FOSSIL FISH REMAINS FROM COASTAL GONDWANA RAGHAVAPURAM MUDSTONE, WEST GODAVARI DISTRICT, ANDHRA PRADESH, INDIA

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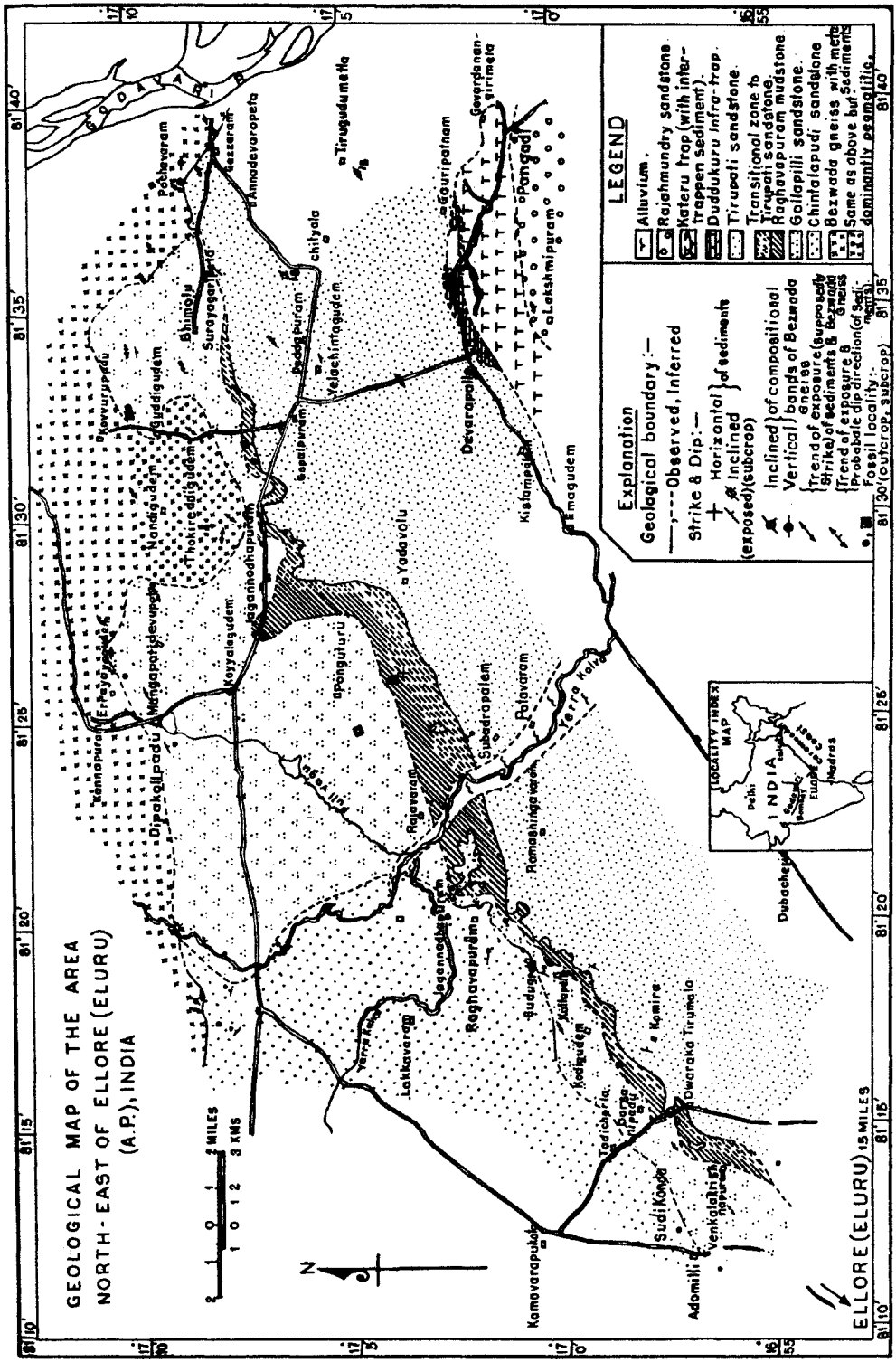
The Raghavapuram Mudstone, an intercalated marginal marine, lower Cretaceous formation in the East Coast Gondwana rocks of India, contains fragmentary remains and complete skeletons of fish. The fragmentary remains consist mainly of scales and vertebrae, together with teeth, fin-rays, neural and haemal spines and parts of tails. Of these, it has been possible to classify empirically the large number of scales into two groups—*Type A* and *Type B*. The former group shows affinity with the scales of some elopids and berycoids and the latter with those of Cretaceous Ichthyodectids. The skeleton is identified as *Clupavus* cf. *neocomiensis* (Bassani) Arambourg 1954, and is compared with those reported from Rajmahal (India) and Tsalfat (Morocco). On the basis of this assemblage of fish faunules, a Neocomian-Cenomanian age-interval has been assigned to the formation. This age-interval is also supported by other associated invertebrate remains such as foraminifers and ammonites.

Contemporary fish remains from other parts of India are regionally discussed. The discovery of these fish remains from lower Cretaceous Raghavapuram Mudstone may now be regarded as the earliest occurrence of the marine teleosts in peninsular India.

INTRODUCTION

A large number of casts and impressions of dissociated fossil fish remains, together with a few almost complete skeletons, have been recovered from the Raghavapuram Mudstone which form an intercalated marginal marine formation in the coastal Gondwana sequence of West Godavari District, Andhra Pradesh, India (Text Fig. 1). The formation is about 57 metres thick. Scales, vertebrae and teeth constitute the major dissociated fish remains of the formation. In addition, stray fin-rays, neural and haemal spines and fragmentary portions of tails are also found to occur. Previously, King (1880) mentioned only the presence of two kinds of cycloid scales in this formation, which were not supported by any illustration or description. The most useful collection in the present search has been, however, the recovery of the more or less complete skeletons of the fish and a few well-preserved scales. There are other animal and plant fossils (Baksi 1966, 1967, 1968) that occur in association with these fish faunules. These include pelecypods, ammonites and foraminifers amongst invertebrates and mainly gymnospermic fronds and cones amongst the phanerogams.



TEXT FIG. 1. Geological map of the area north-east of Ellore (Eluru), Andhra Pradesh, India

Preservation and Recovery

All the fish remains, whether dissociated or complete, are preserved mostly as casts and impressions. Moulds of the centrum of the vertebrae are also common. The void portions in the preservations of these impressions (Plate IV, Fig. 3) lead to the suggestion that the organic remains were destroyed *in situ* by some chemical processes after lithification (hardening) of the overlying sediments. This is in contrast to the other mode of preservation, in which case the organic remains were destroyed almost penecontemporaneously, before the overlying sediment became hardened (lithified). In the latter case, casts and moulds of the same side are obtained, as in the cases of the complete skeletons (Plate V, Fig. 1). These have been particularly evident from the fossils which have been recovered in counterparts. Scales are mostly the impressions and there are cases where the impressions of both sides of the scales are preserved, as revealed by the counterparts. Most of the remains have been obtained by chance-spliting the rock after having some surface indications at places.

Description and Identification

The fragments of fish remains* are described under four heads: (i) Scales, (ii) Isolated Vertebrae, (iii) Tooth, and (iv) Skeleton.

(i) *Scales:* The scales vary in shape, being quadrangular, elliptical to perfectly circular. These range in dimensions from 5 mm to 14 mm, which are the measurements of the longest diameter. These are preserved either as impressions or as thin moulds of the outer surface.

Except for the occurrence of the ill-preserved placoid-type scales, all others are cycloid scales which can be grouped broadly under the following two types:

Type A: Specimens—SKB 20/12/1A/62 and SKB 20/12/1B/62 (counterparts), SKB 4/3/1/63 and SKB 14/12/1/62 (Plate III, Figs. 1–4).

All the scales characteristically show pits (not tubercles as may appear in the Figures due to optical illusion) in the apical region; having circuli 12–16 in number, with very fine, regular, radial ridges. No basal radii are seen. Nuclear area is small. Since these are moulds (and not casts), originally the structures of the apical region are not pits but tubercles or low spines. The hind margin is perfectly entire (not spiny).

Many teleost fishes show this type of scales. These scales are particularly found to occur in some leopids (such as *Holcolepis*) and in berycoids.

Type B: Specimens—SKB 29/12/1/62 and SKB 1/1/1–2/63 (Plate III, Fig. 5; also Plate IV, Fig. 1).

*The type specimens described are kept in the depository of the Geological Studies Unit, Indian Statistical Institute, Calcutta.

Plate III, Figs. 1–5. 1, Cycloid Scale Type A from adjoining north valley (17° 02′ 17″ N : 81° 20′ 46″ E) of a small hill, locally called Bara Konda; Specimen No. SKB 20/12/1A/62; 2, Counterpart to above Fig. 1; Specimen No. SKB 20/12/1B/62; 3, Cycloid Scale Type A (of different shape) from a small hill locally called Narasimha Meta (17° 02′ 47″ N : 81° 20′ 30″ E); Specimen No. SKB 14/12/1/62; 4, Cycloid Scale Type A (partially preserved) from a small hill locally called Bara Konda (17° 02′ 02″ N : 81° 01″ E), Specimen No. SKB 4/3/1/63; 5, Cycloid Scale Type B from the locality as above, Specimen No. SKB 29/12/1/62.

1

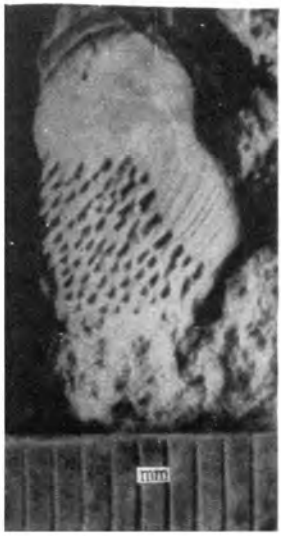
5 mm

2

5 mm

5 mm

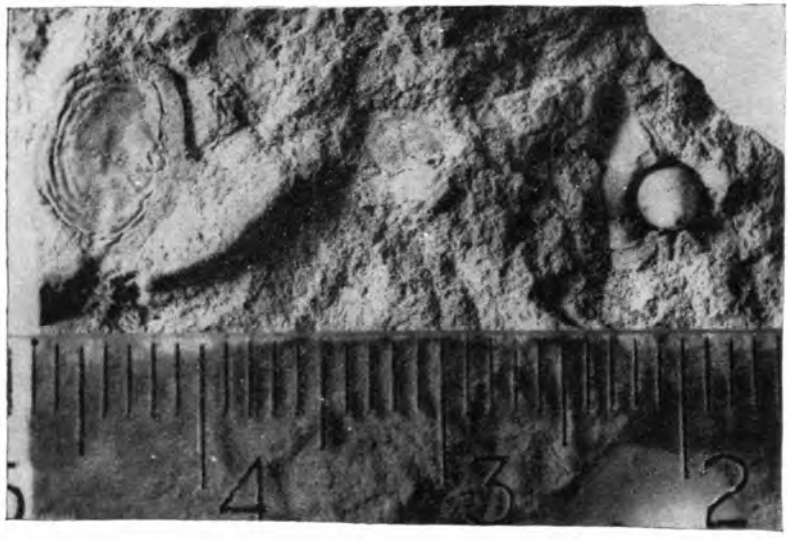
3



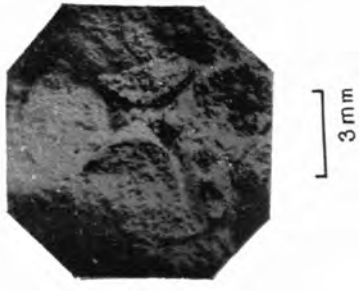
4

6 mm

5



1



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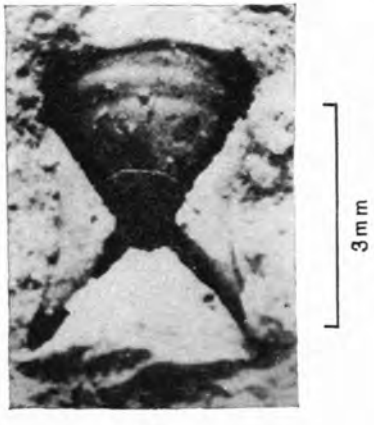


3

4

Somewhat crushed and fragmentary scales of this type are quite frequent in this formation. These have no ornamentation except a few alternate ridges and grooves, which vary between 5–8 in number. The nuclear area is smooth, except a diametrical ridge in some of the specimens.

These are also cycloid scales and are thought to be typical of many primitive teleost groups like some of the Cretaceous Ichthyodectids (e.g. *Ichthyodectes*).

(ii) *Isolated Vertebrae:* Specimens—SKB 21/12/7/62, 1/1/1–1/63, 1/1/1–2/63, 1/1/1–3/63 (Plate IV, Figs. 1–4).

Quite a large number of complete and partial vertebrae are found in this formation. These are preserved as impressions, moulds and casts. Sometimes only the cast of half of the centrum is preserved (Plate IV, Fig. 1). The average size of the full vertebrae is roughly 5–7 mm long and 3–4 mm high.

There are no characters of any diagnostic value to comment on their affinities that they might belong to the leptolepids or any other teleosts

(iii) *Tooth:* A singular specimen in the form of an impression of a shark tooth was found. The tooth (Text Fig. 4) might belong to a lamnoid shark.

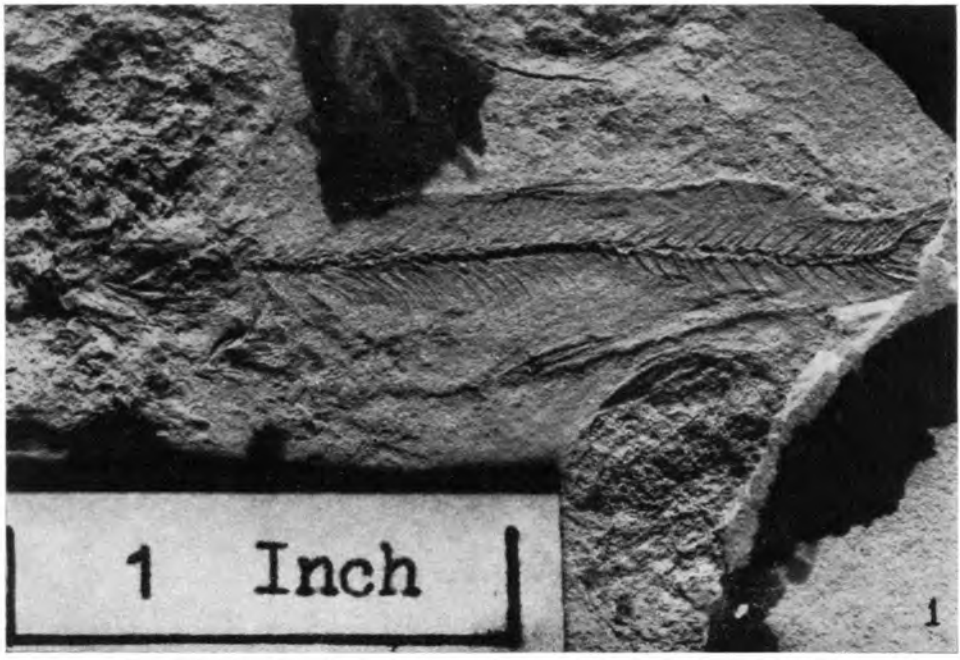
(iv) *Skeleton:* Specimen No. SKB 30/1/1/65; *Locality:* Dwarka Tirumala; Order, Teleostomi; Sub-order, Isospondyli; Family, **Clupeidae**; Genus *Clupavus*; Species, *Clupavus* cf. *neocomiensis* (Bassani) Arambourg 1954 (Plate V, Figs. 1 and 2; Text Figs. 2 and 3).

Description: Shape elongate, fusiform, small body without any abdominal keel, total length of the fish about 5 cm the distance between the tip of the muzzle and the beginning of the caudal about 4 times the head; paired pectoral fins and pelvic fins, dorsal and pelvics opposed, trace of pelvic girdle present; pectoral fin on the level of abdominal profile with 12–14 rays, robust and rarely branching, length of fin-rays 6–7 mm, pelvic fin turned backward at the 18th to 19th vertebrae level and diametrically opposite to the beginning of the dorsal, fin-rays about 10–12, dorsal fin with 13–15 rays, anal fin rather ill-preserved, turned backward and nearer the caudal than the pelvic, with about 6–7 rays, its articulation corresponds to the 9th penultimate caudal vertebrae. Caudal fin conspicuously bifurcate (better seen in SKB 24/2/1/64) and symmetrical, each lobe comprising a tuft of 13–14 principal rays

Efforts have been made to reconstruct the anatomy of the skull as far as practicable. The skull is about 10 mm in length (Text Fig. 2), but nothing of diagnostic value was decipherable.

Vertebrae about 40 in number, of which 14 caudal, relatively more in length than in height, form of an hour-glass; last 4 or 5 caudal vertebrae progressively shortened; hypural plates (Text Fig. 3) 6–7 in number, welded together in appear-

PLATE IV : FIGS. 1–4. 1, A Cycloid Scale Type B on the left half of the photograph and a cast of half-centrum of a vertebra on the right half of the photograph, from Eddla Gattu (17° 01′ 31″ N : 81° 20′ 00″ E), Specimen No. SKB 1/1/1-3/63; 2, Cast of a partially broken vertebra from the same locality as above, Specimen No. SKB 1/1/1-4/63; 3, A complete vertebra from the adjoining north valley (17° 02′ 17″ N : 81° 20′ 46″ E) of the small hill locally called Bara Konda, Specimen No. SKB 21/12/7/62; 4, Mould of a half vertebra from Eddla Gattu (17° 01′ 31″ N : 81° 20′ 00″ E), Specimen No. SKB 1/1/1-2/63.



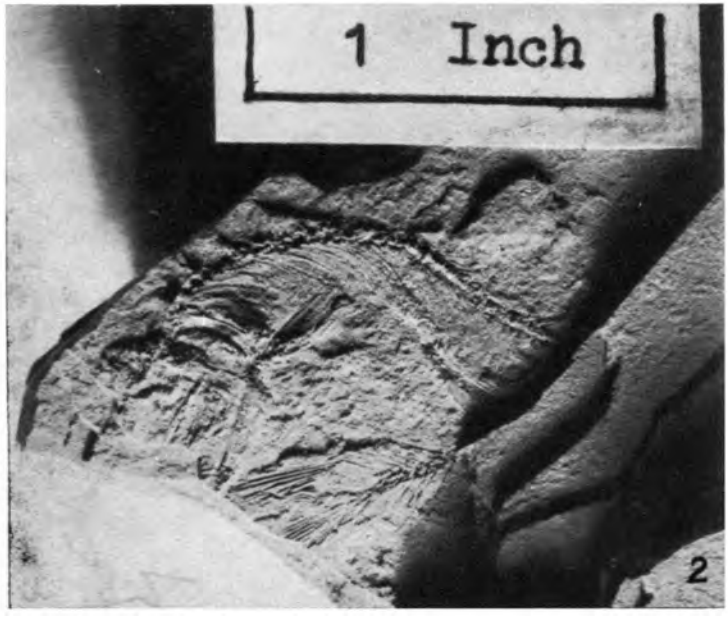


PLATE V : FIGS. 1–2. 1, Skeleton of *Clupavus* cf. *neocomiensis* (Bassani) Arambourg 1954, from Dwarka Tirumala (16° 57′ 36″ N : 81° 15′ 19″ E), Specimen No. SKB 30/1/1-1/65; 2, Skeleton of *Clupavus* cf. *neocomiensis* (Bassani) Arambourg 1954 showing in particular the tail of the fossil (also see the corresponding sketch of the tail in Text Fig. 3) from the same locality as above, Specimen No. SKB 30/1/1-2/65.

ance; 4–5 of them supporting the fins of the dorsal lobe of the caudal and 2 of them supporting the fins of the ventral lobe.

Formula: Vert. 26 or 27+14; D 10 or 12; A 6 or 7; P 12 or 14; V 10 or 12; C 12/14–12/14.

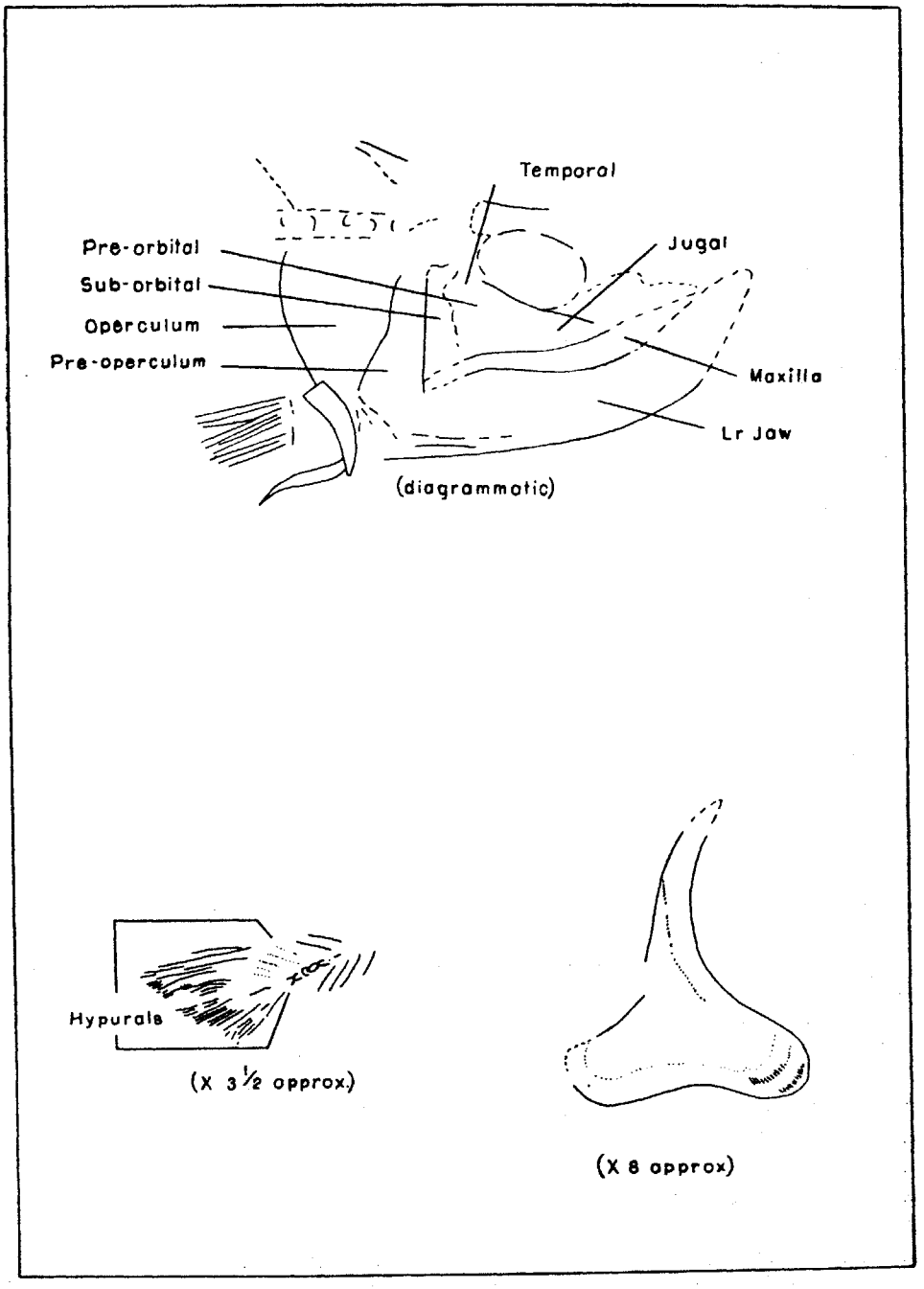
Discussion: The skeleton compares very well with *Clupavus* cf. *neocomiensis* (Bassani) Arambourg 1954 in shape, size, axial and appendicular skeletal structures. In many anatomical structures, there are similarities between *Leptolepis* and *Clupavus*. The distinction between these two depends on the structure of the skull roof (not well preserved in the present specimens) and the caudal fin skeleton (Arambourg 1954). The latter shows similarities with that of the genus *Clupavus*. Moreover, the scales of the *Type A* are very much unlikely in the beds containing *Leptolepis*.

Misra and Saxena (1964) have reported a new fossil fish from the Rajmahal hills and have identified it as *Jhingrania roonwali* n. gen., n. sp. This fossil fish belongs also to a clupeid and appears to have some similarities with *Clupavus* cf. *neocomiensis*. But it has not been compared with the latter, instead, the affinity has been suggested with the living genus *Smithites* Jordan and Gilbert. Moreover, it differs from Morocco or Raghavapuram specimens in having larger size, different fin counts and somewhat different axial skeleton-structures, particularly those of tail. Comparative measurements of fossils obtained from Raghavapuram by the author and from Rajmahal hills by Misra and Saxena (1964) and from Morocco by Arambourg (1954), are given in Table I.

Discussion on Age and Assemblage

The fish remains of the Raghavapuram Mudstone, admittedly a poor fauna as such, reflect some light on the age of the formation. The *Type B* scales belonging to the teleosts compare very well with some of the Cretaceous Ichthyodectids (particularly, *Ichthyodectes*). Although the chirocentrids (e.g. *Thrissops*), in general, are known from the Kimmeridgian, there is no knowledge of the occurrence of scales of this type in any Upper Jurassic forms; so a Cretaceous age may be assigned to these scales. Regarding the *Type A* scales, Dr. Patterson (personal communication) of British Museum of Natural History is of the opinion that these scales are unlikely much before the Aptian and he has found almost exactly similar scales in the English Gault (Albian).

The skeleton throws more light on the age of the fish assemblage. The genus *Clupavus* ranges from Purbeckian to Cenomanian. Combining the evidences of the scales of the *Type A*, as discussed above, with the generic distribution of the genus *Clupavus*, the age interval of the assemblage may be deduced as between Aptian-Cenomanian. With the specific identification of the genus as *Clupavus* cf. *neocomiensis*, the age interval may be further enlarged to accommodate Neocomian also, in which case the oldest occurrence of the scales of the *Type A* has to be lowered to Neocomian. The other associated animal remains, particularly the ammonites and the foraminifers, confirm this age-interval for the formation, which is independently deduced on the basis of the fish faunules.


Temporal
Pre-orbital
Sub-orbital
Operculum
Pre-operculum
Jugal
Maxilla
Lr Jaw
(diagrammatic)
Hypurals
(X 3 1/2 approx.)
(X 8 approx)

TEXT FIGS. 2–4.

TABLE I

Measurements (in mm) *and comparison of the fossil fish from* India *and* Morocco

Criteria of measurements (in mm)	Raghavapuram Specimen No. SKB 30/1/1-1/65 (Baksi)	Tsalfat (Morocco) specimens No. T. 132, No. T. 243 (Arambourg 1954, p. 33)		Rajmahal Specimen No. RSF 135, right half. (Misra and Saxena 1964 (1959), p. 32)
Length without caudal	40	45	51	109
Maximum height	10	9	10	—
Length of the head ..	10	13	13	26
Diameter of the orbit	3+(?)	3,5	4	—
Pre-orbital distance ..	4+(?)	3,5	4	—
Length of the mandible	5–6	5	5,4	—
Pre-dorsal distance ..	23	22	22	57
Pre-anal distance ..	35	40(?)	45	—
Pectoral to pelvic distance ..	15	17	17	35
Distance from pelvic to muzzle ..	23	29	30	62
Pelvic to anal distance	11	14	15	29
Height of the *dorsale*	7	7	2+(?)	—
Length of the *pectorale*	5	10	5+(?)	—
Length of the pelvic fin	3+(?)	4	4	—
Length of the *caudale*	7	10	(?)	—
Formula	Vert.	26 or 27+14;	26 or 27+13	46
	D	10 or 12;	2+10	15
	A	6 or 7;	8 or 9	11
	P	12 or 14;	16 to 18	16
	V	10 or 12	10	8
	C	12/14–12/14	10–10(?)	7,12,8

Jhingrania roonwali (Misra and Saxena 1964) is the earliest report of occurrence of the freshwater teleost from the intertrappean beds (at Sakrighat) of the 'Rajmahal series' of 'Jurassic' age (Misra and Saxena 1964). The latter age of the 'Rajmahal series' is questionable (Krishnan 1960) and hence, this fish remain occupies an ambiguous place in the Mesozoic stratigraphy of India.

The earliest marine teleost known so far from the Mesozoic of perninsular India and more or less well-dated is *Enchodus serratus* Eg. (Lydekker 1887). This

TEXT FIGS. 2–4. 2, Diagrammatic sketch of the skull of *Clupavus* cf. *neocomiensis* (Bassani) Arambourg 1954 from Dwarka Tirumala (16° 57′ 36″ N : 81° 15′ 19″ E), Specimen No. SKB 30/1/1–1/65; 3, Camera-lucida sketch of a portion of the tail of *Clupavus* cf. *neocomiensis* (Bassani) Arambourg 1954 from Dwarka Tirumala (16° 57′ 36″ N : 81° 15′ 19″), Specimen No. SKB 30/1/1–2/65; 4, Camera-lucida sketch of a shark tooth from Bara Konda (17° 02′ 02″ N : 81° 21′ 01″ E) Specimen No SKB 21/12/1/62.

TABLE II

Stratigraphic occurrence of early teleost remains in peninsular India

Age	Stratigraphic units	Fish fauna	Habitat
Eocene	Deothan and Kheri Intertrappean beds (within Deccan Trap)	Mainly teleosts (known by scales)	Freshwater to Estuarine
Cretaceous — Upper	Niniyur Stage; Ariyalur Stage; Trichinopoly Stage; Uttatur Stage	Lameta beds; Dhamni; Intertraps (within Deccan trap) — Mainly a shark fauna	*Clupea* — Marine/Estuarine
Cretaceous — Lower	Raghavapuram Mudstone	Mainly *teleosts*	Brackish marine
Jurassic — Upper, Middle, Lower	Kota formation	Rajmahal series (which part of Jurassic—not known) — only holostean (Family: *Semionotidae*)	A teleost (taking that Rajmahal Sr. is of Jurassic age) — Freshwater/ Freshwater

occurs in the Ariyalur Stage (Senonian-Danian) of the Cretaceous succession of Trichinopoly. Since the Raghavapuram Mudstone is decidedly older than the Ariyalur Stage, the marine, bony teleost remains from the Raghavapuram Mudstone formation should *now be regarded as the earliest occurrence of the group in peninsular India* (Table II).

In fact, the marine Cretaceous fish fauna of India, which is known only from the Ariyalur Stage of South India, consists mainly of sharks. These shark remains are *Ptychodus latissimus* Eg. (also found in the upper Green-sand Chalk of Europe), *Otodus* cf. *semiplicatus* Munst., *Lamna* (*Oxyrhina, Meristodon*) sp., *Corax pristodontus* and *Odontaspis*. The Raghavapuram Mudstone, however, appears to record a paucity of shark faunas, more so, in the context of the occurrence of a rich crop of the teleost scales and vertebrae. Only one kind of shark tooth (that of a lamnoid one) is found in this formation, which is a very rare occurrence. Condemning preservation as a factor, because of good potentiality of shark tooth for preservation as fossils, it may be suggested that the sharks were really very poor in number in the fish population of the Raghavapuram Mudstone. It may be that actually the contemporaneous (Lr. Cretaceous) sea was poor in the sharks which flourished later in the Upper Cretaceous time to dominate the fish population of the Ariyalur Stage. The other possibility remains that the physico-chemical attributes of the basinal environments had a check on the wider distribution of the sharks.

More inland, Hora (1939) records teleost scales in the infra- and inter-trap sediments of Madhya Pradesh (Central India). He favoured a Lower Eocene age of these sediments on the basis of the following fish remains, as indentified by him—*Lepisosteus indicus, Pycnodus lametae, Eoserranus hislopi, Nandus, Pristolepis, Scleropages, Musperia, Clupea* and some percoid fishes. The Lameta fish remains (*Eoserranus, Lepisosteus* and *Pycnodont*) are also regarded of an age between the 'Danian Cretaceous and the Upper Eocene' (Woodward 1908). Regarding the environments of these sediments, Hora (1939) makes an interesting remark that the occurrence of the Nandidae, the Pristolepidae the Polyacanthidae and the Serranidae in the inter-trappean beds at Deothan and Kheri also indicates the maritime nature of the sea, for fishes of these families, even at the present day, are commonly met with in freshwater areas not far removed from the sea. Although he does not commit, these deposits are thought to be of freshwater origin. The marine fish remains of the Raghavapuram Mudstone although decidedly older than the above may, however, prove to be precursors of some of the members of the assemblage of the Deccan infra- and inter-trappeans, particularly worth-mention being the Clupeids.

The Raghavapuram fish remains are certainly younger than the fish fauna of the Kota formation—a formation which once used to have enjoyed a time-equivalency with the present formation. Species of *Dapedium, Tetragonolepis* and *Lepidotes* constitute the fish fauna of the Kota formation. Of these, as known from their type occurrences in Europe, *Dapedium* ranges in age from Rhaetic to Upper Lias, *Tetragonolepis* is confined to Upper Lias and *Lepidotes* is rather a long-ranging genus,

known from Rhaetic to Upper Cretaceous (Jain 1959). None of these holostean (Fm. Semionotidae) fishes occurs in the Raghavapuram Mudstone. With the range and the paleoecology (which is marine in the type area) permitting, *Lepidotes* could have occurred in this formation but the genus probably adapted itself to freshwater environments (Kota formation is supposed to be a freshwater one) before being extinct from peninsular India by the end of the Cretaceous time.

Acknowledgements

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