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Margaret Mary Smith (1916–1987),
James Leonard Brierley Smith (1897–1968)
with their dog Marlin

The publication series (Monographs, Bulletins & Special Publications) of SAIAB (formerly the JLB Smith Institute of Ichthyology), in its new format, honours James Leonard Brierley Smith and Margaret Mary Smith with the name Smithiana, in recognition of their many years of devoted service to African aquatic biology. Their life's work, a team effort, established modern ichthyology in southern Africa and laid the groundwork for the expansion of aquatic biology throughout the region.

Front cover photograph: Left pectoral fin of a preserved coelacanth specimen by Wouter Holleman. © SAIAB, 2006.

CONTENTS

Smithiana Bulletins and Monographs are publications of the South African Institute for Aquatic Biodiversity, for original scientific articles in the fields of taxonomy, systematics, ethology, ecology, biogeography and conservation of the fishes of Africa and its surrounding waters. Priority will be given to papers by staff and associates of the Institute. Manuscripts from outside the Institute will be considered if they are pertinent to the work of the Institute or use the Institute's collections.

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A collection of marine fishes from Angola, with notes on new distribution records

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ABSTRACT. Collections of fishes from demersal trawl surveys to 800 m depth off the Angolan coast in 2001, 2002 and 2005 resulted in several range extensions tabulated here. Specimens of species poorly represented in previous collections allowed improved diagnoses of *Myxine ios, Torpedo bauchotae, Dysommina rugosa, Pisodonophis semicinctus, Xenomystax congroides, Lestidiops cadenati, Ophidion lozanoi, Cataetyx bruuni, Dibranchus atlanticus, Diceratias pileatus, Himantolophus paucifilosus, Neomerinthe folgori, Careproctus albescens, Paracaristius maderensis* and *Pachycara crossacanthum.* All specimens accessioned into the Fish Collection of the South African Institute for Aquatic Biodiversity are listed and colour plates show a selection of species from the trawl catches.

KEY WORDS: demersal trawl, Gulf of Guinea, Benguela Current, range extensions, species diagnoses

INTRODUCTION

The Angolan coast is an area of high biodiversity interest as it forms the boundary between the fauna of the temperate Benguela current, arising from upwelling off the Namibian coast to the south, and the tropical waters of the Gulf of Guinea to the north. The sea off Angola therefore supports a rich and diverse fauna.

Few survey studies of fish off the Angolan coast have been made. Poll (1951, 1953, 1954, 1959) reported on work carried out by L'Expédition Océanographique Belge dans l'Atlantique Sud of 1948–49. Lloris (1984, 1986) reported on mainly deepwater fishes from Spanish government surveys run through the Instituto de Ciencias del Mar, Barcelona, along the adjacent Namibian coast. Surveys in the area by the former Soviet Union were conducted during the 1970s and 1980s (Trunov 1981), but many of these collections remain unreported. A few other summaries and guides have been published that are relevant to the Angolan marine fish fauna. The FAO Species Identification Sheets for the eastern central Atlantic (Fischer et al. 1981) provide identification material for mostly commercial species. The *Check-list of the fishes of the eastern tropical Atlantic* (or "Clofeta"), in three volumes, is a comprehensive guide to the relevant literature on fishes of the area (Quero et al. 1991). *Smiths' Sea Fishes* (Heemstra & Smith 1986) covers the southwestern African coast up to Namibia and thus is a partial guide to the Benguela system fishes, while the dated Blache *et al.* (1970) covers the eastern Atlantic coast to the north of Angola.

Extensive demersal trawl surveys off Angola in March 2001 and March 2002 in depths of 20 to 800 m by the *RV Dr Fridtjof Nansen* under a UNDP/NORAD programme provided South African Institute for Aquatic Biodiversity (SAIAB) with an opportunity to make large representative collections of the fishes of the region. The collection had two purposes, (1) to enhance the Institute's existing fish collection, and (2) to provide the fisheries researchers on the vessel with an updated species list, the documentation of range extensions and descriptions of the rarer species encountered.

Because of space and transport limitations, preparations for the surveys included a review of the species likely to be encountered, using existing guides to the area (Bianchi 1986; Bianchi *et al.* 1993; Schneider 1990) to determine which species should be collected. Decisions were made on which of the known species to collect based on presence or absence from the existing fish collection at SAIAB and on taxonomic status. Those species that required further taxonomic study had higher priority than well-known species. For the lesser-known, deep-water species, efforts were made to obtain representative samples of as many as possible, but concentrating on specimens that were in good condition. Any specimens that were not identified on board were retained for later study. A complete list of all species collected is appended to this paper, together with a summary of trawl station data for cross reference. On the basis of the *Clofeta* synopsis and some more recent literature, we record range extensions (Table 1) of 34 fish species from more northerly waters, two (*Galeichthys feliceps* and *Careproctus albescens*) from more southerly waters and the first eastern Atlantic record of the apparently widespread eel *Dysommina rugosa.* A new morid species collected, *Physiculus cyanostrophus* Anderson & Tweddle 2002, was described earlier.

Colour plates in this paper illustrate a small selection of species caught during the surveys, including some of the species discussed in the text.

MATERIALS AND METHODS

The trawl surveys were designed to obtain biomass estimates using the swept area method (Sparre & Venema 1998) and covered the entire length of the Angolan continental shelf from 20 to 800 m in depth. A total of 342 stations (summarised in Appendix A) were fished in the 2001 and 2002 surveys, with trawl bottom time usually of 30 minutes unless interrupted by hard ground.

Samples were taken from each trawl by the fisheries scientists on board for sorting, weighing and measurement. The fishes in this sample were checked and if there was any uncertainty over identification, the fishes were examined further in the vessel's laboratory, using available identification keys on board. In addition to the sample taken, each trawl haul was examined on deck for any unusual species that were present.

Using the target species list prepared in advance, up to ten good specimens were collected for each of the species and preserved in 10% formalin. Rare, unidentified or questionable specimens were also retained. Most specimens were identified on board, though some species are the subject of further study, as discussed below. Each fish kept was labelled with a code number written in pencil on plastic paper, which was inserted in the mouth or gillcover, cross-referenced with the field notes and station number. Full collection details were added later from the vessel's trawl records at SAIAB where the collection of 1704 specimens of 277 species was transferred to 60% propanol or 70% ethanol and catalogued. The full species list is given in Appendix B.

When time permitted and specimens of the various species were available in good condition, photographs were taken, generally against a standard yellow background, using the vessel's Olympus digital camera. Some photographs were also taken on slide film. Most photographed specimens were kept and preserved, with the specimen and photo cross-referenced, though some larger and/or commoner species were not retained.

In addition to the 2001 and 2002 survey collections, specimens of the uncommon *Lestidiops cadenati*, *Cataetyx bruuni* and *Pachycara crossacanthum* were obtained by Dr Tomio Iwamoto, California Academy of Sciences (CAS), during the UNDP/NORAD cruise of March-April 2005. Data from these specimens were incorporated into our accounts, with the station data added to Appendix A.

Counts and measurements in the species accounts follow Hubbs & Lagler (1947), Fernholm & Hubbs (1981) and McMillan & Wisner (1984) for hagfishes, Robins & Robins (1970) and Smith & Kanazawa (1977) for eels, Bradbury (1988, 1999) for batfishes, Pietsch (1974) and Bertelsen and Krefft (1988) for anglerfishes, Eschmeyer (1969) for scorpionfishes, Anderson (1994) for zoarcids and Robins (1960, 1962) for ophidioids. Counts of vertebrae and unpaired fin rays of elongate fishes were taken from radiographs. Abbreviation used are as follows: SL - standard length; TL - total length; HL - head length; Pelv. - pelvic fin rays.

Authorities for original descriptions are available in Eschmeyer's on-line Catalog of Fishes, http://www.calacademy.org/research/ichthyology/catalog/fishcatmain.asp, and are not included in the reference list here.

SYSTEMATICS

MYXINIDAE

Myxine ios Fernholm, 1981

This hagfish was the first to be captured in West African waters, and is known to occur from off Western Sahara to Iceland (Fernholm & Vladykov 1984). Fernholm (1981) found the species exists in two populations, a northern one with a light grey body and whitish head, and an African one with a uniformly darker grey colour. A single specimen, 303 mm TL, of the African population was collected off northern Angola in 700 m at station 2799 during the 2002 cruise (Appendix B). It agrees with the original description in every respect except that it has 101 slime pores, compared with 103–116 for the West African population, and slight differences in a few morphometric features.

Head and body uniformly dark purplish-grey. Ventral part of snout, mouth, barbels, gill apertures, slime pores, cloaca and distal half of ventral fin fold white. Proportions as percent total length: prebranchial length 30; trunk length 57; tail length 13; body width 4.8; body depth including fin fold: 6.5; body depth excluding fin fold: 5.6; body depth at cloaca: 5.3; tail depth 5.7; first barbel length 1.3; second barbel length 1.3; third barbel length 1.5. Slime pore counts, left side: prebranchial 29, trunk 61, tail 11 = 101 total. Seven gill pouches on each side. Tooth counts: cusps on multicuspids 2/2 each side; unicuspids, right side: outer row 9, inner row 9; unicuspids left side: outer row 10, inner row 9; total cusps 45.

TORPEDINIDAE

Torpedo bauchotae
Cadenat, Capapé & Desoutter 1978
(Plate 1J)

This electric ray was described from two juveniles taken off the Congo and Senegal, depths unknown. Other (unpublished) specimens are known from Ivory Coast and Senegal (B. Seret pers. comm., 2003). Two juvenile females, 148–150 mm TL, were taken off northern Angola during the 2001 cruise in 24 m (Appendix B).

Anterior edge of disk straight, pelvic fins gently rounded. Characteristic black variegations snaking around disk; these wider, therefore disk darker, in 148

Table 1. New records, range and depth extensions for fishes caught in the Angolan trawl surveys. The sources for the previous data, followed by page number, are: C = CLOFETA; S = Smith 1989; L = Lloris 1986.

Name	From	To	Source
MYXINIFORMES			
Myxine ios	W. Sahara	N. Angola	CI:1
ANGUILLIFORMES			
Coloconger cadenati	Gulf of Guinea	N. Angola	CI:168
Uroconger syringinus	Gulf of Guinea	C. Angola	CI:166
Nettastoma melanurum	Gulf of Guinea	N. Angola	CI:174
Xenomystax congroides	Gulf of Guinea	N. Angola	S:566
Hoplunnis punctatus	Gulf of Guinea	N. Angola	CI:173
Chlopsis olokun	Congo	N. Angola	CI:150
Dysommina rugosa	(First East-Central Atlantic record)		S:242
SILURIFORMES			
Galeichthys feliceps	Walvis Bay	S. Angola	CI:230
SALMONIFORMES			
Talismania homoptera	Congo	S. Angola	CI:263
AULOPIFORMES			
Aulopus cadenati	NW Africa	N. Angola	CI:349
Bathypterois quadrifilis	Gulf of Guinea	C. Angola	CI:357
Lestidiops cadenati	Gorée, Senegal	N. Angola	CI:375
GADIFORMES			
Nezumia africana	Gulf of Guinea	S. Angola	CII:560
OPHIDIIFORMES			
Ophidion lozanoi	Senegal	C. Angola	CII:574
Cataetyx bruuni	First since original description (off Angola)		CII:574
LOPHIIFORMES			
Lophiodes kempi	Congo	C. Angola	CII:479
Antennarius senegalensis	Congo	C. Angola	CII:482
Diceratias pileatus	Gulf of Guinea	C. Angola	CII:496
SCORPAENIFORMES			
Scorpaena elongata	Guinea	C. Angola	CII:671
Neomerinthe folgori	Mauritania	N. Angola	CII:667
Careproctus albescens	So. Namibia	S. Angola	L:320
PERCIFORMES			
Boops boops	São Tome-Principe	S. Angola	CII:790
Mycteroperca rubra	Zaire	Luanda	CII:702
Cephalopholis nigri	Zaire	Luanda	CII:695
Chaetodon robustus	Gulf of Guinea	Luanda	CII:838
Labrisomus nuchipinnis	Equatorial Guinea	Luanda	CII:918
Lutjanus fulgens	Gulf of Guinea	C. Angola	CII:776
Pachycara crossacanthum	Gabon	N. Angola	
Priacanthus arenatus	Gulf of Guinea	S. Angola	CII:712
Apogon affinis	Gulf of Guinea	C. Angola	CII:814
Synagrops bellus	Gulf of Guinea	N. Angola	CII:693
Xyrichthys novacula	Gabon	C. Angola	CII:882
Trachinus pellegrini	Nigeria	N. Angola	CII:895
Foetorepus phaeton	Gabon	N. Angola	CII:924
Trachinotus goreensis	Gulf of Guinea	C. Angola	CII:749
Ariomma bondi	Gulf of Guinea	N. Angola	CII:1019
PLEURONECTIFORMES			
Microchirus wittei	Ghana	N. Angola	CII:1043
	Depth: 145-460 m	43-44 m	
Cynoglossus cadenati	Depth: 10-20 m	729-738 m	CII:1051

mm specimen than in the larger individuals. Pale spots surrounded by thin black lineations in this specimen, spots paler (whitish), without lineations in 150 mm specimen. Spiracle surrounded by 9-10 finger-like papillae. Molariform teeth in four rows anteriorly in both jaws. Proportions as percent disk width: total length 1.4–1.5; disk length 83–87; snout to origin of first dorsal fin 93–99; snout to origin of second dorsal fin 1.0; interdorsal distance 3.7–4.1; first dorsal fin base 9.3–9.8; second dorsal fin base 7.5–7.7; transverse spiracle diameter 2.7–2.9; interspiracular width 7.0–7.9; interorbital width 4.8–5.0; mouth width 9.3–9.4; internasal width 5.8–5.9; snout to mouth 13; first gill slit interdistance 25; fifth gill slit interdistance 23–24.

SYNAPHOBRANCHIDAE

Dysommina rugosa Ginsburg 1951

This cutthroat eel has been reported reliably from upper slope depths in the northwestern Atlantic and Hawaii. A single 362 mm TL specimen was taken off northern Angola in 536–542 m during the 2002 cruise (Appendix B) that agrees with North Atlantic specimens (Robins & Robins 1989).

Total vertebrae 133; predorsal vertebrae 11; Dorsal fin rays (D) 314; Anal fin rays (A) 290; Pectoral fin rays (P) 16; Caudal fin rays (C) 15. Pores: preoperculomandibular 5 (pore in position five, under posterior margin of eye, not open on both sides); infraorbital 5; supraorbital 3. No supratemporal commissure. Vomer with four caniniform teeth. Proportions as percent TL: predorsal length 17; preanal 28; body depth at anus 5.9; head length 13; head width 3.3. Proportions as percent head length (HL): head width 26; snout 28; eye diameter 13; jaw length 45; gill opening 16; interbranchial distance 12; pectoral-fin 24; interorbital 15. Colour uniformly dark chocolate brown.

OPHICHTHIDAE

Pisodonophis semicinctus (Richardson 1848)
(Plate 3Y)

This distinctive snake eel was originally described as *Ophisurus semicinctus* Richardson 1848. This name, however, is a junior homonym of *Ophisurus semicinctus* Lay & Bennett 1839, another snake eel now placed in the genus *Leiuranus* Bleeker (McCosker 1977). Richardson's name has been wrongly treated as valid by authors as *Pisodonophis semicinctus*. Also, the species does not belong to *Pisodonophis sensu stricto*, thus a replacement name is required (J. McCosker, pers. comm.). This eel ranges from the Mediterranean coast of Algeria to Angola at inner shelf depths (Bauchot 1986). Three specimens, 616–813 mm TL, were taken during the cruises off northern and central Angola in 25–40 m (Appendix B). Recent descriptive literature for the species includes Blache et al. (1970), Blache & Saldanha (1972), Saldanha (1982) and Bauchot (1986), summarised below.

Total vertebrae 155–162. Lateral line pores: prepectoral 10–12; preanal 53–59. Pectoral-fin rays 10–11. Caudal fin absent, tip of tail a stiff lobe. Proportions as percent total length (TL) (Blache & Saldanha 1972): predorsal length 6.7–8.9; preanal 32–43; head 11–12; body depth 3.3–4.3. Proportions as percent HL: predorsal length 63–79; body depth 29–40; snout 19–21; eye diameter 6.6–10.0; interbranchial distance 18–20; pectoral-fin 28–33.

Head cuneiform in lateral view when mouth closed. Dorsal and anal fins well developed, dorsal-fin origin distinctly in advance of gill opening. Background colour yellow, lighter ventrally, with 14–18 dark brown saddles from nape to tail tip. Pectoral fin yellow. Head with large dark saddle blotch and smaller black spots.

CONGRIDAE

Xenomystax congroides
Smith & Kanazawa in Smith, 1989

This eel is chiefly known from the Gulf of Mexico to off northern Brazil in depths of about 150-500 m, but is also known in the eastern Atlantic from 10 specimens taken from off Liberia to Congo in 156–400 m (Smith 1989). Two specimens were taken off northern Angola during the 2001 cruise at depths of 327–355 m (Appendix B). One specimen (SAIAB 64867, 445 mm TL) has lost the end of its tail (172 total vertebrae) and has a regenerated pseudocaudal fin. Both specimens agree well with the Gulf of Guinea population in the original description but have one less supraorbital pore.

Predorsal vertebrae 4; preanal vertebrae 39–40; precaudal vertebrae 60–61; total vertebrae 216 (undamaged specimen). Branchiostegal rays 10. Pectoral-fin rays 12–13. Pores: lateral line to anus 36–37; preoperculomandibular 14; infraorbital 5 + 0 + 3; supraorbital 1 + 4; supratemporal commissure 3. Proportions as percent TL (undamaged specimen): predorsal 12; preanal 34; head 14. Proportions as percent preanal length (both specimens): predorsal 34–35; head length 41; head width 9.0–10.1; depth at anus 11; pectoral fin 9.2–10.1. Proportions as percent HL: snout 32; eye 11; upper jaw 55–56; gill opening 9.2–10.3; interbranchial 10; pectoral fin 23–25.

Body and tail brownish dorsally with scattered melanophores. Lateral line area pale. Ventral surface pale yellowish. Edges of vertical fins posteriorly and gut black. Intermaxillary tooth patch with three large canines anteriorly (Smith 1989, fig. 598).

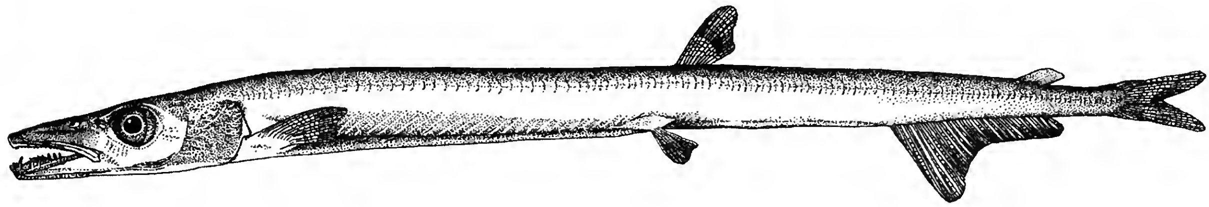

Fig. 1. *Lestidiops cadenati*, 218 mm SL, SAIAB 66083.

PARALEPIDIDAE

Lestidiops cadenati (Maul 1962) (Figs. 1 & 2)

This barracudina was described from a single beach-cast juvenile, 82.5 mm SL, found near Dakar, Senegal in 1953 (Maul 1962). Subsequent references that we found all refer to the holotype (Blache et al. 1970; Post 1972, 1991). Nineteen specimens, 210–233 mm SL, were collected during the two cruises off northern Angola at five stations ranging in bottom depth from 259 m to 364 m (Appendix B). The 2005 CAS collection contains seven specimens 217–318 mm SL from stations 3630, 3656, 3675, 3698 and 3709 (Appendix A). Barracudinas are considered coastal, mesopelagic fishes (Rofen 1966). Vertebral and caudal-fin counts were taken from radiographs of 15 specimens. Other counts and measurements were taken from all 26 fish where possible.

Vertebrae 36–40 + 41–45 = 79–84; D 9–11 (usually 10); A 25–27; P 11–12; Pelv. 9; C xiii–xiv + 10–11 + 9 + ix–xvii (19–20 principals); lateral line sections 130–140; gill rakers 4–13 + 22–29 = 26–41; branchiostegal rays 5; pseudobranch filaments 16–19. Proportions as percent SL: head length 22–24; head width 4.1–4.8; head depth 6.4–7.5; postorbital length 8.4–9.3; upper jaw length 8.4-10.2; lower jaw length 11–13; predorsal length 60–63; preanal length 79–80; prepelvic length 56–60; pectoral-fin length 7.9–9.3; pelvic-fin length 5.2–5.9; body depth at dorsal-fin origin 5.2–7.3; body depth at anal-fin origin 5.0–6.1; gill slit length 11–12; caudal peduncle length 5.2–7.2; caudal peduncle least depth 2.5–2.8; dorsal-fin base 4.5–5.6; anal-fin base 14–15. Proportions as percent HL: head width 19–21; head depth 28–34; postorbital length 38–41; upper jaw length 38–43; lower jaw length 50–57; pectoral base depth 9.2–11.6; pectoral-fin length 35–42; pelvic-fin length 23–25; snout length 44–46; orbit diameter 16–18; gill slit length 50–52; bony interorbital width 9.2–11.0.

Head depressed, snout long and tapering to tip of upwardly-protruding lower jaw that fits into the median diastema of the upper jaw. Over 60 tiny teeth on each premaxilla. Maxilla closely joined to premaxilla, edentate, as is vomer. Palatines with 6–9 retrorse, caniniform teeth in anterior half, usually arranged in groups of two, with innermost the larger; single row of 8–19 smaller, retrorse teeth posteriorly. Dentary with double row of teeth posterior to symphysis, outer teeth small, retrorse, inner teeth long, dagger-like. Eye large, rounded, with adipose eyelid covering anterior and posterior third of pupil. Gill cavity black, gill arches and pseudobranch filaments elongate. Gill rakers reduced to placodes bearing 1–4 strong denticles, with 4-13 placodes on epibranchial, 12–17 on ceratobranchial and 9–12 on hypobranchial. Operculum and suborbital regions with complex, radiating pattern of sensory canals. Body strongly laterally compressed. Ventral carinas (adipose keels) between pectoral and pelvic fins and pelvics and anal fin dotted with tiny melanophores. Lateral line scales (sections) one per myomere anteriorly; three upper and three lower pores posteriorly on each scale to mid-anal fin (Fig. 2; Maul 1962, fig. 5; compare with Rofen 1966, figs. 101, 102). Scales abruptly diminish in size near posterior end of anal fin, becoming two per myomere and with a single dorsal and single ventral pore. Lateral line scales extend to end of caudal peduncle where they are three per myomere, with a few scales turning dorsally right at end. Anus on vertical through dorsal-fin rays 4-8, center of anus situated 20.8–26.2% HL posterior to pelvic-fin insertion. Fins relatively small; pectorals wedge-shaped, dorsalmost five rays longest. Anal fin deeply notched anteriorly, rays 4-6 longest. Dorsal fin low, usually of 10 rays, its origin one eye diameter posterior to vertical through pelvic-fin origin.

Colouration: dorsum dusky brown, pale silvery ventrally. Eye and opercular areas dark blue. Peritoneal pigment patches absent in our material. Fins of largest specimen (CAS 222645; 318 mm SL) dusky.

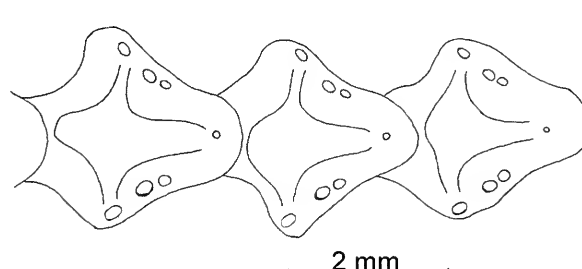

Fig. 2. *Lestidiops cadenati*, SAIAB 66083, lateral line scale detail.

Ophidiidae

Ophidion lozanoi Matallans 1990

This cusk-eel was described from two specimens taken off Western Sahara (holotype) and Senegal (paratype). No further published records are known (J. Matallans pers. comm.), but Robins (1999: 40) listed it from Spain as well. Twenty-one specimens, 117–208 mm SL, were collected during the 2002 cruise off central and northern Angola (Porto Amboim to the Congo River mouth) at depths of 40–259 m (Appendix B). Counts of vertebrae and unpaired fin-rays were taken from six radiographed specimens. Other counts and measurements were taken from 15 specimens 144–208 mm SL (the two types were 130 & 138 mm SL).

Vertebrae 15–16 + 51–53 = 67–69; D 130–147; A 108–119; P 24–25; C 9; Pelv. 2; lower limb gill rakers 4; branchiostegal rays 7; pseudobranch filaments 4–5. Proportions as percent SL: head length 21–22; head width 8.7–11.3; head depth 13–14; predorsal length 26–29; preanal length 40–41; prepelvic length 5.2–6.4; gnathoproctal length 37–38; lateral line length 88-90; body depth at occiput 14–25; body depth at dorsal-fin origin 14–15; body depth at anal-fin origin 13–14; gill slit length 12–15; occipital length 13–14; postorbital length 12–13. Proportions as percent HL: upper jaw length 49–54; lower jaw length 55–60; pectoral base depth 18–19; pectoral-fin length 43–46; pelvic-fin length 33–53; snout length 19–21; orbit diameter 24–27; gill slit length 56–68; bony interorbital width 14–17; occipital length 61–63; postorbital length 57–59.

Anterodorsal edge of snout high as result of large rostral spine; tip of snout vertical (Fig. X). Tail laterally compressed, lateral line coursing along its dorsal third, extending to posterior seventh of total length. First dorsal-fin pterygiophore inserted between vertebrae 6 and 7. Epibranchial tooth plates 2–3, four elongate gill rakers on ceratobranchial. Vomerine teeth 28–51, in triangular or rhomboidal patch. Palatine teeth in three (smallest fish) to five (largest) irregular rows. No pyloric caeca. Peritoneum and orobranchial chamber black, mouth dusky toward sides. Body greyish-brown dorsally with yellowish tinges ventrally in smaller specimens.

Fig. 3. *Cataetyx bruuni*, 100 mm SL, SAIAB 65946, pectoral and caudal fin details from separate specimen, SAIAB 65871.

BYTHITIDAE

Cataetyx bruuni (Nielsen & Nybelin 1963)
(Fig. 3)

This rare brotula was originally described in the genus *Oculospinus* Koefoed 1927 from three specimens taken off Angola at depths of 235–510 m, but was assigned to *Cataetyx* by Cohen (1981). No other descriptive records were found, but Nielsen (1990) mentioned there were a "few specimens from the Gulf of Guinea". We found that these are 27 specimens in four lots in the Museum de La Rochelle, France, and the National Museum of Natural History, Washington, D.C., USA. They range from Senegal to Gabon at depths of 329–1355 m. Three specimens were collected during the 2002 cruise off central Angola (north of Benguela to off Cabo Ledo) at depths of 504–707 m (Appendix B), an adult male 92 mm SL and two gravid females 87–100 mm SL. The CAS 2005 collection is of 21 specimens 65–122 mm SL from stations 3601, 3622, 3641, 3649 and 3656 at depths of 604-809 m (Appendix A).

Vertebrae 15–16 + 48–50 = 61–66; D 107–120; A 81–89; P 26–28; C 10; Pelv. 1; lower limb gill rakers 3; branchiostegal rays 9; pseudobranch absent. Proportions as percent SL: head length 23–26; head width 10–14; head depth 11–13; predorsal length 31–34; preanal length 47–51; prepelvic length 19–21; gnathoproctal length 42–46; body depth at occiput 11–14; body depth at dorsal-fin origin 11–17; body depth at anal-fin origin 11–13; gill slit length 15–16; postorbital length 14–15; pectoral fin length 13–15. Proportions as percent HL: upper jaw length 43–49; lower jaw length 49–56; pectoral base depth 21–26; pectoral fin length 56–63; pelvic fin length 31–42; snout length 21–23; orbit diameter 19–20; gill slit length 63–66; bony interorbital width 14–16; postorbital length 56–60.

Head ovoid, depressed; tip of snout steeply sloping (Fig. 3). Tail laterally compressed; lateral line not evident. First dorsal-fin pterygiophore inserted between vertebrae 7 and 8. Rudimentary gill rakers on epibranchials 2-3; three elongate rakers on upper part of ceratobranchial and seven rudiments ventrally. Vomerine teeth 16–27, in two arcing rows. Palatine teeth in three irregular rows. No pyloric caeca. Opercle with stout, V-shaped spine arrangement; uppermost projecting posteriad, lower projecting ventroposteriad. Skin flap on opercle above posteriorly-directed spine ending in a wide pore. Cleithrum with posteriorly-directed spine just above pectoral base. Posteriorly-directed preorbital spine directly behind posterior nostril. Pelvic fins inserted under opercle. Top of head and body brown, head darker. Opercle, lower side of head and area under eye blue. Cheeks yellowish. Orobranchial chamber and peritoneum black.

OGCOCEPHALIDAE

Dibranchus atlanticus Peters 1876

This batfish is known in the western Atlantic from Canada to Brazil and in the eastern Atlantic from the Gulf of Guinea to Angola in depths of about 100–1260 m (Bradbury 1999). Twenty-six specimens were taken off central and northern Angola during the cruises at depths of 112–614 m (Appendix B). The specimens agree with Bradbury's detailed description, but most have very large tubercles more like those of *D. tremendus* Bradbury 1999 than typical *D. atlanticus* (Bradbury 1999, fig. 8). The central spines of our specimens are not greatly elongated on the tubercles of the tail, as in *D. tremendus*. All tubercles are decorated with spinules, however, and this, with the small sizes and shallow collection depths, identify the species as *D. atlanticus*.

Counts and body proportions from 10 specimens 81–105 mm SL: D 5–6; A 4; P 13–14; Pelv. 5. Neuromast counts: preopercular 2; subopercular 5–6; tail 10–11. Proportions as percent SL: disk margin length 42–44; skull length 28–31; cranium width 20–22; eye width 9.7–10.7; distance jaw to anus 49–53; jaw to anal fin origin 71–74; predorsal length 58–60; interorbital width 8.6–9.4; jaw length 11–12; mouth width 14–16.

DICERATIIDAE

Diceratias pileatus Uwate 1979

This double anglerfish is known in the literature from 45 specimens ranging across the tropical Atlantic from the Bahamas to the Gulf of Guinea (Uwate 1979; Fujii 1983). Pietsch & Randall (1987) reported the first occurrence of the species outside the Atlantic (off Hawaii), which is the largest specimen known at 275 mm SL. Twenty-two female specimens, 20–114 mm SL, from nine stations were collected during our cruises off Angola (Appendix B). This species is mesopelagic and bottom depths ranged from 446–769 m.

Following counts and proportions taken from the ten best specimens, 20–65 mm SL: D 6–7; A 4; P 12–13; C 9; vomerine teeth 0–8 (absent in 20 mm fish); upper jaw teeth 9–17; lower jaw teeth 14–22. Proportions as percent SL: predorsal length 76–79; preanal length 86–89; body depth 59–62; illicial length 36–40; head length 37–40; head depth 57–59; head width 33–36; lower jaw length 44–47. Esca a simple bulb with a small cap (absent in 20 mm fish). Body solid black, covered in minute spinules.

HIMANTOLOPHIDAE

Himantolophus paucifilosus Bertelsen & Krefft 1988

This footballfish was described from 17 females taken at mesopelagic depths across the tropical Atlantic. A single female, 147 mm SL, was taken off central Angola in 2002, bottom depth 672 m (Appendix B).

Counts and proportions as percent SL: D 5; A 4; P 16; C 9; head length 39; head depth 56; predorsal length 87; preanal length 87; body depth 65; illicial length 46; diameter escal bulb 5.5; length distal escal appendage 2.0; anterior appendage absent; length posterior appendage 9.5; length illicial appendage 15. Two illicial appendages just below esca, each with an unbrancing filament. Colour solid black.

SCORPAENIDAE

Neomerinthe folgori (Postel & Roux 1964) (Fig. 4)

This rare scorpionfish was described from a single specimen, 287 mm SL, taken off the Cape Verde Islands in 180–200 m. We found that only two other specimens have been reported, one from Mauritania in 310 m (Cervignon 1960, reported as *Scorpaena* sp. (Eschmeyer 1969)) and another from Namibia in about 200 m (Penrith 1980; Eschmeyer 1986). The species was not mentioned by Blache *et al.* (1970). A gravid female, apparently the largest specimen known at 417 mm SL, was collected off northern Angola during the 2001 cruise in 322–324 m (Appendix B). It agrees with published descriptions, but as it is much larger than the other three (to 340 mm), has significantly shorter predorsal and snout lengths and fewer gill rakers (lowermost somewhat coalesced); variation in other morphometric features is insignificant.

D XII, 11; A III, 5; P 17; C 16; Pelv. I, 5; gill rakers 8 + 8; tubed lateral line scales 28; lateral line scale rows 78.

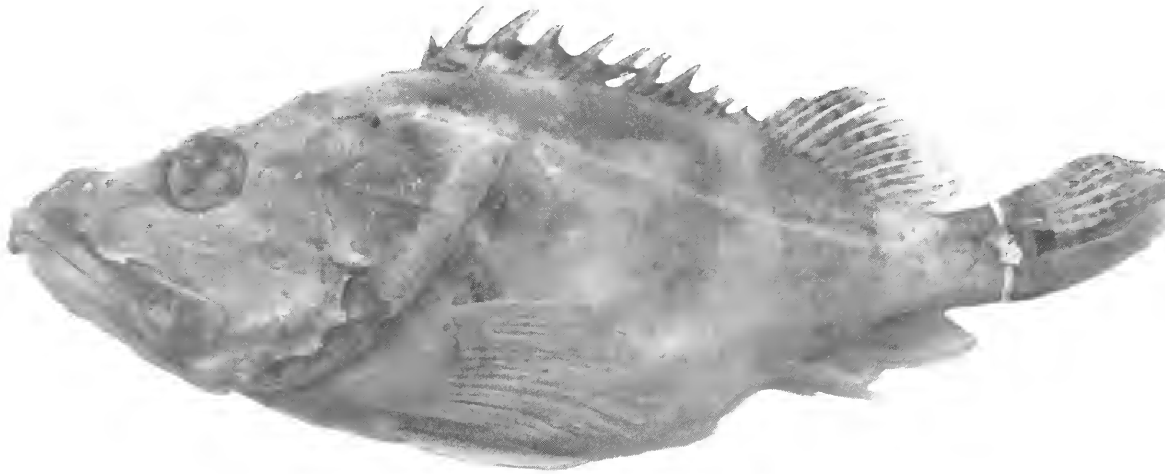

Fig. 4. *Neomerinthe folgori*, 417 mm SL, SAIAB 65015, photograph of right side in mirror image.

Proportions as percent SL: head length 45; head width 25; head depth 32; body depth 36; predorsal length 35; preanal length 73; prepelvic length 36; pectoral-fin length 23. Proportions as percent HL: head width 57; head depth 71; postorbital length 55; orbit diameter 19; snout length 31; upper jaw length 47; pectoral-fin length 51.

Preorbital bone with two spinous lobes over upper jaw, with 11 lateral points and five cirri. Suborbital ridge with 34 small points along centre line. First preopercular spine longest, second small (absent on left side), third and fourth present, fifth a mere nub under skin. Supplemental preopercular spine present. Postorbital ridge with upper posttemporal spine embedded (unexposed); supracleithral, lower posttemporal, pterotic and sphenotic spines present, letter two with several small points. Scales on body ctenoid, 78 lateral scale rows (the count by Postel and Roux 1964, of 85 in the holotype was corrected by Poss & Duhamel 1991, to 77). Cirri on head weakly developed, mostly absent. Background colouration yellowish with black and brownish variegations. Four variegated black bands on body. Caudal fin with narrow bands, posterior margin without wide black band as in holotype.

LIPARIDAE

Careproctus albescens Barnard 1927

Careproctus griseldea Lloris 1982

This snailfish was described from six juveniles taken off Cape Town in 1152–1463 m. It is still rare in collections, and we are aware of 16 other specimens from Cape Town north to off southern Namibia. Lloris (1982) described the first adults as *C. griseldea*. A single adult, 126 mm SL, was taken during the 2002 cruise off southern Angola in 603 m (Appendix B).

Vertebrae 11 + 51 = 62; D 55; A 49; P 26 + 11 = 37; C 11; branchiostegal rays 6. Proportions as percent SL: Predorsal length 23; preanal length 36; head length 23; head width 14; head depth 18; body depth 20; gill slit length 8.2; pectoral-fin length 19. Proportions as percent HL: head width 60; head depth 77; upper jaw length 37; lower jaw length 43; pectoral base depth 32; pectoral-fin length 82; body depth 86; disk width 23; disk length 26; snout length 32; eye diameter 22; gill slit length 36; bony interorbital width 19. Colour uniformly pale grey anteriorly grading into blackish tail. Peritoneum dusky (densely dotted with melanophores, typical of adult, shallow-dwelling *Careproctus* species). Teeth mostly simple, retrorse, a few in inner rows of lower jaw trilobed (tips triangular).

CARISTIIDAE

The manefishes are in great need of systematic revisionary study. No keys to all the species exist (but see below) and a few undescribed genera and species are known in collections (M. Leiby pers. comm. 2002). Until recently, two subgenera of *Caristius* Gill & Smith 1905 were usually recognised, *Platyberyx* Zugmayer 1911, with a high, curved lateral line and vomerine and palatine teeth, and *Caristius* Gill & Smith 1905, with lateral line straight or absent and with or without vomerine or palatine teeth. The manefishes were not considered by Blache *et al.* (1970), but Post (1991) lists four species for the Clofeta area, two *Platyberyx* (*P. opalescens and P. groenlandicus*) and two *Caristius* (*C. macropus and C. maderensis*). Trunov *et al.* (2006) erected *Paracaristius* for *C. maderensis* (type species) and a new southern hemisphere species (*P. heemstrai*), but did not comment on the generic status of *C. macropus*. Nine specimens, 56–173 mm SL, of a manefish were taken during our cruises off central and northern Angola at bottom depths of 601–776 m (Appendix B).

Caristius macropus, originally described from Japan (Bellotti 1903) and well known in the Pacific, has been reported from the Atlantic a few times (e.g., Fraser-Brunner 1931; Parin et al. 1974, but not Norman 1930 [see Maul 1949: 26 for corrected counts]). We distinguish our species from *C. macropus*, and therefore identify it as *P. maderensis*, on the basis of its lower counts and lack of vomerine and palatine teeth. The material agrees well with Mauls' original description and that of Trunov (1981), each based on one specimen. We offer here a tentative key gleaned from other *Caristius* specimens in the SAIAB Fish Collection, the literature and an unpublished key of R. Britz, Natural History Museum, London.

KEY TO ATLANTIC SPECIES OF MANEFISHES

1A. Lateral line high on dorsum, arched 2
1B. Lateral line straight, coursing midlaterally, obsolete 3

2A. D 28–31; A 17–19 .... *Platyberyx opalescens*
2B. D 32–36; A 20–22 .... *Platyberyx groenlandicus*

3A. Rear margin of upper jaw not reaching beyond middle of eye; vomerine and palatine teeth absent; D 26–30; A 15–17; P 15–17; vert. 32-33 .... *Paracaristius maderensis*
3B. Rear margin of upper jaw reaches beyond middle of eye; vomerine and palatine teeth present; D 33–37; A 21–23; P 17–20; vert. 39–40 .... *Caristius macropus*

Paracaristius maderensis (Maul 1949)

Counts and proportions from Angola material (vertebral counts from radiographs of five specimens): Vertebrae 15 + 17–18 = 32–33; D 27–28; A 17–18; P 16–17; C 17 (principal rays); Pelv. 6; gill rakers 6–8 + 14 = 20–22; branchiostegal rays 7; pseudobranch filaments 11–20. Proportions as percent SL: head length 30–36; head width 13–15; upper jaw length 11–12; lower jaw length 15–20; predorsal length 8.8–9.5; preanal length 56–57; prepelvic length 25–30; length longest dorsal ray 58–81; length longest anal ray 25–43; pectoral length 26–31; pelvic length 59–61; body depth 47–48. Proportions as percent HL: head width 41–44; upper jaw length 32–36; lower jaw length 49–56; pectoral base depth 21–23; snout length 11–13; pupil diameter 31–36.

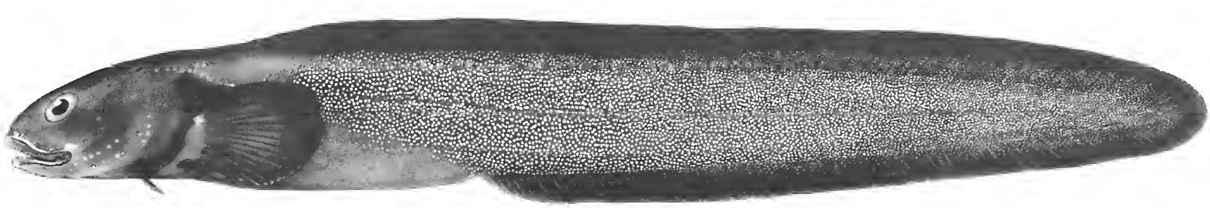

Fig. 5. *Pachycara crossacanthus*, drawing from original description.

ZOARCIDAE

Pachycara crossacanthum Anderson 1989
(Fig. 5)

This rare eelpout was described from six specimens, 227–378 mm SL, collected by French researchers in fish traps set off Senegal and Gabon in depths of 900–1050 m. No other specimens have been reported. Four late juvenile females, 137–155 mm SL, were collected during the two cruises off central and southern Angola at two stations in depths of 672–783 m (Appendix B). The CAS 2005 collection is of four specimens 122–265 mm SL from stations 3609, 3676 and 3684 taken at depths of 725–891 m (Appendix A). Vertebrae and median fin rays were counted from radiographs of all eight fish.

Vertebrae 25–28 + 76–81 = 103–107; D 98–101; A 80–82; C 11–12; P 17; Pelv. 3; vomerine teeth 5–9; palatine teeth 7–13; gill rakers 3–4 + 13–14; branchiostegal rays 6; pseudobranch filaments 4–5. Proportions as percent SL: head length 17–19; head width 8.3–8.7; head depth 8.8–9.6; pectoral-fin length 10–11; predorsal length 19–22; preanal length 41–44; body depth 9.4–10.7; gill slit length 6.6–7.5; caudal-fin length 3.0–3.7. Proportions as percent HL: head width 44–50; head depth 50–54; upper jaw length 31–38; pectoral-fin length 58–66; snout length 18–22; eye diameter 18–24; gill slit length 38–42; interorbital width 7.9–11.2; interpupillary width 23–27; pelvic-fin length 13–21; pectoral base/length ratio 42–47.

The four SAIAB and two CAS juveniles agree in every respect with the larger specimens but have slightly longer heads, pectoral fins and gill slits. Eight preoperculomandibular pores, seven suborbitals, two supraorbitals, four postorbitals (except CAS 222451 and 222647 with three), and no interorbital or occipitals.

Only dorsalmost 5-7 gill rakers on lower limb furcate in the six juveniles (Anderson, 1989, fig. 8). Body lateral lines originating just posterior to postorbital pore four, with mediolateral and ventral branches diverging just above anterior quarter of pectoral fin. Dorsal fin origin associated with vertebra four, with no free pterygiophores. Anal fin origin associated with ultimate precaudal vertebra, with 2-3 ray-bearing pterygiophores inserted anterior to haemal spine of first caudal vertebra in all four fish. Caudal fin with two epural and 9-10 hypural rays.

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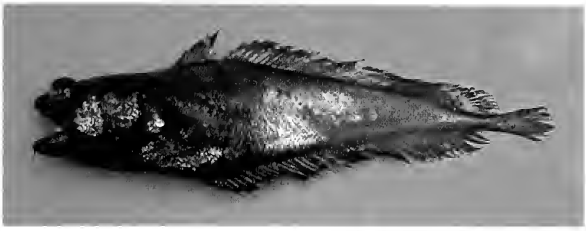
PLATE 1

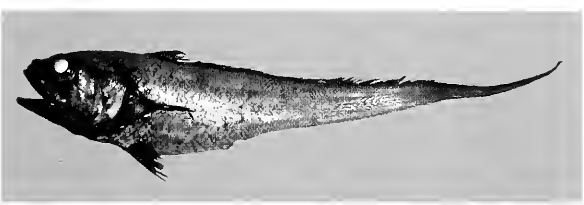
A. *Cepola pauciradiata*. Station 2762, SAIAB 65971. First published live colour photograph of this species.

B. *Coloconger cadenati*. Station 2842, SAIAB 67386.

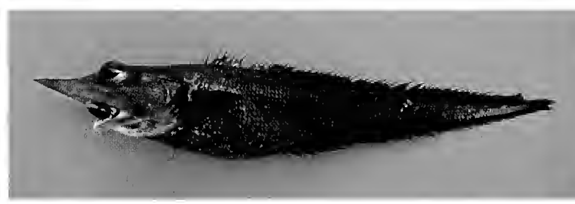


C. *Physiculus huloti*. Station 2765, SAIAB 66038.

D. *Physiculus cyanostrophus*. Station 2753, SAIAB 64639, paratype. First published live colour photograph of this species.



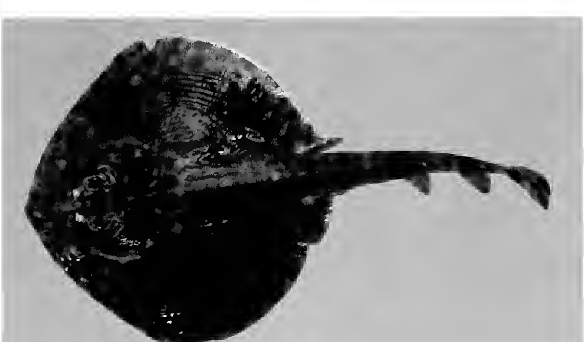
E. *Bathygadus macrops*. Station 2861, SAIAB 67989.



F. *Trachyrhynchus trachyrhynchus*. RV Dr Fridtjof Nansen collection, photo MARTRO1.jpg.

G. *Syacium micrurum*. Station 2472, SAIAB 65501.

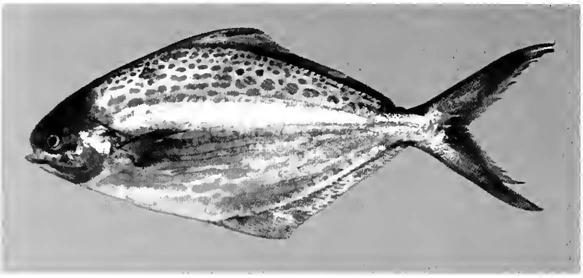
H. *Ebinania costaecanariae*. Station 2701, SAIAB 65804.



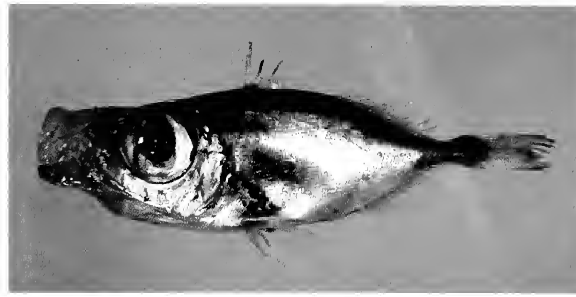
I. *Zanobatus schoenlenii*. Station 2556, SAIAB 65726.

J. *Torpedo bauchoti*. RV Dr Fridtjof Nansen collection, photo Rayto13.jpg.

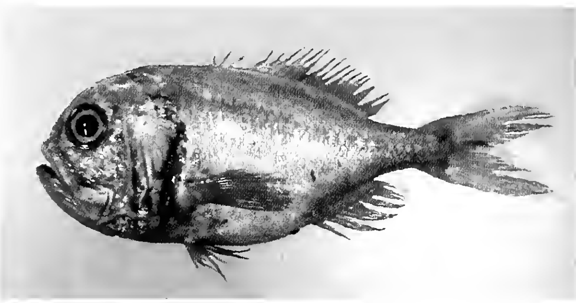
PLATE 2



K. *Stromateus fiatola*. Caught on 12 March 2001, not preserved.



L. *Zenion longipinnis* with mouth everted. RV Dr Fridtjof Nansen collection, photo ZE1Z10.jpg.

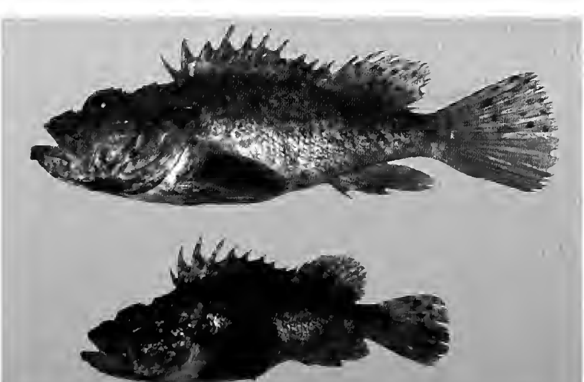


M. *Hoplostethus cadenati*. RV Dr Fridtjof Nansen collection, photo TRHH0031.jpg.

N. *Laemonema lawreysii*. RV Dr Fridtjof Nansen collection, photo MORLA011.jpg.

O. *Centrarchops atlanticus*. Station 2808, SAIAB 68106.

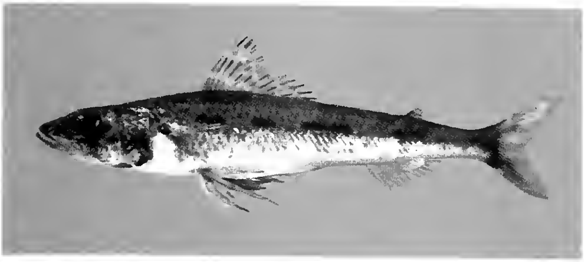
P. *Setarches guentheri*. RV Dr Fridtjof Nansen collection, photo SCRSE031.jpg.



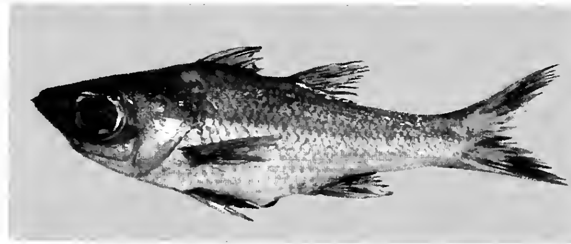
Q. *Scorpaena scrofa*. Two specimens from Station 2555, SAIAB 65733.

R. *Scorpaena normani*. Station 2501, SAIAB 65496.

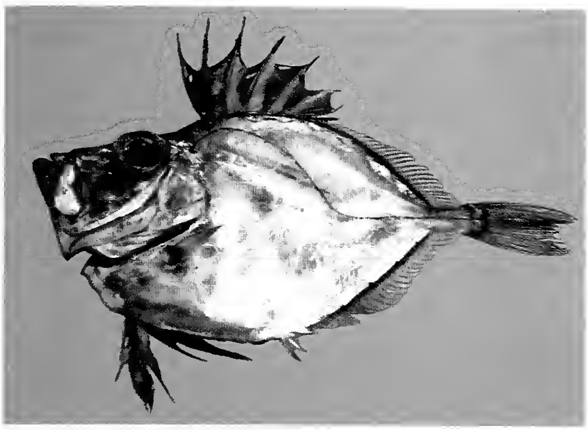
PLATE 3



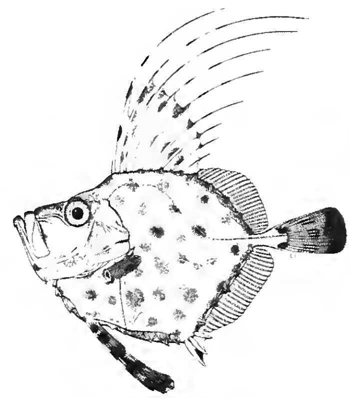
S. *Aulopus cadenati*. Station 2477, SAIAB 64976.



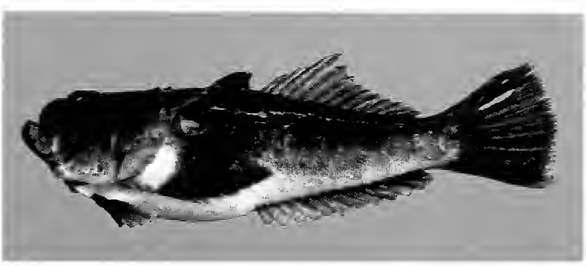
T. *Epigonus constanciae*. Station 2495, SAIAB 64872.



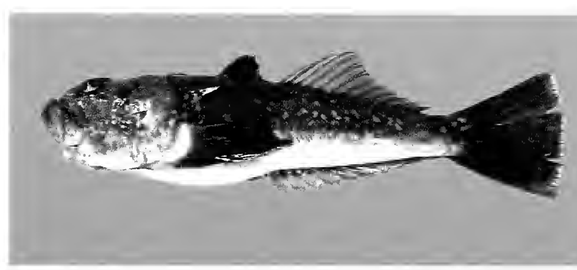
U. *Zenopsis conchifer*. Adult. RV Dr Fridtjof Nansen collection, photo ZEIZN01.jpg.



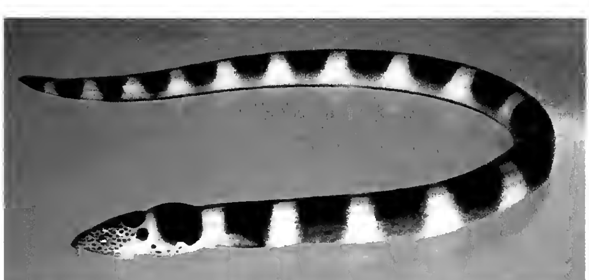
V. *Zenopsis conchifer*. Juvenile, 89 mm SL, SAIAB 67765.



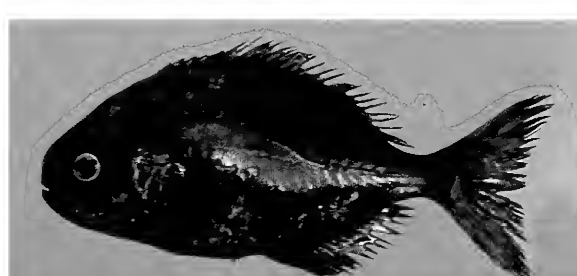
W. *Uranoscopus albesca*. Station 2481, SAIAB 65507.



X. *Uranoscopus cadenati*. Station 2477, SAIAB 65517.



Y. *Pisodonophis semicinctus*. Station 2798, FMNH 117452.



Z. *Schedophilus pemarco* juvenile. Station 2792, SAIAB 67986.

APPENDIX A.

A summary of station data for the 2001 and 2002 cruises. The 2005 survey stations from which specimens were provided by T. Iwamoto are also included.

2001 cruise

Station	Date	Position (Lat./Long.)	Depth (m)
2426	04.03.2001	S 12°37' E 12°58'	745–750
2427	05.03.2001	S 12°27' E 13°17'	515–530
2428	05.03.2001	S 12°26' E 13°19'	315–326
2429	05.03.2001	S 12°28' E 13°26'	39–45
2430	05.03.2001	S 12°22' E 13°29'	70–75
2431	05.03.2001	S 12°24' E 13°22'	105–107
2432	05.03.2001	S 12°20' E 13°20'	574–614
2433	06.03.2001	S 12°05' E 13°25'	444–445
2434	06.03.2001	S 12°05' E 13°34'	86–87
2435	06.03.2001	S 11°59' E 13°43'	25–29
2436	06.03.2001	S 11°53' E 13°40'	65–66
2437	06.03.2001	S 11°48' E 13°34'	103–107
2438	06.03.2001	S 11°52' E 13°31'	189–193
2439	06.03.2001	S 11°51' E 13°27'	268–276
2440	06.03.2001	S 11°46' E 13°21'	432–437
2441	06.03.2001	S 11°28' E 13°20'	624–654
2442	07.03.2001	S 11°29' E 13°27'	109–114
2443	07.03.2001	S 11°30' E 13°33'	73–81
2444	07.03.2001	S 11°29' E 13°40'	35
2445	07.03.2001	S 11°22' E 13°40'	33
2446	07.03.2001	S 11°18' E 13°40'	31–36
2447	07.03.2001	S 11°20' E 13°33'	53–55
2448	07.03.2001	S 11°15' E 13°36'	152–168
2449	07.03.2001	S 11°13' E 13°31'	321–332
2450	07.03.2001	S 11°09' E 13°27'	618–622
2451	08.03.2001	S 10°57' E 13°25'	441–451
2452	08.03.2001	S 10°53' E 13°31'	124–126
2453	08.03.2001	S 10°49' E 13°37'	79–81
2454	08.03.2001	S 10°48' E 13°42'	44–47
2455	08.03.2001	S 10°37' E 13°28'	82–85
2456	08.03.2001	S 10°38' E 13°23'	106–108
2457	08.03.2001	S 10°36' E 13°13'	163–173
2458	08.03.2001	S 10°36' E 13°09'	400–429
2464	09.03.2001	S 10°21' E 13°02'	177–179
2465	09.03.2001	S 10°12' E 12°56'	232–236
2466	09.03.2001	S 10°07' E 12°53'	374–378
2467	09.03.2001	S 10°07' E 12°51'	529–535
2468	09.03.2001	S 10°02' E 12°47'	727–780
2470	10.03.2001	S 10°02' E 12°54'	156
2471	10.03.2001	S 10°03' E 13°01'	94–97
2472	10.03.2001	S 10°02' E 13°08'	69–74
2473	10.03.2001	S 09°56' E 13°13'	29–30
2474	11.03.2001	S 09°44' E 13°11'	23–24
2475	11.03.2001	S 09°45' E 13°03'	81–85
2477	11.03.2001	S 09°45' E 12°50'	178–179
2478	11.03.2001	S 09°49' E 12°51'	214–218
2479	11.03.2001	S 09°38' E 12°42'	432–486
2480	11.03.2001	S 09°28' E 12°39'	444–446
2481	12.03.2001	S 09°33' E 12°47'	168–171
2482	12.03.2001	S 09°28' E 12°52'	101
2484	12.03.2001	S 09°26' E 13°03'	25–27
2485	12.03.2001	S 09°16' E 12°55'	43–44
2486	12.03.2001	S 09°17' E 12°53'	65
2487	12.03.2001	S 09°16' E 12°50'	94–95
2488	12.03.2001	S 09°20' E 12°31'	751–769
2489	12.03.2001	S 09°16' E 12°31'	771–776
2490	13.03.2001	S 09°13' E 12°47'	107–108
2494	13.03.2001	S 09°06' E 12°49'	112–125
2495	13.03.2001	S 09°07' E 12°42'	305–341
2496	13.03.2001	S 09°06' E 12°37'	650–697
2497	14.03.2001	S 08°50' E 12°49'	538–541
2499	14.03.2001	S 08°46' E 13°00'	183–185
2501	14.03.2001	S 08°35' E 13°09'	81–83
2502	14.03.2001	S 08°39' E 13°04'	113
2504	14.03.2001	S 08°36' E 12°55'	368–369
2506	14.03.2001	S 08°24' E 12°45'	637
2507	15.03.2001	S 08°25' E 12°45'	624–633
2508	15.03.2001	S 08°21' E 12°55'	164–169
2509	15.03.2001	S 08°24' E 13°03'	108–110
2513	15.03.2001	S 08°14' E 12°46'	322–324
2515	15.03.2001	S 08°15' E 12°39'	780–783
2517	18.03.2001	S 08°14' E 13°11'	43–44
2518	18.03.2001	S 08°00' E 12°35'	681–694
2521	19.03.2001	S 07°58' E 12°40'	348–364
2522	19.03.2001	S 08°01' E 12°43'	233–248
2525	19.03.2001	S 07°54' E 12°53'	86–87
2528	19.03.2001	S 07°53' E 13°05'	19–21
2529	19.03.2001	S 07°50' E 12°32'	732–744
2530	20.03.2001	S 07°49' E 12°34'	547–553
2531	20.03.2001	S 07°46' E 12°33'	433–456
2532	20.03.2001	S 07°45' E 12°34'	336–340
2533	20.03.2001	S 07°45' E 12°35'	250–251
2538	20.03.2001	S 07°40' E 12°58'	35–36
2539	20.03.2001	S 07°39' E 12°59'	24–26
2540	20.03.2001	S 07°36' E 12°26'	642–651
2542	21.03.2001	S 07°33' E 12°28'	320–366
2543	21.03.2001	S 07°33' E 12°29'	244–248
2546	21.03.2001	S 07°27' E 12°38'	81–83
2547	21.03.2001	S 07°28' E 12°46'	50–51
2552	22.03.2001	S 07°22' E 12°09'	355–364
2553	22.03.2001	S 07°21' E 12°15'	224–232
2554	22.03.2001	S 07°18' E 12°20'	143–149
2555	22.03.2001	S 07°18' E 12°27'	101–102
2556	22.03.2001	S 07°13' E 12°43'	31–32
2557	22.03.2001	S 07°09' E 12°30'	52–53
2561	23.03.2001	S 07°11' E 11°59'	342–346
2562	23.03.2001	S 07°10' E 12°03'	256
2566	23.03.2001	S 07°01' E 12°38'	24
2569	24.03.2001	S 06°59' E 11°46'	548–549
2570	24.03.2001	S 06°57' E 11°50'	327–355
2571	24.03.2001	S 06°57' E 11°53'	236–246
2573	24.03.2001	S 06°54' E 12°07'	89–90
2576	25.03.2001	S 06°37' E 11°57'	110
2577	25.03.2001	S 06°43' E 11°45'	283–285

Station	Date	Position (Lat./Long.)	Depth (m)
2578	25.03.2001	S 06°44' E 11°43'	336

2002 cruise

Station	Date	Position (Lat./Long.)	Depth (m)
2689	01.03.2002	S 17°15' E 11°41'	53–58
2691	01.03.2002	S 17°14' E 11°31'	131–133
2692	01.03.2002	S 17°13' E 11°28'	160
2693	01.03.2002	S 17°14' E 11°21'	344–349
2694	01.03.2002	S 17°13' E 11°16'	603–617
2695	02.03.2002	S 17°00' E 11°41'	36–37
2697	02.03.2002	S 16°58' E 11°33'	102–103
2698	02.03.2002	S 16°31' E 11°34'	93–94
2699	02.03.2002	S 16°18' E 11°40'	65–66
2701	03.03.2002	S 12°35' E 13°03'	760–773
2702	03.03.2002	S 12°23' E 13°16'	723–737
2703	04.03.2002	S 12°26' E 13°26'	61–70
2704	04.03.2002	S 12°26' E 13°24'	94–97
2705	04.03.2002	S 12°24' E 13°21'	110–111
2706	04.03.2002	S 12°17' E 13°34'	41–50
2707	04.03.2002	S 12°16' E 13°32'	71–74
2708	04.03.2002	S 12°16' E 13°27'	96–97
2709	04.03.2002	S 12°15' E 13°25'	111–112
2710	04.03.2002	S 11°56' E 13°20'	657–662
2711	05.03.2002	S 11°55' E 13°21'	575–576
2712	05.03.2002	S 11°56' E 13°23'	471–477
2713	05.03.2002	S 11°58' E 13°30'	264–266
2714	05.03.2002	S 11°59' E 13°32'	101–106
2715	05.03.2002	S 12°01' E 13°37'	70–73
2716	05.03.2002	S 12°02' E 13°39'	49–54
2717	05.03.2002	S 11°47' E 13°45'	26–28
2719	05.03.2002	S 11°46' E 13°33'	110–111
2720	05.03.2002	S 11°45' E 13°29'	160–161
2721	05.03.2002	S 11°45' E 13°23'	349–356
2722	05.03.2002	S 11°44' E 13°18'	672–674
2723	06.03.2002	S 11°30' E 13°22'	351–354
2727	06.03.2002	S 11°32' E 13°43'	27–28
2728	06.03.2002	S 11°16' E 13°45'	23–24
2729	06.03.2002	S 11°16' E 13°42'	20–21
2730	06.03.2002	S 11°13' E 13°38'	113–116
2732	06.03.2002	S 11°15' E 13°28'	529–540
2734	07.03.2002	S 10°51' E 13°45'	35–40
2735	07.03.2002	S 10°55' E 13°44'	52–53
2736	07.03.2002	S 10°55' E 13°35'	114–115
2737	07.03.2002	S 10°38' E 13°40'	30
2739	07.03.2002	S 10°42' E 13°30'	91
2740	07.03.2002	S 10°46' E 13°23'	151–152
2741	07.03.2002	S 10°48' E 13°20'	331–336
2742	07.03.2002	S 10°48' E 13°16'	504–514
2744	08.03.2002	S 10°37' E 13°10'	344–349
2745	08.03.2002	S 10°34' E 13°13'	130–131
2747	08.03.2002	S 10°28' E 13°28'	48–50
2748	08.03.2002	S 10°26' E 13°31'	30–31
2751	08.03.2002	S 10°13' E 13°16'	70–71
2752	08.03.2002	S 10°16' E 13°10'	96
2753	08.03.2002	S 10°22' E 13°03'	168–173
2754	08.03.2002	S 10°24' E 12°55'	610–624

Station	Date	Position (Lat./Long.)	Depth (m)
2756	09.03.2002	S 09°58' E 12°45'	739–749
2762	09.03.2002	S 09°46' E 13°00'	93–94
2763	09.03.2002	S 09°53' E 12°44'	628–707
2764	10.03.2002	S 09°36' E 12°39'	536–542
2765	10.03.2002	S 09°32' E 12°51'	112–114
2766	10.03.2002	S 09°28' E 13°00'	50–52
2767	10.03.2002	S 09°27' E 13°04'	25–26
2768	10.03.2002	S 09°15' E 12°58'	24–27
2769	10.03.2002	S 09°14' E 12°51'	74–76
2770	10.03.2002	S 09°16' E 12°47'	114–116
2771	13.03.2002	S 09°12' E 12°42'	259
2772	13.03.2002	S 09°06' E 12°41'	404–438
2773	13.03.2002	S 09°05' E 12°37'	729–738
2774	14.03.2002	S 08°50' E 12°55'	308–343
2776	14.03.2002	S 08°54' E 13°00'	186–195
2777	14.03.2002	S 08°52' E 12°59'	215–219
2779	14.03.2002	S 08°36' E 12°50'	701–708
2780	14.03.2002	S 08°34' E 12°51'	535–574
2782	15.03.2002	S 08°38' E 13°04'	113
2783	15.03.2002	S 08°35' E 13°09'	81–82
2784	15.03.2002	S 08°35' E 13°15'	52–59
2786	15.03.2002	S 08°36' E 13°19'	28–32
2787	15.03.2002	S 08°20' E 13°06'	82–87
2788	15.03.2002	S 08°26' E 12°46'	700–717
2789	15.03.2002	S 08°28' E 12°47'	601–647
2792	16.03.2002	S 08°28' E 12°53'	308–309
2798	16.03.2002	S 08°15' E 13°16'	25–28
2799	16.03.2002	S 08°16' E 12°41'	703–705
2807	17.03.2002	S 08°04' E 13°08'	40–42
2808	17.03.2002	S 08°03' E 13°10'	26–28
2809	17.03.2002	S 08°04' E 12°36'	732–736
2811	18.03.2002	S 08°02' E 12°38'	524–527
2816	18.03.2002	S 07°52' E 12°59'	55–58
2819	18.03.2002	S 07°46' E 12°30'	730–759
2824	19.03.2002	S 07°38' E 12°45'	88–93
2825	19.03.2002	S 07°36' E 12°48'	68–70
2828	19.03.2002	S 07°34' E 12°14'	721–722
2833	20.03.2002	S 07°21' E 12°39'	57–64
2834	20.03.2002	S 07°19' E 12°43'	42
2835	20.03.2002	S 07°15' E 12°47'	24–26
2836	21.03.2002	S 07°03' E 12°39'	26
2837	21.03.2002	S 07°05' E 12°36'	38
2841	21.03.2002	S 07°15' E 12°09'	229–235
2842	21.03.2002	S 07°20' E 12°04'	416–423
2843	21.03.2002	S 07°21' E 12°02'	521–529
2846	22.03.2002	S 07°06' E 11°57'	272–276
2852	22.03.2002	S 06°58' E 11°40'	724–728
2855	23.03.2002	S 06°51' E 11°50'	255–267
2856	23.03.2002	S 06°51' E 11°54'	132–146
2857	23.03.2002	S 06°46' E 11°58'	100
2858	23.03.2002	S 06°47' E 11°53'	143–156
2859	23.03.2002	S 06°46' E 11°55'	117–126
2860	23.03.2002	S 06°49' E 12°01'	90–91
2861	23.03.2002	S 06°38' E 11°25'	704–720
2868	24.03.2002	S 06°28' E 11°59'	97–98
2869	24.03.2002	S 06°26' E 12°02'	80

Station	Date	Position (Lat./Long.)	Depth (m)
2870	24.03.2002	S 06°25' E 12°05'	54–56
2872	25.03.2002	S 06°15' E 11°25'	383–385
2876	25.03.2002	S 06°08' E 11°54'	74
2877	25.03.2002	S 06°07' E 11°58'	69
2878	25.03.2002	S 06°05' E 12°06'	40
		2005 cruise	
3609	01.04.2005	S 12°23' E 13°17'	729–733
3610	01.04.2005	S 12°27' E 13°15'	646–656
3622	03.04.2005	S 11°56' E 13°20'	652–658
3630	03.04.2005	S 11°32' E 13°21'	361–364
3632	04.04.2005	S 11°28' E 13°19'	733–735
3641	04.04.2005	S 11°11' E 13°24'	806–809
3649	05.04.2005	S 10°56' E 13°21'	640–647
3656	06.04.2005	S 10°49' E 13°16'	501–504
3675	08.04.2005	S 10°07' E 12°52'	381–385
3676	08.04.2005	S 10°03' E 12°47'	725–734
3684	09.04.2005	S 09°40' E 12°34'	884–891
3698	11.04.2005	S 08°48' E 12°47'	662–666
3709	12.04.2005	S 08°28' E 12°53'	304–305

APPENDIX B.

All species collected and deposited in SAIAB from the 2001 and 2002 cruises, indicating the station numbers (see Appendix A for station details) and the SAIAB collection numbers for each species.

NAME	STATION NO. (SAIAB CATALOGUE NO. IN BRACKETS)
MYXINIFORMES	
Myxine ios	2799(66087)
CHONDRICHTHYES	
Scyliorhinidae	
Galeus polli	2497(64537); 2693(65840)
Scyliorhinus cervigoni	2546(65499); 2561(64847); 2562(64602); 2720 (65886); 2740(65998);2745 (68094)
Leptochariidae	
Leptocharias smithi	2538(64850); 2539(64960)
Carcharhinidae	
Carcharhinus limbatus	2513(64650)
Squalidae	
Centroscymnus crepidater	2427(64334)
Deania calcea	2426(64340)
Isistius brasiliensis	2427(64998); 2488(65007); 2732(65972)
Squatinidae	
Squatina oculata	2477(65006)
Torpedinidae	
Torpedo bauchotae	2539(65676)
T. marmorata	2539(65673); 2704(68029); 2833(67966); 2857(67965); 2859(67983); 2868(68030)
T. mackayana	2485(65514); 2539(65672); 2706(67964); 2716(68088); 2727(68096); 2735(65999); 2748(67984); 2786(66076)
T. torpedo	2429(65541); 2430(65714); 2431(65004); 2435(65560); 2517(65503); 2834(68086)
T. nobiliana	2754(68087)
Rhinobatidae	
Rhinobatos albomaculatus	2429(65718); 2454(65730); 2717(68034); 2737(67971)
Platyrhinidae	
Zanobatus schoenleinii	2556(65726); 2566(65727)
Rajidae	
Raja sp.	2494(64915)
R. barnardi	2427(64336); 2450(65716); 2497(65715); 2506(64911); 2540(64927)
R. miraletus	2878(67751)
R. straeleni	2478(65725)
Dasyatidae	
Dasyatis marmorata	2878(67752)
Gymnura micrura	2734(68095)
HOLOCEPHALI	
Callorhynchidae	
Callorhinchus capensis	2698(68039)
Chimaeridae	
Hydrolagus sp.	2861(67976)
H. mirabilis	2852(67402)
Rhinochimaeridae	
Neoharriotta pinnata	2479(64323); 2531(64935); 2732(65973); 2782(66066)
ACTINOPTERYGII	
ALBULIFORMES	
Albulidae	
Albula vulpes	2870(65722)
Pterothrissus belloci	2439(65009); 2448(65607); 2691(65836)
NOTACANTHIFORMES	
Halosauridae	
Halosaurus ovenii	2441(64358); 2479(64376); 2504(64893); 2701(65805); 2702(65821); 2754(65933); 2772(66007); 2773(66016)
ANGUILLIFORMES	
Heterenchelyidae	
Pythonichthys microphthalmus	2499(64914); 2697(65849); 2776(68260); 2783(66074)
Chlopsidae	
Chlopsis olokun	2478(64396)
Synaphobranchidae	
Dysommina rugosa	2764(66023)
Synaphobranchus affinis	2441(64357); 2450(64351); 2496(64900); 2701(65806); 2763(65941); 2764(66024); 2828(66104)
S. kaupii	2515(64885); 2756(65969); 2763(65942); 2764(66025)

NAME	STATION NO. (SAIAB CATALOGUE NO. IN BRACKETS)
Ophichthidae	
Echelus myrus	2485(65746); 2709(67977); 2753(67978); 2856(67946); 2860(67948); 2876(67947); 2877(67945)
E. pachyrhynchus	2562(64937); 2693(68259); 2753(65967); 2855(67979)
Mystriophis rostellatus	2428(67980); 2495(65738); 2689(68257); 2692(67981); 2693(67982); 2697(67953); 2741(67942); 2752(65959)
Pisodonophis semicinctus	2435(65748); 2878(67943)
Colocongridae	
Coloconger cadenati	2497(64878); 2842(67386); 2843(67383)
Congridae	
Bathycongrus bertini	2428(64931); 2439(64936)
Bathyuroconger vicinus	2450(64899); 2694(65845); 2701(65807); 2773(66015); 2788(66078); 2789(66084)
Uroconger syringinus	2751(65961); 2770(68258); 2774(66072); 2783(66062); 2852(67403); 2877(67944)
Xenomystax congroides	2532(64867); 2570(64881)
Unidentified leptocephali	2495(64874); 2497(64879)
Muraenesocidae	
Cynoponticus ferox	2435(65748); 2449(64330); 2458(64397); 2479(64375); 2727(67951); 2734(67952); 2807(66092); 2876(67950)
Nemichthyidae	
Nemichthys scolopaceus	2441(64356); 2450(64352); 2467(64402); 2488(64390)
Serrivomeridae	
Serrivomer beanii	2828(66103)
Nettastomatidae	
Facciolella oxyrhyncha	2479(64374); 2496(64902); 2504(64894); 2842(67387); 2843(67384)
Hoplunnis punctata	2508(64898); 2509(64938); 2710(65868); 2745(65966)
Nettastoma melanurum	2496(64903); 2764(66026); 2852(67949)
Unidentified leptocephali	2507(64870); station data lost(67764); 2710(65873); 2852(67404)
CLUPEIFORMES	
Clupeidae	
Etrumeus whiteheadi	2689(65834)
Ilisha africana	2727(65898)
Sardinella aurita	2727(65899); 2816(66093)
S. maderensis	2443(65000); 2836(67905)
Engraulidae	
Engraulis encrasicolus	2486(64584); 2878(67754)
SILURIFORMES	
Ariidae	
Arius heudeloti	2798(68263)
A. latiscutatus	2770(67972); 2787(68262)
A. parkii	2435(64845); Luanda Harbour (64846)
SALMONIFORMES	
Alepocephalidae	
Alepocephalus sp.	2701(65813); 2764(66028)
Leptoderma macrops	2861(67734)
Talismania antillarum	2701(65812)
T. homoptera	2450(64350); 2488(64385); 2515(64882); 2701(65811); 2764(66027)
Xenodermichthys copei	2450(64347); 2467(64407); 2488(64386); 2701(65810); 2711(65875); 2722(65891); 2732(65978); 2763(65943); 2861(67735)
Platytroctidae	
Maulisia microlepis	2819(66097)
STOMIIFORMES	
Gonostomatidae	
Sigmops elongatus	2488(64388); 2530(64933); 2710(65870); 2742(65990); 2779(66068); 2819(66095)
Triplophos hemingi	2732(65977); 2780(66064); 2788(66079)
Sternoptychidae	
Sternoptyx diaphana	2468(64380); 2488(64391)
S. pseudodiaphana	2468(64381)
Phosichthyidae	
Yarrella blackfordi	2732(65974)
Chauliodontidae	
Chauliodus sloani	2742(65991)

Stomiidae	
Stomias boa boa	2488(64392); 2732(65976); 2742(65989); 2763(65944)
Astronesthidae	
Astronesthes barbatus	2488(64387)
Borostomias antarcticus	2779(67762); 2861(67736)
B. mononema	2507(64913)
Melanostomiidae	
Melanostomias sp.	2780(66063)
Odontostomias micropogon	2450(64354); 2458(64398); 2467(64405); 2694(65844); 2780(66065)
Photonectes parvimanus	2732(65975)
AULOPIFORMES	
Aulopidae	
Aulopus cadenati	2477(64976)
Chlorophthalmidae	
Bathypterois quadrifilis	2515(64883); 2773(66018); 2828(66107); 2852(67405)
Chlorophthalmus atlanticus	2439(64322); 2448(64328); 2449(64342); 2465(64411); 2466(64415); 2495(64873); 2577(64890); 2693(65843); 2843(67385); 2846(67377)
Parasudis fraserbrunneri	2449(64329); 2533(64924); 2542(64919); 2577(64889); 2713(65880); 2846(67378)
Notosudidae	
Scopelosaurus smithii	2467(64406); 2496(64901); 2754(65936); 2819(66096); 2828(66106)
Synodontidae	
Saurida brasiliensis	2436(65597); 2438(65564); 2457(65604)
Trachinocephalus myops	2836(67393); 2837(67396)
Paralepididae	
Lestidiops cadenati	2513(64909); 2552(64896); 2771(66012); 2774(66073); 2792(66083)
L. similis	2449(64332)
Lestrolepis intermedia	2774(69153); 2855(67398)
MYCTOPHIFORMES	
Neoscopelidae	
Neoscopelus macrolepidotus	2861(67737)
Myctophidae	
Diaphus diadematus	2878(67753)
Lampadena pontifex	2468(64382); 2489(64906); 2773(66017)
Notoscopelus resplendens	2488(64389)
Scopelopsis multipunctata	2828(66105)
GADIFORMES	
Macrouridae	
Bathygadus macrops	2754(65934); 2799(66088); 2852(67975); 2861(67989)
B. melanobranchus	2450(64346); 2489(64905); 2828(66110); 2852(67407)
*Coelorinchus coelorhincus**	2732(65980)
Hymenocephalus gracilis	2466(64419)
H. italicus	2842(67389)
Malacocephalus occidentalis	2440(64324); 2451(64412); 2458(64399); 2466(64984); 2479(64378)
Nezumia aequalis	2842(67388)
N. africana	2426(64339); 2861(67738)
N. micronychodon	2441(64355); 2722(65895)
Trachyrincus scabrous	2518(64916); 2809(66091)
Moridae	
Gadella imberbis	2449(64327); 2458(64400); 2466(64420); 2467(64408); 2540(64926); 2722(65894); 2732(65979); 2763(65945); 2771(66013); 2772(66011); 2846(67379); 2852(67408); 2855(67397);
Laemonema laureysi	2458(64401); 2693(65839); 2721(65890); 2772(66010)
Physiculus cyanostrophus	2428(64343); 2709(64638); 2753(64639)
P. huloti	2765(66038); 2876(67742)
Melanonidae	
Melanonus zugmayeri	2701(65808); 2754(65935); 2763(65947); 2779(66071)
Merlucciidae	
Merluccius polli	2438(65563)
OPHIDIIFORMES	
Ophidiidae	
Brotula barbata	2429(65723); 2430(65545); 2431(65005); 2442(65010); 2448(65736); 2539(65011); 2707(68091); 2735(66001); 2762(65970); 2769(66040)
Dicrolene intronigra	2515(64884)
Lamprogrammus exutus	2489(65008); 2694(65848); 2732(65981); 2773(68035)

Monomitopus metriostoma	2515(64888); 2702(65823); 2710(65869); 2754(65938)
Ophidion lozanoi	2753(65968); 2771(66014); 2878(67755)
Bythitidae	
Cataetyx bruuni	2710(65871); 2742(65992); 2763(65946)
Cataetyx laticeps	2489(64904); 2507(64868)
BATRACHOIDIFORMES	
Batrachoididae	
Perulibatrachus rossignoli	2709(65860); 2856(67750)
LOPHIIFORMES	
Lophiidae	
Lophiodes kempi	2458(64897); 2466(65609); 2497(64877); 2521(64932); 2529(64934); 2542(64920); 2553(65741); 2554(65744)
Lophius vaillanti	2479(65719); 2504(65720); 2723(65897)
Antennariidae	
Antennarius senegalensis	2739(65996)
A. striatus	2429(65543)
Chaunacidae	
Chaunax suttkusi	2433(64325); 2466(64421); 2479(64377); 2721(65888); 2741(65997); 2772(66009)
Ogcocephalidae	
Dibranchus atlanticus	2427(64333); 2432(64337); 2765(66039); 2772(66008)
Melanocetidae	
Melanocetus johnsonii	2702(65822); 2828(66108)
Himantolophidae	
Himantolophus paucifilosus	2722(65893)
Diceratiidae	
Bufoceratias wedli	2467(64403); 2488(64394); 2710(65864); 2779(66070); 2788(66081)
Diceratias pileatus	2480(64359); 2488(64393); 2710(65865); 2711(65877); 2722(65892); 2779(66069); 2788(66080); 2828(66109); 2852(67406)
Oneirodidae	
Oneirodes eschrichtii	2701(65803)
Ceratiidae	
Ceratias holboelli	2468(64379)
Cryptopsaras couesii	2711(65876); 2712(65878)
BELONIFORMES	
Exocoetidae	
Fodiator acutus	Luanda Harbour (65962)
Parexocoetus brachypterus	2710(65872); 2842(67390)
BERYCIFORMES	
Trachichthyidae	
Gephyroberyx darwini	2439(64320); 2448(64341); 2571(64880)
Hoplostethus cadenati	2432(64338); 2515(64887); 2773(67987)
Berycidae	
Beryx splendens	2543(64929); 2742(68107)
Melamphaidae	
Scopelogadus beanii	2468(64383); 2489(64907); 2754(65937)
ZEIFORMES	
Macrurocyttidae	
Zenion longipinnis	2439(64321); 2495(64876); 2533(64923); 2543(64928); 2577(64892); 2712(65879); 2744(65965)
Zeidae	
Cyttopsis rosea	2577(64891)
Zenopsis conchifer	Station data lost(67765); 2693(65841)
Zeus faber	2697(68100)
Grammicolepididae	
Xenolepidichthys dalgleishi	2495(64871)
SYNGNATHIFORMES	
Fistulariidae	
Fistularia petimba	2767(66031)
F. tabacaria	2484(65103)
SCORPAENIFORMES	
Scorpaenidae	
Ectreposebastes imus	2468(64384); 2507(64869); 2742(65993); 2773(66019); 2789(66085)
Helicolenus dactylopterus	2428(65745) ; 2495(65510)
Neomerinthe folgori	2513(65015)
Pontinus accraensis	2428(69408); 2448(65608); 2553(65002); 2709(65862)
P. leda	2449(65588)
Scorpaena angolensis	2728(65987); 2747(65957); 2786(66077)
S. elongata	2495(65511) ; 2705(68031); 2709(68033)
S. normani	2431(65556); 2501(65496); 2704(65829); 2735(66002); 2736(66004); 2739(65995)
S. scrofa	2555(65733)
S. stephanica	2435(65561); 2538(65551); 2539(65678); 2714(68032)

Setarches guentheri	2495(64873); 2542(64922); Station data lost (67763); 2872(67746)
Triglidae	
Chelidonichthys capensis	2689(68264)
C. gabonensis	2475(65734); 2689(65835); 2699(65853); 2709(65859); 2766(66029); 2825(68093)
Lepidotrigla cadmani	2431(65559); 2434(65589); 2436(65596); 2437(65562); 2555(65521); 2573(65500)
Peristedion cataphractum	2449(64331); 2578(64856); 2846(67380)
Trigla lyra	2553(65086); 2578(65519); 2693(65842); 2698(65852); 2846(67381); 2855(67399)
Trigloporus lastoviza	2709(68103)
Platycephalidae	
Grammoplites gruveli	2429(65542); 2454(65599); 2472(65611); Station data lost(67766); 2876(67744); 2877(67740)
Psychrolutidae	
Ebinania costaecanarie	2426(65103); 2427(64335); 2450(64353); 2467(64404); 2694(65847); 2701(65804)
Psychrolutes inermis	2710(65867)
Liparidae	
Careproctus albescens	2694(65846)
PERCIFORMES	
Acropomatidae	
Synagrops bellus	2513(64910); 2533(64925)
S. microlepis	2438(64344); 2465(64409)
Dinopercidae	
Centrarchops atlanticus	2539(65735); 2808(68106)
Serranidae	
Anthias anthias	2442(68084); 2555(68085); 2705(68041)
Cephalopholis nigri	Luanda Harbour(65498); 2539(65677)
Epinephelus aeneus	2435(64958); 2444(64996); 2539(65680)
E. caninus	2429(65540)
E. costae	2547(64995); 2747(67970); 2834(68255)
E. haifensis	2429(65539); 2703(65814); 2745(68256)
E. marginatus	2430(65623)
Mycteroperca rubra	Luanda Harbour(65964)
Rypticus saponaceus	2539(65609); 2717(65882); 2878(67756)
Serranus heterurus	2538(65552); 2539(65682)
Priacanthidae	
Priacanthus arenatus	2471(64986); 2703(65819)
Apogonidae	
Apogon affinis	2767(66034); 2878(67759)
A. imberbis	2539(65675); 2767(66035)
Epigonidae	
Epigonus constanciae	2429(64345); 2495(64872); 2721(65889)
E. pandionis	2553(64930); 2842(67391)
Malacanthidae	
Branchiostegus semifasciatus	2443(65724); 2708(67968)
Pomatomidae	
Pomatomus saltatrix	2695(68111)
Carangidae	
Alectis alexandrina	2444(65742)
A. ciliaris	2446(64999)
Caranx hippos	2474(65721)
Chloroscombrus chrysurus	2703(65818); 2748(65955)
Decapterus punctatus	2816(66094)
Selene dorsalis	2429(65538); 2430(64963); 2431(65728); 2473(65620); 2522(65490); 2533(65492); 2703(68114); 2728(65986); 2767(66033)
Trachinotus goreensis	2446(65012); 2768(68036)
T. ovatus	2717(65883)
Trachurus capensis	2443(65616)
T. trecae	2443(65615); 2824(66102)
Coryphaenidae	
Coryphaena equiselis	Angling near station 2835(65106)
Bramidae	
Brama brama	2701(65809)
Caristiidae	
Paracarastius maderensis	2489(64908); 2754(65939); 2763(65948); 2773(66020); 2788(66082); 2789(66086); 2828(66111)
Emmelichthyidae	
Erythrocles monodi	2464(65594); 2470(65600); 2705(68105)
Lutjanidae	
Lutjanus fulgens	2748(65956)
Gerreidae	
Eucinostomus melanopterus	2444(65587); 2473(65621); 2798(66089)
Haemulidae	
Brachydeuterus auritus	2706(65825)
Parakuhlia macrophthalmus	2539(65681); Luanda Harbour(65952); Luanda Harbour(65963)
Parapristipoma octolineatum	2708(68115)
Plectorhinchus mediterraneus	2715(68108); 2717(65884)

Pomadasys incisus	2703(65820); Luanda Harbour(65954)
P. jubelini	2728(68040)
P. perotaei	2728(67973)
P. rogerii	2539(65674)
Sparidae	
Dentex angolensis	2477(65515); 2705(68116)
D. barnardi	2472(65612); 2698(68092)
D. congoensis	2442(65505); 2471(65591); 2475(64588); 2502(65626)
D. gibbosus	2699(65855)
D. macrophthalmus	2477(64978); 2691(65837)
Diplodus sargus cadenati	Luanda Harbour(65950)
Lithognathus mormyrus	2703(68104)
Pagellus bellottii	2472(65613); 2699(65854)
Spondyliosoma cantharus	2431(64972); 2703(65815); 2707(65828)
Centracanthidae	
Boops boops	2431(65555); 2470(65014); 2703(65816)
Spicara alta	2464(65595); 2470(65601); 2705(65830)
Sciaenidae	
Atractoscion aequidens	2689(65832)
Pseudotolithus senegalensis	Luanda Harbour(64973)
Pteroscion peli	2528(64643); 2878(67758)
Umbrina canariensis	2689(65833)
Mullidae	
Pseudupeneus prayensis	2472(65614); Luanda Harbour(65504); 2703(65817); 2767(66032)
Drepanidae	
Drepane africana	2474(64992); 2728(68090); 2786(68089)
Ephippidae	
Chaetodipterus lippei	2538(65003); 2539(65679)
Chaetodontidae	
Chaetodon hoefleri	2429(64980); 2430(64962); 2431(64964); 2437(64983); 2455(65740); 2482(64848); 2703(68113); 2734(66003); 2767(79497)
C. robustus	2539(65671); 2767(68110); Luanda Harbour(65949)
Prognathodes marcellae	2482(64605); 2525(65485)
Pomacentridae	
Chromis chromis	2538(65554)
Cepolidae	
Cepola pauciradiata	2762(65971)
Polynemidae	
Galeoides decadactylus	2473(65729); Luanda Harbour(64993); 2706(65824); 2727(68112); 2768(66042)
Pentanemus quinquarius	2727(65900)
Labridae	
Bodianus speciosus	2484(64629)
Xyrichtys novacula	2556(65484); 2729(65985)
Zoarcidae	
Pachycara crossacanthum	2515(64886); 2722(65896)
Trachinidae	
Trachinus armatus	2878(67757)
T. pellegrini	2825(66100)
Uranoscopidae	
Uranoscopus albesca	2481(65507); 2554(65487); 2714(65881); 2720(65887); 2730(65983); 2736(67988)
U. cadenati	2431(65558); 2452(65618); 2457(65602); 2477(65517); 2478(65495); 2719(65885)
Percophidae	
Bembrops sp. n.	2457(64414); 2478(64395); 2499(64854)
B. greyi	2542(64921); 2578(64855); 2552(65523)
Labrisomidae	
Labrisomus nuchipinnis	Luanda Harbour(65951)
Callionymidae	
Synchiropus phaeton	2855(67400)
Gobiidae	
Awaous lateristriga	Luanda Harbour(65953)
Lesueurigobius koumansi	2452(65617); 2487(65486); 2499(65625); 2697(65850); 2730(65982); 2735(66000); 2784(66075)
Acanthuridae	
Acanthurus monroviae	2484(64844)
Gempylidae	
Gempylus serpens	2450(65001); 2468(65593)
Trichiuridae	
Aphanopus carbo	2809(68038)
Centrolophidae	
Schedophilus pemarco	2707(65826); 2792(67986)
Nomeidae	
Cubiceps pauciradiatus	2710(65866); 2754(65940); 2773(66021); 2819(66098); 2852(67410)
Psenes pellucidus	2811(68097); 2819(660990; 2861(67739)
Ariommatidae	
Ariomma bondi	2576(65502); 2858(67745); 2859(67747)
A. melanum	2569(64895); 2742(65994); 2841(67392)
Stromateidae	
Stromateus fiatola	2727(65901)

PLEURONECTIFORMES	
Citharidae	
Citharus linguatula	2452(65619); 2454(65598); 2456(65592); 2457(65605); 2557(65739)
Paralichthyidae	
Citharichthys stampflii	2485(65512)
Syacium micrurum	2573(65501)
Bothidae	
Arnoglossus imperialis	2429(65544); 2430(65622); 2555(65520)
Bothus podas	2836(67394); 2878(67760)
Chascanopsetta lugubris	2552(65522); 2578(65518); 2846(67382)
Monolene microstoma	2440(65506); 2448(65606); 2457(65603); 2477(65516); 2478(65494); 2533(65493)
Soleidae	
Dicologlossa cuneata	2689(65831); 2699(65856); 2798(66090); 2878(67761)
Solea hexophthalma	2767(66037)
Microchirus boscanion	2691(65838); 2692(65851)
M. frechkopi	2431(65557); 2501(65497); 2707(65827); 2709(65861); 2752(65960); 2769(66041); 2869(67749); 2876(67743); 2877(67741)
M. wittei	2508(64534)
Monochirus hispidus	2485(65683); 2539(65513);2766(66030); 2825(66101)
Vanstraelenia chirophthalma	2430(65624); 2703(67969)
Bathysoela polli	2777(66067); 2855(67401)
Cynoglossidae	
Cynoglossus canariensis	2727(67974); 2773(66022); 2869(68099)
Symphurus ligulatus	2518(65491); 2529(65488)
TETRAODONTIFORMES	
Balistidae	
Balistes capriscus	2445(64853); 2446(64849); 2729(68102)
B. punctatus	2566(64965)
Monacanthidae	
Aluterus heudelotii	2445(64852); 2446(64851); 2835(68261); 2836(67395)
Tetraodontidae	
Ephippion guttifer	2444(64997); 2735(68109)
Lagocephalus laevigatus	2716(68037)
Sphoeroides marmoratus	2538(65553); 2539(65670); 2728(65988); 2767(66036)
S. pachygaster	2490(64975)
Diodontidae	
Chilomycterus spinosus mauretanicus	2446(65590); 2706(68101); 2747(65958); 2870(67748)

* Note: Spelling of *C. coelorhincus* follows recommendation of T. Iwamoto in e-mail to E. Anderson, based on original intent of author.

New species of 'Barbus' and Labeobarbus (Teleostei: Cyprinidae) from the South Rukuru River, Malawi, Africa.

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Abstract. Two new barbine species are described from the South Rukuru River, which flows into Lake Malawi. *'Barbus' seymouri* sp. nov. differs from the *'B' eutaenia / 'B'. miolepis* species complex in the absence of the sheath of enlarged scales at the base of the dorsal fin, which is prominent in the other species of the complex, and in the pigmentation pattern of the mid-lateral stripe. *Labeobarbus nthuwa*, sp. nov. differs from *L. marequensis* of the Middle and Lower Zambezi River system and from *L. johnstonii* of the Lake Malawi system in the presence of a bony dorsal spine, and from *L. codringtonii* of the Upper Zambezi in the absence of the tall dorsal fin. It also differs from *L. johnstonii* in scale counts, and from *L. marequensis* in gill raker counts and caudal peduncle proportions. The fish fauna of the South Rukuru River is separated from that of Lake Malawi and all other inflowing rivers by steep rift escarpment waterfalls. Evidence is presented for river capture from the Luangwa River, which flows to the Middle Zambezi. Other Zambezian species found on the northern Malawi lakeshore are considered to be evidence for a separate, former link to the Zambezi system via the Chambeshi system.

Key Words: new species, Lake Malawi, Luangwa River, river capture

INTRODUCTION

The South Rukuru River rises in the central uplands of Malawi and flows to Lake Malawi (Fig. 1). In its upper reaches it flows north, close to the Zambian border, before turning east and passing between the high Viphya and Nyika plateaux. For much of its northward passage, the terrain is fairly flat and the river slow flowing, but it is fed by fast-flowing mountain streams that arise on the two plateaux, many of which are perennial. After cutting through the Precambrian granitic basement complex rocks of the Njakwa gorge, the river continues to the lake down the rift escarpment as a series of rapids cut through a heavily faulted Karoo-age trough. Shortly before entering the lake, the river drops over the Wongwe and FuFu waterfalls, which form a barrier preventing the upstream movement of lake fishes (Tweddle 1982).

The fish fauna of the South Rukuru River, its tributaries and neighbouring rivers has been sampled on several occasions and differs considerably from that of all other affluent streams of Lake Malawi (Tweddle 1982; 1996; Tweddle & Willoughby 1978). The species collected in the South Rukuru have been compared with known species from other river systems in Africa, and three of the barbine species are new to science. Two species are described here, while the third will be described later in a review of small spotted *'Barbus'* species in the region (Tweddle, in prep.). The use of *'Barbus'* follows Berrebi *et al.* (1996), under which the generic name *Barbus* is restricted to *Barbus barbus* (L.) and its large European congeners. The small African barbine species with radiate scale striations are not closely related and therefore do not belong in the same genus. Until further research clarifies their relationships, the temporary epithet *'Barbus'* will be used.

One of the species described herein is a member of the group of smaller *'Barbus'* species with radially striated scales, a serrated dorsal spine and a mid-lateral stripe. This species also occurs in the Kaziwiziwi River (Fig. 1), a tributary of the North Rumphi River that arises close to tributaries of the South Rukuru on the southern flanks of the Nyika Plateau. The Kaziwiziwi River joins the North Rumphi before it falls steeply over the rift escarpment to Lake Malawi. Below the escarpment, sampling in the North Rumphi yielded only the typical lakeshore stream fauna (unpublished catch data; the lakeshore stream fauna is described by Tweddle (1996)).

The second species to be described is a member of the large African barbine group with parallel-striated scales recognised as the recently reinstated genus *Labeobarbus* Rüppell 1835 (Skelton 2001). In Lake Malawi and its other inflowing rivers, this genus includes two species, *L. brevicauda* (Keilhack) and *L. johnstonii* (Boulenger).

METHODS

Specimens were collected from various sites (Fig. 1) in the South Rukuru River and tributaries and in the Kaziwiziwi River by electric fishing and the three largest specimens of *Labeobarbus nthuwa* (sp. nov.), were purchased from a local angler. Specimens were preserved on site in 10% formalin, transferred to 60% N-propyl alcohol, and were later transferred to 70%

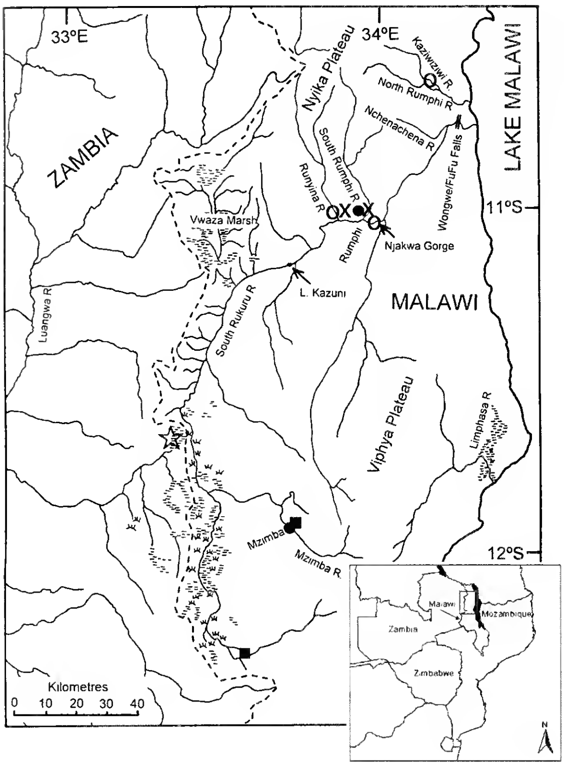

Fig. 1. The South Rukuru and neighbouring catchments. **X** = localities where *Labeobarbus nthuwa* sp. nov. type specimens were collected; O = localities where *'Barbus' seymouri* sp. nov. type specimens were collected; ■ = localities where non-type specimens of *'B' seymouri* listed in text were caught; • = towns of Rumphi and Mzimba; ★ indicates site of possible river capture between Luangwa and South Rukuru river systems. The small map attached shows the location of the main map in southeastern Africa, indicated by the rectangle.

ethyl alcohol.

Measurements were made by vernier calipers to the nearest 0.1 mm following Skelton (1988). Skeletal meristics and fin ray counts were taken from radiographs. Vertebral counts include the four Weberian vertebrae and a single (PU + U1) caudal fin vertebra. Abdominal vertebrae include all anterior vertebrae without an extended haemal spine. Caudal vertebrae possess an extended haemal spine. Lateral line scales were counted from the first scale row behind the gill cover to the end of the body, i.e. the point of flexure of the caudal fin. This usually excludes the last pored scale and smaller scales on the fin base. In transverse scale counts where a count is given as e.g. 2+1, this means two full size scales and either one small scale or a gap between scale and fin with the next scale overlapping the fin base.

Colour descriptions were made from field observations and colour transparencies of live fishes. Pharyngeal bones were dissected and macerated in trypsin for several days before being defleshed. Scales were removed and stained with alizarin red. Scales and pharyngeal teeth were drawn using a camera lucida.

Institutional abbreviations follow Leviton *et al.* (1985). The following abbreviations are used in text and tables: SL, standard length; HL, head length; HD, head depth; SNL, snout length; OD, orbit diameter; POL, postorbital length; IOW, interorbital width; PDL, predorsal length; PPL, prepelvic length; DL, dorsal fin length; PCL, pectoral fin length; PVL, pelvic fin length; AL, anal fin length; BD, body depth; BW, body width; CP, caudal peduncle; CPL, caudal peduncle length; CPD, caudal peduncle depth; AB, anterior barbel length; PB, posterior barbel length; LJW, lower jaw width; LL, lateral line.

STATISTICA 8 software was use for the principal component analysis.

'Barbus' seymouri sp. nov.

Fig. 2.

Holotype. SAIAB 34888, unsexed, 93.3 mm SL; Kaziwiziwi River, North Rumphi River basin, Lake Malawi affluent, Malawi, 10°38'S, 34°05'E; D. Tweddle, 25 September 1980.

Paratypes. SAIAB 34887, 17 specimens, 52.4–108.2 mm SL, collected with holotype. SAIAB 34946, 1 specimen, 74.0 mm SL, collected with holotype. SAIAB 34881, 5 specimens, 28.3–92.4 mm SL, South Rukuru River at Njakwa gorge, 11°02'S, 33°54'E, and Runyina tributary, 11°01'S, 33°47'E, at Rumphi, Malawi, D. Tweddle, 22–23 October 1980.

Other material examined. SAIAB 40797, 20 specimens, 31.6–51.2 mm SL, Mzimba River (South Rukuru tributary), Mzimba, Malawi, 11°54'S33°36'E, D. Tweddle & P.H. Skelton, 2 July 1992; BMNH 1978.8.3.537–556, 20 specimens, South Rukuru River, 12°16'S, 33°29'E, and Mzimba tributary, 11°54'S, 33°36'E, D. Tweddle & N.G. Willoughby, October 1976; BMNH 1978.8.3.1596, 1 specimen, South Rukuru River 12°16'S, 33°29'E, D. Tweddle & N.G. Willoughby, October 1976; further specimens are also deposited in the museum in the Monkey Bay Fisheries Research Unit Museum, Malawi, without accession numbers.

DIAGNOSIS. A moderate-sized (up to 108 mm SL), robust bodied, *'Barbus'* species with an ossified, serrated last dorsal simple ray, 26-29 lateral line scales, fins tinted pinkish-orange, and a midlateral black stripe that extends through the caudal fin to the fork, but does not extend onto the snout. Differs from other orange-finned, serrated-spined *'Barbus'* species in the region (including *'B.' eutaenia* Boulenger, 1904, *'B.' miolepis* Boulenger, 1902, *'B.' choloensis* Norman, 1925, and

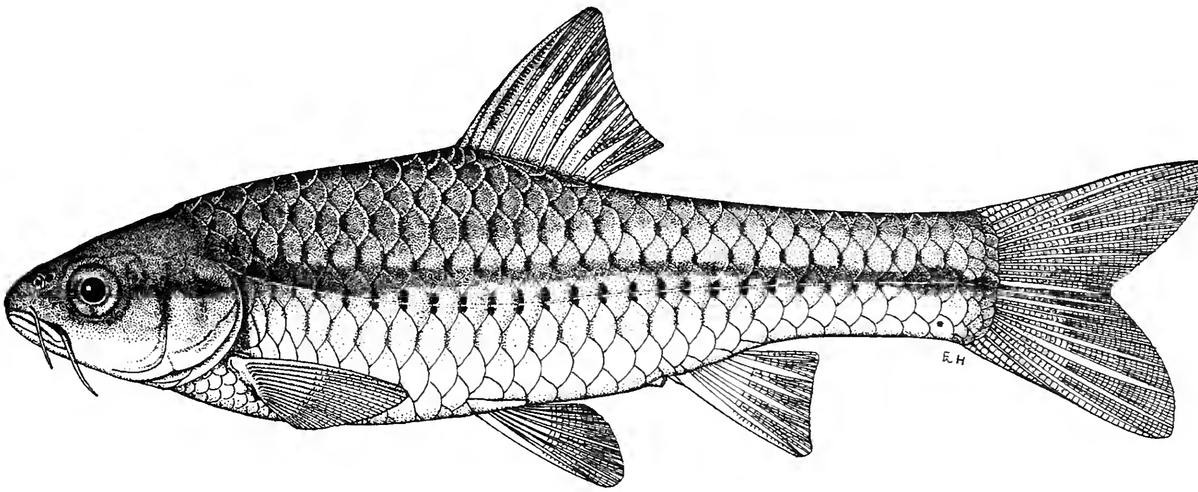

Fig. 2. Holotype of *'Barbus' seymouri* sp.nov.

several other species, some of which are undescribed, recently discovered in Upper Zambezi tributaries (Tweddle *et al.*, 2004)) in the absence of the prominent sheath of enlarged scales at the base of the dorsal fin present in the other species, and in the pattern of pigmentation of the mid-lateral stripe, which is distinct in each species.

Description. Based on the holotype and paratypes. Morphometric and meristic data are given in Table 1.

Body fusiform, slightly compressed, maximum depth approximately equal to head length, located before dorsal fin. Nape rises in hump behind head, particularly in larger specimens. Head moderately deep, four times in SL. Eyes lateral in position, visible from above and below, orbit becoming proportionately smaller in large specimens (OD as %HL = -0.5952 HL + 39.184, r^2 = 0.7346). Snout rounded and short, equal to or slightly shorter than orbit diameter. No tubercles on the head. Nostrils small, short tubular anterior naris adjacent to open posterior naris; nostrils level with dorsal margin of eye and separated from orbit by less than one orbit radius. Mouth subterminal, crescent-shaped and reaching to below anterior border of orbit, lips moderately well-developed. Two pairs of simple barbels, anterior slightly shorter than posterior, which is approximately equal to orbit diameter. Gill cover opening from level with dorsal margin of orbit, attached ventrally close to isthmus. Gill arches with four short, stub-like, widely-spaced gill rakers on ceratobranchial of anterior arch, two on epibranchial.

Pharyngeal bones typical of small African 'Barbus' species with three rows of peg-like pharyngeal teeth with pointed cusps, formula 5,3,2 2,3,5.

Origin of dorsal fin equidistant between tip of snout and base of caudal fin, above or just behind origin of pelvic fins. Dorsal fin becomes relatively shorter with increasing size of specimen, from approximately 30% of SL in smallest specimens to 20% in largest individuals, anteriormost branched ray longest, distal margin concave. Last unbranched dorsal ray ossified and finely serrated (approximately 30 prominent serrations and up to 40 in total) on its posterior side. Pectoral fins reach ⅔ of distance to base of pelvics, tips rounded and distal margin straight. Pelvic fins reach ⅔ of distance to base of anal fin, relatively small and rounded. Anal fin short, extending ⅓ length of caudal peduncle, last unbranched ray longest, distal margin straight. Caudal fin forked, outer rays twice length of median rays, lobes rounded. Caudal peduncle long, length twice depth.

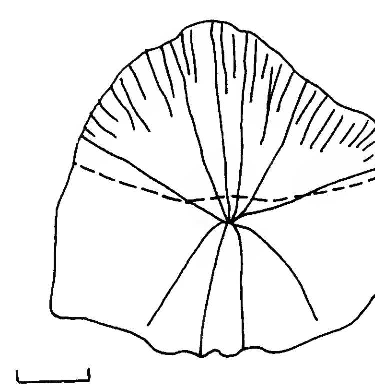

Fig. 3. Predorsal scale of *'Barbus' seymouri* paratype, SAIAB 34887, from right side above lateral line, showing striae. Dashed line indicates limit of embedded area, Scale bar 1 mm.

Anus and genital opening immediately anterior of base of anal fin. Gut short, about equal to SL, in a single simple S-flexure.

Fig. 4. Colour photograph of paratype of *'Barbus' seymouri* from Kaziwiziwi River, SAIAB 34887.

Scales moderately large, cycloid and rounded, well developed in regular rows. Scales radially striate with about 10 radii in total (Fig. 3). Lateral line complete, anteriorly dipping one scale row below the horizontal myoseptum, joining and extending straight along the midline at the anterior end of the caudal peduncle. No sheath of enlarged, elongate scales along base of dorsal fin; short pelvic axil scale present; breast scales well developed,.

Colouration. Live colours (Fig. 4): body and head olive dorsally and sides silvery with whitish-gold sheen ventrally; black midlateral stripe bordered with golden yellow; black post-opercular vertical bar. Dorsal fin with dark olive rays and clear membranes; caudal fin colouration similar but with pinkish-orange tinge, particularly on lower half; pectoral, pelvic and anal fins pale brownish-orange tinted distinctly pinkish-orange. Iris dark anteriorly and posteriorly, pale yellow ventrally with orange highlight dorsally. Specimens from turbid water uniformly pale with faint dark midlateral stripe.

In preserved specimens (60% propyl alcohol), dorsal surface scales densely pigmented with fine melanophores, with a crescent of closely spaced larger melanophores at both anterior and posterior borders of exposed part of scale. Pigmentation less intense in centres of lateral line scales and in the row below the lateral line only a few scattered melanophores present on each scale, although anterior crescent is still fairly prominent. In next row below, only a few scattered melanophores present anteriorly and dorsally on each scale. Below this, all scales pigment-free except for a few melanophores along the ventral scale row between anal and caudal fins. Crescent of dark pigment present behind operculum from lateral line to pectoral fin base. Horizontal myoseptum darkly pigmented beneath the scales, forming a fine but fairly intense mid-lateral stripe, most prominent on the caudal peduncle. In many specimens, underlying pigmentation emphasised by additional melanophores along the line on the scales themselves. At base of caudal fin, lateral stripe broadens slightly as a result of heavier scale pigmentation. Stripe continues through to posterior margin of caudal fin. Mid-dorsal stripe present for full length of body. Rays of the dorsal, pectoral and caudal fins lightly pigmented with fine melanophores, pelvics and anal almost pigment free. Operculum and snout covered in melanophores, which are more abundant but finer on the snout. Both pairs of barbels lightly pigmented.

Distribution and habitat. *'Barbus' seymouri* is found throughout the South Rukuru system above the falls that isolate the fauna from that of Lake Malawi, and in the Kaziwiziwi River above the escarpment down to the lakeshore. The sites where the species is caught are generally clear, strongly-flowing streams with cover in the form of vegetation and/or rocks. In the Mzimba River in Mzimba town, the river changed dramatically between sampling in 1976 and 1992. The narrow, well-vegetated, clear stream of 1976 yielded many large well-coloured specimens of *'B'. seymouri,* whereas in 1992 the wide, shallow, sandy stream at the same site yielded small, pallid specimens only from the road bridge gabions.

Etymology. Named after the late Tony Seymour (Fig. 5), a close friend of the first author and colleague for many years in the Malawi Government Fisheries Department, in recognition of his many years of service to Malawi not only in Fisheries but also in many other aspects of environmental management and conservation, and in particular for his long-term commitment to supporting Lake Malawi's fishermen.

Comparisons. *'Barbus' seymouri* is one of a group of small

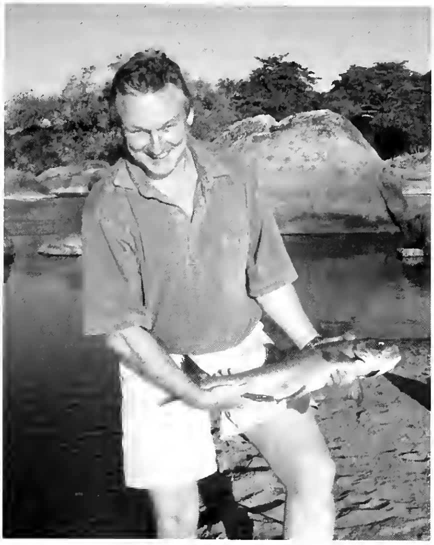

Fig. 5. The late Tony Seymour, after whom *'Barbus' seymouri* is named.

African *'Barbus'* with radiate striated scales, a bony, serrated last unbranched dorsal-fin ray, orange tinted fins and a dark midlateral stripe. The three most similar species so far recorded in eastern, central and southern Africa are *'B.' choloensis*, *'B.' eutaenia* and *'B.' miolepis*. *'Barbus' choloensis* occurs in the south of Malawi in two Lower Shire River (i.e. Lower Zambezi system) tributaries, the Ruo River and the Mwabvi River (Tweddle & Willoughby 1979). *'Barbus' eutaenia* is currently recognised as being widespread in southern-central Africa while *'B.' miolepis* is considered to be a species of the Upper Zambezi, Kafue and Congo river systems (Skelton 2001). All three are robust species with yellow or orange tinted fins, a black mid-lateral stripe and a serrated dorsal spine. The *'B.' eutaenia* / *'B.' miolepis* species complex needs detailed revision and several other species new to science exist, including another possibly distinct species in the lower reaches of the Lufirio River, which flows into northern Lake Malawi from Tanzania (SAIAB 54766). In the Upper Zambezi system several other species in this complex occur, some of which are undescribed (Tweddle *et al.* (2004). Taxonomic review of these species will not affect the status of *'B.' seymouri*.

'Barbus' seymouri has larger scales than *'B.' choloensis* with 4 scales between the dorsal fin and lateral line compared to 5–6 scales in *'B.' choloensis*. *'Barbus' seymouri* has 12 scales around the caudal peduncle and *'B.' choloensis* has 14–16. *'Barbus' seymouri* has a more rounded snout, thus the mouth is slightly sub-terminal, whereas the snout of *'B.' choloensis* is pointed and the mouth terminal. In similar-sized specimens, *'B.' choloensis* has a much larger eye. *'Barbus' choloensis* has pointed caudal fin lobes whereas those *of 'B.' seymouri* are rounded. In *'B.' choloensis*, the mid-lateral stripe is diffuse, confined to the posterior half of the body, broadens to an indistinct oval spot one full scale wide on the caudal peduncle, and does not extend noticeably on to the caudal fin rays. The mid-lateral stripe of *'B.' seymouri* is narrower and better defined, extends the full length of the body following the curve of the scale row above the lateral line, broadens only slightly on the caudal peduncle and continues through the caudal fin to its fork.

'Barbus' seymouri differs from the other species in the *'B.' eutaenia* / *'B'. miolepis* complex in that it lacks the enlarged scales that form a sheath at the base of the dorsal fin in the other species. It also has more lateral line scales (26–29 v. 23–27). The mid-lateral stripe of *'B.' seymouri* is finer than the broad heavy stripe of the other species. The well-defined stripe in the other species extends through the operculum and to the tip of the snout, whereas in *'B.' seymouri* there is only a suggestion of heavier pigmentation in the centre of the operculum and only diffuse melanophores on the snout.

Labeobarbus nthuwa sp. nov.

Fig. 6.

Holotype. SAIAB 39341, 210 mm SL; Runyina tributary of South Rukuru River, Lake Malawi affluent, Malawi, 11°01'S 33°47'E; D. Tweddle & P.H. Skelton, 3 July 1992.

Paratypes. SAIAB 79494, 2 specimens, 217-236 mm SL, collected with holotype. SAIAB 40787, 6 specimens 31.0-36.7 mm SL, Runyina, 11°01'S 33°47'E, and South Rumphi, 11°01'S 33°52'E, tributaries of South Rukuru River; D. Tweddle & P.H. Skelton. SAIAB 39293, 1 specimen, 42.1 mm SL, Runyina tributary of South Rukuru River, 11°01'S 33°47'E; D. Tweddle & P.H. Skelton. SAIAB 51928, 2 specimens, 210-217 mm SL, South Rukuru River at Chikulamayembe, Malawi, 10°45'S 34°07'E; D. Tweddle, R. Bills & P.H. Skelton, 22 October 1995.

Diagnosis. A *Labeobarbus* species with parallel-striated scales, a heavily ossified, unserrated, last unbranched dorsal-fin ray, five unbranched dorsal rays in total, and 30–33 lateral line scales. Differs from the two Lake Malawi *Labeobarbus* species (*L. johnstonii* Boulenger 1907 and *L. brevicauda* Keilhack 1908) in scale counts and the presence of the bony dorsal spine. Differs from *L. marequensis* (A. Smith 1841) of the Zambezi River and east coastal rivers south to the Phongolo in gill raker counts, caudal peduncle proportions and the presence of the bony dorsal spine. Differs from *L. codringtonii* (Boulenger 1908) of the Upper Zambezi River in the absence of the high dorsal fin characteristic of that species.

Description. Based on the holotype and paratypes.

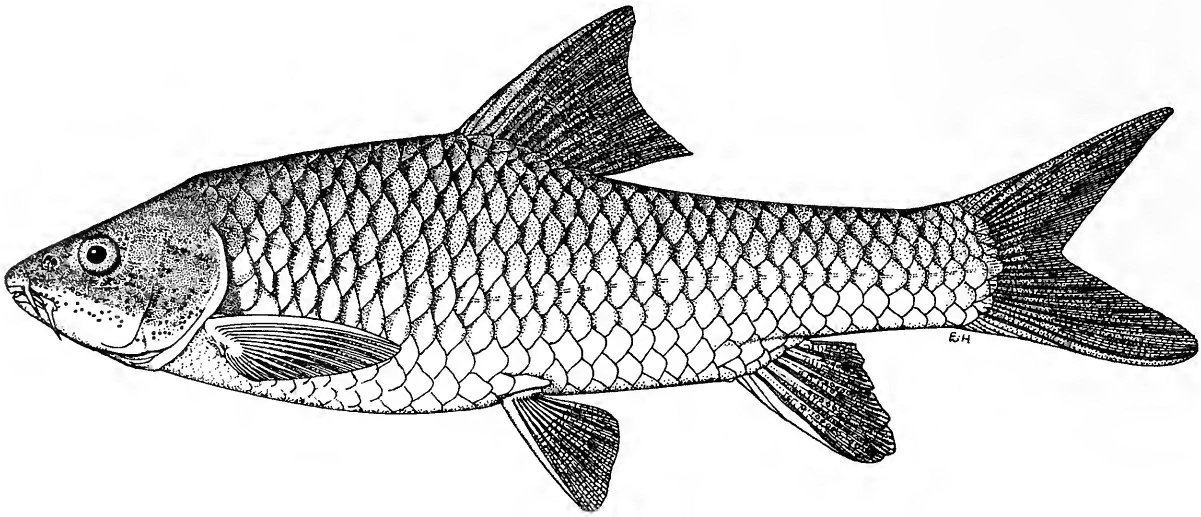

Fig. 6. Holotype of *Labeobarbus nthuwa* sp. nov.

Morphometric and meristic data are given in Table 2.

Body fusiform, slightly compressed, body depth approximately equal to head length in smaller specimens, becoming proportionately deeper with size, to approximately 1½ times head length in adults, deepest at origin of dorsal fin. Head length 4 times in standard length, head depth approximately ¾ head length. Dorsal profile of head in larger specimens straight to slightly concave (Fig. 7), shallowly convex in smaller specimens.

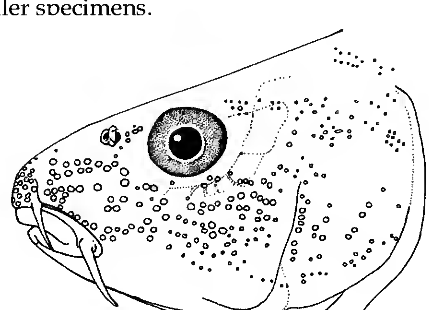

Fig. 7. Head of *L. nthuwa* holotype, showing position of tubercles.

Eyes lateral in position, visible from above and below, becoming proportionately smaller in large specimens (OD as %HL = 54.662 $HL^{-0.236}$, $r^2 = 0.971$). Snout pronounced, particularly in larger specimens, longer than orbit diameter in fish over 40 mm SL, shorter than orbit diameter in smaller specimens. Small conical tubercles present on snout, operculum and sides of head, not extending on to dorsal surface of head or on to body. Nostrils prominent, short tubular anterior naris adjacent to open posterior naris and separated by raised rounded septum. Nostrils at horizontal through dorsal half of eye, separated from orbit by less than one orbit radius. Mouth sub-terminal, not reaching below anterior border of orbit; lips variable, ranging from specimens with straight, keratinised scraping edge to the lower lip (*Varicorhinus*-like) to specimens with rounded, fleshy lips. Two pairs of barbels, anterior just over half length of posterior, which ranges from being equal to orbit diameter in largest specimens examined to less than one-half orbit diameter in smallest specimens. Gill cover opening from level with dorsal margin of orbit, attached ventrally close to isthmus. Gill arches with 8–10 robust gill rakers visible on anterior arch.

Pharyngeal bones robust with pharyngeal teeth in three rows, formula 5,3,2 2,3,5 (Fig. 8).

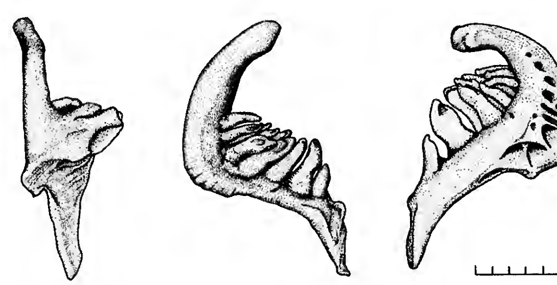

Fig. 8. Left pharyngeal bone of paratype of *L. nthuwa*, SAIAB 79494, from left, lateral view, posterior view and anterior view. Scale bar 5 mm.

Origin of dorsal fin equidistant between tip of snout and base of caudal fin, positioned before origin of pelvic fins, last simple ray heavily ossified and unserrated, anterior branched ray longest, distal margin of fin

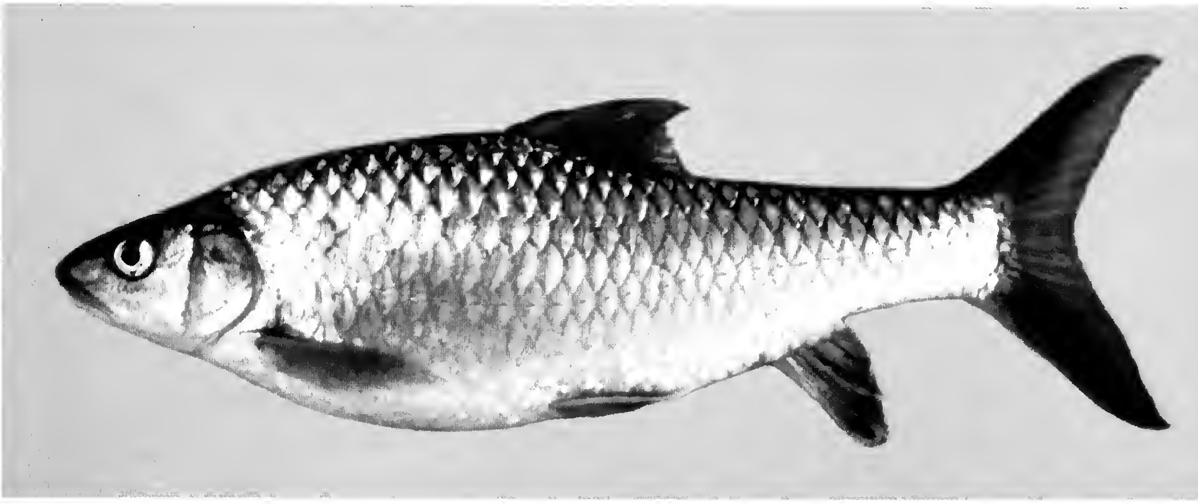

Fig. 10. Colour photograph of *Labeobrabus nthuwa* paratype, SAIAB 79494.

strongly concave. Radiographs show five simple rays in dorsal fin in all but smallest three specimens, where first, very small ray may have not yet developed to a size where it becomes visible. Pectoral fins falcate, reaching ¾ of distance to base of pelvic fins. Pelvic fins pointed with square distal margin, reaching ⅔ of distance to base of anal fin. Anal fin last unbranched ray longest, distal margin shallowly concave, reaching to ½ length of caudal peduncle. Single rows of prominent tubercles present on posterior edge of branched rays of anal fin in adult males. Caudal fin deeply forked, outer rays nearly four times length of median rays, lobes pointed. Caudal peduncle of moderate length, depth generally more than 60% of length. Anus and genital opening located at anterior of base of anal fin. Gut extended and involuted, its length several times longer than SL.

Scales moderately large, cycloid and rounded, well developed in regular rows. Scales with numerous parallel striations on exposed field, less numerous on medial area of embedded field, focus ill-defined (Fig. 9). Lateral line complete, anteriorly dipping one scale row below midline, which it rejoins anterior to anal fin, passing mid-laterally to base of caudal fin. Elongated pelvic axil scale present; breast scales well developed but markedly reduced in size between bases of pectoral fins.

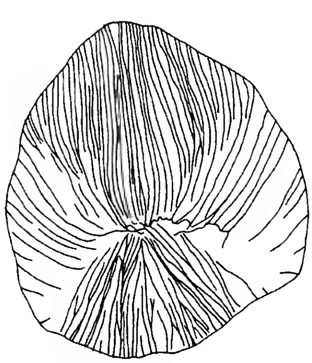

Fig. 9. Scale of *Labeobarbus nthuwa* paratype, SAIAB 79494, from right side above anal fin, showing striae. Scale bar 1 mm.

Colouration. Live colour (Fig. 10) silvery-olive dorsally, silver laterally and ventrally with faint purple sheen that is most prominent on operculum. Dorsal and caudal fins dark olive-grey; anal, pelvic and pectoral fins paler with brownish-orange bases, greyish extremities.

Preserved specimens (60% propyl alcohol) with scales on dorsal surface lightly pigmented with fine melanophores, more closely spaced at anterior border of exposed part of scale. Pigmentation less intense ventral to lateral line scales with melanophores confined to anterior of exposed part of scale. Ventral scales unpigmented. Vertical crescent of dark pigment behind operculum from lateral line to pectoral fin base. Fin membranes between rays of dorsal, caudal and pectoral fins heavily pigmented, outlining the rays. Similar pigment appears on pelvic and anal fins, but less prominently. Caudal fin with fine, dark posterior edge as result of membrane pigmentation. Dorsal surface of the head very finely pigmented, with larger melanophores in the centre of operculum. Posterior edge of operculum unpigmented. Ventral surface of head, lips and barbels are unpigmented.

Distribution and habitat. Adult *L. nthuwa* occur in the main South Rukuru River down to the Wongwe and FuFu falls near the lake (Fig. 1), but have not been found in the lake itself. The upper distribution limit is unknown, but the species occurs at least as far upstream as Lake Kazuni. The species also occurs in larger perennial tributaries flowing from the Nyika Plateau, such as the Runyina, where adults and juveniles were caught, and the South Rumphi, a smaller stream that yielded juveniles only. All sampling sites where the species has been caught were rocky, fast flowing stretches with some deeper pools. The species has not been recorded beyond the South Rukuru River system.

Etymology. Nthuwa (pronounced "ntoowa") is the vernacular name used for this species in the vicinity of the town of Rumphi, and is used here as a noun in apposition.

Comparisons. There are two similar large *Labeobarbus* species in Lake Malawi and all perennial rivers and streams flowing to the lake with the exception of the South Rukuru above the Wongwe and FuFu Falls.

Labeobarbus brevicauda (Keilhack), formerly known as *L. eurystomus* (Keilhack) (Seegers 1995), is easily distinguished from *L. nthuwa* by its higher lateral line scale count (33–37, mean 35 v. 30–33, mean 31), long, robust barbels of equal length and enlarged, molariform pharyngeal teeth.

Labeobarbus johnstonii is closer in appearance to *L. nthuwa* and has similar pharyngeal bones and teeth. Because *L. johnstonii* is variable in form depending on habitat and locality, e.g. Shire River specimens from torrential stretches of river are deeper bodied than specimens from standing or slow moving waters in Lake Malawi and inflowing streams, it was necessary to investigate the full range of variation in the species. A total of 56 specimens from Lake Malawi, various inflowing rivers at different altitudes in different habitat types, the out-flowing Shire River, and small tributaries of that river in the Lower Zambezi system were measured. *Labeobarbus johnstonii* can be separated from *L. nthuwa* by its higher lateral line scale count (31–40, mean 35), by its higher gillraker count (*L. johnstonii*, 10–15, mean 11; *L. nthuwa*, 8–10, mean 9) (Table 3), and by having a flexible and not heavily ossified last simple dorsal ray, as in *L. nthuwa*. *Labeobarbus nthuwa* has five unbranched dorsal-fin rays visible on radiographs of specimens >38 mm SL, whereas in *L. johnstonii*, the usual count is four: only four of 58 specimens radiographed have five unbranched rays.

Labeobarbus nthuwa was also compared with *L. marequensis* from the Zambezi system. *Labeobarbus marequensis*, as currently recognised, is found from the Middle and Lower Zambezi south to the Incomati system in South Africa, including the type locality, the Marico River (Skelton 2001). *L. marequensis* populations show considerable variation, e.g, populations to the south of the Zambezi have higher scale counts and narrower caudal peduncles (discussed by Farquharson 1962). Following preliminary examination of the other populations, our study was restricted to Zambezi populations as these are closest to Malawi drainages, most similar in scale counts, and most likely to be related to *L. nthuwa*. Meristic and morphometric measurements were taken for 46 specimens of *L. marequensis* from the Middle and Lower Zambezi River and tributaries (Table 4). From the Gairezi tributary of the Lower Zambezi, both typical *L. marequensis* and chisel-mouthed forms previously identified as *Varicorhinus nasutus* Gilchrist and Thompson 1911 (see Tweddle & Skelton 1998, for discussion of validity of *V. nasutus*) were measured. The various Zambezi populations differ in the depth of the caudal peduncle. Specimens from the Lower Shire tributary of the Lower Zambezi have very broad caudal peduncles, as deep as long, whereas specimens from the Gairezi tributary have narrow caudal peduncles. A list of the measured specimens of *L. johnstonii* and *L. marequensis* is presented in the Appendix.

Labeobarbus marequensis can be separated from *L. nthuwa* by its higher gillraker count (9–14, mean 11 cf. 8–10, mean 9) and the absence of the ossified last simple dorsal-fin ray. Specimens of *L. marequensis* from Lake Kariba have slightly more robust last unbranched dorsal-fin rays than other populations, but not to the extent that they could be considered spinous. Only two of 36 radiographed specimens of *L. marequensis* had five unbranched dorsal-fin rays, the rest had four.

Because of the wide geographic variation in *L. johnstonii* and *L. marequensis*, caution is needed when describing a new species. To assess the validity of *L. nthuwa*, principal component analysis was carried out on the measurements from all specimens examined. The first principal component summarised body size, as indicated by its large weights for linear measurements and low weights for meristic variables, and did not help to differentiate the species. Components 2 and 3, however, separated *L. marequensis* and *L. johnstonii*, based largely on scale counts (factor 2), barbel lengths and caudal peduncle depth (factor 3) (Fig. 11), whereas *L. nthuwa* was intermediate, with slight overlap with both species. A single aberrant specimen from the Maperera tributary of the Lower Shire River had 32 lateral line scales and only 12 around the caudal peduncle, and was possibly a *L. johnstonii*/*L. marequensis* hybrid as both species occur in the Lower Shire. This specimen is excluded from the convex hull drawn to encompass the *L. johnstonii* data points in Fig. 11.

Labeobarbus nthuwa was compared with the different populations of *L. marequensis* (Fig. 12) and *L. johnstonii* (Fig. 13) in separate analyses. *Labeobarbus nthuwa* and *L. marequensis* were clearly separated, with scale counts and caudal peduncle depth (factor 2) and gillraker counts and barbel lengths (factor 3) identified as key variables. Some clustering of different Zambezi populations of *L. marequensis* is also noted on this figure, and further investigation using genetic and morphometric techniques on fresh *L. marequensis* material is needed to ascertain the relationships between populations of this species.

In the third analysis, *L. nthuwa* was also distinguished from *L. johnstonii* (Fig. 13), based on scale and gillraker counts (factor 2), caudal peduncle depth and barbel length (factor 3). There is considerable overlap between *L. johnstonii* populations and thus they are not outlined in Fig. 13. Middle Shire River specimens, from torrential stretches of river, have more powerful caudal regions

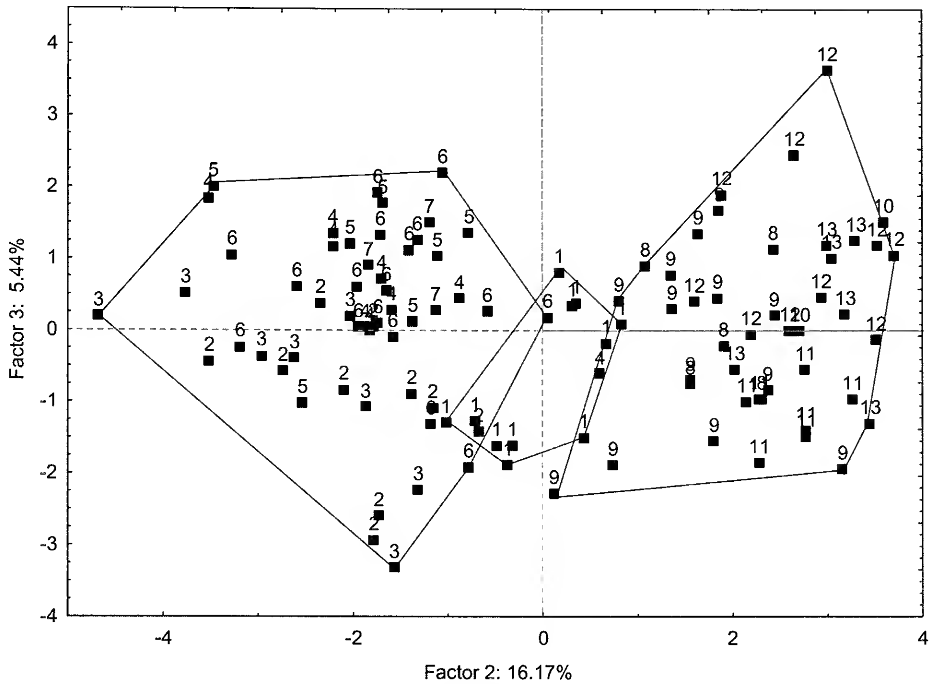

Fig. 11. Separation of *L. marequensis* and *L. johnstonii* with *L. nthuwa* occupying an intermediate position, using PCA based on all morphometric measurements. Numbers represent specimens from different populations (see Figs. 12 and 13 captions). 1 = *L. nthuwa*, 2-7 = *L. johnstonii*, 8-13 = *L. marequensis*. An aberrant specimen of *L. johnstonii* population 4 is omitted from the convex hull for that species, as explained in the text.

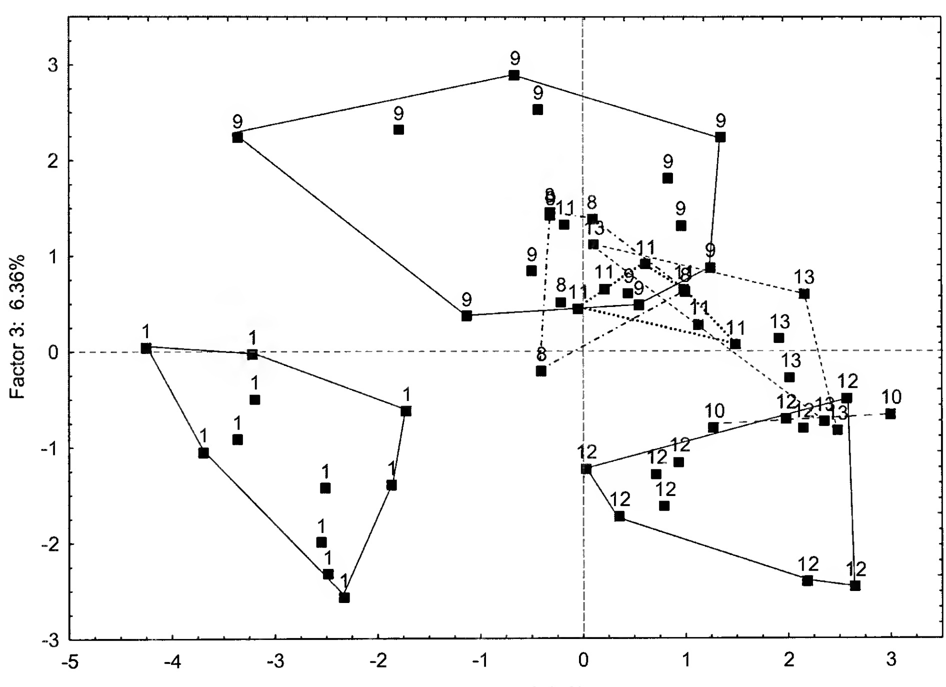

Fig. 12. Separation of *L. nthuwa* from Zambezi populations of *L. marequensis*, numbered as follows: 1 = *L. nthuwa*; 8-13 = *L. marequensis*, 8 = 'normal" mouthed Gairezi River, 9 = '*Varicorhinus*' mouthed Gairezi River, 10 = Ruo River, tributary of Lower Shire River, 11 = Mazoe River, 12 = Lake Kariba, 13 = Luangwa River. Specimens measured are listed in the appendix. The different populations are outlined in the scatterplot.

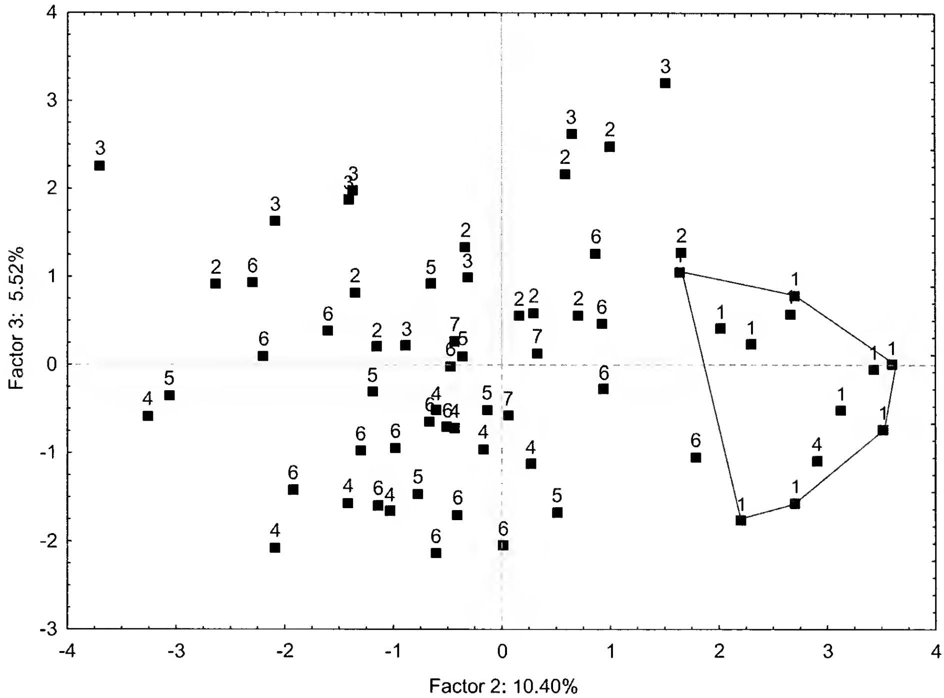

Fig. 13. Separation of *L. nthuwa* from populations of *L. johnstonii*, numbered as follows: 1 = *L. nthuwa*; 2-7 = *L. johnstonii*, 2 = Bua River, 3 = Lake Malawi, 4 = Maperera River, tributary of Lower Shire River, 5 = Lufira River, 6 = Middle Shire River, 7 = North Rukuru River. Specimens measured are listed in the appendix. Because of the large degree of overlap between *L. johnstonii* populations, they have not been differentiated in this scatterplot.

than specimens from standing or slow moving waters in Lake Malawi and inflowing streams, and this was reflected in the weight given to caudal peduncle depth in the third principal component. As a result, Lake Malawi specimens (population no. 3 in Fig. 13) are all found in the upper part of the scatter diagram, while the robust Middle Shire specimens (population no. 6) are mainly in the lower part.

Labeobarbus codringtonii is a species found in rapids of the Upper Zambezi River system and is distinguished from *L. nthuwa* by the absence of the ossified last simple dorsal-fin ray and from both *L. marequensis* and *L. nthuwa* in having a very tall dorsal fin.

DISCUSSION

Banister & Clarke (1980) considered *L. johnstonii* to be 'strikingly similar' to *L. marequensis* in gross appearance, including the form of the pharyngeal bones and teeth and the scale striations. They cautioned that the characters in question are probably plesiomorphic, but stated that, with no other likely candidates in the region, there are no zoogeographical inconsistencies in the suggestion that the two species are related. *Labeobarbus nthuwa* is an addition to this group of similar species.

In scale counts *L. nthuwa* is closer to *L. marequensis* than it is to *L. johnstonii*. *Labeobarbus marequensis* occurs in the Luangwa River. The very close proximity of the South Rukuru River to the Luangwa River watershed on the Zambian border for approximately 150 km of its course, and the presence of swamps and evidence of former lakes in the area (Hopkins 1973) suggests river capture has occurred as a result of tectonic warping of the land surface associated with the Lake Malawi rifting. Unconsolidated pebble sheets up to 30 m above the present level of Lake Kazuni (Fig. 1) probably represent the littoral deposits of a once much more extensive lake (Hopkins 1973) created by such tectonic movements. A probable site of river capture is marked on Fig. 1. Prior to this, much of the present South Rukuru River would have been a west-flowing Luangwa River tributary. The Luangwa River in Zambia flows to the Middle Zambezi. It is possible that *L. nthuwa* is derived from a population of *L. marequensis* present in the Luangwa tributary captured by the South Rukuru River. Unfortunately no *Labeobarbus* specimens are available in museum collections of the Luangwa River's eastern tributaries near Malawi to compare with *L. nthuwa*. An alternative possibility is that *L. nthuwa* evolved from a population of *L. johnstonii* present in the South Rukuru before the Wongwe and FuFu Falls became a complete barrier to migration during rifting.

Another possible interpretation is that *L. johnstonii* is derived from Luangwa River *L. marequensis*, which entered the Lake Malawi system via the South Rukuru River. With the South Rukuru separated from both systems as a result of the river capture to the west and falls to the east, *L nthuwa* would then have evolved its distinctive characteristics in isolation, while the lake populations in continuous contact with each other evolved into the species now recognized as *L. johnstonii*. The alternative suggestion that the ancestor of *L. johnstonii* entered Lake Malawi from the Lower Zambezi via the Shire River (Banister & Clarke, 1980) is untenable because the Shire link is very recent, established only in the Quaternary (Lister 1967).

The South Rukuru River is unique among rivers flowing to Lake Malawi as it contains several fish species absent from the other rivers. In addition to the two species described here, there is another small *'Barbus'* species with midlateral spots, which is possibly distinct from a similar species, also undescribed, on the lakeshore plain. Genetic study is needed to resolve this problem. One of the species described in this paper, *'B.' seymouri*, also occurs in the adjacent Kaziwiziwi River, from where many of the type series, including the holotype, were taken. The species may have found its way into the Kaziwiziwi naturally as a result of river capture, or possibly by human transfer when a fish farm on the Nchenachena tributary of the South Rukuru, very close to the Kaziwiziwi, was used to stock fish ponds in the area in the 1950s.

The South Rukuru River contains two undescribed species of the small catfish genus *Zaireichthys*, only one of which occurs in other Lake Malawi rivers, while the other is found in the Zambezi system (D.H. Eccles *et al.*, in prep.). *Clarias liocephalus* Boulenger occurs in Malawi only in the South Rukuru River. This is a species of the Upper Zambezi, north to the Congo, and through the Central African Great Lakes to the Lake Victoria region (Teugels 1986; Skelton 2001). In addition to these distinct species, there are as yet unquantified differences in the appearance of *Amphilius uranoscopus* (Pfeffer) from the South Rukuru River compared to other Malawi rivers, and the South Rukuru *'Barbus' paludinosus* Peters population grows to a much larger size (15 cm SL) than in other populations elsewhere in its wide range (Jackson *et al.* 1963; personal observations). The distinctness of the South Rukuru fish fauna shows that it is likely to be derived from a different source than the fauna of other rivers flowing into the lake. It is suggested here that the likely source is highland tributaries of the Luangwa River captured by the South Rukuru during tectonic warping of the rift flanks.

The fish fauna of the Lake Malawi catchment as a whole shows close links with both east coast rivers and also with the Zambezi system to the west. The distribution of some of these 'Zambezi' species suggests there may have been more than one source. The following 'Upper Zambezi' species occur along the northern Malawi lakeshore plain, including the Limphasa wetlands (Fig. 1), but not in the south: *Pollimyrus castelnaui* (Boulenger), *'Barbus' bifrenatus* Fowler, *Clarias stappersii* Boulenger, *Tilapia sparrmanii* Smith and *Pseudocrenilabrus philander* (Weber). None of these species occur in the South Rukuru River above the falls. Another "Upper Zambezi" species in the *Hippopotamyrus ansorgii* (Boulenger) species complex occurs in the upper reaches of the North Rukuru River, to the north of the Nyika Plateau (W. Kadye, pers. comm., specimens lodged in SAIAB). Thus the relationship between Lake Malawi and the Zambezi system is complex and cannot be explained simply by the single river capture from a Middle Zambezi tributary for which evidence is presented in this paper.

Worthington (1933) suggested links between northern affluents of Lake Malawi and the Chambeshi system in Zambia, which is currently a headwater system of the Congo River system in an area that is flat and largely covered by marshes and large lakes. Genner *et al.* (2007) also suggested links in this area when discussing the molluscan *Melanoides polymorpha* (Smith) 'complex' of Lake Malawi. They pointed out that the *M. polymorpha* complex formed a clade with *Melanoides anomala* (Dautzenberg and Germain), a taxon now restricted to the southeast of the Congo drainage, and *Melanoides mweruensis* (Smith), an endemic of Lake Mweru. They stated that the Malawi Basin may have been colonised directly via a direct watershed boundary between the headwaters of the Congo River and the northwest of the Malawi Basin. Here tributaries of the Songwe River are adjacent to tributaries of the Chambeshi River that flows directly into the Bangweulu swamps and onto Lake Mweru.

Stankiewicz & de Wit (2006) described historical changes in river directions in this area based on geological evidence. They suggested that in the Miocene the Luangwa and Middle Zambezi rivers changed course from their previous northeasterly flow direction towards an eastward-flowing paleo-Congo River, and may have become landlocked until captured by the Lower Zambezi River. The Chambeshi River also originally flowed north east, either joining the Luangwa or flowing directly into the palaeo-Congo. Its flow was also reversed in the Miocene and it became landlocked, possibly originating Lake Bangweulu. This system was captured first by the Kafue River to become part of the Zambezi River network and then, in the Lower Pleistocene, by the Luapula River to become part of the new west-flowing Congo River network, as it is today. The course of the proto-Luangwa River when flowing northeast cuts across the northern tip of the current Lake Malawi. Thus there have been opportunities for transfer of fish species in the area as proposed by Worthington (1933), explaining the presence of the group of species discussed above in northern Lake Malawi lakeshore streams. Further study is needed on the faunas of Zambian waters between the Upper

Zambezi and Lake Malawi, including eastern Luangwa tributaries, to shed more light on these possible links.

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Table 1. Morphometric and meristic measurements of '*Barbus*' *seymouri* type series.

Measurement	N	Holotype	Range Max	Min	Mean	SD
Standard length (mm)	24	93.30	108.20	28.30	67.40	
Head length (%SL)	24	24.54	29.33	24.42	25.86	1.13
Head depth (%HL)	24	72.49	73.82	65.52	70.70	2.29
Snout length (%HL)	24	30.13	32.00	22.89	28.30	2.10
Orbit diameter (%HL)	24	25.33	37.35	23.96	28.91	3.02
Postorbit length (%HL)	24	47.60	48.36	40.96	45.35	2.06
Interorbit width (%HL)	24	33.62	33.62	27.59	30.69	1.89
Predorsal length (%SL)	24	49.52	53.05	48.65	50.49	1.13
Prepelvic length (%SL)	24	46.20	49.44	44.86	47.56	1.26
Dorsal fin length (%SL)	24	21.11	28.18	18.72	22.73	2.44
Pectoral fin length (%SL)	24	17.58	21.06	16.45	18.86	1.18
Pelvic fin length (%SL)	24	15.43	18.24	13.77	15.98	0.97
Anal fin length (%SL)	24	15.97	19.79	14.79	17.18	1.11
Body depth (%SL)	24	27.65	28.75	24.38	26.49	1.13
Body width (%SL)	24	15.54	16.82	10.95	15.19	1.31
Caudal peduncle length (%SL)	24	25.08	26.80	22.59	25.01	1.02
Caudal peduncle depth (%CPL)	24	51.28	56.45	45.59	50.79	2.53
Anterior barbel length (%OD)	24	91.38	95.65	45.16	80.49	11.12
Posterior barbel length (%OD)	24	118.97	123.08	70.97	103.65	11.81

Meristics

Count	Holotype	Range
Dorsal-fin rays	iv + 7	iii + 7 (N = 2) or iv + 7 (N = 22)
Anal-fin rays	iii + 5	iii + 5 (N = 23) or iii + 6 (N = 1)
Pectoral-fin rays	14	12 (N = 1), 13 (N = 1), 14 (N = 7), 15 (N = 15)
Pelvic-fin rays	8	8 (N = 22), 9 (N = 2)
Total vertebrae	35	34 (N = 17), 35 (N = 7)
Abdominal vertebrae	19	17 (N = 1), 18 (N = 9), 19 (N = 14)
Caudal vertebrae	16	15 (N = 8), 16 (N = 14), 17 (N = 2)
Predorsal vertebrae	10	9 (N = 8), 10 (N = 16)
Preanal vertebrae	19	18 (N = 3), 19 (N = 19), 20 (N = 2)
Rib pairs	13	12 (N = 8), 13 (N = 16)
Lateral line scales	27	26 (N = 6), 27 (N = 11), 28 (N = 5), 29 (N = 2)
Caudal peduncle scale rows	12	12 (N = 24)
Scale rows lat. line - dorsal	4	4 (N = 24)
Scale rows lat. line - pelvic	3	2+1 (N = 9), 3 (N = 14), 3+1 (N = 1)
Scale rows lat. line - anal	2+1	2 (N = 1), 2+1 (N = 21), 3 (N = 2)
Predorsal scale rows	12	9 (N = 1), 10 (N = 9), 11 (N = 13), 12 (N = 1)

Table 2. Morphometric and meristic measurements of *Labeobarbus nthuwa* type series.

Measurement			Range			
	N	Holotype	Max.	Min.	Mean	SD
Standard length (mm)	12	210.00	236.00	31.00	91.43	
Head length (%SL)	12	23.33	28.71	22.86	26.25	2.19
Head depth (%HL)	12	76.73	76.73	70.16	72.92	1.74
Snout length (%HL)	12	37.14	37.14	22.68	29.96	4.48
Orbit diameter (%HL)	12	22.04	32.58	21.30	28.10	4.42
Postorbit length (%HL)	12	46.33	47.98	39.62	42.78	2.82
Interorbit width (%HL)	12	37.76	40.12	23.60	32.03	5.05
Predorsal length (%SL)	12	48.43	52.97	46.14	50.51	2.17
Prepelvic length (%SL)	12	50.81	57.14	49.84	53.30	2.44
Dorsal fin length (%SL)	12	21.62	27.33	20.79	23.42	1.92
Pectoral fin length (%SL)	12	19.86	20.73	19.05	19.68	0.49
Pelvic fin length (%SL)	12	18.00	18.00	15.42	16.62	0.79
Anal fin length (%SL)	12	17.48	19.83	15.98	17.24	1.32
Body depth (%SL)	12	30.14	30.38	25.42	27.40	1.70
Body width (%SL)	12	18.19	19.22	12.35	15.09	2.28
Caudal peduncle length (%SL)	12	19.86	19.90	15.52	18.09	1.42
Caudal peduncle depth (%CPL)	12	59.95	71.59	55.84	62.47	4.77
Anterior barbel length (%OD)	12	68.52	68.52	13.79	33.70	18.17
Posterior barbel length (%OD)	12	96.30	107.83	24.14	58.94	26.18
Mouth width (%HL)	12	26.12	32.38	16.85	23.49	4.88

Meristics

Count	Holotype	Range
Dorsal fin rays	v+9	iv+9 (N = 3), v+8 (N = 1), v+9 (N = 8)
Anal fin rays	iii+5	iii+5
Pectoral fin rays	16	15 (N = 5), 16 (N = 3), 17 (N = 4)
Pelvic fin rays	9	8 (N = 1), 9 (N = 11)
Total vertebrae	40	40 (N = 3), 41 (N = 9)
Abdominal vertebrae	22	21 (N = 1), 22 (N = 5), 23 (N = 6)
Caudal vertebrae	18	17 (N = 1), 18 (N = 7), 19 (N = 3), 20 (N = 1)
Predorsal vertebrae	10	10 (N = 5), 11 (N = 7)
Preanal vertebrae	26	26 (N = 10), 27 (N = 2)
Rib pairs	14	13 (N = 2), 14 (N = 10)
Lateral line scales	32	30 (N = 3), 31 (N = 3), 32 (N = 5), 33 (N = 1)
Caudal peduncle scale rows	12	12 (N = 12)
Scale rows lat. line - dorsal	5	5+1 (N = 12)
Scale rows lat. line - pelvic	3	3 (N = 7), 3+1 (N = 5)
Scale rows lat. line - anal	4	3+1 (N = 3), 4 (N = 8), 4+1 (N = 1)
Predorsal scale rows	11	11 (N = 5), 12 (N = 7)
Gill rakers	9	8 (N = 4), 9 (N = 6), 10 (N = 1)

Table 3. A comparison of the morphometric and meristic characters of *L. nthuwa*, *L. johnstonii* and *L. marequensis*.

	L. nthuwa			*L. johnstonii*			*L. marequensis*		
Measurement	**n**	**mean**	**SD**	**n**	**mean**	**SD**	**n**	**mean**	**SD**
SL	12	91.43		54	104.93		45	100.45	
HL %SL	12	26.25	2.19	54	25.42	1.50	45	25.67	2.17
HD%HL	12	72.92	1.74	56	74.71	3.19	45	74.98	5.37
SNL%HL	12	29.96	4.48	56	33.33	2.81	45	33.00	3.06
OD%HL	12	28.10	4.42	56	27.16	3.29	45	28.95	3.54
POL%HL	12	42.78	2.82	56	43.46	2.71	45	42.18	3.08
IOW%HL	12	32.03	5.05	56	37.21	4.62	45	36.40	6.25
PD%SL	12	50.51	2.17	54	49.64	1.70	45	50.93	1.87
PP%SL	12	53.30	2.44	54	52.43	1.63	45	53.59	1.96
DL%SL	12	23.42	1.92	54	23.81	1.39	45	25.24	3.16
PCL%SL	12	19.68	0.49	54	20.10	1.20	45	20.98	1.82
PVL%SL	12	16.62	0.79	54	17.82	1.10	45	18.85	1.87
AL%SL	12	17.24	1.32	54	18.38	1.38	45	19.38	1.93
BD%SL	12	27.40	1.70	54	28.15	2.25	45	28.70	2.28
BW%SL	12	15.09	2.28	54	15.35	1.17	45	15.71	1.70
CPL%SL	12	18.09	1.42	54	18.65	1.13	45	17.55	1.24
CPD%CPL	12	62.47	4.77	54	64.78	5.35	45	70.18	8.51
AB%OD	12	33.70	18.17	56	40.25	13.64	45	36.70	13.37
PB%OD	12	58.94	26.18	56	61.22	16.34	45	54.84	14.38
MW%HL	12	23.49	4.88	56	28.56	4.74	45	32.08	9.66

	Range		
Counts	***L. nthuwa*** (n = 12)	***L. johnstonii*** (n = 56)	***L. marequensis*** (n = 36)
Dorsal-fin rays	iv+9, v+8, (v+9)	iv+8, (iv+9), iv+10, v+9	(iv+9), iv+10, v+10
Anal fin rays	iii+5	(iii)+5, iii+6, iv+5	iii+5
Pectoral fin rays	(15)-17	14-(16)-17	15-(16)-17
Pelvic fin rays	8-(9)	8-(9)-10	8-(9)
Total vertebrae	40-(41)	40-(41)-43	38-(39)-42
Abdominal vertebrae	21-(23)	22-(23)-24	21-(23)-24
Caudal vertebrae	17-(18)-20	16-(18)-19	16-(17)-19
Predorsal vertebrae	10-(11)	10-(11)-12	(10)-12
Preanal vertebrae	(26)-27	25-(26)-28	24-(25)-27
Rib pairs	13-(14)	14-(15)-16	13-(15)-16
Lateral line scales	30-(32)-33	31-(34)-40	26-(29)-32
Caudal peduncle scale rows	12	12-(14)-16	11-(12)
Scale rows lateral line - dorsal	5+1	5+1-(6+1)-7	4+1-(5)-5+1
Scale rows lateral line - pelvic	3-(3+1)	2+1-(3)-4	2-(3)
Scale rows lateral line - anal	3+1-(4)-4+1	3+1-(4)-4+1	(3)-4
Predorsal scale rows	11-(12)	10-(12)-14	9-(11)-12

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APPENDIX

List of specimens of *Labeobarbus marequensis* and *Labeobarbus johnstonii* used in the morphometric and meristic comparisons.

Labeobarbus johnstonii

SAIAB 74-108, 5 specimens, 108.1–144.5 mm SL, Lake Malawi. SAIAB 74-126, 2 specimens, 141.1 &156.7 mm SL, Lake Malawi, Varicorhinus-mouth form. SAIAB 42112, 1 specimen, 213.0 mm SL, South East Arm of Lake Malawi. SAIAB 42111, 2 specimens (large heads only), South East Arm of Lake Malawi. SAIAB 39340, 1 specimen, 133.3 mm SL, Bua River, Lake Malawi system. SAIAB 50089, 9 specimens, 41.9–111.7 mm SL, Bua River, Lake Malawi system. AMG 8401, 3 specimens, 193.0–225.0 mm SL, North Rukuru River, Lake Malawi system. SAIAB 34910, 7 specimens, 41.7–81.2 mm SL, Lufira River, Lake Malawi system. SAIAB 50174, 14 specimens, 40.5–175.0 mm SL, Wankurumadzi River, Middle Shire system. AMG 8403, 3 specimens, 117.9–170.8 mm SL, Mpatamanga, Middle Shire River. SAIAB 34322, 1 specimen, 120.9 mm SL, Maperera River, Lower Shire system. SAIAB 34854, 8 specimens, 43.9–119.5 mm SL, Maperera River, Lower Shire system.

Labeobarbus marequensis

SAIAB 34938, 1 specimen, 185.0 mm SL, Chiromo, Ruo/Lower Shire River. SAIAB 51947, 1 specimen, 59.6 mm SL, Sankhulani, Ruo River, Lower Shire system. SAM 8801, 1 specimen 482.0 mm SL, (type specimen of *Varicorhinus nasutus*), Middle Zambezi below Victoria Falls. AMG 366, 4 specimens, 143.7–156.4 mm SL, Mazoe River, Lower Zambezi system. AMG 8pf) 33, 3 specimens, 50.6–147.7 mm SL, Mazoe River, Lower Zambezi system. AMG 2100, 1 specimen, 368.0 mm SL, Gairezi River, Lower Zambezi system. AMG (pf) 144, 3 specimens, 180.0–195.0 mm SL, Gairezi River, Lower Zambezi system. AMG 30, 6 specimens, 59.4–99.2 mm SL, Gairezi River, Lower Zambezi system. AMG 1249, 3 specimens, 39.6–60.5 mm SL, Gairezi River, Lower Zambezi system. AMG 67, 4 specimens, 70.1–121.2 mm SL, Gairezi River, Lower Zambezi system. AMG (pf) 351, 3 specimens, 83.2–89.1 mm SL, Gairezi River, Lower Zambezi system. AMG (pf) 1322, 6 specimens, 29.2–51.7 mm SL, Luangwa River, Middle Zambezi system. AMG 2022, 10 specimens, 75.6–154.3 mm SL, Kariba, Middle Zambezi system.

A survey of tail spine characteristics of stingrays frequenting African, Arabian to Chagos-Maldive Archipelago waters.

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Abstract. Tail spine characteristics were examined of 51species (including one subspecies) of stingrays frequenting African, Arabian to Chagos-Maldive archipelago waters. Thirty-four species (313 males, 405 females) possessed intact spines, 12 species lacked tail spines. Spine characteristics recorded were: total length, prebase length, serrations (right and left), serrations or spaces on the spine base and if a dorsal groove was present. Spine total serrations ranged 36–261; spine serrations of males were usually more numerous than of females, sometimes twice as many. Total serration count seemed to be associated with stingray habitat and behavior, those of active open water rays have high counts, while benthic or freshwater ray species have low counts. Disk width, spine length, prebase length and presence of a dorsal groove is not correlated with size or type of stingray. Likewise the number of spine serrations does not increase in more derived genera. A combination of spine characteristics does, however, define a species. These features will help scientists, paleontologists and physicians identify a species.

Keywords: stingrays, tail spine serrations, Africa, Arabia

INTRODUCTION

The public is acutely aware of injuries—even death—resulting from encounters with stingray tail spines. To date no one has examined stingray tail spines for species specific spine characteristics or species-spine-habitat correlations. Schwartz (2005), examined stingrays frequenting the Mediterranean Sea, noting each species could be identified by its spine characteristics, and that the number of spine serrations seemed to be habitat related: two species with high total spine serrations were open water swimmers (*Dasyatis centroura, Pteroplatyrygon violacea*); five species with intermediate serration counts (*Dasyatis pastinaca, Himantura uarnak, Myliobatis aquila, Taeniura meyeni, Dasyatis margarita*) were midwater or benthic inhabitants; and three benthic species had low serration counts (*Gymnura altavela, Pteromylaeus bovinus, Taeniura grabata*).

This study reports spine characteristics of 34 stingray species frequenting the eastern Atlantic ocean waters adjacent to Africa, the Mediterranean and Arabian Seas and waters from eastern Africa to the Chagos-Maldive Archipelago, noting spine shape, total length, prebase length, right and left side serration counts and features, base serrations or space features, and presence or absence of a dorsal spine groove.

The study area (Fig.1) includes the tropical ocean waters off Africa's west coast from 10°N to 15°S, the subtropical and cool temperate waters from 15° to the Cape of Good Hope at 25°S; the tropical coastal waters of East Africa from 15°N to the Tropic of Capricorn, and the subtropical and warm temperate south to 25°S (Whitfield 2005).

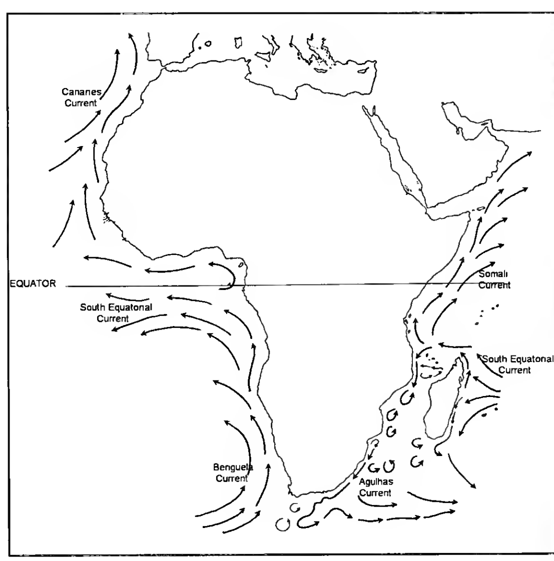

Fig. 1. Outline map of Africa showing the major current patterns (Sources: *The Times Atlas and Encyclopaedia of the Sea* 1989; Lutjeharms 2007).

Fish faunal distributions are influenced by ocean currents. Fig. 1 shows the prevailing currents in the study area. Two points are worth noting. The first is that

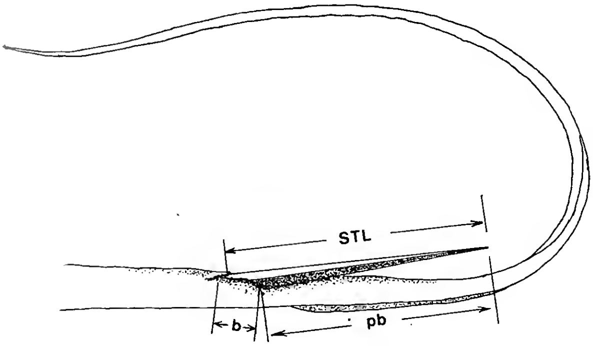

Fig. 2. Diagram of a tail spine *in situ* to show how total length (STL) is measured (based on Halstead, 1978).

during the northwest monsoon (February and March), the wind blows from southeast across the Indian Ocean and across the Indian sub-continent, inducing the development of the North Equatorial Current. A strong countercurrent exists south of the North Equatorial Current at this same time of year. In August and September, during the southwest monsoon, the North Equatorial Current reverses its flow from west to east (and is called the Monsoon Current), and the countercurrent seems to disappear. During this time of year the winds form a major upwelling off the Somali coast (Kindle & Arnone 2001).

The second point is that there is no defined current in the Mozambique Channel, but that water is carried down the Channel in a series of slowly rotating eddies. The South Equatorial Current, impinges on the east coast of Madagascar at about 17°S, divides into a south flowing East Madagasar Current and a north flowing current, which flows around the north of Madagascar and contributes to the southward flowing Mozambique Eddies. The East Madagascar Current, together with the Mozambique Eddies, form part of the Agulhas Current (Lutjeharms 2007).

METHODS

Intact tail spines of 34 preserved stingray species and one subspecies (313 males and 405 females) were examined at the following institutions: Natural History Museum (London), Natural History Museum (Paris), Naturhistorisches Musem (Vienna), South African Museum (Cape Town, South Africa), the South African Institute for Aquatic Biodiversity (formerly the J. L. B. Smith Institute of Ichthyology, Grahamstown, South Africa), Natal Sharks Board (Umhlanga Rocks, South Africa), CSIRO Division of Fisheries (Hobart, Tasmania), Australian Museum (Sydney, Australia), United States National Museum (Washington, DC), California Academy of Sciences (San Francisco, California) and Scripps Oceanographic Institute (La Jolla, California). I follow Compagno's (2005) use of stingray common names.

Most tail spines were left attached to the tail. The skin surrounding the spine base was teased loose when necessary to reveal serrations or spaces on the spine base sides. The base demarcation point was determined by placing a thin plastic ruler parallel to the spine and pushing it forward until it met the base (Fig. 2). Total serrations (right [R] or left [L]), regardless of shape or size of tail spine, were counted from the spine tip to the base. Total spine length (STL) was the length from the spine tip to its posterior dorsal insertion on the tail. Prebase length (pb) was the STL minus the length of the spine from the tip to its base. Base length was the difference of the STL minus the pb. Secondary spines were noted if developing before or behind the primary spine. Disk width (DW) of each specimen was measured in millimeters (mm). Sex was noted as immature or adult. Species' spine serrations are presented alphabetically within a genus in the text and in Table 1.

OBSERVATIONS

PLESIOBATIDAE – GIANT STINGRAYS

Plesiobatis daviesi (Wallace 1967) – giant stingray. Found off southwest Africa, (Wallace 1967). A 270 cm DW species. Spine characteristics: total length averages, males 136 mm, females 81 mm; total serrations averages, males 136, females 104; pb/STL average 68% in both sexes. Six to 15 serrations or a 2–18 mm space on spine base sides; no dorsal groove evident.

DASYATIDAE – WHIPTAIL STINGRAYS

Dasyatis bennetti (Müller & Henle 1841) – frilltailed stingray. Frequents Persian Gulf and Hormoz Straits (Fowler 1941; Garman 1913; Vossoughi & Vosoughi 1999). A 33 mm DW species. Spine characteristics: total lengths, males 77 mm, females 86 mm; total serrations averages, males 94, females 100; pb/TL averages, males 91%, females 91%. Eight serrations on spine base sides, dorsal groove 60–80% of spine length.

Dasyatis brevicaudatus (Hutton 1875) – smooth stingray. Synonyms: *Dasyatis schrienei* (Garrick 1954) and not *D. agulhensis* (Wallace 1967). South and southeast coast of South Africa from False Bay to Maputo (Wallace 1967; Compagno & Heemstra 1984; Compagno *et al.*, 1991). A 2.1 m disk width (DW) species. A 33 mm DW species. Spine characteristics: total length averages, males 100 mm, females 149 mm (longest spine measured was of a female at 338 mm STL – see Table 1); total serrations averages, males 261, females 156; pb/STL averages, males 89%, females 71%. Five to 10 serrations on spine base sides; dorsal groove 30-80% of spine length. A unique feature was cul-de-sacs located medially between serrations (Fig. 3), a feature also possessed by the pelagic stingray *Pteroplatytrygon violacea*.

Dasyatis centroura (Mitchell 1815) - roughtail stingray. Occurs in the eastern Atlantic from Norway to Madeira, Mediterranean and Black Seas (Fowler 1936; Capapé 1977; Compagno & Heemstra 1984; Compagno & Roberts 1984; Dulcic *et al.* 2003; Golani & Capapé 2004). An active midwater to benthic 2.1 m DW species. Spine characteristics: large, heavy spines, wide at base and tapering to tip; total length averages, males 143 mm, females 159 mm; total serrations averages, males 160, females 178; pb/STL averages, males 78%, females 72%. Eleven to 20 serrations or 72–114 mm space on spine base sides; dorsal extends 60-80% of spine length; secondary spines develop below and behind primary spines.

Dasyatis c. chrysonota (Smith 1828) - blue stingray. *D. chrysonata* is often confused with *Dasyatis pastinaca* and *D.c. marmorata,* resolved by Cowley & Compagno (1993). Known from Angola southeast to Cape Agulhas and northeast to St. Lucia, South Africa (Soljan 1948; Wallace 1967; Compagno *et al.* 1991; Cowley & Compagno 1993; Ebert & Cowley 2003; Heemstra & Heemstra 2004; Golani & Capapè 2004). A 48 cm DW species. Spine characteristics: total length averages, males 36mm, females 52 mm; total serrations averages, males 61, females 82; pb/STL averages, males 73%, females 71%. Twelve to 17 mm spaces on spine base sides; dorsal groove 33% of spine length.

Dasyatis c. marmorata (Steindachner 1892) - blue stingray. A subspecies of *D. chrysonata;* found off Senegambia, West Africa, Mediterranean and eastern Atlantic from Spanish Sahara south to Congo (Maigret & Ly 1986; Cowley & Compagno 1993; Capapè & Zaouali 1995; Golani & Capapè 2004). A 27 cm DW species found in coastal benthic habitats. Spine characteristics: total length averages, males 48 mm, females 38 mm; total serrations averages, males 65, females 55; pb/STL averages 48% in both sexes. Twelve to 28 serrations or a 16 mm space on base sides; dorsal groove extends length of spine.

Dasyatis kuhlii (Müller & Henle 1841) - bluespotted stingray. Found from southeastern Africa north to Red Sea (Fowler 1941; Compagno & Heemstra 1984; Compagno *et al.* 1991; Goren & Dor 1994; Vossoughi & Vosoughi 1999; Bonfil & Abdullah 2004). A 38 cm DW stingray. Spine characteristics: lengths 50 mm in both sexes; total serrations averages, males 72, females 61; pb/STL averages, males 67%, females 58%. Two to 13 serrations or a 1–25 mm space on base sides. Dorsal groove extends 10–50% spine length.

Dasyatis margarita (Günther, 1870) - dwarf stingray. Frequents lagoons, brackish water, mangroves and estuaries from Ivory Coast to Congo, west Africa to Angola (Fowler 1936; Compagno & Roberts 1984; Maigret & Ly 1986; Compagno & Cook 1994). A 65 cm DW species. Spine characteristics: average lengths, males 43 mm, females 45 mm; total serrations averages, males 52, females 64; pb/STL averages, males 71%, females 69%. A 10–12 mm space on the base and spine proper; no dorsal groove.

Dasyatis margaritella Compagno and Roberts 1984 - pearl stingray. Frequents marine and inshore waters, even off mouths of rivers, Guinea-Bissau to Congo and West Africa (Fowler 1936; Compagno & Roberts 1984). A 26 cm DW species. Spine characteristics: average lengths males 57 mm, females 61 mm; total serrations averages, males 62, females 78; STL averages, males 72%, females 74%. Three to 10 serrations or a 24 mm space may be present on base sides; no dorsal groove.

Dasyatis pastinaca (Linnaeus 1758) - common stingray. Some consider *D. tortonese* (Capapè 1977; Golani 1996) a separate species, others consider or confuse it with *D. pastinaca* (Serèt, pers. comm. 2005). Found in the northeast Atlantic to Madeira, Mediterranean and Black Seas, South Africa, Angola to KwaZulu-Natal Coast, and Red Sea (Fowler 1936, 1941; Soljan 1948; Wallace 1967; Capapé 1977; Klimaj 1978; Compagno & Heemstra 1984; Compagno & Roberts 1984; Compagno & Randall 1987; Cowley & Compagno 1993, Dulcic & Lipez 2002; Golani & Capapé 2004). A 60 cm DW inshore species. Spine characteristics: average lengths, males 77 mm, females 72 mm; total serrations averages, males 112; females 86; pb/STL averages, males 74%, females 71%. Eight to 18 mm spaces on base sides; dorsal groove 85% spine length.

Dasyatis rudis (Günther, 1870) - smalltooth stingray. Found off coast of Sierra Leone (Springer & Collette 1971; Compagno & Roberts 1984). A benthic 2 m DW stingray. Spine characteristics: length 138 mm; total serrations 108 short and tightly appended to spine proper. Thirty-three to 35 serrations on base sides; dorsal groove 50% of spine length.

Dasyatis thetidis (Ogilby 1899) - thorntail stingray. Once described as *D. agulhensis* or *D. lubricus* (Wallace 1967). Southeastern Africa (Wallace 1967; Last & Stevens 1984; Compagno & Heemstra 1984). A large, inshore, heavy 180 mm DW species. Spine characteristics: average lengths, males 66 mm, females 70 mm; total serrations averages, males 83, females 88; pb/STL averages, males 64%, females 65%. One to 30 serrations on base sides; no dorsal groove evident.

WHIPRAYS

Himantura bleekeri (Blyth 1860) - whiptail stingray. Smith's (1945) *H. bleekeri* specimen may be *H. oxyrhincha.* Occurs in the Arabian Gulf (Kuronuma & Abe 1986). A 39 cm DW species found over sandy substrates. Spine characteristics: average lengths, males 57 mm, females 48 mm; total serrations, males 63, females 49; pb/STL averages, males 63%, females 69%. Five to 18 mm spaces on base sides; no dorsal groove.

Himantura draco (Compagno & Heemstra 1984). No common name. Compagno (2005) considered *H. draco* a synonym of *H. jenkensii.* Stehmann (1995) and Eschmeyer (1998) believed *H. draco* is a valid species. Known from off Durban, South Africa at 50 m (Compagno & Heemstra 1984). DW 38-58 cm. Spine haracteristics: tail spine long, males 53 mm, females 28 mm. Total serrations are, male right 27, left 28, female right 27, left 25; pb/STL 34% for both the male and female. One to 20 serrations or one-12 mm spaces on base sides; dorsal groove 40-75% of spine length.

Himantura fai Jordan & Seale 1906 – pink stingray. Occurs in the Red Sea and Maldives (Capapé 1977; Randall & Anderson 1993; Bonfil & Abdullah 2004; Randall 2005). DW 150 cm. Spine characteristics: long 184 mm tail spine; total serrations (1 female), 88 right, 95 left; pb/STL 70%. No serrations on spine base; dorsal groove 95% of spine length.

Himantura gerrardi (Gray, 1851) – sharpnose stingray. Often confused with *H. draco* or *H. jenkinsii* (Wallace 1967). Found from South Africa to Red Sea and Arabian Sea (Fowler 1941; Wallace 1967; Compagno & Heemstra 1984; Kuronuma & Abe 1986; Compagno & Randall 1987; Goren & Dor 1994; Stehmann 1995; Randall 1995; Randall & Lim 2000; Bonfil & Abdullah 2004). A 90 cm DW species. Spine characteristics: average lengths, males 43 mm, females 63 mm; total serrations averages, males 51, females 81; pb/STL averages, males 71%, females 75%. One to 11 serrations on base sides; dorsal groove 40-57% of spine length. Two forms may be encountered: tail may be banded or mottled.

Himantura granulata (Macleay 1883) - mangrove whipray. Known from Seychelles, Oman and Maldives (Randall & Anderson 1993; Randall 2005). A 90 cm DW stingray. Spine characteristics: average lengths, males 71 mm, females 63 mm; total serrations averages, males 97, females 79; pb/STL averages, males 71%, females 68%. One to four serrations or a one to four mm space on base sides; dorsal groove 60% spine length.

Himantura imbricata (Bloch & Schneider 1811) – scaly stingray: Synonyms are *Trygonoptera walga* and *Trygon panopeus.* Found in the Red Sea and Arabian Gulf (Fowler 1941; Goren & Dor 1994; Khalaf & Desi 1997; Kuronuma & Abe 1986; Compagno & Randall 1987; Randall 1995; Bonfil & Abdullah 2004). A dwarf species with 23 cm DW. Spine characteristics: average lengths, males 43 mm, females 28 mm; total serrations averages, males 56, females 52; pb/STL averages, males 72%, females 65%. One to 13 serrations or a 1–28 mm space on base sides; dorsal groove 63–72% spine length.

Himantura jenkinsii (Annandale 1909) – pointed-nose stingray. Often considered to be *Himantura draco* or *H. gerrardi* (Compagno & Heemstra 1984; Stehmann 1995; Randall 1995; Heemstra & Heemstra 2004). A 100 cm DW stingray. Occurs off KwaZulu-Natal, southeastern Africa (Wallace 1967). Spine characteristics: average lengths 68 mm in both sexes; total serrations averages, males 73, females 72; pb/STL averages, males 72%, females 73%. One serration or a 1–23 mm space on base sides.

Himantura uarnak (Forsskål 1775) – honeycomb stingray. A systematically confused species often considered to be *H. oxyrynchus, H. krempfi* or even *H. bleekerii* (Eschmeyer 1998; Deynat & Fermon 2001). Found in the Mediterranean, Red Sea, Arabian Sea, Persian Gulf and along the east coast of Africa (Fowler 1941; Smith 1955; Smith & Smith 1963; Wallace 1967; Kuronuma & Abe 1980; Compagno & Heemstra 1984; Compagno & Randall 1987; Goren & Dor 1994; Khalaf & Desi 1997; Capapè & Zaouali 1995; Randall 1995; Basusta *et al.* 1998; Heemstra & Heemstra 2004; Bonfil & Abdullah 2004; Golani & Capapé 2004). A highly active 110 cm DW species. Spine characteristics: average lengths, males 70 mm, females 84 mm; total serrations averages, males 83; females 82; pb/STL averages, males 80%, females 68%. One to 22 serrations or a 1–14 mm space on base sides; dorsal groove 87% of spine length. Body may be spotted or reticulate and tail may be banded or plain.

FEATHERTAIL STINGRAYS

Pastinachus sephen (Forsskael, 1775) – cowtail stingray. Found off northeast Africa, Red Sea to Chagos Archipelago (Fowler 1941; Smith 1955, 1967; Smith & Smith 1963; Wallace 1967; Kuronuma & Abe 1986; Compagno & Heemstra 1984; Compagno & Randall 1987; Winterbottom *et al.* 1989; Randall & Anderson 1993; Goren & Dor 1994; Compagno & Cook 1994; Randall 1995; Bonfil & Abdullah 2004). A 180 cm DW stingray. Spine characteristics: average lengths, males 157 mm, females 159 mm; total serrations averages, males 124, females 130; pb/STL averages, males 75%, females 76%. Five to 21 small serrations on base sides, no dorsal groove evident.

PELAGIC STINGRAYS

Pteroplatytrygon violacea (Bonaparte 1832) – pelagic stingray. Often confused with *D. purpureus* (Winterbottom *et al.* 1989). Found in the Mediterranean and along the western and southern African coasts (Soljan 1948; Tortonese 1976; Capapé 1977; Compagno & Roberts 1984; Compagno & Heemstra 1984; Compagno *et al.* 1991; Basusta *et al.* 1998; Mollet 2002, Golani & Capapé 2004). A broad (80 cm DW), open ocean stingray, dark dorsally and ventrally, anteriorly arched in profile. Spine characteristics: average lengths, males 147 mm, females 128 mm; total serrations averages, males 191, females 161; pb/STL averages, males 66%, females 78%. Three to 23 serrations or a 7–9 mm space on base sides; dorsal groove 25% of spine length. The even-sided spine is characterized by cul-de-sacs medially between serrations, similar to *Dasyatis brevicaudatus* (Fig. 3).

RIBBONTAIL STINGRAYS

Taeniura grabata (Geoffroy St. Hilaire 1817) – round fantail stingray. Known from the Mediterranean Sea, eastern Atlantic and eastern Africa (Fowler 1936, 1941; Maigret & Ly 1986; Biscioto & Wirtz 1994; Compagno & Randall 1987; Dingerkus 1995; Basusta *et al.* 1998; Serena *et al.* 1999; Golani & Capapé 2004), erroneously from the Red Sea (Fowler 1936; Compagno & Randall 1987). A ~100 cm DW stingray. Spine characteristics: average lengths, males 50 mm, females 56 mm, tip

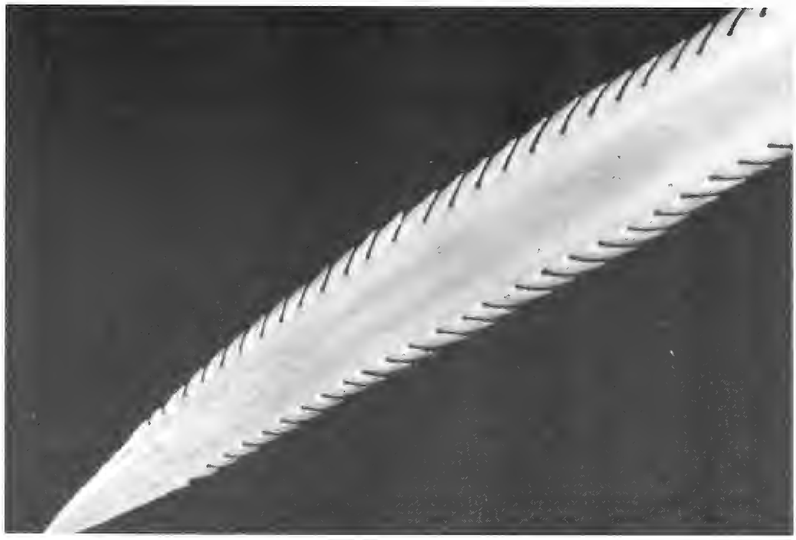

Fig. 3. A typical stingray spine (*Pteroplatytrygon violacea*).

upturned; total serrations averages, males 52; females 39; pb/STL averages, males 64%, females 85%. One to 25 mm space on base sides, extending onto spine proper; dorsal groove 90% of spine length. New spines often develop ahead of primary attachment end; spine end V-shaped.

Taeniura lymma (Forsskål 1775) - blue-spotted stingray. Western Indian Ocean (Fowler 1941; Smith 1955; Smith & Smith 1963; Wallace 1967; Compagno & Heemstra 1984; Goren & Dor 1994; Compagno & Randall 1987; Randall & Anderson 1993; Khalaf & Desi 1997; Basusta *et al.* 1998; Heemstra & Heemstra 2004; Bonfil & Abdullah 2004). An oval-shaped 30 cm DW stingray. Spine characteristics: average lengths 45 mm STL in both sexes; total serrations, males 63, females 59; pb/STL averages, males 80%, females 68%. One to four serrations or a 1-20 mm space on base sides; dorsal groove 40-88% of spine length.

Taeniura meyeni (Müller & Henle 1841) - fantail stingray. Frequents eastern Africa, Madagascar northward to Red Sea, Arabian Sea and Persian Gulf (Fowler 1941; Randall & Anderson 1983; Compagno & Roberts 1984; Bonfil & Abdullah 2004; Randall 2005). A dangerous 180 cm DW species. Spine characteristics: average lengths, males 151 mm, females 63 mm; totals serrations averages, males 84, females 71; pb/STL averages, males 72%, females 74%. One to 10 serrations on base sides; dorsal groove 80% of spine length.

PORCUPINE RAYS

Urogymnus ukpam (Smith, 1863) - thorny freshwater ray. Often placed in *Dasyatis* because of tail size or lack of tail spine in some specimens (Compagno & Roberts 1984; Compagno & Cook 1994). Known from freshwaters of west Africa from Cameroon to Congo (Compagno & Roberts 1984; Compagno & Randall 1987). A large 65 cm DW species. Spine characteristics: average lengths, males 56 mm, females 46 mm; total serrations averages 46 in both sexes; pb/STL averages 55% in both sexes. A 10 mm space on base sides; dorsal groove 33% of spine length.

GYMNURIDAE – BUTTERFLY RAYS

Gymnura altavela (Linneaus 1758) - spiny butterfly stingray. Found in northeast Atlantic from Norway to Madeira, Mediterranean and Black Seas (Fowler 1936; Soljan 1948; Bigelow & Schroeder 1953; Hureau & Monod 1973, Maigret & Ly 1986; Dulcic *et al.* 2003). A >64 cm DW benthic stingray. Spine characteristics: average lengths, males 23 mm, females 33 mm; total serrations averages, males 53, females 62; pb/STL averages, males 69%, females 67%. Two to 23 serrations on base sides; dorsal groove 40-85% spine length.

Gymnura natalensis (Gilchrist & Thompson 1911) - diamond ray. Known from south and eastern South Africa (Wallace 1967; Heemstra & Heemstra 2004). A 182 cm DW stingray. Spine characteristics: average lengths, males 67 mm, females 53 mm; total serrations averages, males 20, females 69; pb/STL averages 36% in both sexes. A 9-13 mm space on base sides; dorsal groove 33% of spine length.

MYLIOBATIDAE – BONNETRAYS

Aetobatus flagellum (Bloch & Schneider, 1801) - long-headed stingray. Frequents Red Sea (Vossoughi & Vosoughi 1999; Randall & Lim 2000: Bonfil & Adullah 2004). A 62 cm DW stingray. Spine characteristics: average lengths, males 35 mm, females 40 mm; total serrations averages 57 in both sexes; pb/STL average 66% in both sexes. One to four serrations on base sides; dorsal groove 60% spine length.

Aetobatis narinari (Euphreson 1790) - spotted eagle ray. Widely distributed along west and east African coasts, in Red Sea and Arabia Gulf (Fowler 1925, 1936, 1941; Smith 1955; Smith & Smith 1963; Wallace 1967; Klimaj 1978; Kuronuma & Abe 1986; Compagno & Randall 1987; Goren & Dor 1994; Stehmann 1995; Randall 1995; Kahlaf & Desi 1997; Bonfil & Abdullah 2004; Randall 2005). A 330 cm DW active, open water species. Spine characteristics: average lengths, males 60 mm, females 78 mm; total serrations averages, males 102, females 114; pb/STL averages, males 76%, females 75%. Ten serrations on base sides; no dorsal groove evident. Usually spotted dorsally, yet Last and Stevens (1984:448) depict an individual spotted on the rear two-thirds of the dorsum. The same is true for three specimens at Vienna, while one specimen at Hobart (CSIRO) is spotless. May possess up to eight tail spines (Gudger 1914).

EAGLE RAY

Myliobatis aquila (Linnaeus 1758) - cowtail stingray. Often described as *Himantura cervis*. Found in the Mediterranean, south and east African coasts and Arabian Sea (Fowler 1936, 1941; Soljan 1948; Wallace 1967; Klimaj 1978; Compagno *et al.* 1991; Lens & Marin 1993; Heemstra & Heemstra 2004). A 83 cm DW species. Spine characteristics: average lengths, males 60 mm, females 45 mm; total serrations averages, males 72, females 56; pb/STL averages, males 70%, females 65%. Two to 23 mm spaces on base sides and onto spine proper; dorsal groove 70% spine length.

BULL RAY

Pteromylaeus bovinus (Geoffroy St. Hilaire, 1817) - bullray. Frequents Mediterranean, western Africa to Namibia and South Africa to Mozambique (Fowler 1936, 1941; Wallace 1967; Maigret & Ly 1986; Garman 1913; Heemstra & Heemstra 2004). A 1.1 m DW stingray. Characteristics are: spine lengths are males 32 mm STL, females 61 mm STL. Serrations total: males 30, females 69. pb/STL's average: males 56%, females 67%. One to seven serrations or a 3-7 mm space on base sides. Dorsal groove 30% of spine length.

COWNOSE RAYS

Rhinoptera javanica (Müller & Henle 1841) - Javanese cownose ray. Synonyms include *R. peli* Bleeker 1863, *R. jayakari* (Boulenger 1895) and *R. sewelli* Misra 1947 (type specimens of last two species are now at the NC State Museum, Raleigh, NC; Schwartz 1990). A midwater to benthic inhabitant from equatorial Africa, southeast Africa, Gulf of Oman and Arabia (Fowler 1934; Smith & Smith 1963; Wallace 1967; Kuronuma & Abe 1986; Schwartz 1990; Vossoughi & Vosoughi 1999). A 195 cm DW species. Spine characteristics: average lengths, males 56 mm, females 109 mm; total serrations averages, males 36, females 72; pb/STL averages, males 69%, females 64%. Two to 10 serrations on spine sides, dorsal groove 40% of spine length.

Rhinoptera marginata (Geoffroy Saint-Hilaire 1817) - Lusitanian cownose ray. Synonyms *R. peli* Cadenat 1960; Quero *et al.* 1990 and *R. bonasus* Séret 1990. Found in the Mediterranean and estuaries of northwest African coast (McEachran & Capapé 1984–1986; Ruitart 1998; Schwartz 1990). A 2 m DW pelagic-benthic species. Spine characteristics: average lengths (females) 25 mm; total serrations average, for females 49; pb/STL average 64%. Spine flat with 3–17 serrations on base sides; dorsal groove 20–50% spine length.

DISCUSSION

Tail spine characteristics are described based for 34 preserved species, one subspecies, and 718 specimens (313 males, 405 females) that possessed tail spines. Spine serration differences existed in relation between a species and the habitat it frequented: species with a total spine serration count of >100 were ocean or pelagic inhabitants (e.g. *Dasyatis centroura* and *Pteroplatytrygon violacea*); species with 70–100 total spine serration were midwater swimmers (e.g. *Dasyatis pastinaca, Himantura uarnak* and *Myliobatis aquila*); those with 50–70 serrations totals were benthic inhabitants (e.g. *Dasyatis chrysonota, Gymnura altavela, Taeniura grabata, Pteromylaeus bovinus*), and those with counts of <50 were usually freshwater inhabitants (e.g. *Urogymnus ukpam*) (Table 1). The spines of *Dasyatis brevicaudata* and *Pteroplatytrygon violacea* are distinct, possessing cul-de-sacs medially between serrations (Fig. 3).

No primitive to advanced species-spine serration relationship (as in *Dasyatis, Himantura, Gymnura, Myliobatis, Rhinoptera* and *Mobula* (Compagno 2005) was evident. Likewise, *Plesiobatis daviesi,* considered a primitive species (Compagno 2005), has tail spines with 120 serrations while the spine serrations of 11 species of dasyatids range from 58 to 209, for *D. marginata* and *D. bennetti* respectively, and spine serrations of 7 species of Himanturids varied from 54 to183, for *H. imbricata* and *H. fai*, respectively. Counts for the other species are summarised in Table 1.

Comparing tail spine serrations characteristics of 11 stingray species reported by Schwartz (2005) with this study, three species' spine serrations totals were the same (*D. centroura, G. altavela* and *U. upkam*). Of the three, *U. upkam* enters freshwaters of West Africa. Total tail spine serrations for *H. bovinus* were lower off Africa than in the Mediterranean Sea (36, this study 44), while serration totals of the remaining seven spines were greater off Africa-Arabia than in the Mediterranean Sea (Schwartz 2005, Table 1).

Twelve other species, also found in African-Arabian waters, do not possess tail spines: *Aetomylaeus nichofii, A. milvus, A. maculatus, A. vespertilio, Gymnura micrura, Mobula rochebrunei, Mobula topacana, Mobula thurstoni, Mobula kuhlii, Urogymnus asperrimus, Mobula ergoodootenkee* and *Manta birostris.* They represented members of advanced stingray families that exhibited a gamut of swimming and habitat usages, suggesting that advanced stingrays are tending to lose tail spines with evolution.

Spines of specimens of *Hexatrygon bickelli* and *Dasyatis garouaensis* (the latter an inhabitant of the Niger and Cameroon Rivers, West Africa) were broken and thus not counted. *Mobula mobular, Gymnura poecilura* and *Aetoplatea tentaculata* which possess tail spines, were not seen. However, examination of the spines of other *Hexatrygon* "species" specimens in Taiwan, Japan and Tasmania (designated species "I" or "H" at the time), revealed that there seem to be two species involved. Specimens labelled "H" have high serration counts (84 or more) and smaller spaced on the base sides, while "I" specimens have lower counts (64-75) and large spaces on base the sides.

CONCLUSIONS

Much taxonomic confusion in general still persists regarding the stingrays inhabiting African-Arabian waters. For example, *Himantura uarnak* is a confusing species complex that Deynat and Fermon (2001) resurrected as *H. oxyrhyncha*, a species found in Thailand, Sumatra and Borneo, from its synonymy and *H. krempfi*, a freshwater species from Thailand, Cambodia, Indonesia and Mekong, as a junior synonym. Compagno (2005) listed *H. oxyrhynchus* as a full species. An *H. oxyrhyncha* specimen in Paris lacked a spine and three of five *H. krempfi* specimens possessed tail spines, their characteristics were: spine length 32, 58 and 60 mm STL; serrations numbered 33, 44 and 52 respectively; 4 serrations or a 20 mm space occurred on base sides, and no dorsal groove was evident.

While stingrays are large, bulky and feared because of their venomous tail spines that may cause injury or death, stingray spine characteristics are distinct within a species and should not be overlooked when describing a species. Their inclusion in a species diagnosis adds another parameter that helps physicians, paleontologists and geologists with species identity and fossil relationships.

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Table 1. Characteristics of 313 male (M) and 405 female (F) tail spines of 50 species of stingrays frequenting African-Arabian to Chagos-Maldive Archipelago waters.

Species & Distribution	No. & sex	Disc width (mm)	L Number of serrations	R	Total	STL (mm)	pb/STL %	B / S	D. groove % STL
			Mean (Range)	Mean (Range)	Mean	Mean (Range)	Mean (Range)		
Plesiobatidae									
Plesiobatis daviesi SA	3M 2F	711–802 340–341	71 43 (41–44)	65 61 (42–96)	136 104	114 (63–171) 81 (63–93)	68 (64–72) 68 (69–78)	6–15 B or 2–18 S	
Dasyatidae									
Dasyatis bennetti A, I	5M 1F	146–288 171	52 (42–84) 43	42 (40–85) 52	94 100	77 (60–88) 86	91 (80–95)	8 B	60–80
Dasyatic brevicaudata SA	1M 14F	240 139–384	115 76 (28–135)	146 80 (29–180)	261 156	100 149 (34–338)	89 71 (58–85)	5–10 B	30–80
Dasyatis centrura M	27M	123–203	78 (17–129)	82 (20–116)	160	143 (30–182)	78 (58–98)	20–116 B or 72–114 S	60–80
Dasyatis chrysonota SW – SA	5M 6F	82–290 191–240	30 (24–37) 39 (34–40)	31 (22–43) 43 (31–56)	61 82	36 (34–35) 52 (38–57)	73 (66–82) 71 (63–77)	12–17 S	33
Dasyatis c. marmorata M, NW	5M 6F	279 315–330	32 (31–40) 24 (23–26)	33 (23–43) 31 (27–33)	65 55	48 (34–58) 48 (38–51)	33 (30–40) 45 (38–51)	12–28 B or 16 S	100
Dasyatis kuhlii SA, RS	47M 43F	190–280 160–310	32 (12–40) 32 (15–67)	40 (17–67) 29 (18–67)	72 61	50 (32–82) 50 (21–37)	67 (32–90) 58 (51–91)	2–13 B or 1–25 S	10–50
Dasyatis margarita NE, NW	5M 4F	135–267 150–222	26 (14–49) 33 (25–48)	26 (19–48) 31 (25–47)	52 64	43 (15–50) 45 (30–66)	71 (48–92) 69 (68–70)	10–66 S	
Dasyatis margaritella NW, A	2M 1F	193–592 186	30 (15–43) 38	32 (18–40) 40	62 78	57 (53–63) 61	72 (70–74) 74	3–10 B or 1–24 S	
Dasyatis pastinaca M, SA, SE, RS	13M 12F	169–443 190–598	59 (30–70) 47 (24–71)	53 (32–67) 39 (16–101)	112 86	77 (47–119) 72 (36–109)	74 (70–76) 71 (63–80)	8–25 S	85
Dasyatis rudis NW	1F	~2000	54	54	108	138	55	33–35 B	50
Dasyatis thetidis SE	2M 2F	350–484 347–801	43 (38–47) 43 (40–44)	43 45	86 88	66 (55–77) 70 (42–91)	64 (61–95) 65 (61–76)	1–30 B	
Himantura bleekeri A	1M 4F	185 165–178	32 25 (22–28)	31 24 (20–30)	63 49	57 48 (42–73)	63 69 (67–69)	5–18 S	
Himantura draco EA, MA, MO	1M 1F	386 380	27 27	28 25	55 52	53 28	34 34	1–20 B or 1–12 S	40–75
Himantura fai MA, RS, I	1F	950	88	95	183	184	70		95
Himantura gerrardi SA, RS, I	12M 38F	230–470 147–515	28 (24–45) 41 (18–74)	23 (17–41) 40 (16–79)	51 85	43 (40–50) 63 (11–107)	71 (56–87) 75 (47–85)	1–11 B	40–57
Himantura granulata S	5M 7F	280–356 234–431	47 (40–53) 39 (23–52)	50 (42–72) 40 (22–52)	97 79	71 63	71 68	1–4 B 1–4 S	60
Himantura imbricata RS, A. I	40M 26F	127–330 80–181	28 (20–38) 27 (22–40)	28 (21–42) 25 (15–38)	56 52	43 (16–64) 28 (27–64)	72 (49–79) 65 (22–93)	1–13 B 1–28 S	63–72
Himantura jenkinsii SE, SA, A	11M 21F	166–660 435–651	40 (27–44) 38 (33–61)	33 (27–39) 34 (26–61)	73 72	68 (50–90) 68 (40–105)	72 (71–82) 73 (65–98)	1 B or 1–23 S	40–75
Himantura uarnak M, SA, RS, A, EA	21M 28F	216–419 241–720	42 (23–100) 43 (17–119)	41 (28–97) 39 (16–119)	83 82	70 (40–120) 84 (33–116)	80 (76–94) 68 (54–71)	1–22 B or 1–14 S	87
Pastinaca sephen NE, M, SA, EA, RS, A, I	4M 28F	180–404 189–507	62 (51–147) 68 (50–238)	62 (37–68) 62 (37–69)	124 130	157 (49–180) 159 (62–300)	75 (66–93) 75 (66–86)	5–21 B	
Pteroplatytrygon violacea M, SW	15M	460–540	94 (53–139)	97 (53–120)	191	147 (111–173)	66 (64–85)	4–23 B	25
Taeniura grabata M, NE	1M 2F	320 276–345	32 18 (14–22)	20 21 (18–23)	52 39	50 55 (41–84)	64 62	1–25 S	
Taeniura lymna SA, SE, RS, A, MA	14M 14F	124–406 110–308	31 (20–42) 33 (33–44)	32 (18–62) 26 (6–44)	63 59	45 (30–66) 45 (24–78)	80 (76–99) 68 (54–71)	1–4 B or 1–20 S	40–88

Table 1 cont.

Species & Distribution	No. & sex	Disc width (mm)	L Number of serrations	R	Total	STL (mm)	pb/STL %	B / S	D. groove % STL
			Mean (Range)	Mean (Range)	Mean	Mean (Range)	Mean (Range)		
Taeniura meyeni EA, RS, A	6M 7F	330–365 271–302	44 (21–98) 36 (14–49)	40 (28–80) 35 (17–55)	84 71	151 (45–230) 63 (48–87)	72 (61–88) 74 (70–82)	1–14 B	60
Urogymnus ukpam SW	2M 3F	266–360 361–650	30 (25–38) 29 (25–38)	21 (19–30) 22 (11–43)	51 51	56 (40–60) 46 (40–61)	55 55	10 S	
GYMNURIDAE									
Gymnura altivela M	34M 44F	83–782 100–179	25 (10–110) 30 (10–49)	28 (14–42) 32 (10–49)	53 62	23 (21–33) 33 (26–53)	69 (60–88) 67 (43–85)	2–13 B	40–85
Gymnura natalensis SW, SE	1M 4F	460 1200–1478	10 33 (20–43)	10 36 (20–86)	20 69	64 53 (30–85)	36 36 (30–82)	9–13 S	33
MYLIOBATIDAE									
Aetiobatis flagellum EA, RS	1M 2F	230 236	28 28 (18–37)	29 29	57 57	35 40 (28–42)	66 66	1–4 B	60
Aetiobatis narinari SW, EA, RS, A, I	5M 22F	461–632 230–482	52 (28–78) 62 (11–87)	50 (28–71) 52 (24–87)	102 114	60 (38–95) 78 (31–91)	76 (58–92) 75 (35–96)	10 B	50
Myliobatis aquila M, SA, SE, A, NW	20M 17F	382–498 218–406	38 (25–60) 28 (10–51)	34 (23–65) 28 (10–51)	72 56	60 (45–83) 45 (15–80)	70 (58–90) 65 (47–81)	2–23 S	70
Pteromylaeus bovinus M, SW, SA, Ma	1M 4F	175 452–536	12 38 (37–63)	18 31 (23–55)	30 69	32 61 (31–88)	56 67 (48–71)	1–7 B or 3–7 S	30
RHINOPTERIDAE									
Rhinoptera javanica NE, SW, A	3M 3F	870–1022 676–932	24 (10–38) 38 (30–42)	12 (10–14) 34 (30–38)	36 72	56 (25–60) 109 (105–120)	69 (68–70) 64 (62–65)	2–10 B	40
Rhinoptera marginata M, NW	4F	378–468	19 (15–21)	30 (19–43)	49	25	64 (53–76)	3–17 B	20–50

Abbreviations: B – no of serrations on spine base; S – space on base (mm). Geographic designations: M – Mediterranean Sea; NW – northwest Africa; NEC – northwest-central Africa; SW – western and southwestern Africa; SA – South Africa; EA – eastern and southeastern coasts of Africa; S – Seychelles; RS – Red Sea; A – Arabian Sea; Ma – Maldives; I – waters between east Africa and the Chagos-Maldive Archipelago.

MATERIAL EXAMINED

Institutional abbreviations follow Leviton *et al.* 1985.

Plesiobatis daviesi: AMS 4127, CAS 3350.1, 1104127.1, CSIRO 4107.1, ORI B865

Dasyatis bennetti: MCZ 40418, USNM 13785, 193662, 19781, 21618.

Dasyatis brevicaudata: ANSP 167402, 16704, 167405, 167409, CAS 26470, 27449, MCZ 23860, SI 0457, 804861.001, 35710.00, I 35900.02, IB 7911, BRI 805, CSIRO 1B07911

Dasyatis centroura: MCZ 562, 203759, NMW 50202, 77995a, 88086, 32 uncatalogued.

Dasyatis chrysonata: CAS C314, 117, 1334, 41536, 1 uncatalogued, HUJ 13768.12450, RUS 131823.

Dasyatis marmorata: NMW 82939, 89680.

Dasyatis kuhli: AMS 1B122, ANSP 121539, 127372, 131644, 15851, 171543, 171544, 171545, 171546, 171641, 25843, CAS 104, 270, 278, 280, 310, 21664, 29993, 3237, 60773(3), 61832, 68134, 68137, 68144, 60-252, 60-373, CSIRO 197671, I 11131, 21038.09, H4122.3, H4961, 4926(2), MCZ127372, 22154, 22546, MTUF 2070, NMW 50218, 86966, 90201, 94588, SI 1131, 118180, 19767, 21844, 504, S1982.00, I 1653, 10123, 14878, I1652, 3482.001, 21833.013, USNM 206144, 222533, 222545, 222546.

Dasyatis margarita: MNHN 2605(2), 3826, 7954(4), NMW 6241, 50241.

Dasyatis margaritella: MCZ 459, 222589, 222592, NMW 3837, 22407, 50200, 50203, 61326, 68326, 78007, 87250, 87273, USNM 004595, 193622, 222589, 222592.

Dasyatis pastinaca: ANSP 29998, 350984, CAS 9865, 110560, 12110, 12830, 12845, 19880, NMW 77972, 78931, 79498, 83082, 86608.

Dasyatis rudis: USNM 202730.

Dasyatis thetidis: CAS 40960, 67575, SI 3047.001, B 6518, H3228.2.

Himantura bleekeri: USNM 222606, 222610, 222624(6).

Himantura draco: RUIS 1996(2), ZMMU -P 19174.

Himantura fai: USNM 051712.

Himantura gerrardi: ANSP 172801,BPBM 33201, 33202, 33199, CAS 141, 590, 680, 808, 2437, 2460, 2568, 7888, 20960, 41048, 52984, 63045, 63085, 63086, 63097, 68132, 68138, 68142, 68144, 68145, 68152, 68195, 75869, 12772, 60-28, 60-129, 60-205, 60-326, 60-400, LACM 38130.47, 38113.48, NMW2003.0025, 61774.

Himantura granulata: CAS 3097, 41048, 63006, 68144, 68145, 68149, 68152, 75869, LACM 8311, 38130.47, NMW 2003.0025, 60774.

Himantura imbricata: ANSP 03108, BPBM 33199, CAS 224(3), 1347, 2223, 2224, 4658, 27435, 48660, 34295, 41675, 41677, 41678, 41680, 41681, 41682, 41683, 41684, CSIRO 20762.001, I 2867, IB 457, MCZ 223, 224(3), C 123(22), SAM 41635, USNM 222529, 222552, 222561, 222564.

Himantura jenkensii: CAS 2645, 7855(2), 68131, 68133, 68135, 68136, 68142, 68148.

Himantura uarnak: ANSP 25842, 25843, CAS 1060, 2433, 2525, 8807, 63093, 63095, 68111, 68144, 68150, 68151, MCZ 201806, MTUF 25070, NMW 1897, 8972, 22453, 22459, 37325, 60176, 60773, 60776, 65715, 66799, 78972, 81604, 86650, 86659, 87125, 87352, 87329a, 87052a, 87852, USNM 119225, 148100, 201806, 206132, 207045, 220153, 232879, 33700.

Pastinaca sephen: ANSP 103715(3), CAS 6155, 65240, 68155, CSIRO 2213.11, H4116.04, 4213.02, 114172.4, MTUF 25108, 26701, 26711, 26712, 26899, 26902, NMW 0711, 2017, 2021, 60759, SI 1908, USNM 147420, 205138, TUFIL 26701, 26711.

Ptryoplatytrygon violacea: MTUF 3425, 106471, 11056, 67675, 74436, MZUP 49011, NMW 42672, 88604, 191234, S10, 29-308, 33-35, 58-35, 54-38, 54-93, 63-120, 73-418, 79-51, 76-21, 79-59, 79-275, 79-283(3), 79-219, 79-295, 79-320, 79-309, NMW H2672, 88604, 191234, USNM 222566, 222646.

Taeniura grabata: BPBM 9204, 9205, 9206, HVJ8359, 12418.

Taeniura lymna: CAS 60-160, HV224, MCZ 1251, 40480, NMW 2645, 8791, 50223, 78008, 78020, 78189, 87178, 87189, 87188, 3 uncatalogued, S10, 4568, SI 14564, I 5067.03, 13832, 107687, 197785, USNM 40436, 49326, 222621, 226314, 262618.

Taeniura meyeni: CAS 63103, CSIRO I 17314.001, NMW 77976, 89471, SI 17364.000.

Urogymnus upkam: CAS 42761, USNM 219780.

Gymnura altavela: NMW 2008, 2009, 50231, MZUP 9721, 9914, 9918, 10380, USNM 20261, 20762, 70 uncatalogued.

Gymnura natalensis: CAS 14025, 1 uncatalogued, LJVC 682023, 824023, SAM 25019, 33293, SAS 25017.

Aetobatis flagellum: USNM 206131, 22684, 256190.

Aeotbatis narinari: ANSP 71284, 81715, 10224, 179204, CAS 11675, 62395, 63105, 63111, 68154, 71650, 113807, LJVC 87114, MTUF 4343, 110569, 167675, B9166, 26700616, NMW 6073, 10755, 66725, 87161, 87246, 82829, 88207, 88556, 89551, USNM 63175, 205141, 222689.

Myliobatis aquila: MCZ 150-S, 828, 89927, NMW 3857, 6653, 8531, 50236, 50237, 60780, 81159, 87165, 87195, 87366, 87844, 886605, RUSI 04804, 10423, 19823, 444352, SAM 12842, 26452, 26528, 33294, 32575, 333453, 34392, USM 030, 202823, 203457, 22577.

Pteromylaeus bovinus: NMW 89825, USNM 202709, 202763, 222709, 232329.

Rhinoptera javanica: China 34916, MCZ 316, NCSM 2 uncatalogued types, ORI 0347, B646, SCB 98006.

Rhinoptera marginata: MNHN 2605(2), 3824, 7954(4), NMW 50241, 56241, 59055.

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