First Record of Fossil Otoliths from the Siwaliks of India

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Abstract

This is the first record of fossil otoliths from the Siwalik formation, palaeomagnetically dated to ~2 Ma, exposed near Village Nadah (Haryana, India). The fossil otoliths belong to the Channidae. One otolith is well preserved and is determined as *Channa* aff. *striata* (Bloch), whereas the other two specimens are corroded and can only be classified as *Channa*. sp. Our findings confirm and extend earlier records of channid fishes from those areas that were based on disarticulated skeleton remains.

Keywords: Otoliths, Siwalik, Channidae, India

Introduction

The inner ear of teleost fishes has three different pairs of mineralized structures, named lapillus, sagitta, and asteriscus, and more generally termed as otoliths (Platt and Popper 1981; Nolf, 1985, 1995). The three otolith pairs are morphologically different, with the sagittae usually being the largest one (Nolf, 1985). Otoliths have importance in hearing by enabling the inner ear to mediate the sense of hearing and balance (Popper *et al.*, 2005). In addition, otoliths play an important role in the identification and taxonomy of fossil fish faunas because they display diagnostic features such as outline, pattern and degree of incision of the sulcus, convexity and concavity of their faces and the thickness, that are genus and species specific (Nolf, 1985; 1995).

Fossil otoliths from India are still insufficiently known. Gowda (1966, 1967) was the first who described otoliths from India, the otoliths were found in Upper Cretaceous (Cenomanian) marine sediments. Further, otoliths were reported from marine sediments of Early and Middle Eocene age (Sahni and Saxena, 1982, Middle Eocene of Kutch, Gujarat; Nolf and Bajpai, 1992, Middle Eocene of India and Java; Samant and Bajpai, 2001, Lower Eocene (Cambay Shale); Nolf *et al.*, 2006, Lower Eocene (Ypresian) of Vasatan Lignite Mines, Gujarat). In addition, Rana (1988) reported otoliths from freshwater species from sediments within the Deccan Trapp (Cretaceous-Paleogene Transition) of Rangapur, Hyderabad district, Andhra Pradesh.

However, until to date no otolith records from India are known from Neogene sediments. The objective of this study is to report otoliths from freshwater sediments of the Neogene-Quaternary Siwalik succession of India.

Geology of the Area

The Pinjor Formation of the Siwalik Group is well exposed in the Nadah area (Fig. 1). Lithologically, Pinjor Formation comprises of alternating sequence of soft and friable, greenish grey, dull colour gravelly sandstone with conglomerate lenses and small lenticular calcrete horizons. Conglomerates are polymodal and polymictic, hard, compacted, matrix supported, calcareous cemented and occasionally containing sand lenses, clay pockets, dominated by sub-angular to sub-rounded clast of quartzite, gneiss and granite and khaki colour hard clay which is calcareous. The sandstones in the lower part of this unit comprise impersistent lenses of cemented conglomerates while their frequency and thickness increases towards the top. The Nadah succession has been dated to ~2 Ma based on palaeomagnetic dates, sedimentation rates and fission track ages from tuffaceous mudstones (Tandon and Kumar, 1984; Ranga Rao *et al.*, 1988). The grey mudstone beds that has yielded the otoliths contains ferruginous and calcareous nodules and shows evidence of bioturbation; it is capped by nodular calcium carbonate bands (~15 cm thick) indicating a shallow seasonal pool of limited aerial extent (Patnaik, 1995).

Fig. 1: (A). Location map of the Nadah area with fossil locality in geological map marked by star (modified after Tandon and Kumar, 1984). (B) Litholog showing complete Nadah succession. (C) Detailed litholog of the section showing location of the sample that has yielded the fossil otoliths.

Material and Methods

The otoliths studied come from the Upper Siwalik deposits that are exposed in the vicinity of Chandigarh near Nadah (N 30°41'20.4", E 76°54'21.6"). The otoliths have been recovered together with many rodents, fish teeth, micro-gastropods, ostracods, and charophytes from ~1500 kg of sediment by washing and screening. Mostly the sediment was dissolved in water but for some hard calcareous sediment, kerosene was also used. The dissolved material was screened by different mesh sizes down to 120µm, the remains in the mesh were dried and finally microfossils and otoliths were picked. The terminology used for the otolith description follows Nolf (1985) and is shown in Fig. 2a. For the determination of the otoliths, we used Nolf (1985), Gaudant and Reichenbacher (1998) and Krainara and Wunnitkul (2004) for comparison with recent species and Jost *et al.* (2006) for comparison with fossil species.

Systematic Palaeontology

The described otoliths are housed in the repository of the Centre of Advanced Study in Geology, Panjab University, Chandigarh.

Class OSTEICHTHYES Huxley, 1880
Subclass ACTINOPTERYGII Klein, 1885
Infraclass TELEOSTEI Mueller, 1848
Superorder ACANTHOPTERYGII, Gouan, 1970
Order CHANNIFORMES Greenwood et al. 1966
Family CHANNIDAE (Berg, 1940)
Genus *Channa* Scopoli, 1777
Channa aff. *striata* (Bloch, 1793)
Fig. 2: b

Horizon and Locality: Grey mudstone of the Pinjor Formation of Upper Siwalik, Nadah, near Chandigarh, India.

Material: 1 right sagitta (no. RRS/VF/PU-10).

Description: The sagittae is 3 to 4 mm in length and 2 to 3 mm in width with a thickness of about 1 to 2 mm at the centre. Outline is oval and elongate in shape, ventral border is thick with highly sculptured knobs and furrows. Dorsal border also sculptured and with a cap like ridge in the middle. Anterior and posterior borders are angular. Inner face is highly convex along the long axis while outer face is somewhat concave. The colliculum are most pronounced at the ostium end. The sulcus is long, wide and curved towards the ventral border; it is closed at the posterior end, but opened interiorly. The incision on the crista superior and crista inferior represents the separation of ostium and cauda, which is additionally indicated by the starting point of the caudal colliculum that is ovate on the posterior side and angular and curved towards the anterior side. The rostrum is angularly curved. The antirostrum and excisura are not clearly recognizable. The outer surface shows distinct growth lines.

Remarks: The otolith shows some similarity to that of *Channa striata* (see Gaudant and Reichenbacher, 1998: Fig. 2B). The general outline and cauda are similar, but the ostium is

more bent towards the ventral border in the fossil specimen and the central part of the crista superior and crista inferior are horizontal, , whereas in *C. striata* they are curved. The borders of the fossil otolith are dentate, whereas in *C. striata* only the dorsal border is dentate and the ventral border is smooth. Based on the above mentioned differences to the present-day species the fossil otolith is assigned to *Channa* aff. *striata* (Bloch).

Channa sp.
Fig. 2: c, d

Material: Two left sagittae (no. RRS/VF/PU-11, 12)

Description: The otolith of specimen no. RRS/VF/PU-11 (Fig. 2c) is thick, but strongly corroded. It displays a subrounded outline, posterior border is nearly vertical and undulant, and the ostial border is broken. The ventral border is smooth and the dorsal border is weakly dentate. The sulcus has a broad and small ostium and a long curved cauda, terminating just before the postero-ventral border. The bends are most pronounced towards the cauda end. The obtuse angles on the crista superior and crista inferior indicate the separation of ostium and cauda. The rostrum is curved, but broken anteriorly, antirostrum and excisura are not preserved.

The otolith of specimen no. RRS/VF/PU-12 (Fig. 2d) is strongly corroded and the anterodorsal part is not preserved. The sulcus is slightly curved toward the posterior margin and the ostium is straight with an anterior opening. Inner and outer surface are weakly convex, along the long axis.

Remarks: These specimens show some similarity with the otolith of *Channa* aff. *striata* described above, but can not be determined on the species level due to their incomplete preservation.

Discussion and Conclusion

Fossil otoliths of Channidae from the Siwalik deposits of India were not known before and confirm previous reports on the presence of these fishes that were based on skeletal remains from the Middle Siwaliks of Northern India (Lydekker, 1886; Sahni and Khare, 1977) and from the Siwaliks of Pakistan (McClelland, 1844). The rich channid material described by Sahni and Khare (1977), comprising thousands of isolated skeletal remains from the Ladhyani beds (Haritalyangar), Himachal Pradesh, was assigned to three new *Channa* species, i.e. *C. bhimachari* (Sahni and Khare (1977)), *C. gregoryi* (Sahni and Khare (1977)), and *C. romeri* (Sahni and Khare, 1977). In addition, fossils of Channidae were mentioned from the Pleistocene of Java (Boesman, 1949).

At present, the genus *Channa* (*Ophiocephalus*) is represented by four species in the Indian subcontinent: *C. punctatus* (Bloch, 1793), *C. marulius* (F. Hamilton, 1822), *C. gachuna* (F. Hamilton, 1822), and *C. striatus* (Bloch, 1793). They live in the rivers of the Indo-Gangetic plain and also in the peninsular Indian rivers and in the rivers of the south and southeastern countries, such as Burma, Ceylon, Malaya, Thailand, China, Islands of the East Indian Archipelago (Sahni and Khare, 1977). The otoliths from the Pinjor Formation of the Siwalik group extend the range of fossil Channidae from the Neogene up to the Pleistocene,

but more studies are necessary to understand the relation between the fossil and the present-day species.

Fig. 2: (a) Morphological nomenclature of the inner face of the otolith (sagittae). (b) Inner face of the right sagitta of *Channa aff. striata*. (c-d) Inner face of left sagittae of *Channa sp.* Scale bar: 500 µm.

Abbreviations used: an- anterior part; ant- anterostrum; ex- excisura; ro- rostrum; ob-ostial border; db- distal border; pb- posterior border; vb- Ventral border; cs- crista superior; ci- crista inferior; co-colliculum.

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