

LOWER JURASSIC LOWER VERTEBRATES FROM KOTA FORMATION, PRANHITA-GODAVARI VALLEY, INDIA

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ABSTRACT

The Lower Jurassic Kota Formation of Pranhita-Godavari Valley is well known for its Vertebrate fauna like fishes, dinosaurs, pterosaur, crocodiles and early mammals. A number of lower vertebrates have been recovered along with mammals. The lower vertebrates particularly hybodontid (a fresh-water shark), percoid fish, amphibia, sphenodontid and platynotid (lizard) are reported for the first time from the Kota Formation. The paper presents the systematic description of the new forms. The addition of the new forms has thrown new light in tracing out the evolutionary trends of lower vertebrates in the Lower Jurassic period. A critical evaluation may help us in understanding the palaeoecological and palaeobiogeographical aspects.

INTRODUCTION

The Kota Formation has yielded a rich assemblage of vertebrate fauna. The fossil fishes include members of the families Semionotidae, Coelacanthidae and Pholidopheridae (Yadagiri and Prasad, 1977). Reptiles are well represented in the Kota Formation. These include a rhamphorhynchid Pterosaur, Sauropod dinosaurs and crocodiles (Jain, 1974).

The mammalian fauna came to light with the discovery of their dental remains in the Lower Jurassic Kota Formation (Datta, Yadagiri and Rao, 1978). The occurrence of early mammals in India may be considered fairly large in number during Early Jurassic times, as three new genera of symmetrodonts and an amphidontid symmetrodont have already been described (Datta, 1981; Yadagiri, 1984, 1985).

The mammalian remains were obtained by screening marly clay through a series of sieves. Alongwith mammals, a number of well preserved skeletal parts of lower vertebrates were recovered from the washed material which were systematically studied. They include a fresh water shark (hybodont), and a percoid fish, lizards and frogs. The present paper describes the above fossil groups systematically.

GEOLOGICAL SETTING

The Upper Gondwanas of the Pranhita-Godavari Valley were considered as consisting of three "groups" namely Maleri, Kota and Chikiala in order of succession (King, 1881). Later, Jain *et al.* (1964) and Kutty (1969) have modified the stratigraphy in the light of lithology and additional vertebrate fossils collected from these formations. The Kota Formation is composed of sandstones and clay bands with a prominent zone of limestone (Yadagiri, 1979). The vertebrate remains, in particular fishes, indicate a Liassic age for the formation (Jain,

1973, 1974, Yadagiri and Prasad, 1977).

The microvertebrate collection has been made from the clays immediately underlying the fossiliferous limestone horizon. The clay and associated sandstone beds are underlain by the Dharmaram Formation of Rhaetic age (Kutty, 1969).

SYSTEMATIC DESCRIPTION

Well preserved lateral teeth of a freshwater shark of Hybodontidae Family were collected for the first time from Lower Jurassic Kota Formation, India.

<i>Class</i>	Elasmobranchii
<i>Order</i>	Heterodontiformes
<i>Family</i>	Hybodontidae
<i>Genus</i>	<i>Lonchidion</i> ESTES (1964)

Lonchidion indicus n. sp.

(Pl. I—a, b)

Holotype: GSI, TI. 1. (Pl. I—a, b)

Diagnosis: Tiny fresh water hybodonts with nonsculptured, low crowned, elongated lateral teeth having a large labial projection, well defined and distinct projection on lingual face, teeth with enameloid layer.

Description: The lateral teeth are elongate and somewhat swollen. The teeth plate curves in anterior and posterior portions (Pl. I—b) and can be clearly seen in the occlusal view. The surface of the tooth lacks prominent sculpture or striae, except for variable development of undulations. The crown of the tooth is constricted where it joins the root. There is a sharp well developed crest which runs the length of the tooth possessing tiny cusps. The central cusp has a prominent projecting pro-

cess in the labial side which is smooth and conical. From the central cusp, a continuation of the occlusal crest extends labially along the process. The central cusp on lingual side has a less prominent projecting process, which is considered as an important character.

The total length of the lateral tooth (GSI.TI.1) in occlusal view is 2.4 mm. The width of the tooth is 0.9 mm. It possess three undulations on either side of the central cusp, the central cusp being the largest. The tooth crown is fully enameloid.

Comparisons: A freshwater xenacanthid (pleuracanth) shark fossil was reported by Jain (1980) from Upper Triassic Maleri Formation. The Kota specimens were compared with other known fresh water hybodonts. They are comparable in generic characters, but differ in specific characters. The fresh water hybodonts are known from Triassic and Cretaceous horizons and *Lonchidion indicus* from Kota Formation is the first report from Jurassic.

Lonchidion selachas Estes (1964) is the type species of the genus recovered from the Lance Formation (Cretaceous, Maestrichtian) of Wyoming. These teeth are similar to *Lonchidion indicus* in that the crowns in both species are smooth and possess a well developed labial buttress, but they differ in the shape of the buttress. The size of the teeth in *Lonchidion selachas* (2.6 mm) is comparable to *Lonchidion indicus* (2.4 mm). However the presence of accessory cusps in *Lonchidion selachas* and a distinct projecting process on lingual side are characters which support in differentiation of a new species. *Lonchidion humblei* was reported from the Dockum Group (Triassic) of Texas (Murry, 1981). *Lonchidion indicus* is similar to *Lonchidion humblei* in possessing a smooth crown whose occlusal crest is compressed into a rather sharp ridge. But it is larger than *Lonchidion humblei* (1.0-1.56 mm).

Six taxa from the Wealden (Lower Cretaceous of Great Britain) have been referred to *Lonchidion*. *Lonchidion breve breve* (Patterson, 1966) is very common sub-species throughout Wealden. The teeth are small, crown length range from 1.4 to 3.4 mm. However, the labial buttress, in *Lonchidion indicus* does not overhang as it does in most species of *Lonchidion breve breve*.

Teeth of *Lonchidion babulskii* (Carpetta and Case 1975) were discovered in Monmouth Group (Cretaceous; Maestrichtian) of New Jersey. This species is similar to *Lonchidion indicus* in having teeth swollen on the lingual face; and their lateral borders inclined lingually. However this species differs by its larger teeth (approximately 3-7 mm) and the labial buttress overhangs the root.

Type Locality: GSI. TI. 1 from Yamanapalli excavation

and GSI.TI.2 from Paikasigudam both are complete lateral teeth.

Etymology: The *Lonchidion* species reported from India, hence the species name 'indicus'.

Order Perciformes

Genus et sp. indeterminate

(Pl. I—c, d, e)

Referred specimens: Pharyngeal, teeth GSI.TI.3 to GSI.TI.6.

Type Locality: Paikasigudem, Kota Formation, Lower Jurassic.

Description: About 60 specimens of pharyngeal teeth were recovered from Paikasigudem which show variation in size, ranging from 0.5 mm to 1 mm and in shape of the hook in the apex of the teeth. The pharyngeal teeth are laterally compressed and bear a characteristic hook at the apex. The shapes are variable (Pl.I—c,d,e) but the specimens are noteworthy for the length and slenderness of hooked-shaped cusp. The specimens have a shiny enameloid covering and are characterised by transparent enamel grown in the top portion of the hooked cusp.

Comments: The pharyngeal teeth are found in isolated condition but laterally compressed nature and the characteristic hooked-shaped cusp are comparable to *Platycodon nanus*. The size range in Kota specimens is 0.5 mm to 1 mm. The hooked cusp curves at an angle of 45° from the crown and the top portion is in transparent enamel.

Sahni and Kumar (1980) and Sahni *et al.* (1981) have reported *Stephanodus* from Subathu type section. Jain and Sahni (1983) described *Stephanodus* from *Pisdura* (Lameta Formation). The Kota pharyngeal teeth are comparable to a limited extent with *Stephanodus* in having flattened crown with claw like cusp. However, in *Stephanodus* the clawlike cusp is characterised by an inner ridge which is slender and sharp. The crown is conical in shape it may be grouped under family Scianidae. The genus and species are indeterminate.

Class	Amphibia
Order	Salientia
Family	Pelobatidae

(Pl. I—f, g, h)

Holotype: Mandible (GSI.TI.19) (Pl. I—f, g)

Referred specimen: right ilium (GSI.TI.20)

Diagnosis: The dentary of medium size with foramen on exterior, labial surface smooth, teeth pleurodont with a

pointed apex, the shaft of the ilia is relatively stout and shorter, the acetabulum is large, its posterior border almost flush with the surface, and its anterior border prominently raised.

Description: The dentary is of medium size, which measures 0.9 mm in length. A gradual curvature is seen from the middle of the dentary in the exterior towards dorsal and ventral as well. A foramen is present on labial side. The teeth on lingual side extend vertically down in the dentary upto a tooth gutter. The teeth on lingual side are partly eroded, showing outer margins which are in triangular form.

The ilium is characterised by the shape of the acetabulum and the relatively greater elongation of the posterior ischial process. The shaft is relatively stouter and suboval and there is a small dorsal tubercle. From this point the shaft rises and is slightly expanded. The acetabulum is relatively large; its posterior border almost flush with the surface, and its anterior border prominently raised. The ischial process is pointed and the pubic process is expanded enough so that the border of the acetabulum falls well within the boundaries of the bone.

Comparisons: Pelobatidae are restricted today to the Eastern oriental region (*Megophrys*), temperate Europe (*Pelobates*), North America (*Scaphiopus*) and the Seychelle Islands. Recently, a Pelobatid was reported from Deccan traps in India (Sahni *et al.* 1982).

The Kota Pelobatid differs from the unnamed pelobatid from Deccan traps in having smooth surface. The maxilla of the Pelobatid from Traps shows ornamentation. The ilium of Kota specimen also different in having relatively large acetabulum and short and stout shaft. It also differs from other known genera of pelobatidae. The teeth in the dorsal margin of the dentary rise in pyramidal form. On lingual side, the teeth are arranged at an angle and in contact with each other. The above characters distinguish the new form from other known pelobatidae. However designating the specimens to new genus is deferred for the present.

Horizon and type locality: Lower Jurassic Kota Formation, Paikasingudem, Andhra Pradesh.

Order	Urodela
Suborder	Meantes
Family	Sirenidae

(Pl. I—i, j)

Holotype: GSI.TI.16, a lower Jaw.

Referred specimens: Mandible with one teeth (TSI.TI.17 and mandible with four teeth GS.TI.10).

Diagnosis: The dentary has a strong medial curvature toward the symphysis, which is slightly expanded posteriorly. Anteriorly, the Jaw is narrow, and teeth reach almost to its lower border. The teeth bearing border is sharply constricted posteriorly. Externally, a deep incised groove runs anteriorly. No other foramina are present in the dentary. The teeth are pleurodont and nonpedicellate. Each teeth is thin walled and has a basal foramen. The midshaft of the teeth are not wedge shaped as in *Habrosaurus dilatatus*.

Description: There are three specimens in the collection which are helpful for describing the form. The lower Jaw (GSI.TI.16) possess the anterior part and part of posterior. The preservation of teeth is incomplete. One tooth is fairly well preserved, except the apex, in the specimen GSI.TI.17. In the specimen GSI.TI. 18, four teeth are preserved but the apices are broken.

The lower jaw preserved measures 1.7 mm. Exterior surface is smooth. The dentary is slender anteriorly and deepen posteriorly. The bone in dorsal view has a pronounced curvature. The tooth bearing border runs horizontally for most of its length, but rises slightly at its posterior end. Anteriorly the Jaw is narrow, and teeth reach almost to its lower border. Meckels' groove is not visible in this part of the Jaw.

The teeth are pleurodont nonpedicellate, that is, there is no division of the tooth into separate base (pedicle) and crown. Each teeth is thin walled and has a basal foramen. The tip of tooth is broken in the specimens, so it cannot be ascertained about the nature of apices. However, it is observed that the teeth are in cylindrical form with thin wall and they are of uniform size through unlike wedge shaped teeth in *Habrosaurus dilatatus* (Estes, 1964).

Comparisons: Urodeles in India were reported (Presumably for the first time) from the Takli Formation of Nagpur (Intertrappeans) by Sahni *et al.* (1982). Urodeles have not been reported earlier from beds younger than Mid Jurassic. Fossil sirens are reported in the Cretaceous of North America from the Albian of Texas, from the Maestrichtian of Montana and Wyoming (Estes, 1964).

Recent members of the family sirenidae are restricted to the southern coast of North America. They share a number of common features with the cretaceous Habrosaurus. Kota urodeles has certain similarities when compared with *Habrosaurus* like medial curvature toward the symphysis and constiction of tooth bearing border in the posterior. The exterior surface is smooth in both the forms. The teeth of Kota urodeles are pleurodont and nonpedicellate. Each teeth is equidimensional from base to top and they are in contact with each other externally. The apex portion of the tooth is not preserved in the specimen, so it cannot be ascertained whether it is bent or not. Further comparisons and palaeobiogeographical

aspects are deferred because of lack of other skeletal elements.

Horizon and type locality: Paikasigudem in Andhra Pradesh, India. Marly clays from Kota Formation of Lower Jurassic age.

Order Rhynchocephalia
Family Sphenodontidae

(Pl. I—o, p, q)

Holotype: Mandible with four teeth (GSI.TI. 17), successional dentition.

Referred specimens: Mandibles with four teeth GSI.TI.8 and GSI.TI.9 which represent hatchling dentition and mandibles with three teeth (GSI.TI.10 and GSI.TI. 11) which represent additional teeth, GSI.TI.12, the mandible consisting of successional dentition.

Diagnosis: A sphenodontid in which the cheek teeth are wider than long, acrodont and blunt pyramidal in form, slightly concave anterior face and straight posterior edge. The dentition consists of three sets of teeth viz., hatchling teeth consisting of pyramidal and conical teeth that alternate in size; successional dentition consisting of larger, anteroposteriorly compressed teeth of equal size and additional teeth consisting of relatively large teeth.

Description: The collection represents isolated mandibles possessing different sets of dentition. They have been assigned to the dentition which are similar to *opisthias*, the North American Late Jurassic sphenodontid. However, the Kota sphenodontid differs with *Opisthias rarus* which has vertical ridges (3 to 4) on lateral face of the teeth and each tooth embraces the other at base.

The teeth in Kota Sphenodontid are acrodont, pyramidal in form. The apices of some of the teeth are worn out. The hatchling dentition in GSI.TI.8 and 9, the large tooth is pyramidal in shape and followed by conical smaller teeth on either side. The apex of the large teeth is blunt. The two mandibles consisting of hatchling dentition measure 1.4 mm and 1.2 mm respectively.

The additional dentition of *Kota Sphenodontid* is present in two mandibles (GSI.TI.10 and 11) which can be seen in Pl. I-Q. One tooth is larger in pyramidal form, but the apex is slightly sharp. A vertical ridge is present on the lateral face of the teeth. The smaller teeth are also in the pyramidal form. One is in contact with the large one and the second one is apart with a gap. Vertical ridges are also present on the smaller teeth. The apices in these teeth are sharp.

Comparisons: The dentition of an adult *Sphenodontis* consists of three sets of teeth (Harrison, 1901). In the terminology of Robinson (1976) these are: 1. a hatchling dentition consisting of relatively small, conical teeth, conical teeth that alternate in size. 2. a successional dentition consisting of larger, somewhat antero-posteriorly compressed teeth that do not alternate in size, these replace a portion of the hatchling dentition, 3. additional teeth consisting of relatively, larger teeth added behind the hatchling and successional teeth. Sphenodontids thrived from Triassic to Recent. The Rhynchocephalian *Hyporodapedon* of Rhynchosauridae family was described from Maleri Formation of Pranhita-Godavari Valley. A sphenodontid is reported for the first time from Kota Formation.

The small Jaw fragments (1.2 mm to 1.6 mm) bearing teeth are very similar in form, particularly in teeth shape, to the North American Late Jurassic Sphenodontid *Opisthias* (Gilmore 1909). In *Opisthias rarus*, the teeth have a quadrangular base. No hatchling teeth are present. The successional teeth show considerably more wear than the more posterior additional teeth.

In Kota sphenodontid, three sets of teeth are present which are found in isolated mandibles. The successional teeth differ with teeth in *Opisthias rarus* having vertical ridges on lateral surface. The additional teeth with sharp apex are similar to teeth of *Opisthias rarus* in having sharp apices but differ in having a vertical ridge on the lateral surface. Moreover, the teeth are smaller in size than *Opisthias rarus*. The designation of Kota sphenodontids to generic level is deferred now for want of additional specimens

Type Locality: Paikasigudem in Andhra Pradesh, Lower Jurassic Kota Formation.

Order Sauria
Suborder Anguimorpha
Infra Order Platynota
Superfamily Varandidea
Family Parasaniwidae, ESTES,

Genus *Paikasisaurus* n. gen.
Paikasisaurus indicus n. sp.

(Pl. I—r, s.)

Holotype: GSI.TI.14, left dentary with the teeth.

Referred Specimen: GSI.TI.15, left dentary with one tooth

Diagnosis: Small size platynota with uniform sized teeth having simple basal fluting. The lack of complicated infolding of the tooth base into the medullary cavity separates it from other varanoids, teeth are compressed

laterally, much more so at the crown, and have trenchent borders, convex anteriorly and concave posteriorly, and usually more or less recurved. The apices are sharply pointed and each tooth has a basal foramen in the interdental position. The teeth are traversed by striae.

Description: The dentary is relatively slender and lightly built and its external face is unornamented with large antero-posteriorly elongate inferior alveolar foramina. The intermandibular septum is fused to the floor of the Meckelian groove. The dentary preserved is 1.3 mm in size and teeth are as tall as 1 mm. Teeth are subpleurodent, and the bases are oval expanded, and thrown into smooth, internally directed folds. The striae rise from the border of the base run upto apex and of the same length all around the tooth. The teeth are compressed on sides much more so at the crown, and have trenchent borders, convex anteriorly, concave posteriorly, and usually more or less recurved. The apices are sharply pointed. Each tooth has a basal foramen in the interdental position.

Comparisons: The living members of Platynota group, the monitor lizards of the old world form the family Varanidae. An East Indian monitor attains the length of a dozen feet. Romer (1962) commented that Platynota appear in the Upper Cretaceous, but is obvious from a phylogenetic standpoint that the ancestral platynotans must have developed before the end of Jurassic. *Paikasisaurus indicus* now supports this view.

The dentary of *Paikasisaurus indicus* possess a number of characters such as simple basal fluting extending into the medullary cavity and lack of complicated infolding, which characterised to include in the family Parasaniwidae (Estes, 1964).

In *Parasaniwa wyomingensis* from Lance Formation, a pair of two teeth are together with a gap in between the pairs. The pair of teeth preserved in *Paikasisaurus* is similar to the dentition of *Parasaniwa*, but it cannot be ascertained about the gap between the pairs of teeth. *Parasaniwa wyomingensis* can be distinguished from *Paraderma bogerti* by its more compressed, fang-like teeth and higher teeth count. *Paikasisaurus* though somewhat closely related to *Parasaniwa*, it differs in the size of the teeth and shape of teeth. The tooth in *Paikasisaurus* measures 1 mm in size whereas it is 4 mm in *Parasaniwa*. Moreover the ratio of maximum width to height of the tooth in the former is 1 whereas it is 2 in the latter. That is to say the teeth of *Paikasisaurus* is stouter than *Parasaniwa* but is compressed with a recurved sharp apex.

Horizon and type locality: Paikasisigudem in Andhra Pradesh. Marly clays of Kota Formation.

Etymology: Named after the locality from where the fossils were collected and the species after India.

SIGNIFICANCE OF LOWER VERTEBRATES FROM LOWER JURASSIC KOTA SEDIMENT

The report of lower vertebrates from Lower Jurassic Kota Formation is of great significance because some of the forms are reported for the first time from India and a few forms are recorded from older geological horizons. A critical evaluation will help us in tracing out their evolutionary trends and in understanding palaeoecological and palaeobiogeographical aspects.

The Lower Vertebrates particularly hybodontids (freshwater shark); percoid fish, amphibia (fossil frog), sphenodontid and platynotid (lizard) are reported for the first time from Lower Jurassic Kota Formation, Pranhita-Godavari Valley, India. The Kota Formation earlier has yielded a rich vertebrate fauna which include two sauropod dinosaurs *Barapasaurus tagoreli* (Jain *et al.* 1979) *Kotasaurus yamanpalliensis* (Yadagiri *et al.* 1979 and Yadagiri (in press), fishes (Yadagiri, 1980), a Pterosaur *Campylongnathoides indicus* (Jain, 1974) and early mammals (Datta *et al.* 1978, Yadagiri 1984, 1985). Now, with the addition of new forms, a well balanced palaeoecological model for the Lower Jurassic period can be reconstructed. The Kota vertebrate fauna includes an interesting assemblage of stream and stream bank community (fishes, crocodile and amphibia) terrestrial community (dinosaurs, sphenodontids and early mammals) and arboreal community (Pterosaurs).

A fresh water, xenacanthid, *Xenacanthus indicus* (Jain, 1980) was reported from underlying Maleri Formation (Upper Triassic), so it is not a surprise to find a hybodont (fresh water shark). *Lonchidion* was earlier reported from Triassic (Murry; 1981). Lower Cretaceous (Patterson, 1966) and Upper Cretaceous (Estes, 1964), *Lonchidion indicus* from Kota Formation is closely related to *Lonchidion selachas* from the Lance Formation (Maestrichtian) of Wyoming.

The Pharyngeal teeth from Kota Formation, though has certain resemblance to *Stephanodus*, it is not possible to assign them to any particular genus based on isolated teeth. The occurrence of pharyngeal teeth in Kota sediments is very high when compared to other Lower Vertebrates.

Fossil frogs are known from India from intertrappean beds viz., *Indobatrachus pussilus* and *Indobatrachus malabricus* (Verma, 1975).

*Kota Urodela is comparable to Sirenidae family. Interestingly, Sirenids are now restricted to southern coast of North America. The fossil record so far known extends upto Cretaceous. The detailed palaeobiogeographical account of Kota urodeles will be attempted later after new collections and detailed comparisons.

Sphenodontids thrived from Triassic to Recent. The Rhynchocephalian *Hyperdapedon* of Rhynchosauridae family was described from Maleri Formation of Pranhita-Godavari Valley. The report of sphenodont from Kota Formation extends the geographical distribution which was known earlier from North America and South Africa.

The living members of Platynota group, the monitor lizards of the old world form the family varanidae. An East Indian monitor attains the length of a dozen feet. *Paikasisaurus indicus* from Kota Formation possibly is the ancestor for such monitor lizards.

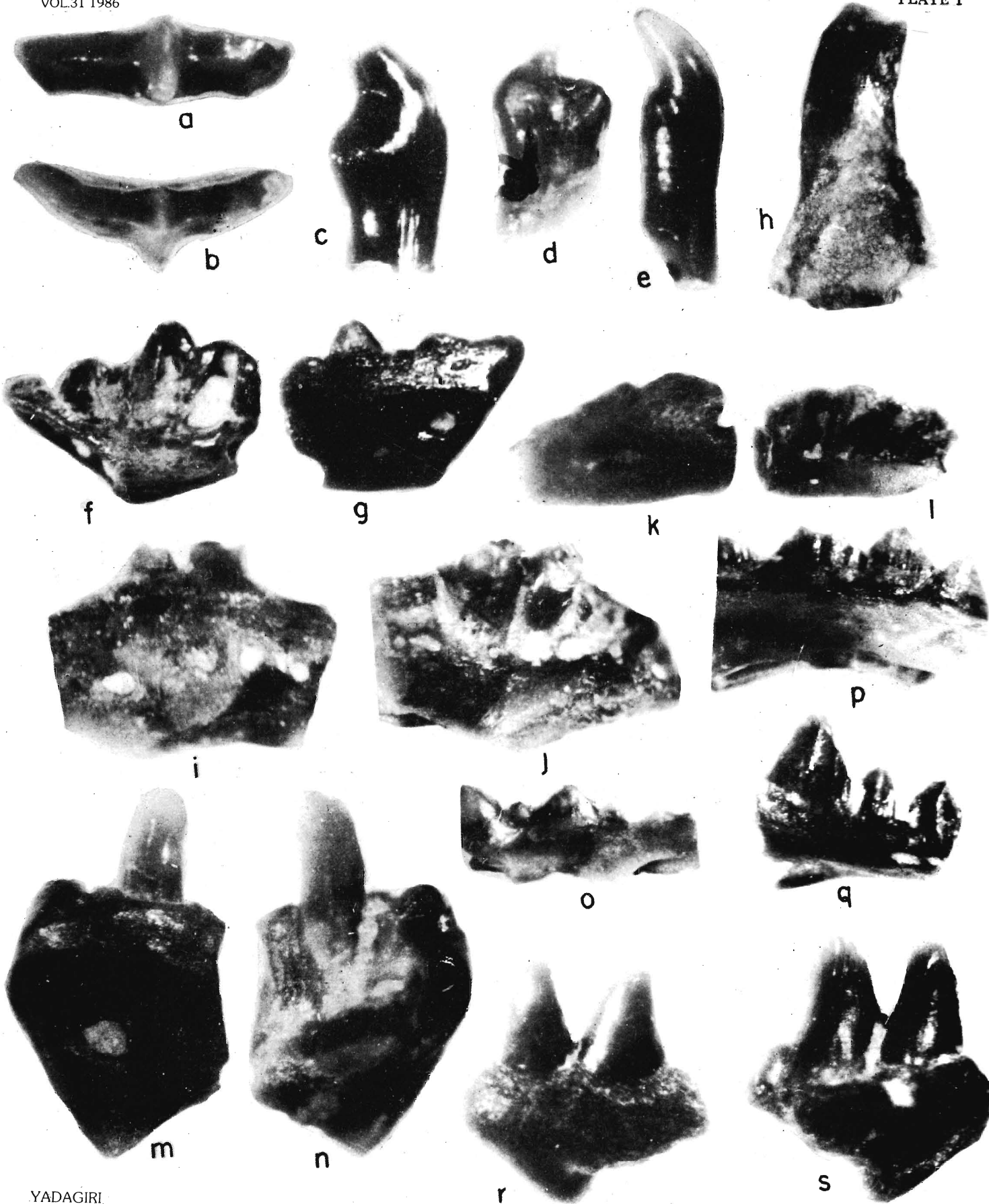
The phylogenetic relationships and palaeobiogeographic considerations are deferred for the present, as the faunal material recovered from different localities from Pranhita-Godavari Valley, is under study.

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EXPLANATION OF PLATE

PLATE I

- a, b *Lonchidion indicus* n. sp. Labial view (a) and occlusal view (b)
X 26
- c, d, e Pharyngeal teeth, Labial views (c) X 50(d) X 80; (e) X 110
- f, g, h Kota pelobatid, mandible in labial view (f) and lingual view (g)
X 50; right illum (h) X 66
- i, j Kota urodeles, lower jaw, holotype in labial view (i) and lingual
view (j) X 26
- k, l, m Mandible in labial view (k) and lingual view (l) X 26. Mandible
with one tooth in labial view (m) and lingual view (n) X 43
- o, p, q Kota sphenodontid, lower jaw with successional dentition (o)
X 69 hatchling dentition (p) X 35 and additional teeth (q) X 41
- r, s *Paikasisaurus indicus* n. sp. left dentary with teeth in labial
view (r) and lingual view (s) X 50.