SPIXIANA	**38**	1	145–160	München, August 2015	ISSN 0341–8391

A practical key for the identification of large fish rostra

(Pisces)

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Lange, T., Brehm, J. & Moritz, T. 2015. A practical key for the identification of large fish rostra (Pisces). Spixiana 38 (1): 145–160.

Large fish rostra without data of origin or determination are present in many museum collections or may appear in customs inspections. In recent years the inclusion of fish species on national and international lists for the protection of wildlife resulted in increased trading regulations. Therefore, useful identification tools are of growing importance. Here, we present a practical key for large fish rostra for the families Pristidae, Pristiophoridae, Xiphiidae and Istiophoridae. This key allows determination on species level for three of four families. Descriptions of the rostrum characteristics of the respective taxa are given.

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Introduction

Rostra are found in many fish species and can be used for hunting (Wueringer et al. 2012a) or in self-defense against predators (Martin 2005). Among these species are swordfish with strongly elongated flat and sword-like rostrum (Nakamura 1985), sawfishes and sawsharks with their saw-like appearance (Compagno & Last 1999, Ebert & Wilms 2013) and marlins, spearfish and sailfish with their in cross-section rounded bills of variable length (Nakamura 1985). These predators use their extremely elongated rostra as an aide in hunting their prey in different ways: some have been observed using it to find their prey through electrosensory means (Wueringer et al. 2012b) or by digging through the ground (Pogonoski et al. 2002); others using it to stun (Shimose et al. 2007) prey by slashing with side-to-side movements of their head (Pogonoski et al. 2002) or ramming (Nakamura 1983). The usage of a rostrum to immobilize prey by pressing it on the ground was likewise observed (Wueringer et al. 2012a). Moreover, the filter feeding paddlefish *Polyodon spathula* is equipped with a spoon-like rostrum which is used as an electrosensory organ for locating plankton in water columns (Wilkens & Hofmann 2007).

A second possible use of the rostrum is for self-defense: lateral swipes are presumably executed for that purpose (Martin 2005). Sawfish are also known to have accidentally injured swimmers and fishermen (Compagno & Last 1999).

This identification key is limited to large fish with saw-like rostra, as well as the resembling sword- and billfish. These rostra are comprised of cartilage or primarily one bone, in the latter case predominantely the premaxilla. Not included are fish with short rostra like sturgeons (Acipenseriformes: Acipenseridae) or with strongly elongated jaws like gars (Lepisosteiformes: Lepisosteidae), garfish, needlefish (Beloniformes: Belonidae) and halfbeaks (Beloniformes: Hemiramphidae). To our knowledge, these species' rostra are not likely to be traded or collected and their elongated jaws are comprised of many bones, distinguishing them from the aforementioned.

Due to overexploitation of populations of chondrichthyans through fisheries or by-catch as well as habitat degradation, about one-quarter of these species are currently threatened worldwide (Dulvy et al. 2014). Coupled with restricted geographic ranges and dependency on threatened habitats such as mangroves and estuaries, this leads to the sawfish (Pristidae) being the most threatened family of chondrichthyans, perhaps of all marine fishes (Dulvy et al. 2014). Thus, stronger conservation efforts are eligible.

The rostra of the sawsharks family, Pristiophoridae, have a saw-like appearance similar to the Pristidae. New species have been described during the last years (Yearsley et al. 2008, Ebert & Cailliet 2011), the latest being *Pristiophorus lanae* Ebert & Wilms, 2013, and their population structures and biology is still relatively unknown, as well as that of several other sawshark species (Heupel 2006, Wang et al. 2009). Thus, their status of endangerment cannot yet be assessed (IUCN 2013) and therefore implementation of conservation measures presumably needed is difficult. As a first step, a practical identification tool could be useful in order to accurately identify encountered species and trophies of the respective species.

Large fish specimens are very rarely collected in one piece for fish collections, but remarkable parts such as rostra are common in museum collections (Sutarno et al. 2012). Also donations of such objects from private individuals are not rare and are usually handed to museum collections without any data of origin or species determination. Furthermore, fish rostra are regarded as souvenirs or objects for private collections and therefore often removed if a respective animal is accidentally caught in nets or fishing lines (Whitty et al. 2014). On the other hand, conservation and trading agreements included more and more of these fish species in recent years. Thus, customs are increasingly confronted with the need for identification of such objects. Additionally, the mineralized rostrum is one of the longest-lasting body parts after the death of an individual (Whitty et al. 2014). Therefore, we here present a key based on different rostrum characteristics without requiring a whole specimen.

Material and methods

The identification key is mainly based on literature augmented by the study of museum specimens deposited in the Deutsches Meeresmuseum (DMM) in Stralsund (Germany).

Abbreviations

BL – body length: from tip of lower jaw to caudal fork (used for billfishes); SL – standard length: from tip of snout to the base of the caudal fin; TL – total length: from tip of snout to distal tips of caudal fin; SRL – standard rostrum length: Pristidae rostrum length from tip to midpoint of rostrum at the level of point behind most proximal left tooth (Whitty et al. 2014), Pristidae rostrum length alternatively given as length from tip to midpoint of the rostrum where it begins to broaden and meet the head, Pristiophoridae rostrum length given as preoral length.

Material examined

Whole specimen: *Pliotrema warreni* Regan, 1906 – DMM I-E/4946; *Pristiophorus nancyae* Ebert & Cailliet, 2011 – DMM I-E/4817; DMM I-E/3460 (2 specimens); DMM I-E/4872; DMM I-E/4902; DMM I-E/4506. **Head with rostrum:** *Pristis pristis* (Linnaeus, 1758) – DMM I-E/4937. **Skeleton (cranium with rostrum):** *Pristiophorus cirratus* Lathan, 1794 – DMM I-E/6514, preoral length 28.5 cm; *Pristiophorus nudipinnis* Günther, 1870 – DMM I-E/6515, preoral length 18.0 cm. **Rostrum:** *Anoxypristis cuspidata* (Latham, 1794) – DMM I-E/296, length 75.0 cm; DMM I-E/1541, length 64.9 cm; DMM I-E/1543, length 51.5 cm; DMM I-E/1545, length 72.0 cm; DMM I-E/1553, length 56.5 cm; DMM I-E/1563, length 58.8 cm; DMM I-E/6512, length 74.7 cm; *Pristis pectinata* Latham, 1794 – DMM I-E/306, length 118.1 cm; DMM I-E/1550, length 100.0 cm; DMM I-E/1557, length 100.4 cm; DMM I-E/6510, length 136.9 cm; *Pristis pristis* – DMM I-E/234, length 85.7 cm; DMM I-E/302, length 80.6 cm; DMM I-E/1542, length 71.6 cm; DMM I-E/1549, length 74.4 cm; DMM I-E/1551, length 84.7 cm; DMM I-E/1552, length 59.3 cm; DMM I-E/1556, length 61.4 cm; DMM I-E/1560, length 87.0 cm; DMM I-E/6513, length 66.5 cm; DMM I-E/4353, length 92.8 cm; *Pristis zijsron* Bleeker, 1851 – DMM I-E/236, length 120.7 cm; DMM I-E/1546, length 119.3 cm; DMM I-E/6511, length 121.2 cm; *Xiphias gladius* Linnaeus, 1758 – DMM I-E/732, length 63.5; DMM I-E/2944, length 67.0 cm; DMM I-E/3279, length 61.0 cm; DMM I-E/6508, length 103.0 cm; DMM I-E/6509, length 84.0 cm. **Images:** *Pristis clavata* Garman, 1906 – MCZ S-733 Holotype (Mcz-base Harvard); *Pristiophorus delicatus* Yearsley, Last & White, 2008 – CSIRO H 931-01 Holotype (Yearsley et al. 2008); *Pristiophorus japonicus* Günther, 1870 – BMNH 1867.2.20.1 Syntype; *Pristiophorus nancyae* – SAM 33511 Paratype (Ebert & Cailliet 2011); *Pristiophorus schroederi* Springer & Bullis, 1960 – USNM 185946 Holotype (Springer & Bullis 1960).

Key for large sized fish rostra

1. Prominent teeth on sides of rostrum. 2
– No teeth on sides of rostrum. 12

2. Smaller and larger teeth alternating. .... 3 (Pristiophoridae)
– Teeth more or less of same size. .... 8 (Pristidae)

3. Larger rostral teeth serrated. .. *Pliotrema warreni*
– Larger rostral teeth smooth. .... 4 (*Pristiophorus*)

4. Rostrum with double row of 4-5 large pits on underside; larger rostral teeth with prominent transverse ridges at their bases. .... *Pristiophorus nancyae*
– No pits on underside of rostrum; larger rostral teeth without prominent transverse ridges at their bases. 5

5. Rostrum short, broad and strongly tapering. .... *Pristiophorus nudipinnis*
– Rostrum elongated, narrow and only slightly tapering. 6

6. 9–10 large rostral teeth in front of barbels. .... *Pristiophorus cirratus*
– 11 or more rostral teeth in front of barbels. 7

7. 11–15 large rostral teeth in front of barbels. .... *Pristiophorus delicatus* & *P. schroederi*
– 15–26 large rostral teeth in front of barbels. .... *Pristiophorus japonicus* & *P. lanae*

8. No teeth on basal quarter of rostrum. .... *Anoxypristis cuspidata*
– Teeth present all along the rostrum. .... 9 (*Pristis*)

9. Distinct groove on posterior edge of rostral teeth reaching the base of teeth (Fig. 1A). 10
– Groove on posterior edge of rostral teeth absent or very poorly developed or if present not reaching the base of teeth (Fig. 1B). 11

10. Rostrum tapering to end; 14-24 (more often 20 or less) rostral teeth on each side. .... *Pristis pristis*
– Rostrum broad (only little tapering to end); 20–32 (usually more than 25) rostral teeth on each side. .... *Pristis pectinata*

11. 18–24 rostral teeth on each side; rostrum tapering; groove on teeth present (not reaching its base). ....*Pristis clavata*
– 23–34 (35) rostral teeth on each side; rostrum not tapering; groove on teeth absent or very poorly developed. .... *Pristis zijsron*

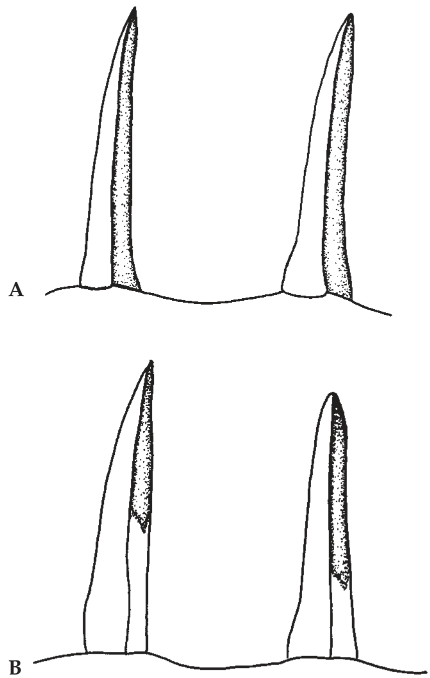

Fig. 1. Dorsal view of lateral rostral teeth with grooves on posterior edges in *Pristis*, tip of rostrum positioned to the left. **A.** Groove reaching base of teeth (*Pristis pristis*); **B.** Groove developed but not reaching base (*Pristis clavata*); after Whitty et al. 2014.

12. Profile of rostrum nearly round; denticles on lower side present. .... Istiophoridae
– Rostrum flattened with sharp edges; smooth, without denticles on lower side. .... *Xiphias gladius*

Taxa accounts

Pristidae

Sawfishes are a group of gigantic shark-like batoids reaching up to eight meters in total length. Their greatly elongated snout is supported by a rostral cartilage bearing a single row of large, transverse teeth on each side (Compagno & Last 1999) and is used for hunting and stunning prey (Compagno 1977, Last & Stevens 2009). Their taxonomy is still much disputed (see Faria et al. 2013). Until recently, seven valid species were recognized as belonging to the Pristidae, however, Faria et al. (2013) synonymized *Pristis microdon* and *Pristis perotteti* with *Pristis pristis*. Their results are based on external morphological characters and mitochondrial DNA sequences, i. e. the NADH-2 gene.

The conservation status of all species of the family Pristidae is in the categories Endangered to Critically Endangered (IUCN 2013). Fishing pressure from by-catch and the shark fin industry in combination with habitat destruction represent the main threats to their conservation (Dulvy et al. 2008).

Anoxypristis cuspidata (Latham, 1794)
Fig. 2A

Common names. Knifetooth Sawfish, Narrow Sawfish, Pointed Sawfish (Compagno et al. 2005, D'Anastasi et al. 2013).

Geographic distribution. Indian Ocean and Western Pacific (Compagno & Last 1999, D'Anastasi et al. 2013).

Rostral characters. No teeth at basal part of the saw, up to one quarter of rostrum in adults (Last & Stevens 1994b); teeth flattened, triangular; gap between the two most posterior teeth approximately 4–9 times the gap between the most anterior ones (Compagno & Last 1999); teeth showing no crown, i. e. off-white, hard coating covering roots and grooves at bases of teeth (Whitty et al. 2014); rostrum slender (in comparison with rostra of the genus *Pristis*), sides of rostrum nearly parallel (not tapering); 16–30 rostral-tooth pairs (Compagno & Last 1999, Faria et al. 2013); length to width at the last tooth 10–12 : 1 (Compagno & Last 1999); regional variations in rostral tooth count existent (Table 1).

Size. Common length 240–470 cm TL, maximum length probably up to 610 cm TL (Compagno & Last 1999) with the common SRL measuring 13.7–60.3 cm (Whitty et al. 2014).

Red List category. Endangered A2cd; population trend: decreasing (D'Anastasi et al. 2013).

Main threats. There are two main threats posed against *A. cuspidata*: fishery and habitat degradation. Fishing pressure is caused through incidental by-catch, mainly due to entanglement of their toothed rostra in fishing gear, high post release mortality as well as intentional catch for their high value products, e. g. their rostrum (Peverell 2005, Tobin et al. 2010). Illegal, unregulated and unreported catch is known for Northern Australia (Lack & Sant 2008) and may also be a danger to populations in other areas. Since the distribution of *A. cuspidata* is primarily coastal and it depends on inshore nursing grounds, habitat degradation, e. g. due to pollution by expanding mining industry (Mudd & Patterson 2010) coupled with the ever-increasing urbanization of coastal areas is an additional threat. Moreover, the existence of distinct genetic stocks leads to the presumption that in the case of drastic shrinkage of certain populations local extinction cannot be impeded by exchange with neighbouring populations (D'Anastasi 2010).

Pristis clavata Garman, 1906
Fig. 2B

Common names. Dwarf Sawfish, Queensland Sawfish (Compagno & Last 1999, Kyne et al. 2013b).

Geographic distribution. Western Central Pacific and Eastern Indian Ocean, i. e. tropical northern Australia (Thorburn et al. 2008, Morgan et al. 2011).

Rostral characters. Teeth present all over rostrum, slightly flattened, elongated and thorn- or cone-like; groove existent, but ends before tooth base (Thorburn et al. 2007); gap between the two most posterior

Table 1. Tooth counts (pairs) and regional variations on rostra of the family Pristidae.

	West Atlantic	East Atlantic	West Pacific	East Pacific	Indian Ocean
A. cuspidata			17–30[1] Australia: 17–26[4]		22–29[1]
P. clavata			18–24[2,4] (Australia)		
P. pectinata	20–30[1]	20–27[1]			
P. pristis	14–23[1] Nicaragua and Costa Rica: 14–20[3]	14–19[1]	14–23[1] Australia: 16–24[4]	15–23[1]	16–21[1]
P. zijsron			24–32[1] Australia: 24–31[4]		27–34[1]

[1] Faria et al. 2013; [2] Morgan et al. 2010; [3] Faria 2007; [4] Whitty et al. 2013.

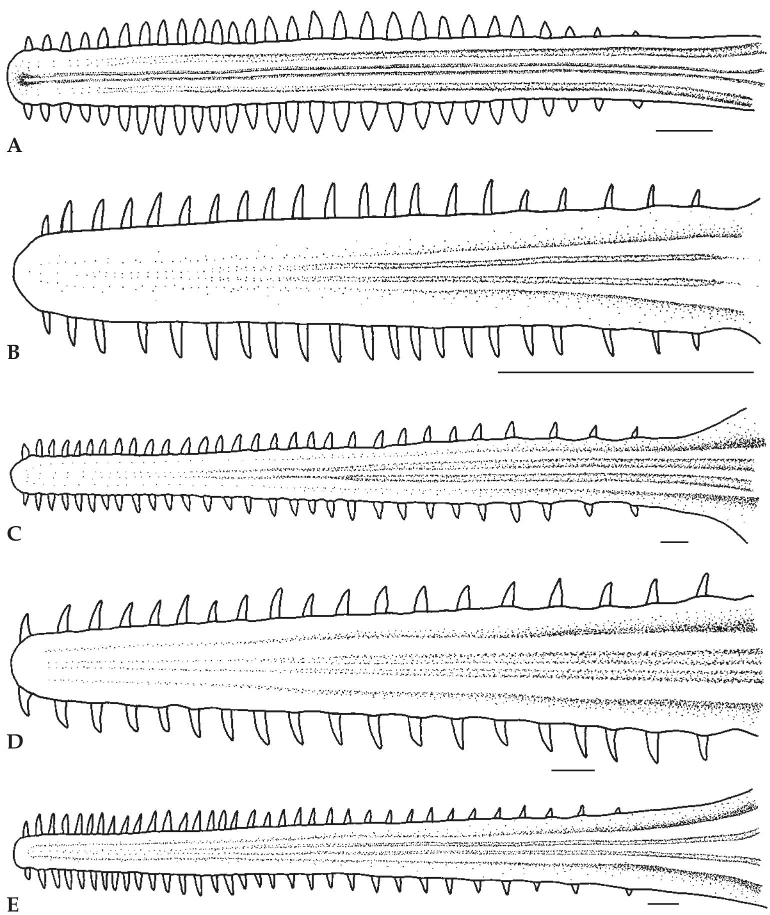

Fig. 2. Idealized drawings of rostra of the family Pristidae. **A.** *Anoxypristis cuspidata* (DMM I-E/1545); **B.** *Pristis clavata* (after Holotype MCZ S-733); **C.** *Pristis pectinata* (DMM I-E/6510); **D.** *Pristis pristis* (DMM I-E/234); **E.** *Pristis zijsron* (DMM I-E/6511); Scale line equals 5 cm.

teeth approximately twice the gap between the most anterior ones (Compagno & Last 1999); juvenile teeth showing crowns, at least partially visible in adults (Whitty et al. 2014); rostrum sturdy, not (Froese & Pauly 2014) or only slightly tapering (Compagno & Last 1999); 18–24 rostral-tooth pairs (Morgan et al. 2010, Whitty et al. 2014); length to width at the last tooth 6 : 1 (Compagno & Last 1999).

Size. Common length 233 cm TL (captured individuals still immature) and larger (Thorburn 2006, Thorburn et al. 2008), maximum known TL 318 cm (Whitty et al. 2014), with the common SRL measuring 14.6–54.4 cm (Whitty et al. 2014), maximum saw length up to 22-24 % of TL (Thorburn 2006), i.e. possibly up to 76.3 cm.

Red List category. Endangered A2cd; population trend: decreasing (Kyne et al. 2013b).

Main threats. By-catch in all types of fishery combined with the low biological reproduction rate of *P. clavata* poses the main threats to its populations. The elongated and toothed rostra as well as demersal living of all sawfish lead to a high risk of capture in trawling, net fisheries, line fishing, as well as recreational fishing (Stevens et al. 2005). In the last case this sawfish is most likely not released, but as other species of this kind it is killed for its trophy, the rostrum (Thorburn et al. 2003). Alarmingly, fishing activities cover all known areas of its distribution (Larson et al. 2006).

Pristis pectinata Latham, 1794
Fig. 2C

Common names. Smalltooth Sawfish, Wide Sawfish (Carlson et al. 2013).

Geographic distribution. Western Atlantic Ocean (tropical and subtropical waters), distribution in Eastern Atlantic uncertain (Carlson et al. 2013, Faria et al. 2013).

Rostral characters. Teeth present all over the rostra, slightly flattened, elongated and thorn- or cone-like, groove on posterior edge existent and reaching base of teeth; gap between the two most posterior teeth approximately 2–4 times the gap between the most anterior ones (Compagno & Last 1999); teeth showing visible crowns; rostrum relatively narrow, not tapering; 20–32 rostral-tooth pairs (most common 25–29); length to width at the last tooth 6–8 : 1 (Compagno & Last 1999); sexual dimorphism in tooth shape: male rostral teeth broader than females' (Herman et al. 1997); regional variations in rostral tooth count existent (Table 1).

Size. Common length over 400–550 cm TL (Compagno & Last 1999, Last & Stevens 1994a), maximum known length 760 cm TL (Last & Stevens 1994a) with rostrum up to 25 % of TL (McEachran & de Carvalho 2002), i. e. possibly up to 190 cm.

Red List category. Critically Endangered A2cd; population trend: decreasing (Carlson et al. 2013).

Main threats. Fishery and habitat degradation are the main threats to *P. pectinata*. Due to depleted populations this sawfish is not cost-effective and therefore no longer targeted in commercial fishing with at times exception of the shark fin industry (CITES 2007). By-catch now presents the primary cause for population decrease, as well as degradation of estuaries and mangroves, which are essential for this species (CITES 2007). These habitats are greatly threatened by a number of human activities (CITES 2007).

Pristis pristis (Linnaeus, 1758)
Fig. 2D

Synonyms. *Pristis microdon* Latham, 1794; *Pristis perotteti* Müller & Henle, 1841 (Faria et al. 2013).

Common names. Largetooth Sawfish, Common Sawfish (Compagno & Last 1999, Compagno et al. 2005).

Geographic distribution. Eastern Atlantic, Western Atlantic, Indo-West Pacific and Eastern Pacific (Kyne et al. 2013a).

Rostral characters. Teeth present all over the rostra, slightly flattened, elongated and thorn- or cone-like, groove existent over whole length of posterior edge (Thorburn et al. 2007); teeth evenly spaced, gap between the two most posterior teeth approximately 1–2 times the gap between the most anterior ones (Compagno & Last 1999); teeth showing no visible crowns in juvenile or adults (Whitty et al. 2014); 14–24 rostral-tooth pairs, usually 20 or less tooth pairs (Faria et al. 2013, Whitty et al. 2014); space between teeth taller than their length (Compagno & Last 1999); rostrum broad and sturdy, tapering to the top; sexual dimorphism in rostral tooth count: females most often 17–23 (usually ≤20), males most often 19–23 (Whitty et al. 2009); if count ≥22 than most likely male (Whitty et al. 2014); regional variations in rostral tooth count existent (Table 1).

Size. Common length 240–656 cm TL (Compagno & Last 1999), maximum known length 750 cm TL (de Carvalho & McEachran 2003) with the common SRL measuring 18.3–123.8 cm (Whitty et al. 2014).

Red List category. Critically Endangered A2cd; population trend: decreasing (Kyne et al. 2013a).

Main threats. *Pristis pristis* is mainly endangered by fishery and habitat destruction coupled with the low reproductivity of this large and long-living sawfish: 30 years being the age of the oldest recorded individual (Miller 2005). Though it was formerly targeted most of the *P. pristis* killed in fisheries in recent times have occurred through by-catch (CITES 2007), due to entanglement of their elongated, toothed rostrum in all kinds of fishing gear. In some areas of distribution recreational fishing is increasing and sawfish rostra taken as 'trophies' (Thorburn et al. 2003).

Degradation and destruction through human impact of habitats important to specific stages of this species life further threatens its populations. Primarily affected are freshwater systems, estuaries and mangroves (CITES 2007), e. g. through designed alterations to rivers that are part of the migration route of young sawfish.

Pristis zijsron Bleeker, 1851
Fig. 2E

Common names. Green Sawfish, Olive Sawfish, Narrowsnout Sawfish, Longcomb Sawfish (Compagno & Last 1999, Faria et al. 2013, Palmeira et al. 2013, Simpfendorfer 2013).

Geographic distribution. Indo-West Pacific (Compagno & Last 1999).

Rostral characters. Teeth present all over the rostra, slightly flattened, elongated and thorn- or cone-like, no groove existent (or just slightly present); gap between the two most posterior teeth approximately 2–7 times the gap between the most anterior ones (Compagno & Last 1999); at least proximal teeth showing crowns (Whitty et al. 2014); rostrum slender, sides of rostrum nearly parallel; 23–34 (rarely 35 or possibly more) rostral-tooth pairs; length to width at the last tooth 7–10 : 1 (van Oijen et al. 2007, Compagno & Last 1999); regional variations in rostral tooth count existent (Table 1).

Size. Common length over 400–550 cm TL (Compagno & Last 1999, Heemstra 1995), maximum known length 730 cm TL (Compagno et al. 1989) with the common SRL measuring 15.0–154.6 cm (Whitty et al. 2014).

Red List category. Critically Endangered A2cd; population trend: decreasing (Simpfendorfer 2013).

Main threats. Incidental by-catch in fishery poses the primary risk to the sustainability of this sawfish species. The greatest threats are inshore gillnet and trawl fishing gear (Stevens et al. 2005) throughout most distribution areas, in which *P. zijsron* is often entangled due to its large size and long rostrum. Critical by-catch levels (Zhou & Griffiths 2008) combined with low reproductive rates, as well as habitat loss (e. g. intertidal areas) through coastal development and pollution add up to its status being critically endangered.

Pristiophoridae Bleeker, 1859

Sawsharks are a small-sized, morphologically distinct group of sharks, possessing a long, narrow and flat rostrum with a row of transverse teeth on both sides giving it a saw-like appearance and a pair of long barbels ventral in front of the nostrils (Ebert & Wilms 2013, Compagno 1984). In between the large lateral teeth lie numerous smaller teeth and the ventral side of the rostrum shows lines of teeth as well (Compagno & Last 1999). As in pristids, the rostrum is presumably used as an offensive weapon in prey capture (Compagno 1984) and is believed to have evolved analogous to that of the sawfish (Keyes 1982).

Currently, this small family of sharks includes two genera, *Pliotrema* with one species and *Pristiophorus* with seven species (Ebert & Wilms 2013). Each species seems to be endemic to a specific region in the western North Atlantic, the western North Pacific, the Indo-West Pacific or the western Indian Ocean. The conservation status for some sawsharks varies between Least Concern and Near Threatened. However, the data is deficient or the population status unknown for most of these species and two recently described sawsharks, namely *Pristiophorus nancyae* and *Pristiophorus lanae*, are not yet included into the IUCN red list (IUCN 2013). The main threat is by-catch in commercial fishery (IUCN 2013).

Pliotrema warreni Regan, 1906
Fig. 3A

Common name. Sixgill Sawshark (Ebert & Wilms 2013).

Geographic distribution. Subtropical and warm-temperate waters of Mozambique, South Africa and Madagascar (Fowler 2004).

Rostral characters. Rostral teeth sharp; the large teeth serrated on posterior edges (Compagno 1984) and separated by two, sometimes three, smaller teeth (von Bonde 1933); one pair of barbels, as well as lines of small teeth on ventral side of elongated rostrum.

Size. Common length 110–136 cm TL (Compagno 1984), maximum known length 170 cm TL (Compagno et al. 1989).

Red List category. Near Threatened; population trend: unknown (Fowler 2004).

Main threats. *Pliotrema warreni* is mainly endangered through by-catch of demersal bottom trawlers of commercial fishery occurring throughout its known range. Population status is unknown but the level of by-catch is thought to be too high compared to the presumed low reproductivity of this species (Fowler 2004).

Pristiophorus cirratus Lathan, 1794
Fig. 3B

Common names. Common Sawshark, Longnose Sawshark (Compagno 1984, Walker & Simpfendorfer 2003).

Geographic distribution. Endemic to southern Australia (Ebert & Wilms 2013).

Rostral characters. Rostrum elongated, narrow and slightly tapering; 9–10 large, smooth-edged rostral teeth on each side in front of the ventral pair of barbels and 9 behind them (Compagno 1984); large teeth separated by several small or medium-sized ones, one line of small teeth situated on each lateral edge of ventral side of rostrum.

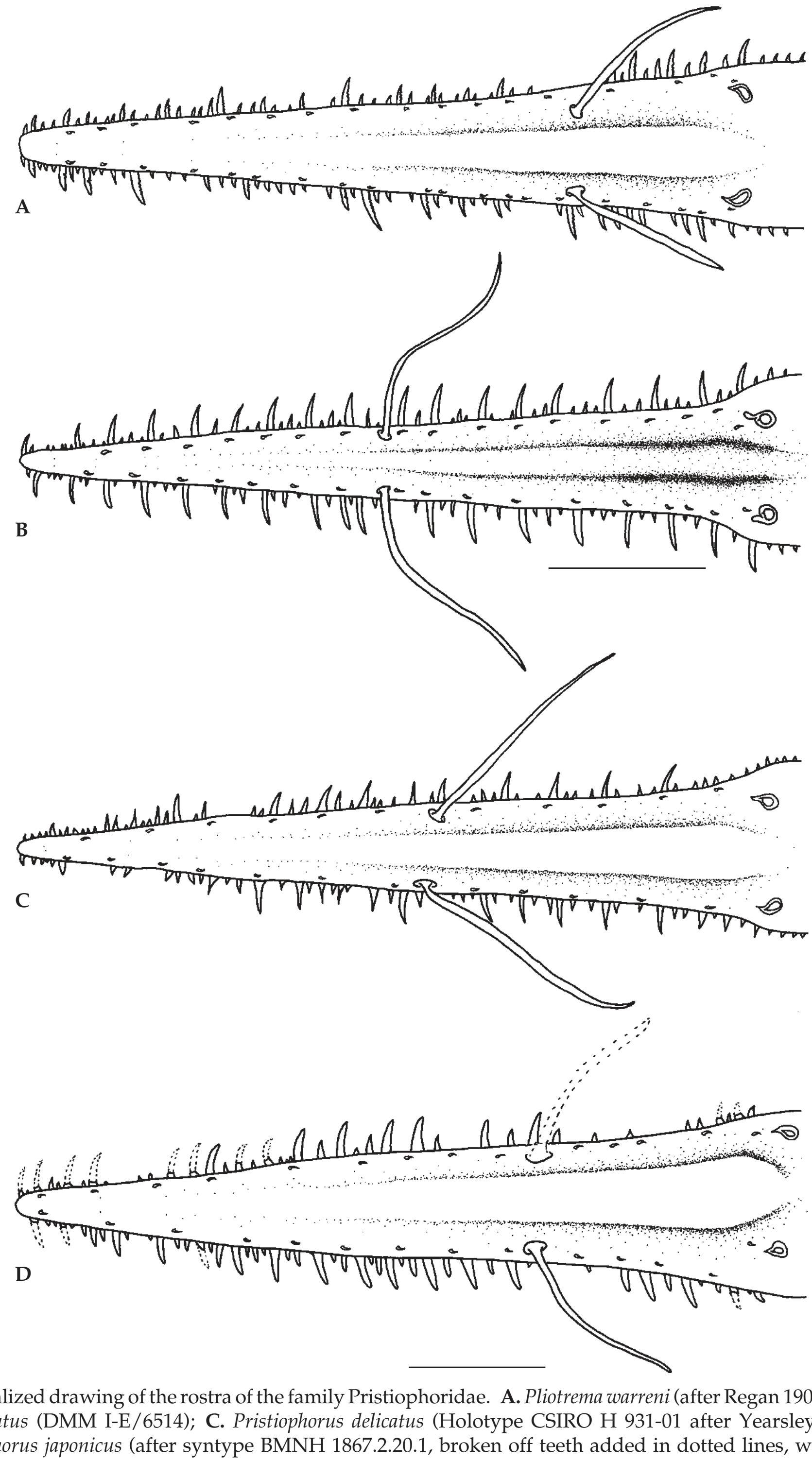

Fig. 3. Idealized drawing of the rostra of the family Pristiophoridae. **A.** *Pliotrema warreni* (after Regan 1906); **B.** *Pristiophorus cirratus* (DMM I-E/6514); **C.** *Pristiophorus delicatus* (Holotype CSIRO H 931-01 after Yearsley et al. 2008); **D.** *Pristiophorus japonicus* (after syntype BMNH 1867.2.20.1, broken off teeth added in dotted lines, where obvious breakage, due to high number of missing teeth); Scale lines equal 5 cm.

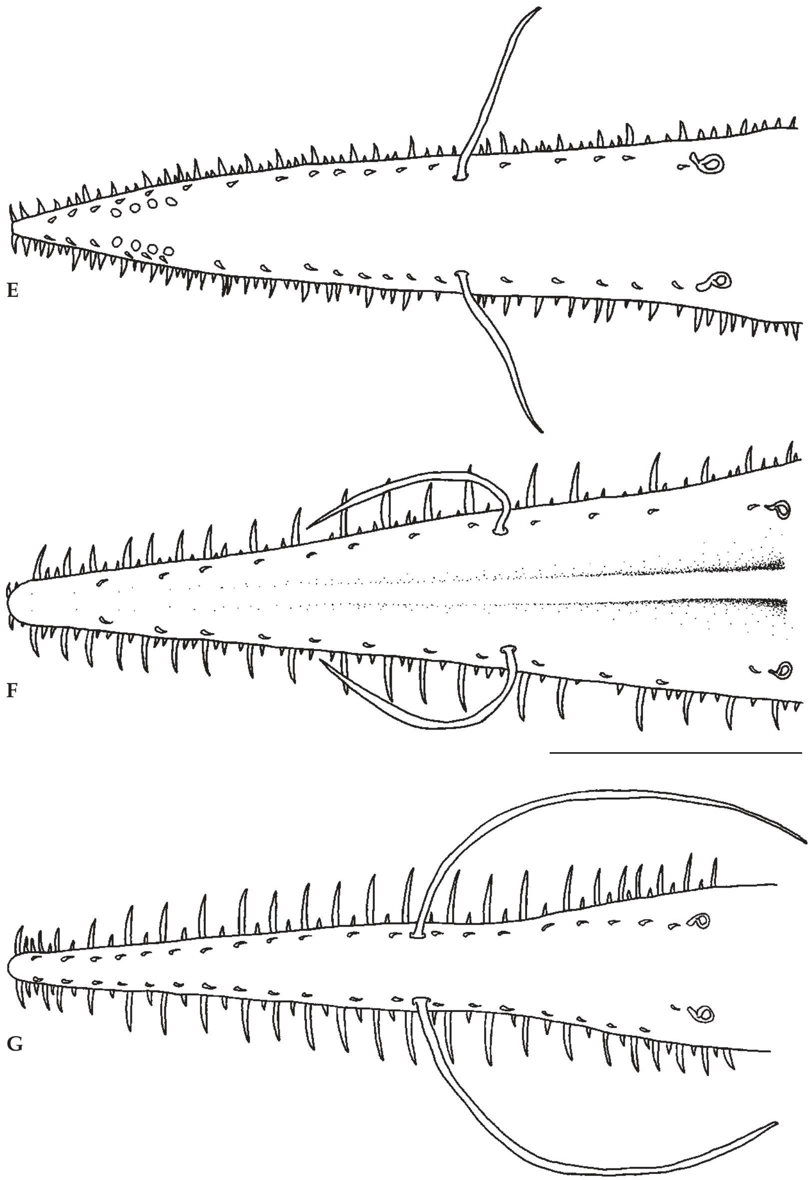

Fig. 3. (continued). E. *Pristiophorus nancyae* (Paratype SAM 33511 after Ebert & Cailliet 2011); **F.** *Pristiophorus nudipinnis* (DMM I-E/6515); **G.** *Pristiophorus schroederi* (holotype USNM 185946 after Springer & Bullis 1960); Scale line equals 5 cm.

Size. Common length around 125 cm TL (Frimodt 1995), maximum known length 149 cm TL (Ebert & Cailliet 2011); rostrum length 27–28 % of TL (Compagno 1984), i. e. up to 33.8–41.7 cm.

Red List category. Least Concern; population trend: stable (Walker & Simpfendorfer 2003).

Main threats. The main threat to *P. cirratus* is from by-catch in fisheries with gillnets and demersal trawl nets. The number of sawfish caught are mostly through gillnet fishery targeting *Mustelus antarcticus* (Walker 1999).

Pristiophorus delicatus Yearsley, Last & White, 2008
Fig. 3C

Common name. Tropical Sawshark (Yearsley et al. 2008).

Geographic distribution. Northeastern Australia (Heupel 2003, Yearsley et al. 2008).

Rostral characters. Rostrum very elongate, blade-like and tapering towards the tip which is very narrowly rounded (Yearsley et al. 2008); large and slender rostral teeth are smooth-edged and distally recurved, the gaps vary with 2–3 small or medium-sized teeth in between; longest teeth positioned around middle of rostrum (Yearsley et al. 2008); 11–15 large lateral teeth found anterior to the ventral pair of barbels (Ebert & Cailliet 2011).

Size. Common length 43.8–84.5 cm TL, maximum known length 84.5 cm TL (Yearsley et al. 2008); rostrum length 29.1–30.9 % of TL (Yearsley et al. 2008), i. e. up to 24.4–26.0 cm.

Red List category. Least Concern; population trend: unknown (Heupel 2003).

Main threats. Population size and possible threats are unknown. The small size at maturity may lead to a higher productivity (Heupel 2003) which could help in stabilizing its population.

Pristiophorus japonicus Günther, 1870
Fig. 3D

Common name. Japanese Sawshark (Compagno 1984).

Geographic distribution. Northwest Pacific (Ebert & Wilms 2013).

Rostral characters. Rostrum long, narrow and tapering; 15–26 large and smooth-edged rostral teeth anterior to the ventral barbels, about 9–17 behind them (Compagno 1984); distinction from *P. lanae* difficult due to similar tooth counts; large teeth separated by several small or medium-sized ones.

Size. Maximum known length 153 cm TL (Ebert & Wilms 2013); rostrum length 26–29 % of TL (Compagno 1984), i. e. up to 39.0–43.5 cm.

Red List category. Data Deficient; population trend: unknown (Wang et al. 2009).

Main threats. Known activities endangering *Pristiophorus japonicus* are by-catch in gill nets, trawl nets and bottom longline fisheries due to the thorns on its snout. The number caught is small but population size and trend is unknown, therefore this species could be naturally rare or already depleted (Wang et al. 2009).

Pristiophorus lanae Ebert & Wilms, 2013

Common names. Lana's Sawshark, Philippine Sawshark (Compagno et al. 2005, Ebert & Wilms 2013).

Geographic distribution. Philippine Islands and likely wider distributed in the western North Pacific (Ebert & Wilms 2013).

Rostral characters. Rostrum elongated, flattened and blade-like and tapering towards the tip; 17–26 large and smooth-edged lateral rostral teeth in front of the pair of ventral barbels, 7–17 behind them; distinction from *P. japonicus* difficult due to similar tooth counts; large teeth separated by 1–3 small or medium-sized ones; lines of small ventral teeth present (Ebert & Wilms 2013).

Size. Maximum known length 83.0 cm TL (Ebert & Wilms 2013); rostrum length 27.5–31 % of TL (Ebert & Wilms 2013), i. e. up to 22.5–25.7 cm.

Red List category. Not yet evaluated.

Main threats. By-catch by deepwater fisheries is possible (Ebert & Wilms 2013); threats and populations size unknown.

Pristiophorus nancyae Ebert & Cailliet, 2011
Fig. 3E

Common name. African Dwarf Sawshark (Ebert & Cailliet 2011).

Geographic distribution. Western Indian Ocean around central and southern Mozambique, a wider distribution along African coast possible but so far unknown (Ebert & Cailliet 2011, Ebert & Wilms 2013).

Rostral characters. Long, narrow and blade-like rostrum, tapering towards the tip; 15–22 large and smooth-edged lateral teeth anterior to ventral pair of barbels, 6–10 behind them; juveniles (< 40 cm) 1–3 small or medium-sized teeth between the large ones, adults up to 4; lines of small ventral teeth present; bases of lateral and ventral teeth show prominent transverse ridges; double row of 4–5 deep pits present ventrally on anterior part of rostrum (Ebert & Cailliet 2011).

Size. Maximum known length 62 cm TL (Ebert & Cailliet 2011); rostrum length 27.7–29.6 % of TL (Ebert & Cailliet 2011), i. e. up to 17.2–18.4 cm.

Red List category. Not yet evaluated.

Main threats. By-catch by fisheries is possible (Ebert & Cailliet 2011); threats and population size unknown.

Pristiophorus nudipinnis Günther, 1870

Fig. 3F

Common names. Shortnose Sawshark, Southern Sawshark (Compagno 1984, Walker 2003).

Geographic distribution. Endemic to southern Australian waters (Walker 2003, Ebert & Wilms 2013).

Rostral characters. Relatively short and broad rostrum, strongly tapering towards the tip; about 13 large lateral rostral teeth in front of ventral pair of barbels, 6 behind them (Compagno 1984); large lateral teeth spaced irregular with several small or medium-sized teeth in between; two lines of small teeth situated ventrally near the lateral margins.

Size. Maximum known length 124 cm TL (Ebert & Cailliet 2011); rostrum length 23–24 % of TL (Compagno 1984), i. e. up to 28.5–29.8 cm.

Red List category. Least Concern; population trend: stable (Walker 2003).

Main threats. The main activities endangering *P. nudipinnis* are by-catch in gillnets targeting *Mustelus antarcticus* (Walker 1999) or demersal trawl nets. But due to the decline and stabilization of catch rates and introduction of a Total Allowable Catch in 2002 combined with a relatively high biological productivity of this species, the populations of *P. nudipinnis* are assumed to be stable (Walker 2003).

Pristiophorus schroederi Springer & Bullis, 1960

Fig. 3G

Common names. Bahamas Sawshark, American Sawshark (Compagno 1984, Heupel 2006).

Geographic distribution. Endemic to the Western Central Atlantic between Florida, Cuba and the Bahamas (Compagno 1984, Ebert & Wilms 2013).

Rostral characters. Rostrum thin, narrowly tapering and proportionally longer than that of the other *Pristiophorus* species (Springer & Bullis 1960); about 13–14 large smooth-edged lateral teeth anterior to ventral pair of barbels, 9–10 posterior (Compagno 1984); large and small or medium-sized teeth alternating with few exceptions; two lines of short, thorn-like and strongly recurved teeth situated ventrally reaching from tip to nasal openings (Springer & Bullis 1960).

Size. Maximum known length 81 cm TL (Ebert & Cailliet 2011); rostrum length 31–32 % of TL (Compagno 1984), i. e. up to 25.1–25.9 cm.

Red List category. Data Deficient; population trend: unknown (Heupel 2006).

Main threats. There are currently no threats known to *P. schroederi*. Due to its distribution over a narrow range in depths (438–641 m) and limited area this species could be assessed as Near Threatened or higher if deepwater fishery occurred in its habitat. Presently there is no information confirming these fisheries as well as a lack of information on the biology of *P. schroederi* which makes threat assessment and conservation difficult (Heupel 2006).

Xiphiidae

The swordfish are a monotypic family consisting only of *Xiphias gladius*. Its rostrum is strongly elongated, flat, missing any teeth and is used for killing prey (Collette 1995). Their habitat is mostly oceanic, migrating during the year for feeding, spawning and overwintering. They can be found over a wide depth range when foraging (Nakamura 1985).

Except for the Mediterranean population, *Xiphias gladius* is considered to be well-managed and therefore of Least Concern (Collette et al. 2011) and their main threat is from commercial fishing and by-catch in tuna longline fisheries.

Xiphias gladius Linnaeus, 1758

Common names. Swordfish, Broadbill, Broadbill Swordfish (Nakamura 1985, Collette et al. 2011).

Geographic distribution. Pandemic in tropical, temperate and sometimes cold waters (Nakamura 1985, Collette et al. 2011).

Rostral character. The sword-like rostrum is strongly elongated, flat and blunt-tipped, the edges are sharp and distinct. The rostrum has no teeth and its cross-section is flat-oval (Nakamura 1985).

Size. Common length below 300 cm TL (Collette 1995), maximum length 455 cm BL (IGFA 2001); rostrum length 50 % and more of BL (Nakamura, 1983).

Red List category. Least Concern; population trend: decreasing (Collette et al. 2011).

Main threats. Endangerment is mainly caused through by-catch in recreational, sport or commercial fishery, especially in tuna longline fishery. In particular the Mediterranean Sea population suffers from overfishing (ICCAT 2009).

Istiophoridae

The Istiophoridae are a pandemic distributed family of eleven species in five genera inhabiting warm seas (Nakamura 1983). Migration is possible during the course of the year for feeding, spawning or overwintering (Nakamura 1983, 1985). Like swordfish, these species can be recognized among other things by their elongated rostrum which varies strongly in length according to species. Species identification only based on rostrum characters seems limited, but a respective key for at least six species was presented by Fierstine & Voigt (1996).

The species of Istiophoridae are assessed to be of Least Concern up to Vulnerable (IUCN 2013). Their main threat is by-catch in fisheries.

Rostral character. Small denticles on underside; rostrum length changes during growth, juveniles have relatively longer bills in comparison to body sizes. Long: about one third of body length in adult *Istiophorus albicans* and *I. platypterus*, medium sized: 24 to 31 % of BL in *Kajikia audax*, *K. albidus*, *Tetrapturus georgii*, *T. pfluegeri*, *Istiompax indica*, *Makaira mazara*, *M. nigricans*, or short: 14–18 % of BL in *T. angustirostris*, *T. belone*. In general, *Istiophorus*: long and slender bill; *Tetrapturus*: short-long and stout; *Makaira* and *Istiompax*: medium-sized and extremely stout; *Kajikia*: medium-sized and stout (Nakamura 1983, 1985).

Size. The species maximum known lengths range from 184 cm BL in *T. georgii* (Nakamura 1985) to 500 cm TL in *M. nigricans* (Randall 1995) and *M. mazara* (Allen & Steene 1988).

Red List category. Least Concern to Vulnerable A2bd (*K. albida*, *M. nigricans*), some species not yet listed or Data Deficient (IUCN 2013).

Main threats. Endangerment is primarily caused through by-catch in longline and recreational fisheries (Restrepo et al. 2003).

Discussion

The herein presented key for larger fish rostra showed that the identification on species level is possible for Pristidae, Xiphiidae and most Pristiophoridae. In reverse, it showed that the rostrum is a suitable character complex for the identification of species. It was, however, not possible to clearly distinguish *Pristiophorus delicatus* from *P. schroederi* and *P. japonicus* from *P. lanae* based on rostrum characters only. Identifying Pristiophoridae species can be further complicated if several teeth in front of the barbels are missing and therefore the number of teeth cannot be clearly determined. In this case the position of the barbels can help to identify the species. Several studies describe the pre-barbel length as percentage of the pre-oral length (Ebert & Cailliet 2011, Ebert & Wilms 2013); however, a rostrum of complete length including the specimen's mouth is essential to determine the pre-oral length.

For some pristids local variations are pronounced leading to the description of distinct species which were recently synonymized. What was previously misinterpreted could now even be useful to identify the origin of such rostra (Table 1). Further variation in rostral morphology may come from sexual dimorphisms: These have been described in different species as possible deviance in rostrum length, rostral tooth shape or rostral tooth count. The latter is confirmed for at least *P. pristis* (Thorburn et al. 2007); the data for other species is inconsistent between different studies (Faria et al. 2013, Whitty et al. 2014). Compagno & Last (1999) state the existence of a distinction between male and female in tooth count but this is not confirmed in more recent studies, possibly due to small sample sizes (Whitty et al. 2014). Another study statistically describes a significant difference between the sexes in *P. pectinata* (Wiley et al. 2008); however it can be perceived as small enough to have virtually no impact in the field. In *P. clavata* such a sexual dimorphism seems to be absent (Whitty et al. 2014). A variation in rostrum length is known for *P. pristis* (Thorburn et al. 2007) but deals with the relationship of TL and rostrum length in the studied individuals. Given that this identification key is based on the assumption of only (a part of) the rostrum being available for usage, this sexual dimorphism can be neglected. In general, these sex-related differences are more of statistical nature and will not be helpful in the determination of sex, if only a single rostrum is available for study. Aside from variations in rostral tooth count and an overlap between several species of Pristidae, accurate determination of older specimens can prove difficult due to the wearing-off of teeth and their bases. The described tooth characteristics are very useful in distinguishing juvenile sawfish. However, in this as well as another study (Whitty et al. 2014), worn-off teeth in older specimens could be observed resulting in the alteration of juvenile groove structure. This leads especially to a strong similarity of *P. pristis* and *P. clavata* as grooves on the posterior edge of the rostral teeth reach further towards the bases in the latter than observed in the respective juveniles. In this case the comparison of the visible crowns can be helpful as *P. pristis* shows none and *P. clavata* at least partial ones. Further observations showed wear on *P. pectinata*'s rostral teeth to lead to reduction of the characteristics in its grooves. This again leads to a possible confusion with *P. zijsron*. Morphometric parameters can be added to the identification of a species if the rostrum on hand includes the entire length up to the most proximal pair of teeth. Whitty et al. 2014 describe the measurement pairs tip width (width at most distal tooth pair) to SRL (TW/SRL) and standard rostrum width (width at most proximal tooth pair) to SRL (SRW/SRL) as being helpful for some sawfish comparisons in addition to the known rostral tooth characteristics. Unfortunately, there are no known studies including the respective data for *P. pectinata*. For this study, 4 rostra of *P. pectinata* were available, their TW/SRL is 0.052–0.058 (0.056 ± 0.001) and SRW/SRL is 0.120–0.143 (0.129 ± 0.005). Due to the small sample number these values can only be used as reference and are not further significant.

Species level identification of istiophorids only based on rostrum characters seems difficult, but on the other hand rostra bear several useful characters for species identification in whole specimens. Presently existing identification keys distinguish species by using whole specimens; Fierstine & Voigt (1996) try to distinguish 6 species based exclusively on the rostrum; however their key is mainly useful if the entire rostrum is available and cross-sections can be examined. Istiophorids and *Xiphias* show very wide distribution ranges, but possible regional differences in rostrum characteristics are not yet described.

Rostra of Istiophorids and *Xiphias* are less commonly kept or traded as trophies than those of sawfishes and sawsharks. Especially some of the pristid species are close to extinction (Kyne et al. 2013, Simpfendorfer 2013, Whitty et al. 2014). For pristiophorids, the situtation may be better, but is mainly less clear as data on stock size and population trends are not yet available. Further research on actual distribution ranges and stock sizes as well as conservation measures and enforcement of international trading regulations, e. g. by CITES, are necessary. We hope that this rostrum identification key can positively contribute to improve the situation so that specialists, e. g. fisheries inspectors or ichthyologists as well as non-specialists, e. g. custom officers or employees in nature conservation offices, are able to identify and distinguish larger fish rostra.

Acknowledgements

We thank James Maclaine of the Life Sciences Department, Vertebrates Division at the Natural History Museum, London, for readily providing us with images of the *Pristiophorus japonicus* syntype available in their collection. We also would like to thank an anonymous reviewer for his detailed and helpful commentary on this manuscript, as well as Jean-Michel Carter for his help in proof-reading.

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