Late Cretaceous (Maastrichtian) fish otoliths from the Deccan Intertrappean Beds, India: a revision

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Abstract

The study of the Maastrichtian Deccan Intertrappean otolith association allows for the reconstruction of a fish fauna of 22 taxa, of which 16 are identified at species level. Three species are new: "genus Heterotidinarum" *heterotoides*, "genus Percoideorum" *citreum* and *Dapalis erici*. The represented taxa include typical freshwater ones, essentially freshwater ones with some marine intruders, near shore marine groups including a significant portion of freshwater intruders and predominantly marine fishes, including however some scarce freshwater residents. The most probable interpretation of such an association is that the Deccan Intertrappean Beds correspond to freshwater environments of a coastal area, where intrusion by marine elements or temporary connections with the marine realm existed. The Indian Maastrichtian and Ypresian faunas are compared with the European fossil record. The fossil record of osteoglossids, ambassids, and channids points to ancient Eurasiatic affinities of European freshwater and brackish Paleogene and Early Miocene fish faunas.

Keywords: Osteichthyans, otoliths, India, Deccan Intertrappean Beds, Late Cretaceous, Maastrichtian.

Résumé

L'étude des otolithes des dépôts sédimentaires intercallés dans les coulés du volcanisme Deccan a permis d'identifier une faune de 22 taxa d'Ostéichthyens dont 16 ont pu être identifiés au niveau de l'espèce. Trois de ces derniers, «genus Heterotidinarum» *heterotoides*, «genus Percoideorum» *citreum* et *Dapalis erici* constituent des espèces nouvelles. Parmi les taxa représentés, on trouve des poissons typiques des eaux douces, des poissons vivant essentiellement en eau douce mais se divaguant parfois dans les eaux marines, des taxa typiques des eaux côtières mais incluant aussi pas mal d'espèces résidant de façon permanente en eau douce et finalement, des taxa typiquement marins mais incluant de rares espèces résidant dans le milieu dulçaquicole. L'interprétation la plus plausible d'une telle association est qu'elle correspond à un environnement d'eau douce dans une plaine côtière, où des intrusions d'éléments marins étaient possibles, soit des connections avec le milieu marin ont temporairement existé. La comparaison des faunes recensées du Maastrichtien et de l'Yprésien d'Inde avec des faunes européennes suggère l'existence d'un ancien domaine faunique d'eau douce eurasiatique. Ceci est surtout mis en évidence par l'ancienne répartition des ostéoglossidés, d'*Anthracoperca*, des ambassidés et des channidés dans le Paléogène et le Miocène inférieur européen.

Mots-clefs: Ostéichthyens, otolithes, Inde, Deccan Intertrappean, Crétacé terminal, Maastrichtien.

Introduction

Beginning in 1988, RANA (1988 and 1996) and RANA & SAHNI (1989) published three papers describing new otolith-based fish species from the Late Cretaceous Deccan Intertrappean freshwater deposits. A fourth paper (RANA, 1990) provided a general overview of the vertebrate fauna and paleoecology of these deposits, with some minor nomenclatorial changes but no additional new otolith-based taxa. The osteoglossiforms described in the 1988 paper were previously identified by Nolf, during a visit of Rana to the Brussels IRSNB in 1987, but unfortunately all the other published material could not be investigated with the same infrastructure of comparative Recent material and optimal optic equipment with a camera lucida. Also, the museological storage of the fossils suffered from some imperfection, resulting in the damage or loss of a few specimens.

Additional fish otoliths collected by one of us (G.V.R. Prasad) from the intertrappean beds of Naskal proved to be very helpful in ascertaining the previously described

non-osteoglossiform taxa. In a second stage, R. S. Rana brought over all published material and all additionally collected material from the Deccan Intertrappean beds to Brussels. This allowed us to interpret these fossils with the help of the very extensive IRSNB comparative collection of Recent otoliths, and to make new camera lucida drawings of the specimens with a Wild M5 binocular microscope. The material studied here was collected from four intertrappean sites: Chemalgutta, (18°22'37''N 78°15'15''E), Nagpur, (21°0'9''N 79°4'19''E), Naskal (17°14'30''N 77°53'15''E) and Rangapur (17°11' 20''N 77°56'E).

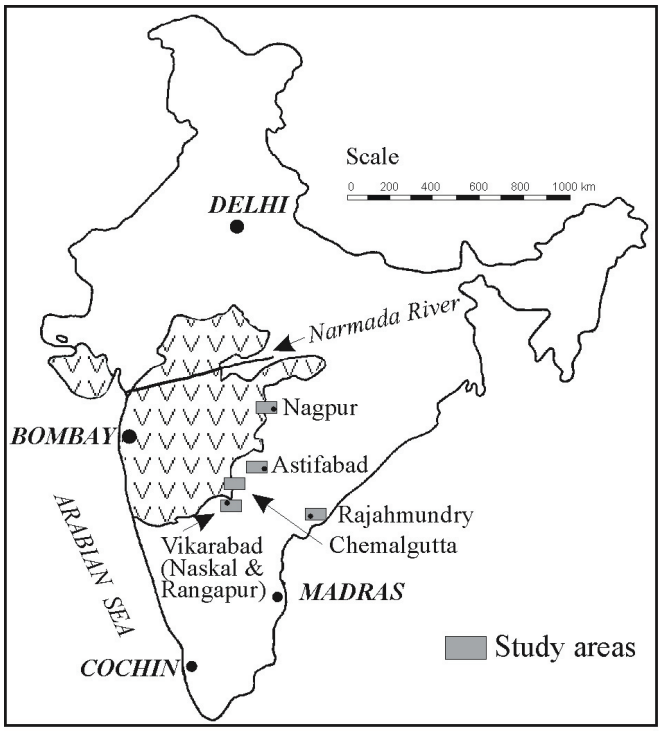

Fig. 1 — Extension of the Deccan basalts, and location of the cited sections.

Geological and paleontological context

The continental flood basalts, popularly known as "Deccan Traps", cover over one third of the total surface of peninsular India (Fig.1). The thickness of the lava pile grows from the northern and eastern boundary of its extension to a value possibly in excess of 2000 m, inland of the Bombay coast, along the western Ghats (KHAJURIA *et al*., 1994, COURTILLOT *et al*., 1986). At several places (see RANA, 1988, RANA, 1990, PRASAD & CAPPETTA, 1993 and our Fig. 1), these volcanic rocks are interbedded with fossiliferous sedimentary deposits designated as "infratrappean" (underlying the basal flow) and "intertrappean" (enclosed between two flows). These sedimentary beds are thin lens-shaped patches, which a thickness that varies between 1 and 5 m. Their lateral extension is also very restricted, in the order of 1 to 4 km, but at some places less than 1 km. Lithological sections of the most important sites are shown in Fig. 2. The Nagpur intertrappean beds have also been called Takli Formation (SAHNI *et al*., 1987), but this formation name cannot be used, as the intertrappean beds are not mappable and this name cannot be extended to other intertrappean sites.

Intertrappean sediments mainly consist of marls, sandstones, siltstones, mudstones, cherts, carbonaceous shales, and limestones. They provided a large number of microvertebrate, invertebrate, and plant remains. The microvertebrate fauna comprises fish, anurans, lacertilians, snakes, turtles, crocodiles, dinosaurs, and mammals. The invertebrate fauna is composed of gastropods, bivalves and ostracodes. Charophytes, pollen, and spores substantiate the floral component. A significant variation is, however, noticed in the biotic component of the investigated localities. The intertrappean beds of Naskal (southeastern margin of the Deccan Traps) yield predominantly freshwater and terrestrial elements whereas the infra- and intertrappean sequence of the eastern margin (e.g. Nagpur, Asifabad) contain a mixed assemblage of freshwater and marine elements, of which the selachian teeth were studied by PRASAD & CAPPETTA (1993).

Deccan volcanism is now considered to be initiated in the late Maastrichtian and continued up to early Paleocene, extending over a period of 4 m.y. It has been demonstrated that dinosaurs do occur in the intertrappean beds, and a Late Maastrichtian initiation of Deccan volcanism is inferred from different groups of vertebrates, invertebrates, and palynofossils from the infratrappean beds. A Late Maastrichtian age is also suggested for the intertrappean beds of Naskal, Asifabad, Nagpur, Padwar, Ranipur, and Kutch, not only based on the fishes, dinosaurs, ostracods, and palynofossils, but also because of the striking similarity between the fauna and flora of infra- and intertrappean beds. A few intertrappean beds, however, particularly subsurface sections of the southeast and west coasts and outcrops of Latipur, yield fossils that favour a slightly younger age (Early Paleocene) (KHAJURIA *et al*., 1994), but this does not concern the fossils of the localities studied here.

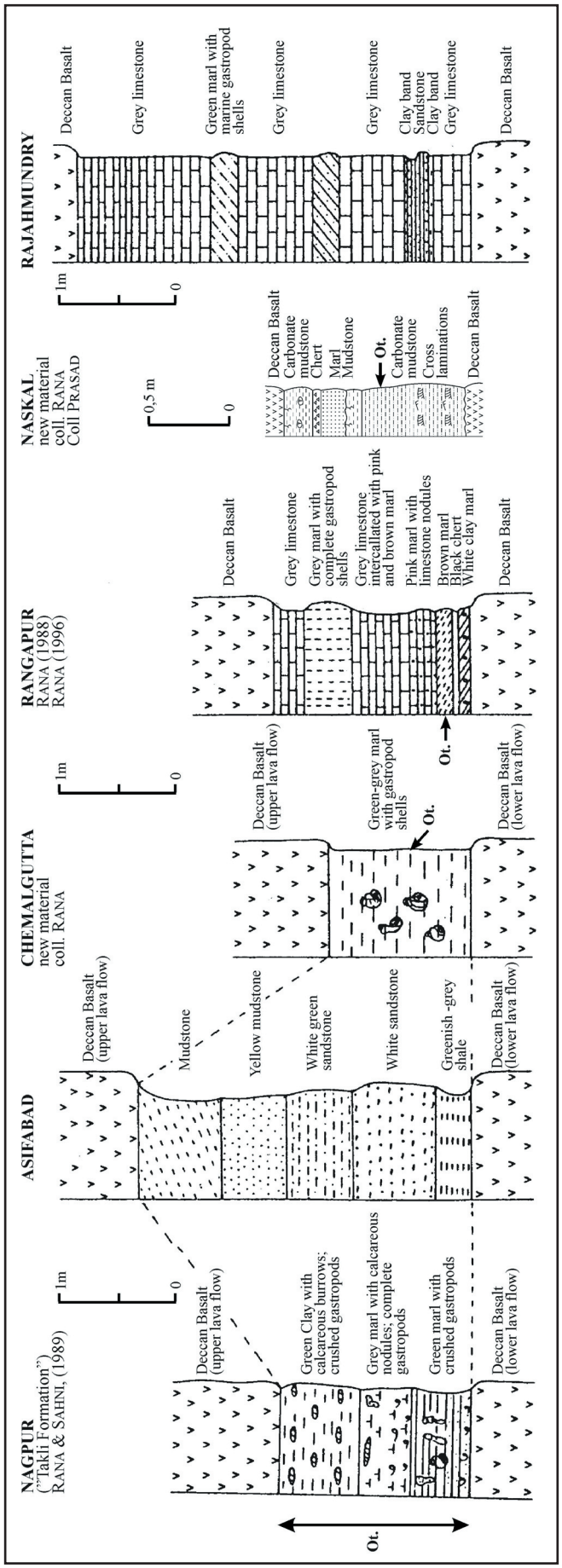

Fig. 2 — Stratigraphic columns of the Intertrappean beds of peninsular India (Nagpur, Asifabad, Chemalgutta, Rangapur, Naskal and Rajahmundry), after RANA, 1990, modified.

Systematic paleontology

The classification adopted is the one proposed by NELSON (2006). For general information about otoliths (morphological nomenclature, composition, diagnostic value, ontogenetic changes, etc.), the reader is referred to NOLF (1985). Concerning collective (or open) generic nomenclature, the current procedure used is that applied in numerous papers on otolith taxonomy. For species of uncertain generic position (i.e., whose systematic position can be identified only at familial, subordinal, or ordinal level) the word "genus," followed by the name of the family or higher category in plural genitive, followed by the species name is used; e.g., "genus Heterenchelyidarum" *circularis*. See also NOLF (1985) for further explanation.

The type material of some of the species described by RANA (1988 and 1996) and RANA and SAHNI (1989) is constituted by a mixture of different taxa and some became synonyms. These cases are treated in the synonymy of the concerned taxa. Others were based on non-diagnostic otoliths or are preoccupied, unavailable names. Therefore, an overview of all valid, doubtful and obsolete taxa is given in Table 1.

Family LEPISOSTEIDAE
Lepisosteidae ind.
Pl. 1, Fig. 3

1989 – "Lepisosteidarum" sp. - RANA & SAHNI, p. 147, pl. 1, fig. 1.

Material
A single otolith from Nagpur.

Discussion
A small right otolith, not diagnostic at specific or generic level, apparently belongs to a lepisosteid. It is compared here to those of the Recent species *Lepisosteus oculatus* (WINCHELL, 1864) (Pl. 1, Fig. 1), *L. platostomus* RAFINESQUE, 1820 (Pl. 1, Fig. 2), and *L. platyrhincus* DE KAY, 1842 (Pl. 1, Fig. 4). NOLF (1985, fig. 30, p. 37) also figured an otolith of the Recent *L. osseus* (LINNAEUS, 1758), but it should be noted that this drawing is wrongly oriented (with the dorsal rim to the left side). Recent lepisosteids (four species of

VALID TAXA IN THE DECCAN INTERTRAPPEAN BEDS		Iconography	Nagpur	Chemalgutta	Naskal	Rangapur
LEPISOSTEIDAE	Lepisosteidae ind.	Pl. 1, Fig. 3	Np	-	-	-
OSTEOGLOSSIDAE	"genus Heterotidinarum" *heterotoides* n. sp.	Pl. 1, Figs. 9-13	-	C	Nk	R
	"genus Osteoglossidarum" *deccanensis* RANA, 1988	Pl. 2, Figs. 4-6	-	-	Nk	R
	"genus Osteoglossidarum" *intertrappus* RANA, 1988	Pl. 2, Figs. 1-3	-	-	Nk	R
NOTOPTERIDAE	"genus Notopteridarum" *nolfi* RANA, 1988	Pl. 3, Figs. 1-2	-	C	Nk	R
CLUPEIDAE	"genus Clupeidarum" *valdiyai* RANA & SAHNI, 1989	Pl. 3, Figs. 6-7	Np	-	-	-
	"genus Clupeidarum" *sahnii* (RANA, 1996)	Pl. 3, Figs. 8-10	-	-	-	R
GONORYNCHIDAE	"genus Gonorynchidarum" *rectangulus* (RANA, 1988)	Pl. 4, Figs. 1-2	Np	-	Nk	R
	"genus Gonorynchidarum" sp.	Pl. 4, Figs. 7-8	Np	-	-	R
? ARIIDAE	? Ariidae	Pl. 4, Fig. 10	-	-	Nk	R
Percoidei inc. sed.	*Anthracoperca bhatiai* (RANA, 1996)	Pl. 5, Figs. 1-6	-	-	Nk	R
	"genus Percoideorum" *citreum* n. sp.	Pl. 5, Figs. 23-26	-	C	Nk	-
	"genus Percoideorum" *nagpurensis* (RANA & SAHNI, 1989)	Pl. 5, Figs. 11-12	Np	-	-	-
	"genus Percoideorum" *rangapurensis* RANA, 1988	Pl. 5, Figs. 7-10	-	-	Nk	R
	Percoidei sp. 1	Pl. 5, Figs. 19-22	-	-	Nk	R
	Percoidei sp. 2	Pl. 4, Fig. 6	?	-	-	R
? CENTROPOMIDAE	"genus ? Centropomidarum" *takliensis* (RANA & SAHNI, 1989)	Pl. 6, Fig. 10	Np	-	-	-
AMBASSIDAE	*Dapalis erici* nov. nom.	Pl. 5, Figs. 13-18	-	-	-	R
	"genus Ambassidarum" *cappettai* (RANA & SAHNI, 1989)	Pl. 6, Fig. 9	Np	-	-	-
APOGONIDAE	"genus Apogonidarum" *curvatus* (RANA, 1996)	Pl. 6, Figs. 1-8	-	-	Nk	R
NANDIDAE	"genus ? Pristolepidinarum" *jaegeri* (RANA & SAHNI, 1989)	Pl. 6, Figs. 14-15	Np	-	-	-
BLENNIIDAE	"genus Blenniidarum" sp.	Pl. 6, Fig. 16	-	-	-	R

DOUBTFUL AND OBSOLETE CITATIONS

RANA, 1988

"Clupeidarum" sp. - RANA, 1988, p. 469, pl. 1, fig. 1, pl. 2, fig. 1; pl. 2, fig. 2 = non diagnostic clupeoid otoliths;
"Apogonidarum" *ovatus* n. sp. - RANA, 1988, p. 477, pl. 1, fig. 10-11; pl. 3, fig. 12-13 = non diagnostic apogonid otoliths;
"Percoideorum" *ellipticus* - RANA, 1988, p. 478, pl. 1, fig. 15; pl. 4, figs. 2-3 = non diagnostic percoid otoliths and not available name;
"Percoideorum" *rangapurensis* RANA, 1988, pl. 1, fig. 16; pl. 4, fig. 6 (paratype) ? = "g. Apogonidarum" *curvatus* (RANA, 1996); non holotype pl. 1, fig. 17;
"Percoideorum" sp. 1 - RANA, 1988, p. 479, pl. 4, figs. 8-9 = non diagnostic percoid otoliths; non pl. 1, fig. 18; pl. 4, fig. 7 (="genus Percoideorum" *erici* nov. nom);
"Percoideorum" sp. 2 - RANA, 1988, p. 480, pl. 1, fig. 19-20; pl. 4, fig. 10-11 = non diagnostic percoid otoliths.

RANA & SAHNI, 1989

"Clupeidarum" sp. - RANA & SAHNI, 1989, p. 149, pl. 2, figs. 9-10 = unidentified lagaenar otoliths;
"Chandidarum" *cappettai* sp. nov. - RANA & SAHNI, 1989, pl. 3, fig. 2: = paratype, lost; cannot be evaluated on the basis of the iconography; unidentified percoid otolith; non pl. 3, fig. 1 (holotype) = "genus Ambassidarum" *cappettai*;
"Serranidarum" *jaegeri* sp. nov. - RANA & SAHNI, 1989, pl. 3, fig. 5 (paratype) only = non diagnostic percoid otolith; non pl. 3, fig. 4 (holotype) and pl. 3, fig. 6 (paratype) ="genus ? Pristolepidinarum" *jaegeri*;
"Serranidarum" *takliensis* sp. nov. - RANA & SAHNI, 1989, pl. 3, fig. 12 (paratype) only = non diagnostic percoid otolith; non pl. 3, fig. 13 (holotype) = "genus ? Centropomidarum" *takliensis*;
"genus Percoideorum", sp. A - RANA & SAHNI, 1989, pl. 4, figs. 3-7 = non diagnostic percoid otoliths;
"genus Percoideorum", sp. B - RANA & SAHNI, 1989, pl. 4, figs. 8-12 = non diagnostic percoid otoliths;
"genus Percoideorum", sp. C - RANA & SAHNI, 1989, pl. 4, figs. 13-15 = non diagnostic percoid otoliths.

RANA, 1996

"genus Serranidarum" sp. 1 - RANA, 1996, p. 480, pl. 3, fig. 2-4 = non diagnostic percoid otoliths;
"genus Serranidarum" sp. 2 - RANA, 1996, p. 481, pl. 3, fig. 5-7 = non diagnostic percoid otoliths;
Apogon sp. - RANA, 1996, p. 482, pl. 4, fig. 1-4 = non diagnostic apogonid otoliths;
"Lactariidarum" *ellipticus* - RANA, 1996, p. 482 (partim): pl. 4, fig. 7-8 = non diagnostic percoid otoliths; non pl. 4, figs. 5-6 (= "genus Apogonidarum" *curvatus*);
Badidae, gen. et sp. ind. - RANA, 1996, p. 482 (partim): pl. 4, figs. 10, 12a, 14-17, 20; non pl. 4, fig. 9 (= "genus Blenniidarum" sp.).

Table 1 — An overview of nominal taxa cited from the Deccan Intertrappean Beds.

Lepisosteus and three species of *Atractosteus*) are only known from the eastern United States, Central America, and eastern Cuba (see distribution map in BERRA, 2001, p. 48), but they are known by fossils (primarily Cretaceous till Eocene skeleton material and scales) from North America, South America, Europe and India. Lepisosteids are freshwater fishes, occasionally brackish, and very rarely in marine water.

Family OSTEOGLOSSIDAE
Subfamily HETEROTIDINAE
"genus Heterotidinarum" ***heterotoides*** n. sp.
Pl. 1, Figs 9-13

Type material
Holotype: a right otolith from Naskal (Pl. 1, Fig. 9) (IRSNB P 8428); seven paratypes from Naskal, of which two are figured (Pl. 1, Figs 10-11) (IRSNB P 8429-8430); eight paratypes from Rangapur of which two are figured (Pl. 1, Figs 12-13) (IRSNB P 8431-8432); five paratypes from Chemalgutta.

Dimensions of the holotype
Length (incomplete): 5.6 mm; height: 2.9 mm; thickness: 1.2 mm.

Stratum typicum
Maastrichtian, Deccan Intertrappean Beds at Naskal.

Derivatio nominis
Alludes to a resemblance with otoliths of the Recent genus *Heterotis* RÜPPELL, 1828.

Diagnosis
This species is characterized by relatively robust, elongate otoliths with a very prominent rostrum. Unfortunately, in all specimens, the extreme end of the rostrum is broken. In a dorso-ventral section, the ventral rim has a sharp profile, while the dorsal rim is smooth. The dorsal rim shows an obtuse angulous expansion, just posterior to its center. In juvenile specimens, the outer face is convex in all directions, but in larger ones, e.g. the holotype, it is nearly flat in the antero-posterior direction and a lateral expansion is formed near to the dorsal rim (see Pl. 1, Fig. 9c). The inner face is convex, especially in the dorso-ventral direction. In larger specimens, a very slight hollow zone occurs near to the ventral rim. The sulcus is wide and covers nearly the complete length of the otolith, with the exception of the extreme posterior end. The ostium opens largely to the ostial rim, but near to the central part of this rim, a very small crest is visible in some of the well preserved specimens. The area just above the anterior part of the caudal crista superior has a swollen aspect.

Affinities
The otoliths of this species seem to be most closely related to those of the Recent African species *Heterotis niloticus* (CUVIER, 1829) (Pl. 1, Figs 5-6) and to the South American *Arapaima gigas* (SCHINZ in CUVIER, 1822) (Pl. 1, Figs 7-8) but differ from them by somewhat higher otoliths and a more salient dorsal expansion. These two taxa are grouped together in the subfamily Heterotidinae, which, unlike the Osteoglossinae, are unknown from the present-day South Asian and Australian realm.

"genus Osteoglossidarum" ***deccanensis*** RANA, 1988
Pl. 2, Figs 4-6

1988 – "Osteoglossidarum" *deccanensis* sp. nov. - RANA, p. 472, pl. 1, figs 2-3; pl. 2, figs 4-6.

Material
26 otoliths from Naskal and 28 from Rangapur.

Discussion
Otoliths of this species are easily distinguished from those of "genus Osteoglossidarum" *intertrappus* that often occur in the same beds by their more compact and thick otoliths. They seem to be most closely related to the Recent *Scleropages* species (see Pl. 2, Figs 7 and 8). The Recent distribution of *Scleropages* includes Southeast Asia, southern New Guinea, and northern Australia, including Queensland (BERRA, 2001).

"genus Osteoglossidarum" ***intertrappus*** RANA, 1988
Pl. 2, Figs 1-3

1988 – "Osteoglossidarum" *intertrappus* sp. nov. - RANA, p. 473, pl. 1, figs 4-5; pl. 2, figs 8-10.

Material
15 otoliths from Naskal and 42 from Rangapur.

Discussion
As mentioned above, otoliths of this species are readily distinguished from those of "genus Osteoglossidarum" *deccanensis* by their thinner otoliths but also by differences in their outline: a more salient central part of their dorsal rim and a slightly hollow posterior portion of their posterodorsal rim.

Family NOTOPTERIDAE
"genus Notopteridarum" *nolfi* RANA, 1988
Pl. 3, Figs 1-2

1988 – "Notopteridarum" *nolfi* - RANA, p. 474, pl. 1, figs 6-7; pl. 2, fig. 12; pl. 3, fig. 1.

Material
Four otoliths from Chemalgutta, 69 from Naskal, and 29 from Rangapur.

Discussion
Notopterid otoliths are easily recognized by their very salient prominent rostrum and by their expanded anteroventral portion. In a dorso-ventral section, the ventral rim is relatively sharp and well marked. In the Recent species *Chitala chitala* (HAMILTON, 1822) (Pl. 3, Fig. 3) and *Papyrocranus afer* (GÜNTHER, 1868) (Pl. 3, Fig. 4), the transitional part of the ostial and caudal portion of the crista inferior shows two very salient dorsal expansions, separated by a rounded, ventrally expanded zone. The Recent *Xenomystus nigri* (GÜNTHER, 1868) shows only the ventral expansion of the concerned crista inferior portion. In the fossil "genus Notopteridarum" *nolfi*, the transitional part of the ostial and caudal crista inferior shows none of all these modifications and looks like a narrow channel, which is probably the plesiomorphic condition in notopterid otoliths. Notopterids are living in fresh and, occasionally, brackish waters from West and Central Africa to India and in Southeast Asia.

Family CLUPEIDAE
"genus Clupeidarum" *valdiyai* RANA & SAHNI, 1989
Pl. 3, Figs 6-7

1989 – "Clupeidarum" *valdiyai* sp. nov. - RANA & SAHNI, p. 149, pl. 2, figs 1-2.

Material
Two otoliths from Nagpur.

Discussion
Otoliths of "genus Clupeidarum" *valdyiai* are easily distinguished from those of "genus Clupeidarum" *sahnii* (RANA, 1996) (Pl. 3, Figs 8-10), the second Deccan intertrappean clupeid, by their more elongated otoliths and their sharper antirostrum. We know of no Recent clupeid genus whose otoliths match very closely with those of both concerned fossil species.

"genus Clupeidarum" *sahnii* (RANA, 1996)
Pl. 3, Figs 8-10

1996 – *Harengula sahnii* n. sp. - RANA, p. 479, pl.1, figs 9-7.

Material
Eleven otoliths from Rangapur.

Discussion
see above, under "genus Clupeidarum" *valdiyai*.

Family GONORYNCHIDAE
"genus Gonorynchidarum" *rectangulus*
(RANA, 1988)
Pl. 4, Figs 1-2

1988 – "Salmoniformorum" *rectangulus* - RANA, p. 475, pl. 1, figs 8-9; pl. 3, figs 6-7.
?1989 – "Elopidarum" *elongatus* - RANA & SAHNI, p. 148, pl.1, fig. 6.
1996 – "Megalopidarum" sp. 1- RANA, p. 478, pl. 1, figs 1-2.

Material
Two otoliths from Naskal and seven otoliths from Rangapur; probably one otolith from Nagpur.

Discussion
Except for their elongate outline and salient rostrum, otoliths of this species have little in common with those of Recent salmoniforms, to which they were attributed in the original description. See CHAINE (1945, pl. 6, 1956, pls 1-3) and NOLF (2004, pl. 4), for the iconography of various Recent taxa. They match much better with those of Recent gonorynchid species (see Pl. 4, Figs 3, 4, 5, 9) with who they share a dorsally expanded anterior portion of the cauda, and a dorsal open ending of the cauda. Otoliths of the fossil "g. Gonorynchidarum" *rectangulus* seem to be characterized by a very strongly expanded anterior part of their cauda and a salient but blunt posterodorsal angle. Their greatest thickness is located in their dorsal portion.

"genus Gonorynchidarum" sp.
Pl. 4, Figs 7-8

1989 – "Elopidarum" *elongatus* sp. nov. - RANA & SAHNI, p. 148, pl. 1, figs 7 and 8.

Material
Ten otoliths from Nagpur and three from Rangapur.

Discussion
Apparently, a second species of gonorynchids is represented in the Deccan Intertrappean Beds. It was described as "Elopidarum" *elongatus* by RANA & SAHNI (1989), but unfortunatly the holotype, which judged from the drawing was the best specimen, is lost. This is also the case for the paratypes figured on RANA & SAHNI's pl. 1, figs 5, 9, and 11, and for the two species attributed to "Elopidarum" *elongatus* by RANA (1996, pls 7 and 8). Therefore, it is impossible to judge adequately the features of the species. The two remaining paratypes (RANA & SAHNI's pl. 1, figs 7 and 8 probably represent a gonorynchid which otoliths differ from "genus Gonorynchidarum" *rectangulus* by shorter otoliths with a more cutting ventral rim profile that becomes finely serrated in larger specimens. Probably the lost specimen of pl. 1, fig. 8 of RANA (1996) is an upside down figured otolith of the same taxon. As it is impossible to judge from the original drawing if the lost holotype of "g. Elopidarum" *elongatus* belongs to "g. Gonorynchidarum" *rectangulus* or to the second species, we prefer to leave the two here figured paratypes in open nomenclature.

Family: ?ARIIDAE
? Ariidae
Pl. 4, Fig. 10

1989 − "Ariidarum" sp. - RANA & SAHNI, p. 150, pl. 2; figs 11-14.

Material
Fourteen otoliths from Naskal and 27 from Rangapur.

Discussion
Some small, rather poorly preserved utricular otoliths may belong to ariids or some related group of catfishes.

PERCOIDEI incertae sedis
Anthracoperca bhatiai (RANA, 1996)
Pl. 5, Figs 1-6

1996 − *Dapalis bhatiai* n. sp. - RANA, p. 480, pl. 2, figs 9-11.
1996 − *Dapalis buffetauti* n. sp. - RANA, p. 480, pl. 2, figs 12 and 15; not figs 13-14.

Material
Eight otoliths from Naskal and 14 from Rangapur.

Discussion
The otoliths of this species are most closely related to those observed in skeletons of *Anthracoperca siebergi* VOIGT, 1934, from Lutetian freshwater deposits of the Geiseltal, Germany, and figured by MICKLICH & GAUDANT (1989, figs 2-4). Similar otoliths are also known from lowermost Ypresian ("Sparnacian" facies) at Lihons, in the Paris Basin. Strong thickening of the otoliths, like in the holotype of *A. bhatiai* (Pl. 5, Fig. 1), is also observed in the *A. siebergi* material from Lihons. Otoliths of *A. siebergi* however, are markedly more elongate than those of *A. bhatiai*. The holotype and one of the figured paratypes of *Dapalis bufetauti* (see synonymy) also belong to *A. bhatiai*, causing a rather complicated nomenclatural problem that will be treated under the discussion concerning *Dapalis erici*.

"genus Percoideorum" ***citreum*** n. sp.
Pl. 5, Figs 23-26

Type material
Holotype: a left otolith from Naskal (Pl. 5, Fig. 23) (IRSNB P 8445); five paratype from Naskal, of which three figured (Pl. 5, Figs 24-26) (IRSNB P 8446-P 8448); one paratype from Chemalgutta.

Dimensions of the holotype
Length: 3.2 mm; height: 2.0 mm; thickness: 0.7 mm.

Stratum typicum
Maastrichtian, Deccan Intertrappean Beds at Naskal.

Derivatio nominis
Citreum (Latin) = lemon, alludes to the lemon-shaped outline of the otoliths.

Diagnosis
This species is characterized by bi-aculeate otoliths, which confers them a lemon-shaped outline. In a dorso-ventral section, both dorsal and ventral rims are relatively sharp. The outer face is smooth and nearly flat. The inner face is regularly convex in all directions and bears a well-incised sulcus, which is constituted by a relative short, wide ostium and a narrower, more elongated cauda. The cauda is regularly curved in ventral direction and shows some widening in its posterior part. The area just above the caudal crista inferior is slightly hollow. The ventral area does not show a clear ventral furrow.

Affinities
These otoliths show a generalized perciform morphological condition, but it is hazardous to attribute them to any precise Recent perciform family.

"genus Percoideorum" *nagpurensis*
(RANA & SAHNI, 1989)
Pl. 5, Figs 11-12

1989 – "Serranidarum" *nagpurensis* sp. nov. - RANA & SAHNI, p. 152, pl. 3, figs14-15; pl. 4, fig. 1.

Material
Three otoliths from Nagpur.

Discussion
This species is characterized by very elongate and bi-aculeate otoliths, with a pointed rostrum and lacking marginal ornamentations. Although these otoliths are well recognizable among the Deccan Intertrappean material, they represent a very generalized plesiomorphic perciform otolith type, and it is difficult to allocate them to a precise Recent family.

"genus Percoideorum" *rangapurensis* RANA, 1988
Pl. 5, Figs 7-10

1988 – "Percoideorum" *rangapurensis* sp. nov. – RANA, p. 479, pl. 1, fig.17; not fig. 16.

Material
Fourteen otoliths from Naskal and 47 from Rangapur.

Discussion
These otoliths are well recognizable by their oblique sulcus and characteristic outline, showing an obtuse but salient angle in the central part of their dorsal rim, a clear rostrum and antirostrum, and an ostial rim with a well marked but moderately deep excisura just below the antirostrum. These otoliths do not fit within any of the Recent percoid families known to us and may belong to an extinct family, possibly near the ambassids. The paratype figured on pl. 1, fig. 16 of RANA (1988) belongs to a different species, maybe "genus Apogonidarum" *curvatus* RANA, 1996.

Percoidei sp. 1
Pl. 5, Figs 19-22

1988 – "? Serranidarum" sp. – RANA, p. 477, pl. 1, fig. 14; pl 3, fig. 14; pl. 4, fig. 1.
1996 – "Serranidarum" *nagpurensis* RANA & SAHNI, 1989 - RANA, p. 480, pl. 2, figs 16-18; pl. 3, fig.1 (not RANA & SAHNI, 1989).

Material
Fourteen otoliths from Naskal and nine from Rangapur.

Discussion
Although these otoliths are recognizable in the Naskal and Rangapur assemblages, their morphology reflect a generalized percoid morphology that is observed in juvenile fishes of various families, and it is difficult to judge if the figured series really represents a single taxon.

Percoidei sp. 2
Pl. 4, Fig. 6

1996 – "Megalopidarum" sp. 2 - RANA, p. 478, pl. 1, fig. 4.

Material
One otolith from Rangapur; a specimen from Nagpur may belong to the same species.

Discussion
These specimens represent a percoid otolith type with a recognizable morphology, apparently different from the other here described percoid taxa, but more material is required to define it adequately.

Family ? CENTROPOMIDAE
"genus ? Centropomidarum" *takliensis*
(RANA & SAHNI, 1989)
Pl. 6, Fig. 10

1996 – "Serranidarum" *takliensis* sp. nov. - RANA & SAHNI, p. 152, pl. 3, fig. 13; not fig. 12.

Material
One otolith from Nagpur; a second non-figured specimen from Nagpur may also belong to this species.

Discussion
This small juvenile otolith belongs to a plesiomorphic percoid family, maybe a centropomid. It is compared here to the Recent *Centropomus undecimalis* (BLOCH, 1792) (Pl. 6, Fig. 11) and to *Lates niloticus* (LINNAEUS, 1758) (Pl. 6, Fig. 12). NELSON (2006) accepts centropomids and latids as separate families, but other authors, e.g. ESCHMEYER (1998) considers latids as a subfamily of centropomids. Centropomines are shallow marine fishes of tropical and subtropical America, both Atlantic and Pacific. Some individuals may enter coastal freshwaters seasonally. The genus *Lates* includes seven African freshwater species, and one, *Lates calcarifer* (BLOCH, 1790), widely distributed in coastal, estuarine,

and freshwaters, from the Persian Gulf to China and the Indo Australian archipelago.

Family AMBASSIDAE

Dapalis erici nov. nom.

Pl. 5, Figs 13-18

1988 − "Percoideorum" sp. 1 - RANA, p. 479, pl. 1, fig. 18; pl. 4, fig.7, not figs 8-9.
1988 − *Chanda ovatus* n. sp. - RANA, p. 479, pl. 2, fig. 7, not figs 6 and 8.
1996 − *Dapalis buffetauti* n. sp. - (partim) RANA, p. 480, pl. 2, figs 13 -14; not figs 12 and 15.

Type material

A left otolith (Pl. 5, Fig. 13) (the paratype of *Dapalis buffetauti* figured by RANA, 1996, pl. 2, fig. 14); 7 paratypes of which five figured; see explanation of the plate for details on the figured specimens. All available material is from Rangapur.

Dimensions of the holotype

Length: 2.3 mm; height: 1.7 mm; thickness: 0.6 mm.

Stratum typicum

Maastrichtian, Deccan Intertrappean Beds at Rangapur.

Derivatio nominis

This species is named in honor of Eric Buffetaut, as originally intended by RANA (1996). The original series figured by Rana as *Dapalis buffetauti* was a mixture of two different species (see synonymy). As the holotype of *D. buffetauti* is an *Anthracoperca bhatiai* otolith, the species name "*buffetauti*" is unavailable for the second species, which is called here *D. erici*.

Diagnosis

This species is characterized by generally round shaped otoliths with a well-marked rostrum and a weakly incised excisura. All specimens show some crenulation at their margins, which in larger specimens, is restricted to the ventral rim. The outer face is smooth, nearly flat in the antero-posterior direction, and slightly convex in the dorso-ventral direction. The inner face is slightly convex in all directions. The sulcus, well incised, is constituted by a wide ostium and a narrower cauda, which is about twice as long as the ostium, and which posterior end shows a marked ventral flexure. In large specimens, the central portion of the dorsal rim tends to become angulous and the rostrum more salient.

Affinities

The otoliths of this new species match best with those of the fossil ambassid genus *Dapalis* GISTEL, 1848, originally described from skeleton material. WEILER (1939) described otoliths *in situ* from skeletons of the type species, *Dapalis macrurus* (AGASSIZ, 1836) and WEILER (1955) from *Dapalis formosus* (VON MEYER, 1851). Subsequently, various other otolith-based species of *Dapalis* have been described, see e.g. REICHENBACHER (2000) for iconography of some species. Large otoliths of *D. erici* look a bit similar to those of "genus Percoideorum" *rangapurensis* (RANA, 1988), but otoliths of the latter species are slightly more elongate, have a more expanded posterodorsal portion and do not show the marked ventral flexure at the end of their cauda.

"genus Ambassidarum" ***cappettai***

(RANA & SAHNI, 1989)

Pl. 6, Fig. 9

1989 − "Chandidarum" *cappettai* sp. nov. - RANA & SAHNI, p. 150, pl. 3, fig. 1, ? not fig. 2.

Material

A single otolith from Nagpur.

Discussion

This species was based on two specimens that may not belong to the same species. The paratype figured by RANA & SAHNI (1989, pl. 3, fig. 2) could not be located and cannot be evaluated any more. The holotype, refigured here, cannot be assimilated to any of the other Deccan Intertrappean percoid taxa and probably represents an ambassid otolith. However, more material is required for a clear definition of the species.

Family APOGONIDAE

"genus Apogonidarum" ***curvatus*** (RANA, 1996)

Pl. 6, Figs 1-8

?1988 − "Percoideorum" *rangapurensis* sp. nov. - RANA, pl. 1, fig. 16 only, not pl. 1, fig. 17 (holotype); not pl. 4, figs 4-6.
1996 − *Apogon curvatus* n. sp. - RANA, p. 481, pl. 3, figs 12-13, erroneously labeled as *Apogon spatulatus* in the legend of pl. 3, p. 488.
1996 − *Apogon spatulatus* n. sp. - RANA, p. 481, pl. 3, figs 8-11.
1996 − "Lactariidarum" *ellipticus* n. sp. - RANA, p. 481, pl. 4, figs 5-6; not figs 7-8.

Material
Six otoliths from Naskal and 19 from Rangapur.

Discussion
This species has been described under various names, among which the type material of *Apogon curvatus* constitutes the best-preserved and most diagnostic material. The holotype of this species is refigured here on Pl. 6, Fig. 2. Pl. 6, Fig. 1 represents an even better specimen that was selected among material that was not figured previously. These well preserved specimens illustrate most clearly the apogonid features of the otoliths: oval shape, slightly crenulated rims and rounded rostrum. The type material of *Apogon spatulatus* consists of eroded otoliths, resulting in less crenulated rims and a more pointed rostrum. One paratype of "Percoideorum" *rangapurensis* and two eroded paratypes of "Lactariidarum" *ellipticus* also belong to the same species, but none of them has any impact on the nomenclature of the taxon, as their holotypes belong to different species. The otoliths figured here do not correspond to any of the Recent apogonid genera known to us and may represent an extinct genus.

Family NANDIDAE
Subfamily PRISTOLEPIDINAE
"genus ? Pristolepidinarum" *jaegeri* (RANA & SAHNI, 1989)
Pl. 6, Figs 14-15

1989 − "Serranidarum" *jaegeri* - RANA & SAHNI, p. 151, figs 4 and 6; ? fig. 5.

Material
Two otoliths from Nagpur.

Discussion
In the discussion following the diagnosis of "genus Serranidarum" *jaegeri*, RANA & SAHNI (1989) evocated resemblance with various serranids but these morphological similarities are based mainly on plesiomorphic features of juvenile serranid otoliths. Based on the now available Recent comparative material, we found the best resemblance in both outline and sulcus morphology with otoliths of the pristolepidine nandid *Pristolepis fasciatus* (BLEEKER, 1851) (Pl. 6, Fig. 13).

Family BLENNIIDAE
"genus Blenniidarum" sp.
Pl. 6, Fig. 16

1996 − Badidae gen. et sp. indet. - RANA, p. 482, pl. 4, fig. 9; not figs 10, 12a, 12b, 14-17, 20.

Material
A single otolith, Rangapur.

Discussion
Among the nine otoliths figured as "Badidae gen. et sp. indet. by RANA (1996, pl. 4), only the figs 9, 10, 12a, 12b, 15 could be traced back in the collection. Comparison with an extensive series of Recent badid (a subfamily of the nandids) otoliths showed that none of them belongs to this group. The figs 12a, 12b, 14-17 and 20 of RANA are small, non-diagnostic eroded otoliths. His fig. 16 however, corresponds to a well-preserved otolith which morphology fits best within the blenniids. Our knowledge of Recent otoliths in this vast group is rather restricted, but CHAINE's (1956) iconography at least provides some overview of blenniid otoliths. It also should be mentioned that the blenniid family counts at least some freshwater species (e.g. the southern European and North African *Salarias fluviatilis*), which is compatible with the Deccan intertrappean paleoenvironment.

Conclusions

The study of the Maastrichtian Deccan Intertrappean otolith association allows for the reconstruction of a teleost fauna of 22 taxa, of which 16 could be identified at species level. Three species are new: "genus Heterotidinarum" *heterotoides*, "genus Percoideorum" *citreum,* and *Dapalis erici*. The general paleontological content of microvertebrate, invertebrate, and plant remains is suggestive for a freshwater environment, or at least a predominantly freshwater environment with some temporary communications with the marine realm. The associations of Nagpur and Asifabad contain a mixed assemblage of freshwater and marine elements (selachian teeth), studied by PRASAD & CAPPETTA (1993). With the exception of such elements, one can state that the Deccan Intertrappean fauna includes the most significant Late Cretaceous freshwater fish fauna known at world scale. Among the studied localities, the richest association (15 taxa) was found at Rangapur, followed by Nagpur (10 taxa), Naskal (10 taxa) and Chemalguta (3 taxa). This restricted data set does

not allow further conclusions, because divergences between the three associations are essentially based on absences, not on true differences. It should however be mentioned that the association of Nagpur does not include osteoglossids and notopterids.

Paleoecological considerations

Looking at the otolith associations, one can state that none of the represented taxa are incompatible with a freshwater environment. In the present-day fauna, Lepisosteidae, Osteoglossidae, and Notopteridae are typical freshwater fishes, although very occasionally they may enter into brackish water. There is also evidence that some fossil osteoglossids, like the European Eocene "genus Heterotidinarum" *acutangulus* (STINTON, 1977) and "genus Osteoglossidarum" *rhomboidalis* (STINTON, 1977), and the North American (Gulf Coast) Maastrichtian "genus Heterotidinarum" *tavernei* (NOLF & STRINGER, 1996) regularly entered marine waters or perhaps were residents.

Recent clupeids are mainly marine fishes. Worldwide, there are 57 genera and 188 species, of which about 57 freshwater ones that occasionally enter brackish water. Many others (especially the Caspian Sea ones) are anadromous or otherwise extend into freshwater but are primarily marine (NELSON, 2006). Recent gonorynchids are marine fishes, but the fossil genus *Notogoneus* is known from Paleogene freshwater deposits of Europe. Ariids are coastal marine fishes, but many enter freshwater and some only occur in freshwater.

The extinct percoid genus *Anthracoperca* is described from Middle Eocene freshwater deposits of Europe (Geiseltal, Germany), and the above cited Early Eocene specimens from Lihons in the Paris Basin are also from a facies that should be interpreted as mainly freshwater. Among centropomids, the genus *Centropomus* is nearshore marine, but some individuals may enter coastal freshwaters seasonally. The genus *Lates* (included in centropomids in many classifications) includes seven African freshwater species, and one, *Lates calcarifer* (BLOCH, 1790), widely distributed in coastal, estuarine, and freshwaters, from the Indo-West Pacific realm. There are 41 Recent species of ambassids, of which 21 are confined to freshwater. Many fossil species are known from European Eocene, Oligocene and Early Miocene lagoon and freshwater deposits. Apogonids (about 273 species) are mainly marine fishes, often reef-associated or circum-reef dwelling, but several species frequent mangrove shores and a few species of *Apogon* occur in estuaries and the lower reaches of rivers. Recent pristolepidine nandids are freshwater fishes ranging from peninsular India to Borneo. The large blenniid family consists mainly of near shore marine fishes but counts at least some freshwater species, e.g. the southern European and North African *Salarias fluviatilis*.

The otolith-based data exclude a full marine or predominantly marine environment for the Deccan Intertrappean deposits. The represented taxa vary from typical freshwater ones like lepisosteids, notopterids and nandines, over essentially freshwater ones with some marine intruders, like osteoglossids, nearshore marine groups including a significant portion of freshwater intruders (clupeids, gonorynchids, ariids, centropomids, ambassids) to predominantly marine fishes, including however some scarce freshwater residents (apogonids, blennioids). On the other hand, one cannot claim that such an association is completely devoid of elements with marine affinities. The most probable interpretation is that the Deccan Intertrappean Beds correspond to freshwater environments of the coastal area, where intrusion by marine elements or temporary connections with the marine realm existed.

Paleobiogeographical considerations

Looking for paleoenvironments with comparable otolith associations, one comes to the Early Eocene deposits of Vastan, India (see NOLF *et al*., 2006) to some of the early Eocene "Sparnacian" facies of Europe, and to the Oligocene till Early Miocene Paratethys facies of central Europe. Direct comparison of all those associations is difficult because the precise ecological conditions were quite different at each locality. However, some relevant aspects of paleobiogeography can be highlighted, like the more worldwide ancient distribution of lepisosteids (additionally documented by skeletons and scales from various European sites) and of osteoglossids, the vast ancient Eurasiatic distribution of ambassids, and the vast ancient Eurasiatic distribution of plesiomorph perciform taxa (including *Anthracoperca*). The presence of channid otoliths and skeletons (NOLF, 1985; GAUDANT & REICHENBACHER, 1998; STINTON, 1978) in the Late Eocene of Southern England and the Lower Miocene of the Paratethys is another aspect of ancient Eurasiatic affinities of the European freshwater and brackish fish fauna.

Notably absent in the Deccan Intertrappean beds are the gobiids and the cyprinodonts. The earliest known gobiids are from the Early Eocene of Vastan, India. In Europe, gobiid otoliths suddenly appear in great numbers in the marine Early Oligocene of Aquitaine (southwest France), and are a characteristic constituent of Oligo-Miocene brackish and freshwater

environments. Cyprinodontids are another important constituent of European Oligo-Miocene brackish and freshwater otolith associations. In the Recent fauna, their Old World distribution is restricted to the coastal plains of the Mediterranean, the south Arabian coast, the Red Sea, and the Persian Gulf. They are unknown in the Recent Indian fauna and have no Indian fossil record. A logical conclusion is that they never have been there.

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Explanation of the plates

The specimens previously figured in the papers of RANA (1988), RANA & SAHNI (1989) and RANA (1996) are deposited in the collections of the Department of Geology of the Garhwal University, Srinagar (Garhwal), India (GU/RSR, numbers). Because these specimens were not numbered at the time of their publication, the acronym GU/RSR is followed with a reference to the original iconography. All newly figured specimens are deposited in the collections of the Institut royal des Sciences naturelles de Belgique (IRSNB). The fossil otoliths bear numbers of the collection of types and figured fossil fish specimens of the IRSNB. The Recent otoliths are part of the reference collection of Recent otoliths at the same institution. The latter collection is arranged in systematic order without numbering; therefore, such specimens, when figured, bear only the notation "coll. IRSNB." The abbreviations F and R in the upper right corner of each compartment of the plates indicate if the figured specimens in that compartment are fossils (F) or Recent (R). In the text of the explanations, L stands for left otolith and R for right otolith. The annotations Fig. a, b and c are used to indicate respectively ventral, inner (=mesial) and posterior views. Figures without a letter show inner views. The scale bars in each compartment represent the 1 mm measure.

PLATE 1

Fig. 1 — *Lepisosteus oculatus* (WINCHELL, 1864), L, Recent, Apalachicola River, USA (coll. IRSNB).
Fig. 2 — *Lepisosteus platostomus* RAFINESQUE, 1820, L, Recent, southern USA (coll. IRSNB).
Fig. 3 — Lepisosteidae ind., R, Takli Formation, Nagpur (GU/RSR, RANA & SAHNI, 1989, pl. 1, fig. 1).
Fig. 4 — *Lepisosteus platyrhincus* DE KAY, 1842, L, Recent, Florida (coll. IRSNB).
Figs 5-6 — *Heterotis niloticus* (CUVIER, 1829), L, Recent, Africa, (coll. IRSNB).
Figs 7-8 — *Arapaima gigas* (SCHINZ in CUVIER, 1822), R, Recent, Freshwater, South America (coll. IRSNB).
Figs 9-13 — "genus Heterotidinarum" *heterotoides* n. sp., 9-10 = R, 11-13 = L; Deccan Intertrappean Beds, 9 = holotype (IRSNB P 8428), 10-13 = paratypes, 10-11 from Nascal (IRSNB P 8429, P 8430), leg. PRASAD; 12-13 from Rangapur (IRSNB P 8431, P 8432).

PLATE 2

Figs 1-3 — "genus Osteoglossidarum" *intertrappus* RANA, 1988, L, Deccan Intertrappean Beds, Rangapur, 1 = holotype (GU/RSR, RANA, 1988, pl. 1, fig. 4. and pl. 2, fig. 8), 2-3 = paratypes (GU/RSR, RANA, 1988, pl. 2, figs 9-10).

Figs 4-6 — "genus Osteoglossidarum" *deccanensis* RANA, 1988, R, Deccan Intertrappean Beds, Rangapur, 4 = holotype (GU/RSR, RANA, 1988, pl. 1, fig. 2 and pl. 2, fig. 4), 5-6 = paratypes (GU/RSR, RANA, 1988, pl. 2, figs 6 and 5).
Fig. 7 — *Scleropages leichardti* GÜNTHER, 1864, L, Recent, freshwater, Australia (coll. IRSNB).
Fig. 8 — *Scleropages formosus* (SCHLEGEL & MÜLLER, 1844), L, Recent, freshwater, Tailand, (coll. IRSNB).
Fig. 9 — *Osteoglossum bicirrhosum* (CUVIER, 1829), L, Recent, freshwater, British Guyana (coll. IRSNB).
Fig. 10 — *Osteoglossum ferreirai* KANAZAWA, 1966, L, Recent, aquarium (freshwater, South America) (coll. IRSNB).

PLATE 3

Figs 1-2 — "genus Notopteridarum" *nolfi* RANA, 1988, L, Deccan Intertrappean Beds, Rangapur, 1 = paratype (GU/RSR, RANA, 1988, pl. 1, fig . 7 and pl. 3, fig. 1), 2 = holotype (GU/RSR, RANA, 1988, pl. 1, fig. 6 and pl. 2, fig. 12).
Fig. 3 — *Chitala chitala* (HAMILTON, 1822), L, Recent, freshwater, Thailand (coll. IRSNB).
Fig. 4 — *Papyrocranus afer* (GÜNTHER, 1868), L, Recent, freshwater, Africa (coll. IRSNB).
Fig. 5 — *Xenomystus nigri* (GÜNTHER, 1868), R, Recent, freshwater, Africa (coll. IRSNB).
Figs 6-7 — "genus Clupeidarum" *valdiyai* RANA & SAHNI, 1989, R, Takli Formation, Nagpur, 6 = holotype, (GU/RSR, RANA& SAHNI, 1989, pl. 2, fig. 2), 7 = paratype (GU/RSR, RANA & SAHNI, 1989, pl. 2, fig.1).
Figs 8-10 — "genus Clupeidarum" *sahnii* (RANA, 1996), R, 8 = holotype of *Harengula sahnii* (GU/RSR, RANA, 1996, pl. 1, fig. 9), 9-10 = paratypes, (GU/RSR, RANA, 1988, pl. 1, figs 16 and 13)

PLATE 4

Figs 1-3 — "genus Gonorynchidarum" *rectangulus* (RANA, 1988), 1 = L, Deccan Intertrappean Beds, Naskal, (IRSNB P 8433), leg. PRASAD, 2 = R, holotype, (GU/RSR, RANA, 1988, pl. 1, fig. 8 and pl. 3, fig. 6).
Fig. 3 — *Gonorynchus abbreviatus* TEMMINCK & SCHLEGEL, 1846. L, Recent, off Taiwan (coll. IRSNB).
Figs 4-5 — *Gonorynchus greyi* (RICHARDSON, 1845), L, Recent, off Adelaide, Australia (coll. IRSNB).
Fig. 6 — Percoidei sp. 2, R, Deccan Intertrappean Beds, Rangapur (GU/RSR, RANA, 1996, pl. 1, fig. 4, as "Megalopidarum" sp. 2).
Figs 7-8 — "genus Gonorynchidarum "sp., L, Takli Formation, Nagpur (GU/RSR, RANA & SAHNI, 1989, pl. 1, figs 8 and 7, as "Elopidarum" *elongatus*).
Fig. 9 — *Gonorynchus gonorynchus* (LINNAEUS, 1766), L, Recent, off South Africa (coll. IRSNB).
Fig. 10 — ? Ariidae, L, Takli Formation, Nagpur (GU/RSR, RANA & SAHNI, 1989, pl. 2, fig. 11).

PLATE 5

Figs 1-6 — *Anthracoperca bhatiai* (RANA, 1996). L; 1, 2, 4, and 5 = Deccan Intertrappean Beds, Rangapur, 1 = holotype of *Dapalis bhatiai* (GU/RSR, RANA, 1996, pl. 2, fig. 11), 2 and 5 = paratypes of *Dapalis bhatiai* (GU/RSR, RANA, 1996, pl. 2, figs 9-10), 4 = holotype of *Dapalis buffetauti* (GU/RSR, RANA, 1996, pl. 2, fig. 12), figs 3 and 6 = Deccan Intertrappean Beds, Naskal, (IRSNB P 8434, P 8435), leg. PRASAD.
Figs 7-10 — "genus Percoideorum" *rangapurensis* RANA, 1988, 7-8 = L, 9-10 = R; 7, 8,10 = Deccan Intertrappean Beds, Rangapur (IRSNB P 8436 - P 8438), 9 = Deccan Intertrappean Beds, Rangapur, holotype (GU/RSR, RANA, 1988, pl. 1, fig. 17 and pl. 4, fig. 5).
Figs 11-12 — "genus Percoideorum" *nagpurensis* (RANA & SAHNI, 1989). 11 = L, paratype (GU/RSR, RANA & SAHNI, 1989, pl. 4, fig. 1), 12 = R, holotype (GU/RSR, RANA & SAHNI, 1989, pl. 3, fig. 15).
Figs 13-18 — *Dapalis erici* nov. nom. 13-14 and 16-18 = Deccan Intertrappean Beds, Rangapur, 13-15 = L, 16-18 = R; 13 = holotype (GU/RSR, RANA, 1996, pl. 2, fig. 13, paratype of *Dapalis buffetauti*), 14-18 = paratypes , 14 = (GU/RSR, RANA, 1996, pl. 2, fig. 14, paratype of *Dapalis buffetauti*), 15 = (GU/RSR, RANA, 1988, pl. 1, fig. 18, as "Percoideorum" sp. 1), 16 and 17 = (IRSNB P 8439, P 8440), 18 = (GU/RSR, RANA, 1996, pl. 2, fig. 7, paratype of *Chanda ovatus*).
Figs 19-22 — Percoidei sp. 1, 19-20 = L, 21-22 = R; Deccan Intertrappean Beds, Naskal, (IRSNB P 8441 - P 8444), leg. PRASAD.
Figs 23-26 — "genus Percoideorum" *citreum* n. sp., Deccan Intertrappean Beds, Naskal, 23-24 = L, 25-26 = R; 23 = holotype (IRSNB P 8445), 24-26 = paratypes (IRSNB P 8446 - P8448), leg. PRASAD.

PLATE 6

Figs 1-8 — "genus Apogonidarum" *curvatus* (RANA, 1996), 1, 3-5 = L; 2, 6-8 = R; 1-6 = Deccan Intertrappean Beds, Rangapur, 2 = holotype (GU/RSR, RANA, 1996, pl. 3, fig. 12), 1 and 3 = paratypes (IRSNB P 8449, P 8450), 4 = (GU/RSR, RANA, 1996, pl. 3, fig. 11, paratype of *Apogon spatulatus*), 5 = (GU/RSR, RANA, 1996, pl. 3, fig. 9, holotype of *Apogon spatulatus*), 7-8 = Deccan Intertrappean Beds, Naskal, (IRSNB P 8451, P 8452), leg. PRASAD.

Fig. 9 — "genus Ambassidarum" *cappettai* (RANA & SAHNI, 1989), L, Takli Formation, Nagpur, holotype (GU/RSR, RANA & SAHNI, 1989, pl. 3, fig. 1).

Fig. 10 — "genus ? Centropomidarum" *takliensis* (RANA & SAHNI, 1989), L, Takli Formation, Nagpur, holotype (GU/RSR, RANA & SAHNI, 1989, pl. 3, fig. 13).

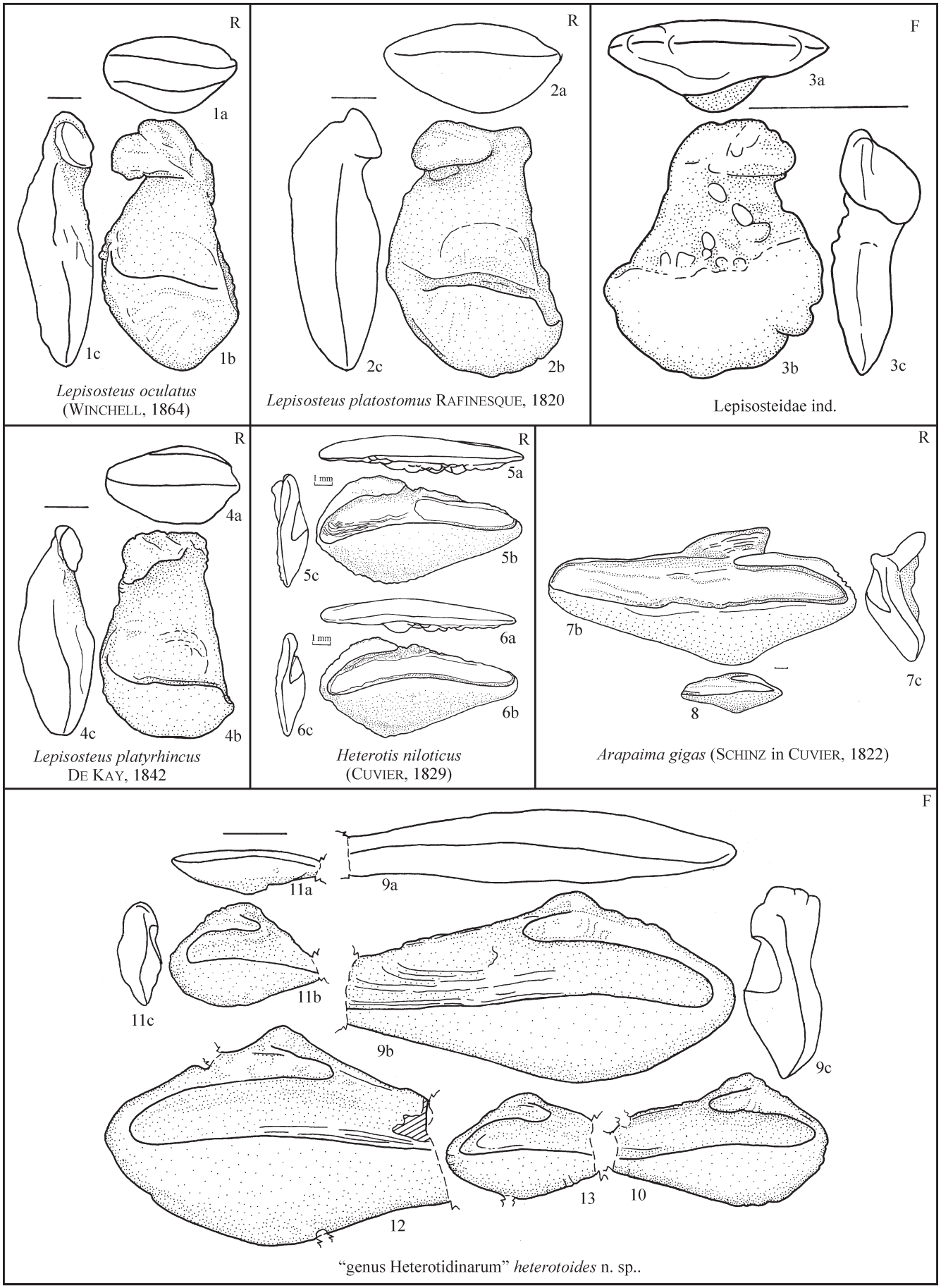
Fig. 11 — *Centropomus undecimalis* (BLOCH, 1792), L, Recent, off Santa Margatita Island, Venezuela (coll. IRSNB).

Fig. 12 — *Lates niloticus* (LINNAEUS, 1758), L, Recent, Africa, Lake Albert (coll. IRSNB).

Fig. 13 — *Pristolepis fasciatus* (BLEEKER, 1851), L, Recent, Thailand (coll. IRSNB).

Figs 14-15 — "genus ? Pristolepidinarum" *jaegeri* (RANA & SAHNI, 1989), 14 = L, 15 = R; 14 = paratype (GU/RSR, RANA & SAHNI, 1989, pl. 3, fig. 6), 15 = holotype (GU/RSR, RANA & SAHNI, 1989, pl. 3, fig.4).

Figs. 16 — "genus Blenniidarum" sp., R, Rangapur (Rana, 1996, pl. 4, fig. 9).



Lepisosteus oculatus (WINCHELL, 1864)

Lepisosteus platostomus RAFINESQUE, 1820

Lepisosteidae ind.

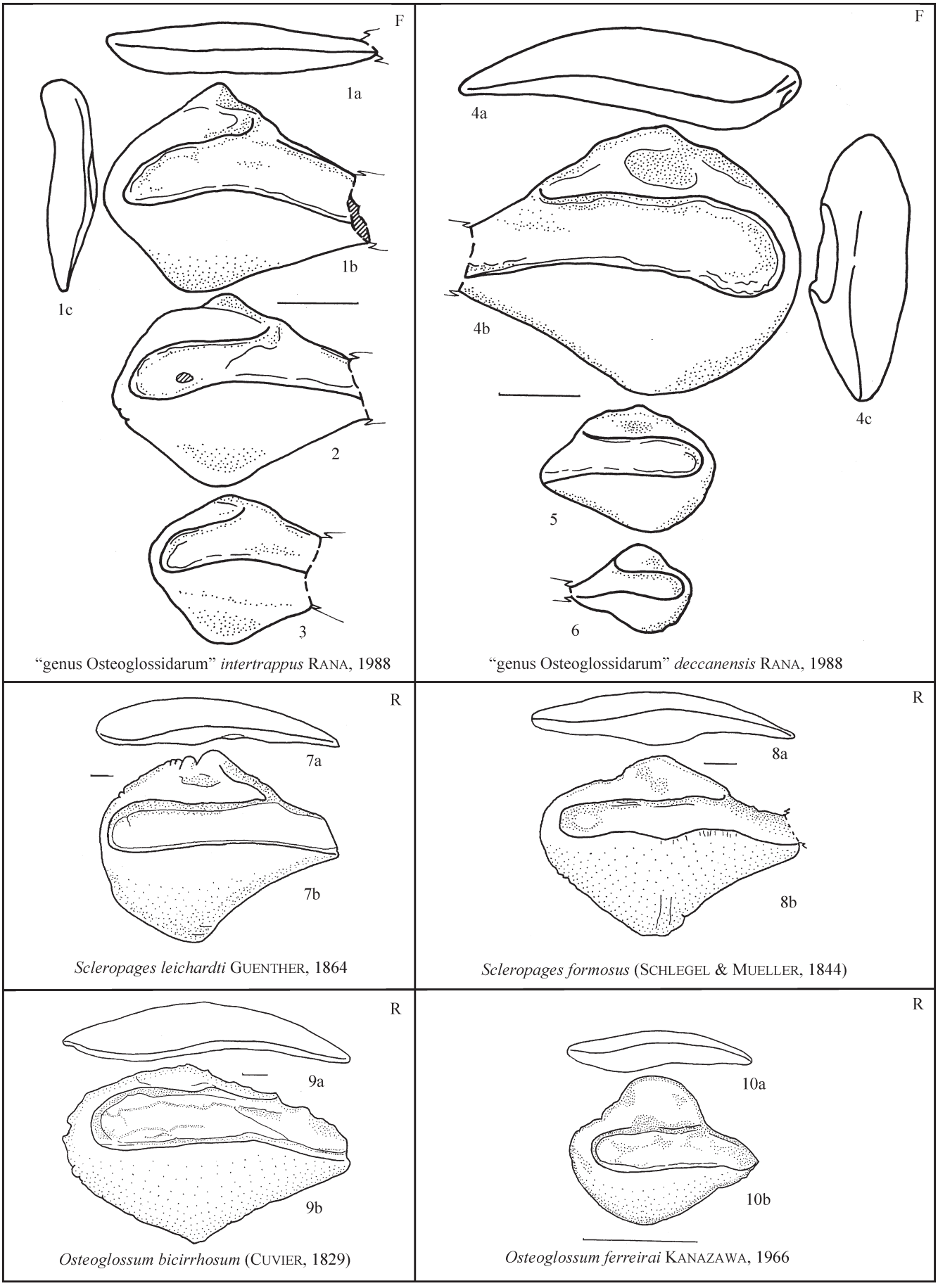
Lepisosteus platyrhincus DE KAY, 1842

Heterotis niloticus (CUVIER, 1829)

Arapaima gigas (SCHINZ in CUVIER, 1822)

"genus Heterotidinarum" *heterotoides* n. sp..

PLATE 1



"genus Osteoglossidarum" *intertrappus* RANA, 1988

"genus Osteoglossidarum" *deccanensis* RANA, 1988

Scleropages leichardti GUENTHER, 1864

Scleropages formosus (SCHLEGEL & MUELLER, 1844)

Osteoglossum bicirrhosum (CUVIER, 1829)

Osteoglossum ferreirai KANAZAWA, 1966

PLATE 2

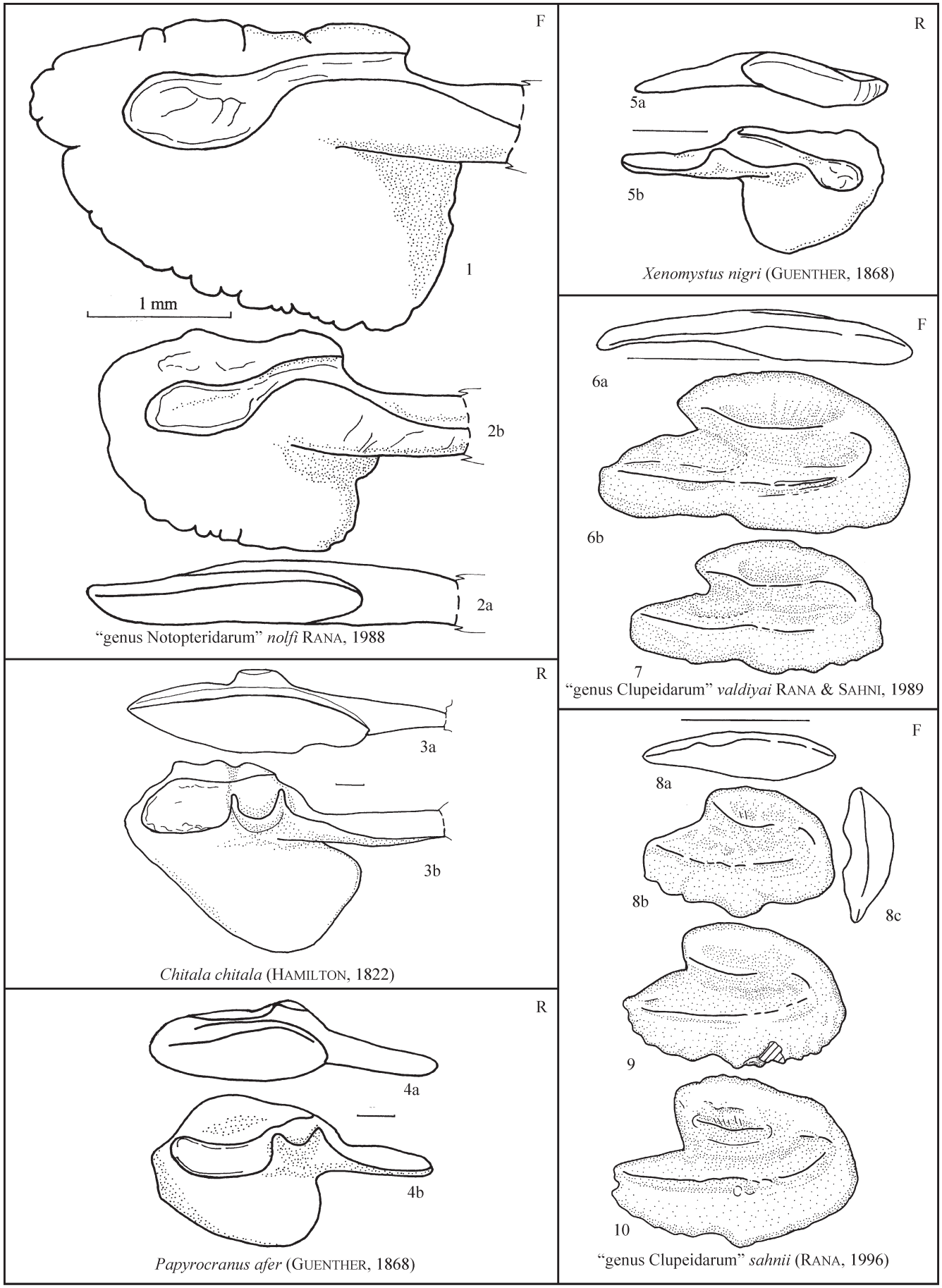

F
1
1 mm
2b
2a
"genus Notopteridarum" *nolfi* RANA, 1988
R
3a
3b
Chitala chitala (HAMILTON, 1822)
R
4a
4b
Papyrocranus afer (GUENTHER, 1868)
R
5a
5b
Xenomystus nigri (GUENTHER, 1868)
F
6a
6b
7
"genus Clupeidarum" *valdiyai* RANA & SAHNI, 1989
F
8a
8b
8c
9
10
"genus Clupeidarum" *sahnii* (RANA, 1996)

PLATE 3

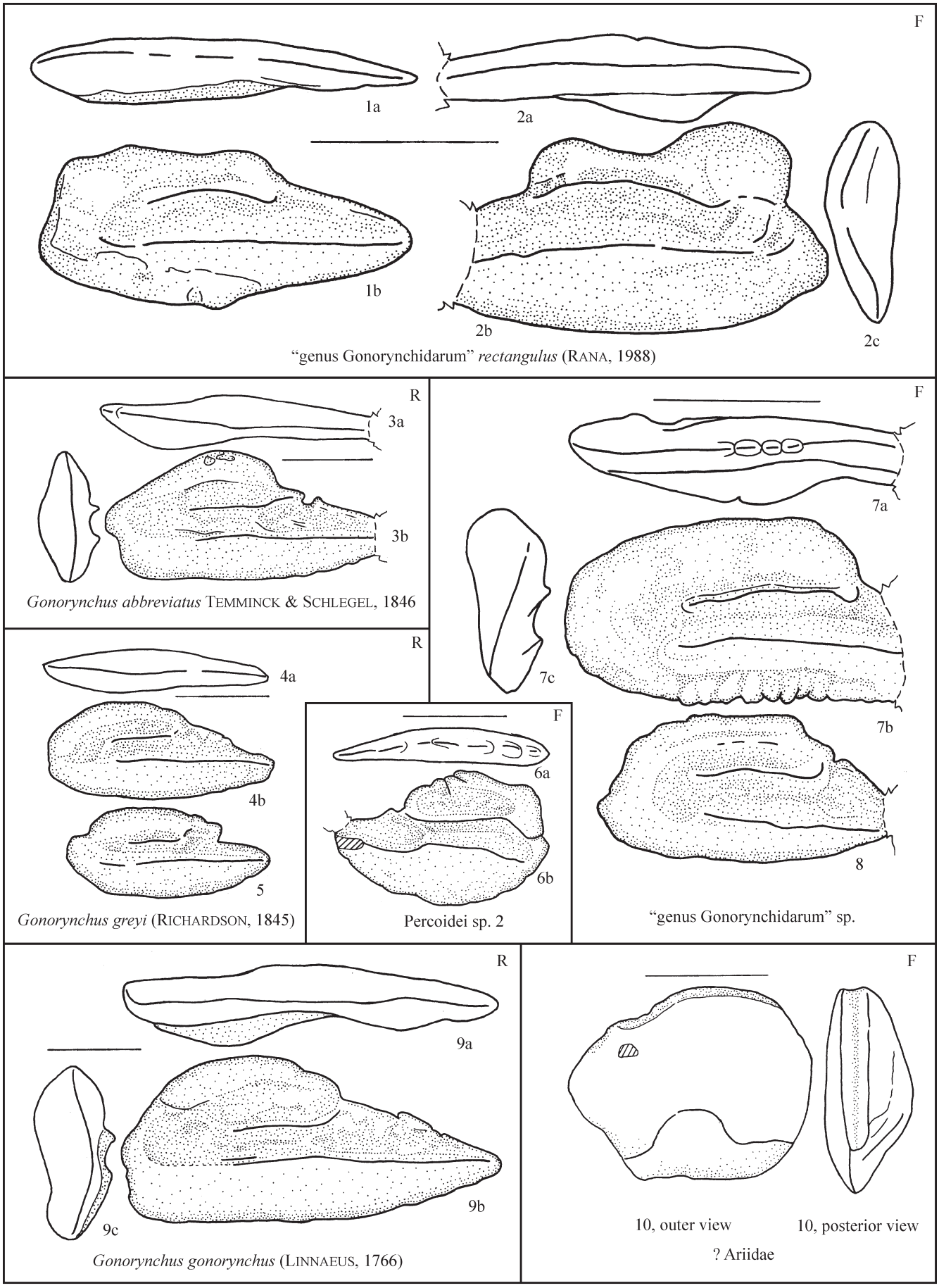
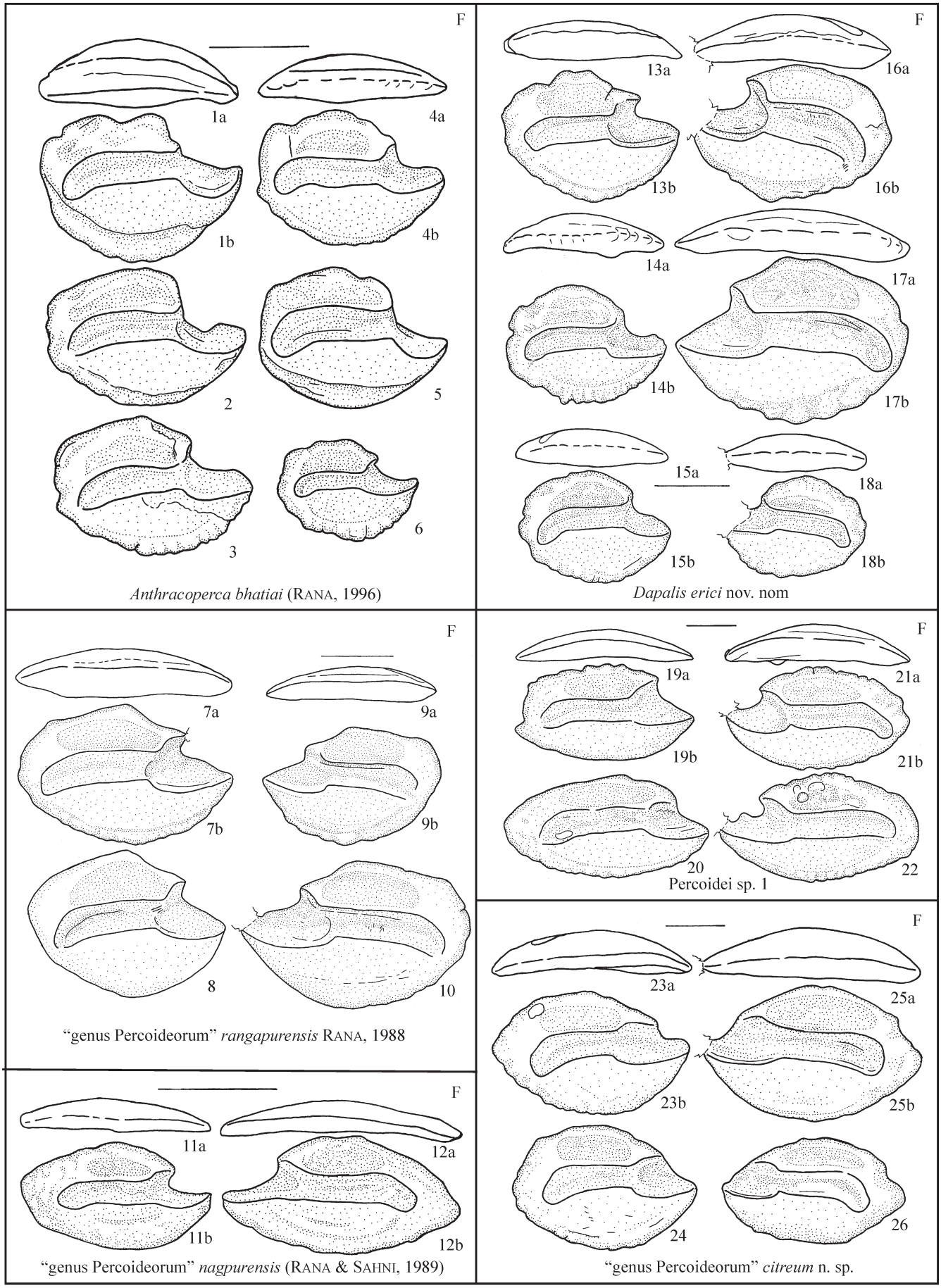

F
1a
2a
1b
2b
2c
"genus Gonorynchidarum" rectangulus (RANA, 1988)
R
3a
3b
Gonorynchus abbreviatus TEMMINCK & SCHLEGEL, 1846
F
7a
7c
7b
8
"genus Gonorynchidarum" sp.
R
4a
4b
5
Gonorynchus greyi (RICHARDSON, 1845)
F
6a
6b
Percoidei sp. 2
R
9a
9b
9c
Gonorynchus gonorynchus (LINNAEUS, 1766)
F
10, outer view
10, posterior view
? Ariidae

PLATE 4



Anthracoperca bhatiai (RANA, 1996)

Dapalis erici nov. nom

"genus Percoideorum" *rangapurensis* RANA, 1988

Percoidei sp. 1

"genus Percoideorum" *nagpurensis* (RANA & SAHNI, 1989)

"genus Percoideorum" *citreum* n. sp.

PLATE 5

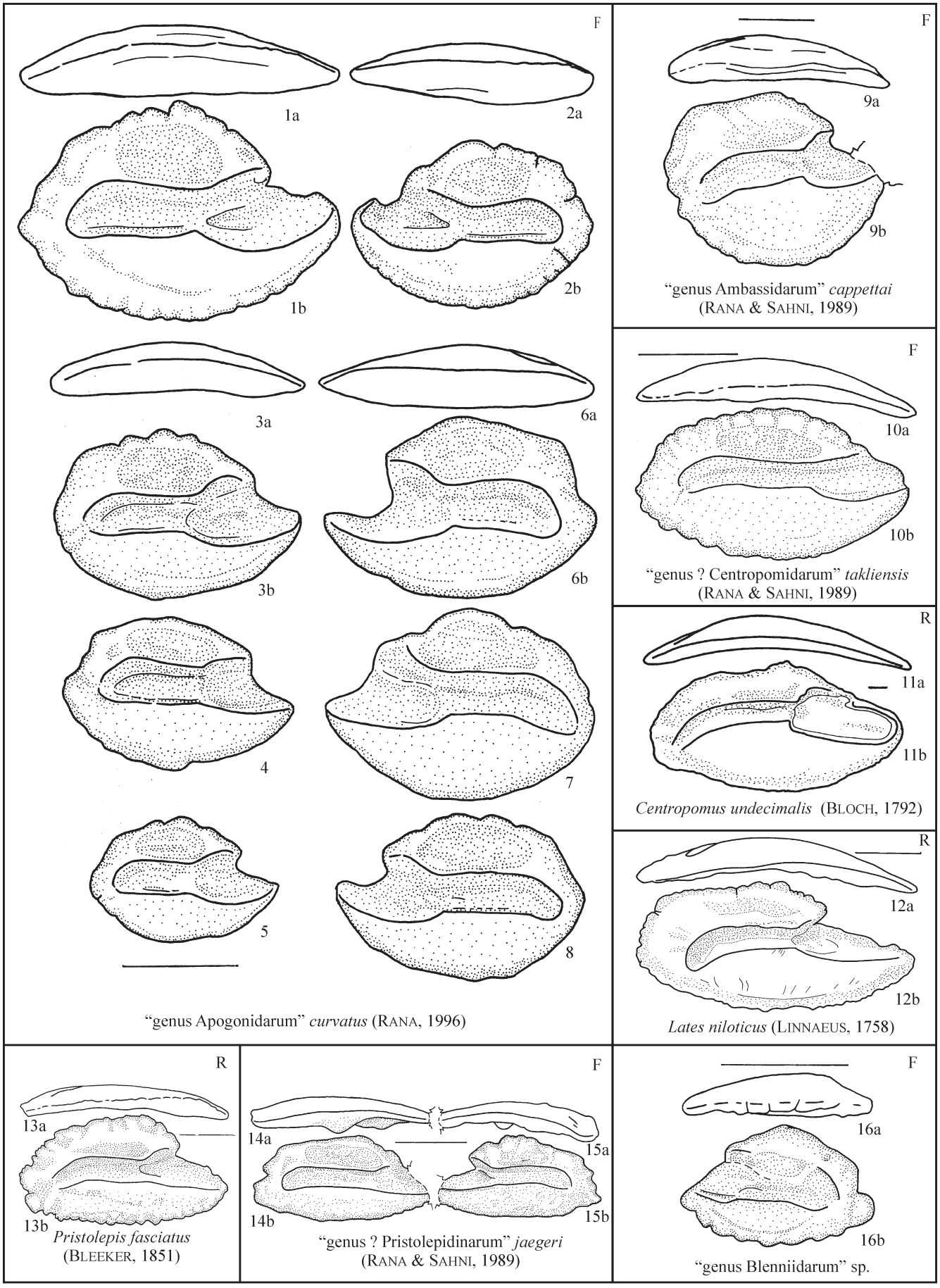

F
1a
2a
1b
2b
3a
6a
3b
6b
4
7
5
8
"genus Apogonidarum" curvatus (RANA, 1996)
F
9a
9b
"genus Ambassidarum" cappettai
(RANA & SAHNI, 1989)
F
10a
10b
"genus ? Centropomidarum" takliensis
(RANA & SAHNI, 1989)
R
11a
11b
Centropomus undecimalis (BLOCH, 1792)
R
12a
12b
Lates niloticus (LINNAEUS, 1758)
R
13a
13b
Pristolepis fasciatus
(BLEEKER, 1851)
F
14a
15a
14b
15b
"genus ? Pristolepidinarum" jaegeri
(RANA & SAHNI, 1989)
F
16a
16b
"genus Blenniidarum" sp.

PLATE 6