinus canicula*: 92 jaws (56 females, 36 males) and 24 eggs, *Scyliorhinus retifer*: 6 jaws (4 females, 2 males) and 8 eggs, *Scyliorhinus stellaris*: 47 jaws (39 females, 8 males) and 19 eggs and *Scyliorhinus torazame*: 6 jaws (6 females) and 2 eggs.

The most significant result from these additional observations was surely the very high diversity of odontological morphotypes of *Scyliorhinus canicula* and *Scyliorhinus stellaris*.

If medium sized, jaws isolated from the body of its owner are quite impossible to be distinguished at the specific rank.

## 14.5. Fossil material examined from Belgium

All together, the following private Collections : Collection Luc Anthonis, Collection Marc Bejaer, Collection Jacques Boel, Collection Pieter De Schutter, Collection Bert Gijzen, Collection Guy Van Den Eeckhaut, Collection Eric Vanderhoeft, Collection Eric Wille and Collection Didier Winderickx allowed the senior authors the incredible possibility to examine some more than 21.000 isolated teeth of the different fossil taxa of the Scyliorhiniformes.

### These teeth have also a very diversified stratigraphic origin

#### Cretaceous material

The following Cretaceous Formations and localities have yielded (1968-2012) more than 5000 isolated teeth of Scyliorhinidae: Lower Turonian from Autrepes, Chercq and Roisin, Coniacian from Maisières, Santonian from Lonze, Lower Campanian from Obourg and Trivières, Upper Campanian from Obourg, Lower Maastrichtian from Orp-le-Grand, Upper Maastrichtian from Orp-le-Grand, Obourg, Lixhe and Eben Emael.

#### Tertiary material

The following Tertiary Formations and localities have yielded (1969-2012) more than 16.000 isolated teeth of Scyliorhinidae:

#### PALEOCENE

Tuffeau Formation and Vroenhoven Tuffeau Formation (Danian), Orp-le-Grand Sands Formation and Lincent Tuffeau Formation (Seelandian), Dormaal Sands Formation (Thanethian).

#### EOCENE

Ypresian: Kortemark Silt Formation, Kortemark Silt Formation, Egem Clay Formation, Panisel Sands Formation and Forest Sands Formation. Lutetian: Brussels Sands Formation and Lede Sands Formation. Bartonian: Wemmel Sands Formation and Asse Clay Formation.

#### OLIGOCENE

Rupelian: Kerniel Sands Formation, Berg Sands Formation, Sint Niklaas Phosphorite Bed and Boom Clay Formation.

#### MIOCENE

Edegem Sands Formation, Kiel Sands Formation, Deurne Sands Formation and Antwerp Sands Formation.

#### PLIOCENE

Lower part of the Sands of Kattendijk Formation, Upper part of the Sands of Kattendijk Formation, Oorderen Sands Formation and Merksem Sands Formation.

### **14.6. Comparative fossil material examined from other Countries**

#### **Germany**

Thanks to our German friends: Christof and Rudolf Halter, materials from the Upper Campanian and the Lower Maastrichtian from North West Germany.

#### **Denmark**

Thanks to our Danish friends: Thomas Blüma and Niels Bunde, material from the Mö Clay Formation (deep water, Ypresian).

#### **The Netherlands**

Thanks to our Dutch friend: John Jagt, materials from the Lower Maastrichtian and Upper Maastrichtian Formations of the Sint Pieter Berg Quarries.

#### **England**

Thanks to our English and Welsh friends: Alison and David Ward, Jerry Hooker and Chris Duffin, Upper Jurassic Formations from southern England, Middle and Upper Cretaceous Formations from southern England and Paleocene to Middle Eocene Formations from southern England.

#### **France**

Thanks to our French friends: Jean-Piere Biddle, Jean-Paul Baut, Luc Candoni, Didier Dutheil, Bertrand Génault, Serge Guenegues and Jean-Loup Welcomme: Upper Jurassic Formations, Upper Cretaceous Formations and Paleocene to

Middle Oligocene Formations from the Paris Basin. Eocene Formations from the Landes and Miocene Formations from Montpellier areas.

### **Morocco**

The Upper Cretaceous to Lower Eocene materials collected by Georges Wouters, Michel Girardot, Nadine Delcroix and the senior-author in the years 1970 to 1974. Which means more than 6.000 teeth of Scyliorhinidae of shallow waters.

### **Tunisia**

The Eocene material collected by our B.G.S. colleague Dr. Henri Neybergh in the Upper Eocene strata from South Tunisia. This represents more than 1.500 teeth of Scyliorhinidae of coastal and continental slopes waters.

### **Senegal**

The material collected, in 1984, by J-P. Prian (B.R.G.M., France) in the Eocene to Miocene strata, for phosphate prospection, offered, after sifting and sorting, to the University of Montpellier II, with all the S.E.M. pictures realised in Belgium. It was a little lot of about 150 teeth of Scyliorhinidae of coastal and continental slopes waters.

### **Cabinda**

All the material of the Collections Darteville and Casier stored in the M.R.A.C. (Tervuren, Belgium). See its inventory in Darteville and Casier Publications. (Bibliography: DARTEVELLE & CASIER, 1943, DARTEVELLE & CASIER, 1953 and DARTEVELLE & CASIER, 1959).

### **U.S.A.**

Thanks to G. Case (Florida, U.S.A.) and R. Smith (Brussels, Belgium): Material from Eocene to Miocene Formations from the Atlantic coasts and material from the Miocene of California.

### **Russian Federation**

Thanks to Dr. Zelezko: Material from Paleocene to Oligocene Formations from central Asia.

## **14.7. Odontological criteria added to the oviparity and the lack of dorsal fin spines to justify this new conception**

A palaeontologist cannot detect the existence of one *neurocranial crista* on the base of isolated teeth. The last suggestions to establish a new Parasystematic classification for the other Order taxa were electronically published in the beginning of 2012\*

\*See the Bibliography: HERMAN & VAN WAES, 2012, HERMAN & VAN WAES, 2012 (Supplement), HERMAN & VAN WAES, 2012 (End) and HERMAN & VAN WAES, 2012 (Erratum).

Such as demonstrated in this Tetralogy, normally, five important odontological criteria must be detected to justify this revision.

## **15. Order Scyliorhiniformes nov Ord.**

**Biological characteristics of this Order:** This new Order is based on the living Genus *Scyliorhinus* de BLAINVILLE, 1816. All the species of this Genus did not have any dorsal fin-spines. All the species of this Genus are oviparous.

**Odontological characteristics of this Order:** The base of the extern side of the dental crown overhangs the top of the crown-root junction. Their dental root always presents pronounced medio-intern reinforcement, presenting a very large central foramen. Their dental crown is composed by one distinct principal cuspid preceded by one poorly developed cuspid or flanked by one, or two pair(s) of lateral cuspids also relatively poorly developed. Their dental crown presents very discrete basal striations. Their dental root is hemiaulacorhizid, with a large central half groove and the intern side of the root presents numerous vascularisation's pores, regularly spaced.

Their odontological characteristics were described in detail and different elements of their dentition were illustrated with S.E.M. photographs in HERMAN, EULER-HOVESTADT & HOVESTADT, 1990: Plate 31 to Plate 36.

These two biological criteria, are undetectable on isolated fossil teeth, but the absence of dorsal fin spines is evident on skeletons and the nine odontological criteria added are more data than requested following our simplified cladographic method.

## **Families and Genera included in this new Order**

### **Family Palaeoscylliidae nov. Fam.**

This Family is proposed to regroup, according to their publication date, the ten following fossil Genera: Genus *Palaeoscyllium* WAGNER, 1857, Genus *Microscyliorhinus* CASE, 1964, Genus *Protoscyliorhinus* HERMAN, 1977, Genus *Pseudoscyliorhinus* MÜLLER & DIEDRICH, 1991, Genus *Casieria* NOUBAHNI & CAPPETTA, 1997, Genus *Stenoscyllium* NOUBAHNI & CAPPETTA, 1997 Genus *Cretascyliorhinus* UNDERWOOD & MITCHELL, 1999, Genus *Eypea* UNDERWOOD & WARD, 2004, Genus *Bavariscyllum* THIES, 2005 and Genus *Platyrhizoscyllium* ADNET, 2005. All these taxa were sufficiently argued to be admitted without critical comments.

### **Family Scyliorhinidae de BLAINVILLE, 1816**

This Family is proposed to add, according to their publication date, the three following fossil Genera to the nineteen living Genera, already enumerated and re-examined: Genus *Megascyliorhinus* CAPPETTA & WARD, 1977, Genus *Premontreia* CAPPETTA, 1992 and Genus *Porodermoides* CAPPETTA, 1997. These three taxa were sufficiently argued to be admitted without critical comments.

The diverse populations known of the Genus *Megascyliorhinus* seem to have been inhabitants of the Anglo-French-Belgian Basin during the lower to the upper part of the Ypresian. They represented a population of Scyliorhinidae having, apparently, a restricted distribution zone. Recent information seems to demonstrate that this taxon was also represented by eastern Eocene populations.

The diverse populations of the different species of the Genus *Premontreia* seem to have been Paleocene-Eocene derived populations from the central European to northern African populations of one of its different Genera (maybe the Genus *Poroderma*\*) of the Family Scyliorhinidae, already existing. Both populations were coastal to continental shelf inhabitants.

It is the same case for the Genus *Porodermoides*\*

\*The Genus *Poroderma* is not yet mentioned as fossil taxon, but it is interesting to point out that it was represented by ancestral populations since the Thanetian in North Africa and since the Ypresian in the Anglo-French-Belgian Basin.

## **16. Order Atelomycteriformes nov. Ord.**

**Biological characteristics of this Order:** This new Order is based on the living Genus *Atelomycterus* GARMAN, 1913. All the species of this Genus did not have any dorsal fin-spines. All the species of this Genus are oviparous.

**Odontological characteristics of this Order:** Their odontological characteristics were described in detail and different elements of their dentition were illustrated with S.E.M. photographs in HERMAN, EULER-HOVESTADT & HOVESTADT, 1990: Plates 7 and 8.

These two biological criteria, are undetectable on isolated fossil teeth, but the absence of dorsal fin spines is evident on skeletons, but nine odontological criteria, more than requested following our simplified cladographic method, are present.

This new Order comprises, momentarily only one new Family: the Family Atelomycteridae regrouping the nine other living Genera of the Family Scyliorhinidae. The Family Atelomycteridae should certainly be divided into two distinct Families.

Diverse evolutive considerations concerning this last Family, apparently without fossil taxa, will be more deeply investigated later.

## **17. Order Halaeluriformes nov. Ord.**

**Biological characteristics of this Order:** This new Order is based on the living Genus *Holohalaelurus* (FOWLER, 1934). All the species of this Genus did not have any dorsal fin-spines. All the species of this Genus are oviparous.

**Odontological characteristics of this Order:** Their odontological characteristics were described in detail and different elements of their dentition were illustrated with S.E.M. photographs in HERMAN, EULER-HOVESTADT & HOVESTADT, 1990: Plate 23 to Plate 25.

These two biological criteria, are undetectable on isolated fossil teeth, but the absence of dorsal fin spines is evident on skeletons. The seven odontological criteria present are more data than the requested criteria following our simplified cladographic method.

### **Families and Genera included in this new Order**

This new Order comprises only one Family: the Family Holohalaeluridae, with three Genera: the Genus *Halaelurus* GILL, 1862, the Genus *Holohalaelurus* FOWLER, 1934 and the Genus *Galeus* CUVIER, 1816.

This Family represents a long succession of different populations suddenly affected by deep genetic perturbations, to finally finish producing complete asymmetric teeth (the different populations of the Genus *Galeus*).

## **18. Order Pentanchiformes nov. Ord.**

### **Family Pentanchidae nov. Fam.**

#### **Genus *Pentanchus* SMITH & RADCLIFFE, 1912**

#### ***Pentanchus profundicolus* SMITH & RADCLIFFE, 1912**

This new Order is based on the living Genus *Pentanchus* SMITH & RADCLIFFE, 1912 and its unique species *Pentanchus profundicolus*. Teeth of *Pentanchus profundicolus* were never described in detail.

### **Fossil Genra included in this new Order**

This new Order has no fossil record (December 2012).

## **19. Order Triaenodoniformes nov. Ord.**

### **19.1. Generalities**

This new Order is proposed for another anatomically and odontologically isolated taxon, comprising only one Family: the Family *Triaenodonidae*, with two Genera. One Genus is worldwide distributed (*Triaenodon* MÜLLER & HENLE, 1837) and a second one (*Cephalurus* BIGELOW & SCHROEDER, 1944) occupying, apparently, a minuscule territorium off the coasts of one little Island of the Philippines Archipelago.

## 19.2. Family *Triaenodonidae* HERMAN & VAN DEN EECKHAUT, 2010

### Genus *Triaenodon* MÜLLER & HENLE, 1837

#### Genus *Triaenodon* (RÜPPEL, 1837)

This Genus is represented by the multiple populations of one living species: *Triaenodon obesus* RÜPPEL, 1837 and the Anglo-French-Belgian populations of one species, recently identified\* as *Triaenodon willei* HERMAN & VAN DEN EECKHAUT, 2010.

\*In fact, one of our field collaborators, Jean-Pierre Luypaerts, believed, since the summer 1983, that some little teeth he discovered in one shelly lens in the Sands of Brussels at Neder-Okkerzeel (Flemish Brabant, Belgium) represented one unknown taxon.

#### *Triaenodon obesus* RÜPPEL, 1837

*Triaenodon obesus*, commonly called the *coral shark* is in possession of teeth with dental crown without serrulation, with one principal cuspid and one pair of lateral flat, triangular and divergent cusplets.

Its record size is 168 centimeters\* of total length. Its reproduction mode is viviparity. Its depth range is comprised between rising coral patches to 40 and meters depth.

\*Information received from Dr. Philippe Van Win, a Belgian Doctor with Medecine-without-boundaries, a friend whose last work station was the French Vanuatu Island. Just before his unexplained disappearance, he was collecting information and jaws of the Chondrichthyan fishes of this region. He sent many of these jaws to the senior-author, with very precise indications concerning the places where the animals were caught.

### Genus *Cephalurus* BIGELOW & SCHROEDER, 1944

This Genus is represented by a, very poorly known, population of the species *Cephalurus cephalus* (GILBERT, 1892). Its odontological characteristics are very similar to these of the teeth of both fossil and recent species of the Genus *Triaenodon*.

The senior-author considers that the small and scarce population of *Cephalurus cephalus* has for ancestor one proximate population of *Triaenodon* which has been deeply affected in its genetic patrimonium. It was surely an important geochemical event which was responsible for the quick migration from corallian coastal zones to abyssal plains.

The quite completely disappeared dermal denticles protection of the *lollipop-shark* reminds us of the fact that *Triaenodon obesus* is also called the *smooth-shark* and that this phenomenon is an additional argument in favour of their direct filiation.

Teeth of *Triaenodon obesus* are illustrated with S.E.M. pictures (See Bibliography: HERMAN, EULER-HOVESTADT, 1988). Some teeth of *Cephalurus cephalus* are illustrated with S.E.M. pictures (See Bibliography: HERMAN, EULER-HOVESTADT, 1990: Plate 13 to Plate 16) and the dentition of *Triaenodon willei* is illustrated with S.E.M. pictures (See Bibliography: HERMAN & VAN DEN EECKHAUT, 2010: Plate 58, fig.: 1-3 and Plate 59, fig.: 1-4).

## 19.3. Data discovered in diverse readings

Despite the huge distribution area of the Genus *Triaenodon*, its diverse populations seem to be very homogenous. Their distribution area covers the entire Indo-Pacific region. In the Indian Ocean, it occurs from northern Natal (South

Africa) to the Red Sea and the Indian subcontinent, including Madagascar, Mauritius Island, the Comores Islands, the Aldabra Islands, the Seychelles Islands, the coasts of Sri-Lanka and the Chagos Archipelago.

In the western and central Pacific, it is present along the coasts of southern China, along the coasts of Taiwan, along the coasts of the Ryukyu Islands, along the coasts of the Philippines Islands, along the coasts of southern Asia and Indonesia, around the coasts of numerous islands and inlets of Melanesia, Micronesia and Polynesia, as far as Hawaii in the North and the Pitcairn Islands in the southeast.

In the eastern Pacific, it occurs along the coasts of Costa Rica to the coasts of Panama and the coasts of the Galapagos Islands.

Associated, almost exclusively, with coral reef habitats, the diverse populations of this species are most often encountered around coral heads and ledges with high vertical relief, and additionally over sandy flats, in lagoons, and near drop-offs to deeper water.

It prefers very clear waters and rarely swims far from the bottom. On certain occasions, it may enter water less than a meter deep. An exceptional record signalises the catch of one specimen at a depth of 330 meters off of one of the Ryukyu Islands. (See Bibliography: RÜPPEL, 1837, COMPAGNO, 1984, HERMAN & VAN DEN EECKHAUT, 2010, MÜLLER & HENLE, 1837).

#### **19.4. Remarks concerning the Genus *Triaenodon***

The quite complete Indo-Pacific distribution of its populations made this Genus a potential source for many other taxa having more restricted distribution zones.

The most interesting deduction from its dental histology and ornamentation made it the favourite candidate for the paternity of the *lollipop cat-shark*, scientifically named *Cephalurus cephalus*.

#### **19.5. Other paleontologists' opinion concerning the Family Scyliorhinidae and Carcharhinidae**

Most important data concerning the fossil taxa of these two Families were furnished by the following colleagues: Henri Cappetta, Detlev Thies and David Ward. The most largely diffused are these of Dr. Cappetta, author of the Handbook 1987 and its revised edition, the Handbook 2012, both edited by Dr. Fritz Pfeil Verlag. München (Bavaria, Deutschland).

The international importance accorded to these two publications oblige to examine, priorarily, the conclusions of its author, such as the comments concerning the validity of all the Post-Triadici Elasmobranchii, he published in 2006.

#### **19.6. General conclusions**

All the living Scyliorhinomorphii are oviparous and quite homodont. They possess no dorsal fin spines. Their neurocranium is relatively low, their vertebral column is extraordinarily supple. If their dermal protection is dense enough to be used as a sanding tool, it is called shagreen (*Chagrin* in French) to remind its rapid retraction\* when drying, but its elements are much less imbricated than those of the living Heterodontiformes or than those of the most primitive living Orectolobiformes (*Orectolobus*, *Sutorectus* and *Eucrossorhinus*), living Squatiniformes (*Squatina*) and living Pristiophoriformes (*Pristiophorus*).

\*The French writer, Honoré de Balzac, used this faculty as central *theme* for one of his best-sellers: *La peau de chagrin* published in 1831.

The cutting edges of the dental crown of all the living or fossil species they regroup never present serrulation.

All the fossil skeletons attributed to the Scyliorhiniformes present dorsal fin prints without dorsal fin spines. Only the oviparity mode of reproduction remains hypothetical.

The Scyliorhinomorphii may be considered as cousins of the earliest Heterodontomorphii, because both remained at the most primitive reproduction stage: oviparity.

The most primitive living Orectolobiformes all attained the ovoviviparity stage. It remains, of course, impossible to precise when their ancestors passed from the oviparity stage to the ovoviviparity stage.

The Family Scyliorhinidae *sensu* Gill in 1862 included 17 living Genera and Sub-Genera and more than 150 species, making it the largest Family of sharks.

Cat-sharks may be distinguished by their elongated cat-like eyes and two small dorsal fins set far back. Most species are fairly small, growing no longer than 80 cm.

Some, such as *Scyliorhinus stellaris* can reach 160 cm in length. Most of the species have a patterned appearance, ranging from stripes to patches to spots. They feed on invertebrates and smaller fish.

The new Super-Order Scyliorhinomorphii here proposed may be subdivided, such as suggested in 1990\* (p. 192) into five Orders: the Order Scyliorhiniformes (based on the living Genus *Scyliorhinus*), the Order Atelomycteriformes (based on the living Genus *Atelomycterus*), the Order Holohalaeluriformes (based on the Genus *Holohalaelurus*), the Order Cephaluriformes (based on the Genus *Cephalurus*) and the Order Pentanchiformes (based on the living Genus *Pentanchus*).

\*See Bibliography: HERMAN, EULER-HOVESTADT & HOVESTADT, 1999.

## 20. Reconstitution of the Natural History of the Scyliorhinomorphii

Central Europe seems to be the cradle of the *Scyliorhinidae*. They will continue to progress in the northern, southern and eastern direction, invading successively along the coasts the Indian Ocean, the occidental and central parts of the Pacific Ocean to the American Pacific coasts where they were stopped by the rising of the Andes.

Only one taxon of the Genus *Parmaturus* crossed the Andes via a strait in central America and returned, using the young Gulf Stream, to its cradle at the lower Oligocene. Its presence is ascertained by the discovery of some of its anterior teeth in the Lower Belgian Oligocene at Belsele (Eastern Flanders, Belgium).

To cross the totality of the Pacific Ocean they surely used the existing coasts of one submerged archipelago or one subsided continent.

Starting from central Europe, at the lower Jurassic, the Genus *Scyliorhinus* colonised progressively the totality of the equatorial to cold temperate waters of the planet and crossed the Andes just before their complete emersion.

The other Genera preferred (or were obliged ?) to colonise the continental slopes. Only one of these Genera, of which the majority of the living species are bathyal, abyssal or hadal, the Genus *Parmaturus* succeeded in threading its way through a submarine canyon\*, to cross the Andes just before their complete emersion and to reach western Europe (Belgium) at the lower Oligocene: *Parmaturus steurbauti*.

\*Canyon resulting from one of the transversal faults affecting the Andes in their central American parts.

The Natural History of the Family Heterodontidae, with *Heterodontus janefirdae* CASE, 1980, the Natural History of the Family Pristiophoridae, with *Pristiophorus rupeliensis* STEURBAUT & HERMAN, 1978 and the Natural History of two Hexanchiformes (one *Hexanchus* and one *Heptranchias*) were practically\* the same.

\*With some differences explained just below.

1°. The Genus *Pristiophorus* has longer survived in the European waters. Its rostral teeth are the most common vertebrate remains in the sands of the Breda Formation (Liessel, Province of Brabant, The Netherlands).

Rostral teeth are also found in the lower part of the Kattendijck Sands Formation (Lower Pliocene at Kallo, Verrebroek and Doel, Eastern Flanders, Belgium)

2°. The most primitive eggs of the living species of the Scyliorhinidae seem to be those of *Cephalloscyllium laticeps* (DUMERIL, 1853), which are the only to have transversal folds (winklins).

These provide a supplementary surface for oxygenation but they hamper the stabilisation of its eggs.

These are simplified remains\* of the external expansions of the spiral *Heterodontus* eggs, which are of uncertain physiological utility.

\*Such as the human appendix.

These external structures increase considerably the surface destined to the capture of the dispersed oxygen molecules in marine waters requested for the oxygenation of the embryo enclosed in its egg.

These external structures are very efficient, but they are also very easily damageable and, consequently possible sources of serious bacterial infections directly transmissible to the embryo.

The biological solutions were the suppression of these potentially dangerous formations and the development of longitudinal wrinkles on the external walls of the eggs, compensating partly the decrease of the oxygenation, but increasing the time necessary for the maturation of the eggs.

3°. The ancestors of two fossil taxa of the Hexanchiformes have used one branch of the young lower Oligocene Gulf Stream to cross the North Atlantic Ocean: one *Hexanchus*, the ancestor of the living Bahamas species: *Hexanchus vitulus* SPRINGER & WALLER, 1969 and of one *Heptranchias* (*Heptranchias* sp.) from the Lower Belgian Oligocene also discovered at Belsele (Eastern Flanders, Belgium).

## **21. Additional reflexions concerning the Evolution of the Elasmobranchii**

### **Primitive biological characteristics**

#### **Five pairs of branchial arches**

After very long discussions, the possession of six or seven pairs of branchial arches, initially considered as a positive evolutionary trend, was contrarily but definitely considered as a kind of degeneration and the possession of five branchial arches recognised as the most primitive anatomical constitution for all the Chondrichthyan fishes.

The causes which are responsible for such successive degenerations were not identifiable without admitting important genetic modifications and the astrophysical origin of these genetic perturbations.

Consequently, the conservation of only five pairs of branchial arches is another argument to consider the Scyliorhinomorphii as primitive Elasmobranchii.

Numerous Genera of the Scyliorhinomorphii were repetitively confronted with these metronomic phenomena and have found only one solution: an adaptation to very deep environments ensuring an efficient protection against radioactive particles or highly ionised particles.

The degree of abnormalities of the morphology of their teeth allows to distinguish different steps ranging from a light dissymmetry in the number of their lateral cuspids to a complete dissymmetry and distortion of the dental crown.

#### **Oviparity**

Oviparity is the most primitive reproduction system, not only for the Chondrichthyes, but also the unique reproduction system for all the Osteichthyes, absolutely all the Reptilia and Aves, and the reproduction system for the most primitive Mammalia.

The Chondrichthyes are the unique group of marine vertebrates which will try ovoviviparity and aplacental viviparity successfully.

Orectolobomorphii, Heterodontomorphii and Holocephali are oviparous animals.

### **Possession of dorsal fin spines**

One pair of dorsal fin spines is a characteristic of all the living taxa of the Heterodontomorphii and all the living taxa of the Squalomorphii.

A sufficient number of fossil skeletons exists attesting the possession of dorsal fin spines to allow to suppose that all the valid fossil taxa of these two Super Orders were in the same case.

## **22. Mass extinction causes and unsuspected migration problems**

### **22.1. Possible causes of mass extinctions**

After 38 years of diversified reading and field observations, the senior author arrived to the conclusion that the eight following natural processes, still existing, may be responsible for vertebrates mass extinctions. They are enumerated according to the order in which they were discovered or foreseen.

-The fall of large meteorites, such as the Yucatan meteorite, at the Cretaceous-Tertiary boundary, explaining the final and sudden extinction of the last northern American dinosaurs, which seems definitively considered as a very localised phenomenon.

-Birth of hotspots, such as in northern India, explaining the final and sudden extinction of the last Indo-Asiatic dinosaurs, which seems presently to be considered as a dramatic phenomenon having affected the whole biosphere.

-Local huge Dinoflagellata proliferations, infecting some rivers and so causing regular, if not annual mass extinctions of marine vertebrates. This phenomenon was mentioned for the first time by J. L. B. Smith (See bibliography: SMITH, 1956) but not explained before the present suggestion.

-Carbon hydrates gas emanations, making normal life impossible in restricted Basins, such as the Mons Basin, indirectly suggested by André Delmer, formerly Director of the Belgian Geological Survey. He never published this but transmitted the idea, in 1974, to his young geologist Dr. Jacques Herman, as a possible orientation for his future paleontological research.

-Intense ionisation resulting from solar winds, suggested by Dr. Edgard Casier, formerly associated researcher of the Belgian Institute of Natural Sciences (See bibliography: CASIER, 1962).

-Intense irradiation of the totality, or local parts, of the Biosphere, pre-supposed by Dr. Professor Maurice Leriche of the Lille and Brussels Universities, when making, in 1905, a clear difference between variety and mutation affecting the diverse populations constituting one species.

-Tsunamis, resulting from phases of intense telluric activity, suggested by Guy Van Den Eeckhaut, free collaborator of the Belgian Geological Survey and the senior author as explanation for the mass extinctions discovered in the Middle Lutetian of Belgium (See Bibliography: HERMAN & VAN DEN EECKHAUT 2010).

-Typhoons, resulting from meteorological perturbations, suggestion here proposed for the vertebrate remains accumulations always including tree trunks and other heavy terrestrial material.

### **22.2. Unsuspected migration problems and possibilities**

#### **First supposition: The Wegener theory**

After the very poorly argued conception of the existence of two or three intercontinental bridges, it was Alfred Wegener who was the first to be astonished by the perfect imbrication of the north-eastern Brazilian coast in the African coast of the Gulf of Guinea. (See Bibliography: WEGENER, A. 1915 and WEGENER, A. 1920).

The only result of the proposal, in 1929, of his theory was that different scientific congresses were organised in Germany to ridicule him.

### **The Plate Tectonic theory is generalized and accepted.**

It was the discovery of the regular formations of couples of ridges parallel to the Middle-Atlantic Ridge, sustained by the regular frequency of the magnetic terrestrial field inversions, which confirmed this theory in the beginning of the 1960s.

### **The rising of the Mount Lebanon**

When the Mount Lebanon had emerged was, migration from the old Tethys, or the young Mediterranean Sea became impossible, before the human creation of the Suez Canal by the French ingenior Ferdinand Lesseps which always ignored this faunistic consequence.

He went to Central America to try to realise its second dream: the Canal of Panama that a little Diptera (a *mosquito*) will stop the intervention of American militaries.

### **The disappearance of the Nazca Archipelago is admitted**

Since the beginning of the 1990s, it becomes obvious that the isolated volcanic islands, such as the Pitcairn Islands, are the only remains of an important continent or, at least, of a very elongated Archipelago.

This lost Archipelago assured the migrations of coastal faunas from the extremity of Indonesia to the central eastern coast of America. (See Bibliography: BARAZANGI, ISACKS, TINKER, WALLACE, BECK, MYERS, PAPANIKOLAS, CAHILL & ISACKS, 1992 and JAMES, 1978).

## **23. Problems to resolve the colonisation of the lower parts of the continental slopes, the abyssal plains and the hadal areas**

### **23.1. Huge pressures: regular increase of the pressure**

After multiple bibliographic researches oriented in diverse disciplines, the senior author has never discovered any satisfying explanation concerning the anatomo-physical solutions that various fossil and living taxa have used to resolve this problem.

These taxa comprise all the Chlamydoselachiformes, different Genera of the Squaliformes, different Genera of the Scyliorhiniformes and different taxa of the Rajiformes.

More surprising, different species of Squaliformes are able to decompress nightly in a few hours to pass from 600 meters depth to surface waters.

The senior author is obliged to arrive to the same conclusions as these given for the huge pressures problems. But it remains the same fact: all the taxa of living Chlamydoselachiformes, different Genera of Squaliformes, different Genera of Scyliorhiniformes and different taxa of Rajiformes have also discovered solutions to resolve this second problem.

What is logical is that they were obliged to resolve simultaneously these three problems.

## 23.2. Scarcity of food: Different solutions

Production of constant, or sporadic, bioluminescent signals, constant or sporadic sending of micro vibrations and production of chemically attractive molecules are diverse possibilities to have a real chance that potential preys near these emission sources.

## 23.3. Bioluminescence

### Historical data

The most ancient mentions of this natural phenomenon are these of the mariners of the Queen Hatchepsout (dead *circa* 1458 B.C.). Coming home, after their long and regular expeditions to the Pount Country, they said that some nights the surface of the sea (the Red Sea) was like siver.

A little later, the Phenician mariners penetrating in the Atlantic Ocean also said that some nights the surface of the sea (the Atlantic Ocean) was like siver, particularly in the Madeira Islands.

Plinius the Ancient, in the first half part of the first century of our calendar, had also observed this phenomenon along the meriterranean coast of Italia.

Charles de la Condamine, this extraordinary French geographer, had also observed, during his seven years passed in Ecuador, that some nights, coastal bands of the Pacific Ocean were iridescent.

### Bioluminescence

One apparently efficient solution presenting an additional advantage was chosen by different species of Squaliformes sharks: bioluminescence. This additional advantage consists in scaring off a potential predator.

It is important to realize that two species of the same Genus (e.g. *Etmopterus spinax* and *Etmopterus princeps*) developed radically different solutions to scare off a potential predator.

*Etmopterus spinax* adopted bioluminescence, whereas *Etmopterus princeps* chose for the secretion of chemical repulsive substances.

This phenomenon seems not to have been observed before in sharks, except by some Brittany fishermen.

They signalled the existence of these different techniques to the senior author when he accompanied them on their fishing campaigns in order to collect a maximum of jaws of these uncommon fishes.

### Distribution

The majority of the marine light emissions belong to the light spectrum of blue and green, the wave lengths that can easily be transmitted through water. Very seldom some species emit in red or infrared.

Terrestrial bioluminescence is rarer but allows a greater variety of colours. The best known forms of terrestrial bioluminescence are the lampyres and the lucioles.

### Functions

#### Generalities

There are four main theories for the evolution of the characteristic of bioluminescence.

#### 1. Camouflage

Though it may seem paradoxical, certain fish use bioluminescence for camouflage. Indeed, at average depths predators hunt their prey from below, the outline of the prey appearing as shadows in the dim light coming from the surface.

Certain fish become artificially transparent to the predators below them thanks to the bioluminescence produced on their ventral surface, which simulates the light of the surface.

## **2.Attraction**

Bioluminescence can also be used as a lure by various abyssal species, like certain Lophiiformes : *Linophryne lucifer* COLLETT, 1888, an abyssal fish with a frontal bioluminescent appendix. This dangling luminescent appendix, which sprawls over the head of the fish, allows it to attract small animals within attacking range.

The attraction of sexual partners is another function of bioluminescence. This is the case with the lampyres which use a periodic flash at the level of their abdomen to attract a partner for reproduction.

Bioluminescent plankton, which is found in clear waters such as on the northern coasts of Brittany near Saint-Malo, in artificial basins, in Corsica and in the south-east of France.

The micro-organisms of which plankton is composed use bioluminescence to be better perceived by the fish: the fish attracted by these lights approach and swallow them.

Plankton reproduces more quickly in the abdomen of fish than in the surrounding water (presence of bacteria, higher temperature ...). In regions where the water is rather clear little bluish clouds may be formed when the water is stirred.

## **3.Repulsion**

Certain squids and small crustaceans use a chemical bioluminescent mix (as well as the sludge of bioluminescent bacteria) in order to ward off the attacks of predators, in the same way as many squids use ink: a cloud of luminescence is expelled diverting or repulsing a potential predator, allowing the squid or crustacean to flee in all security.

## **4.Communication**

Bioluminescence could also play a direct part in the communication between bacteria. It equally induces the symbiosis between bacteria and a host and it could play a part in the aggregation of a colony.

## **5. Searching a partner**

Julien Claes (U.C.L., Belgium) demonstrated that bioluminescence allows the Squaliformes to find a partner in aphotic zones.

## **Types of bioluminescence**

Bioluminescence can be divided into three main types: an intracellular bioluminescence, an extracellular one and the one of the symbiotic bacteria.

### **Intracellular Bioluminescence**

Intracellular bioluminescence is generated by specialized cells in the body of certain multicellular species. The light is emitted at the outside through the skin or it is intensified by lenses and reflecting materials (as crystals of urate for the lucioles or guanine plates of certain fish). This type of bioluminescence exists in numerous species of squids.

### **Extracellular Bioluminescence**

Extracellular bioluminescence results from the reaction between the luciferine and the enzyme luciferase. When synthesized each component is stored in the skin glands or beneath it. The expulsion and the mix of each reagent with the exterior produces luminous clouds.

This type of bioluminescence is common in some species of crustaceans and in abyssal cephalopods.

### **Symbiosis with luminescent bacteria**

This phenomenon is only known in marine animals like Ctenophora, Cnidaria, Annelida, Mollusca, Echinodermata and Pisces. It seems to be the most widespread type of bioluminescence in the animal kingdom.

At different places of the body, the animals dispose of little vesicles, commonly called *photophores*, which contain luminescent bacteria.

Certain species produce continuous light, the intensity of which can be neutralized or modulated by various specialized structures. The luminous organs are generally linked up to the nervous system, which allows the animal to control the luminous emission.

### **Recent references concerning bioluminescence**

The references concerning the discoveries realised by J. Claes (U.C.L.L.N., Belgium) and some colleagues are regrouped in this paragraph to make the biographical research easier.

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### **Remarks concerning the bioluminescency**

Bioluminescency of deep water sharks seem for many scientifics, a recent discovery, because undetectable on specimens preserved in formaldeid solutions or in alcohol.

But it was a well-known phenomenon for all deep water fishermen. Portuguese fishermen from the Portugal coasts of from the Madeira Islands, as well as all the deep water fishermen operating in the Central North Atlantic knew this phenomenon and precised that it was, in the large majority of the cases, the caught females which emitted particularly intense flashes before dying.

## **24. Order Carcharhiniformes Ord. rev.**

In this Publication, a new subdivision of the former Order Carcharhiniformes is proposed. This Order was already seriously pruned in 2010, see Bibliography: HERMAN & VAN DEN EECKHAUT, 2010, by the extraction of the Family Galeoceridae HERMAN & VAN DEN EECKHAUT, 2010 and the Family Triaenodonidae HERMAN & VAN DEN EECKHAUT, 2010.

The only odontological point that all the living\* and fossil species of the Order Carcharhiniformes present, is the more or less pronounced serrulation of the anterior and posterior cutting edges of all their teeth.

\*Some specific taxa, such as species of the Genera *Rhizoprionodon* and *Scoliodon* possess posterior teeth with a dental crown presenting a highly reduced serrulation and even a complete disappearance of the serrulation. This phenomenon indicates an extremely rare phenomenon of progressive reduction and disappearance of one extern mark of ornamentation, which generally became more and more accentuated (the exception made the rule).

Based on odontological criteria, the last unrevised Order of the living Neoselachii may easily be divided into the five following Families:

1.Family Carcharhinidae JORDAN & EVERMANN, 1896 based on the Genus *Carcharhinus* and regrouping the following three Genera: Genus *Carcharhinus* de BLAINVILLE, 1816, Genus *Nasolamia* COMPAGNO & GARRICK, 1983, and Genus *Rhizoprionodon* WHITLEY, 1929.

2.Family Loxodonidae nov. Fam., based on the living Genus *Loxodon* regrouping the two Genera: the Genus *Loxodon* MÜLLER & HENLE, 1838 and the Genus *Negaprion* WHITLEY, 1940.

The teeth of *Negaprion* species differ, principally, from the teeth of the *Loxodon* species\* by their obviously, larger dental crown.

\*The dental crown of the Genus *Loxodon* is reduced to a narrow, but elongated point presenting an oval section.

3.Family Hemipristidae nov. Fam., based on the living Genus *Hemipristis*, regrouping the five Genera: *Hemipristis* AGASSIZ, 1843, *Prionace* LINNAEUS, 1758, *Dirrhizodon* KLUNZINGER, 1871, *Heterogaleus* GOHAR & MAZHAR, 1964 and *Glyphis* AGASSIZ, 1843.

4.Family Triaenodonidae HERMAN & VAN DEN EECKHAUT, 2010, based on the Genus *Triaenodon* regroups the two Genera: *Triaenodon* HERMAN & VAN DEN EECKHAUT, 2010 and *Cephalurus* BIGELOW & SCHROEDER, 1941.

5.Family Sphyrnidae GILL, 1872, based on the Genus *Sphyrna*, regroups, certainly, the two Genera *Sphyrna* AGASSIZ, 1842 and *Eusphyra* GILL, 1872 but, maybe also, the Genera: *Rhizoprionodon* WHITLEY, 1929 and *Scoliodon* MÜLLER & HENLE, 1838.

These suggestions, based on materials of comparable signification and sources, need some deeper investigations, reserved for future research.

## **25. Possible ancestors of the Batoidei**

The Batooids are bottom living animals, in possession of five branchial arches\* completely flattened but having preserved a perfect symmetry. Their ancestors must have been symmetric but less flattened animals, in possession of five branchial arches.

\*The Genus *Hexatrygon* HEEMSTRA & SMITH, 1980 is the unique and traumatic exception.

The most primitive Batoidei, the Dasyatidae, the Rhinobatidae, the Gymnuridae and the Cyclobatidae, are in possession of holoaulacorhizid teeth. Hemiaulacorhizid ancestors remain unknown.

All the species of the Genus *Raja* have conserved the oviparous reproduction system. All the species of the Genus *Dasyatis* are holoaulacorhizid as well as all the species of the Genus *Gymnura*.

Surprising but obvious observation: Only one Genus of the living Neoselachii is like the most primitive living Batoidei (the Family Rajidae BONAPARTE, 1831). It is simultaneously oviparous, electro-sensitive, slightly bioluminescent\* and uses Magnetic Field Inversion: the Genus *Apristurus* GARMAN, 1913. Its is in possession of enhanced hemiaulacorhizid teeth with a similar medio-intern radicular protuberance.

\*Its deep water representatives.

Additionally, all the primitive Rajidae (Batoidei), such as all the *Apristurus* (Neoselachii) taxa are bottom living, or proximal to the bottom living animals.

## **26. List of the new taxa proposed**

### **26.1. Concerning the former Scyliorhiniformes**

In this Publication, one new Super Order is proposed: the Super Order Scyliorhinomorphii, five new Orders: the Scyliorhiniformes, the Order Atelomycteriformes, the Order Halaeluriformes, the Order Pentanchiformes and the Order Triaenodoniformes and five new Families: the Family Proscylliidae, the Family Atelomycteridae, the Family Halaeluridae, the Family Schroederichthyidae and the Family Pentanchidae. The living Genus *Cephalurus* integrates the existing Family Triaenodonidae.

### **26.2. Concerning the Carcharhiniformes**

In this Publication, two new Families are distinguished in the Order Carcharhiniformes: the Family Loxodonidae and the Family Hemipristidae.

## **27. Bibliography**

### **27.1. Preliminary remarks**

#### **Some bibliographical rectifications**

The history of some Nations was sometimes so perturbed that many of their scientific Series disappeared, changed names or were subdivided in different branches. This is particularly true for many Polish revues and, more recently, for

the relatively recent subdivision of the centralist communist Russian Academy of Sciences (U.R.S.S. - N.A.U.K.-Moscou) which was in the beginning of the 1970s divided in diverse Regional Branches.

The approximative denomination of these different branches and the ignorance of their locality of edition made it easy to detect articles cited but never read and to explain the persistence of the incomprehension of the systematic propositions of the Russian researchers by their occidental colleagues.

### **Importance of this very long Bibliography**

This Bibliography is very exhaustive because the senior-author, coming to the step of the reconstitution of the natural history of different lineages of Elasmobranchii, he had to point out the existence of all their composing taxa, every where and when from the Upper Jurassic to the present times.

### **Sclerorhynchiformes or Ganopristifomes**

Diverse authors used, preferentially, the term ganopristid shark because they understood very well the histological signification of this term englobing all the Genera, which Henri Cappetta included in 1974 in its Sclerorhynchiformes\* to supplant the term Ganopristifomes proposed by Jacques Herman in his doctoral defence of 6 January 1974.

\*Proposed much later than 6 January 1974.

To make the validation of his Sclerorhynchiformes easier, he used, purely and simply, the anatomical arguments utilised by the senior-author in the Paper he submitted to the French Academy of Sciences of Paris (See Bibliography).

After the apparition of this paper, he was obliged to refuse categorically the validity of all the other PhD's presented in the world.

## **27.2. Selected references**

**These are subdivided in two categories: Biological references and Paleontological references**

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## **28. Acknowledgments**

### **Some foreign researchers**

Bernard Séret, Louis Dubertret , Leonardo Compagno, William Eschmeyer, Matthias Stehmann and Bruce Welton.

### **Some directors or colleagues of the S.G.B. :**

Cécile Baetemen, André Delmer, Michiel Dusar, Marcel Gulinck, Eric Groessens,  
Robert Legrand, Herman Goethals, Roland Paepe, Henri Neybergh and Georges Vandenv.

### **Some directors or colleagues of the I.R.S.N.B. :**

André Capart, Jean-Pierre Gosse, Boudewijn Godeeris, Patrick Grootaert, Sébastien Houziaux, Georges Lenglet,  
Thierry Smith, Etienne Steurbaut and Wim Van Neer.

### **Among the technical personnel of the S.G.B. :**

Fabrice Dermien, Hendrik Goossens, Frans Moorkens and Jacques Rémy.

### **Among the technical personnel of the I.R.S.N.B. :**

Particularly our friend Julien Cillis.

### **The personnel of the Library of the I.R.S.N.B.**

M. Laurent Meese, Mmes. Ariane Boland, Arlette De Meersman, Marie Depris, Katrien Hautekerke, Jacob Lieve and  
Kim Willems.

**and**

### **The personnel of the Library of the S.G.B.**

Mmes. Maria Stasseyns, Viviane De Vleeschouwer and Fabienne Desmet.

**Diffusion de *Géominpal Belgica 4* :**

**Editeur responsable: Docteur Jacques Herman. I.S.S.N. : 2033 - 6365**

**Beigemsesteenweg 319. 1852 Beigem (Grimbergen). Belgique – België – Belgien.**

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**In OTHER COUNTRIES:**

**M.N.H.N. Paris (F), S.V.P. Bethesda (Society of Vertebrate Paleontology) (GB), Naturalis Museum (NL) and N.H.M.M. (NL).**

**And to the following persons concerned (alphabetical classification):**

**J.-P. Baut (F), Jacques Boel (B), Taco Bor (NL), Didier Dutheil (F), Dirk en Maria Hovestadt (NL), Alberto Cione (E), Eric Collier (F), René Fraaije (NL), Bertrand Génault (F), Hermann Goethals (B), Gerardo Gonzalez-Barba (E), Arie Janssen (NL), Olivier Landemaine (F), John Maisey (U.S.A.), Frederik Mollen (B), Dirk Nolf (B), Noud Peeters (NL), Fritz Pfeil (D), Eric Simon (B), Etienne Steurbaut (B), Thierry Smith (B), Bernard Séret (F), Matthias Stehmann (D), Pieter De Schutter (B), Louis Taverne (B), Detlev Thies (D), and Barry van Bakel (NL), Eric Vanderhoeft (B), Eric Wille (B) and Didier Winderickx (B).**

**And to all the unknown researchers: independent ones, students or graduates,  
Thanks to the freely accessible Website mentioned above.**