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Estheriid zonation in the Gondwana

S. C. Ghosh, Ashim Datta, A. Nandi & S. Mukhopadhyay

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Estheriid fauna of the Indian Gondwana is represented by 18 genera of fossil conchostraca. On the basis of recent discoveries of leaiid estheriids from the Lower Gondwana formations four new biozones are added to the previously established horizons. Nine estheriid biozones are now established for the entire Gondwana sequence of India. Lacuna, however, still exist in some of the formations. The biozones proposed are helpful for basinal correlation. There are some excellent index fossils to distinguish the Late Permian and Early Triassic Gondwana sediments and emplace precisely the boundary between them. With the record of Leaiid estheriids emerging from the Indian subcontinent, for the first time, all the five continents of the Gondwanaland can be tied up, solving a long existing problem in understanding the migratory route of the fauna. Indian fauna bears many of the common elements of the Gondwana estheriids of other continents from Late Permian to Jurassic periods. Estheriellids are confined to india (Early Triassic), Africa (Late Triassic) and South America (Jurassic-Cretaceous) only. The Indian species of *Estheriella* bear closer affinity to those of Europe (Bundenstein, Germany). It suggests dispersal of the bioprogram through land connections between the two super-continents during the Early Triassic.

Key-words—Estheriids, Leaiids, Estheriellids, Bioprogram, Gondwana stratigraphy, Continental Drift.

S. C. Ghosh, Ashim Datta, A. Nandi & S. Mukhopadhyay, Geological Survey of India, 4 Chowringhee Lane, Calcutta 700 016, India.

सारांश

गोंडवाना में ऍस्थेरॉयड मंडलन

ऍस० सी० घोष, आशिम दत्ता, ए० नन्दी एवं ऍस० मुखोपाध्याय

भारतीय गोंडवाना का ऍस्थेरॉयड जीवजात अश्मित कॉन्कोस्ट्रेका की 18 प्रजातियों से अभिलक्षणित है। अधरि गोंडवाना शैल-समूहों से उपलब्ध लिऑयड ऍस्थेरॉयडों के अन्वेषण के आधार पर पहले से स्थापित संस्तरों में चार नये जैवमंडल और सम्मिलित किये गये हैं। भारत के सम्पूर्ण गोंडवाना अनुक्रम हेतु अब कुल मिलाकर नौ ऍस्थेरॉयड जैवमंडल स्थापित किये गये हैं। यद्यपि कुछ शैल-समूहों में अभी भी शोध-कार्य होना है। प्रस्तावित जैवमंडल द्रोणीय सहसम्बन्धन में सहायक हैं। कुछ ऐसे विशेष सूचक जीवाश्म हैं जो अर्नातिम परमी एवं प्रारम्भिक त्रिसंघी गोंडवाना अवसादों में विभेद प्रदर्शित करते हैं तथा इनके बीच में एक स्पष्ट सीमा भी इंगित करते हैं। भारतीय उपमहाद्वीप से उपलब्ध लिऑयड ऍस्थेरॉयडों के अभिलेखों के आधार पर गोंडवानाभूमि के सभी पाँचों महाद्वीपों में देशान्तरगामी जीवजात के मार्ग की चिरकालीन समस्या को सुलझाया जा सकता है। अर्नातिम परमी से जूराई कल्प तक अन्य महाद्वीपों की तरह भारतीय जीवजात में गोंडवाना ऍस्थेरॉयडों के बहुत से सामान्य अवयव मिलते हैं। ऍस्थेरियेल्लिड केवल भारत (प्रारम्भिक त्रिसंघी), अफ्रीका (अर्नातिम त्रिसंघी) एवं दक्षिण अमेरिका (जूराई-क्रीटेशी) में ही मिलते हैं। **ऍस्थेरियेल्ला** की भारतीय जातियाँ यूरोपीय जातियों से घनिष्ठ सजातीयता व्यक्त करती हैं। इससे प्रारम्भिक त्रिसंघी कल्प में इन दो महाद्वीपों के मध्य भूमि-संयोजन के माध्यम से जीवजात का एक स्थान से दूसरे स्थान तक प्रवासन व्यक्त होता है।

FOSSIL conchostracans, commonly known as Estheriids, are one of the branchiopod Crustaceans belonging to the Phylum Arthropoda. They are essentially fresh to brackish water dwellers, but generally found in the ephemeral pools of seasonal nature (Tasch, 1969). They can stand the pH volume between 7 and 9 and are intolerant to salinity (Tasch, 1963). For these inherent characteristics, the

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estheriids are unable to cross oceanic barrier and prefer land routes for their migration.

These fresh to brackish water invertebrate fossils are reported from most of the Gondwana formations of India. Previous finds (Jones, 1862; Feistmantel, 1877) were restricted to Mesozoic Gondwana (Ghosh, 1982b). Recent finds of Permian estheriids by Geological Survey of India have augmented information on Gondwana estheriids. Leaiid, the Permian estheriid has been reported for the first time from the Pali Formation of Sohagpur Basin, Madhya Pradesh (Datta, 1987). Subsequently, several finds from Talchir, Barakar and Raniganj formations have been recorded. Though the estheriid occurrences are geographically scattered when stratigraphically arranged they indicate several definite biozones (Text-fig. 1) which can be useful for correlation within a basin (Ghosh *et al.*, 1980). Some of the biozones can be utilized for interbasinal correlation (Ghosh, 1982c).

Fossil conchostrocans are found to occur in both the northern and southern continents. The faunal assemblage of Indian Gondwana are more akin to those of other members of Gondwanaland. Indian Gondwana fauna also show some affinities to those of northern continent. An attempt has been made to describe the data accrued till date on Indian Gondwana estheriids, their distribution in different basins (Table 1a, b), the estheriid biozones (Text-fig. 1) and to discuss briefly the global comparison of the fauna with special reference to Gondwanaland continents.

ESTHERIID BIOZONES

Advent of estheriids in Indian subcontinent is evidenced by *Estheria* sp. (cf. *striata* Muenst) Diener, 1915 (=?*Cyzicus (Euestheria)* sp.) from Carboniferous Po-Series (Horizon G, Lipak River Section, Spiti) in the Himalaya. Moreover, from the Museum specimen of Speckled Sandstone, Salt Range, a fragmentary estheriid has been noticed. These evidences suggest the appearance of fossil conchostraca from the north-west of India in the geological history of fossil conchostraca. Subsequently a part of the Pangean fauna became the main stock from which later taxa developed and dispersed during Gondwana sedimentation.

Leaiids are reported from all other Gondwana continents, mostly from the Upper Permian strata (Tasch, 1970). It is a well distributed fauna of America and Europe during Carboniferous-Permian age (Raymond, 1946; Kobayashi, 1953). Absence of any leaiid record from Indian subcontinent had posed a difficult problem to the palaeontologists supporting distribution of this terrestrial fauna through land routes (Tasch, 1987). A definite Leaiid horizon of Upper Permian age has now been located (Datta, 1987) which is correlatable with other continents (Novojilov, 1956).

The biozones proposed as per the major genera and characteristic taxa found are reproduced in Text-figure 1 and described separately as follows:

Leaiid Biozone I

The geologically oldest record of fossil conchostraca from the Indian Gondwana is from the Talchir green needle-shale above the basal boulder bed in Saharjuri Basin, Bihar. The fragmentary nature of the valves though do not permit proper identification up to generic level, but the presence of two (Pl. 1, fig. 1; Pl. 3, fig. 7) radial ribs originating from the umbonal region confirm its affinity to family Leaiidae assigning a Late Palaeozoic age to the strata. Associated biota include insect remains and a few fish scales. This horizon needs re-examination in Saharjuri Basin and in other basins as well, as leaiid species depending on the characters of the radial ribs can assign a precise age (Novojilov, 1956). Lower age limit of Talchir Formation can thus be determined.

Leaiid Biozone II

Remains of fossil conchostraca were noticed by Dr S. Chandra, (J. N. Univ., New Delhi) in a bore-hole core in Jharia Coalfield. The compact Barakar carbonaceous shale on closer examination was found to contain fragments of a Leaiid and an Estheriinid shell (Pl. 1, fig. 2) confirming continuation of fauna within the Barakar Formation. Associated biota comprise anthracocid non-marine bivalves.

There is no record of fossil conchostraca from the Barren-Measures and/or its equivalent formations. Thus, a gap has been provided at the corresponding strata (Text-fig. 1) in the biozone column.

Hemicycloeaia-Monoleaia Biozone

The upper greenish-grey shale member of Raniganj Formation intersected in a bore-hole in Andal area, eastern Raniganj Coalfield yielded *Monoleaia* sp., a Leaiid with one posteriorly directed radial rib (Pl. 1, fig. 3A). Some fragments of *Cyzicus* (?) were also found associated with them. This biozone is, however, found to be better developed in Sohagpur Basin, further to the west.

A 0.20 m thick red mudstone band found at the base of Richai Hill in the western periphery of

Sohagpur Basin, has yielded one of the richest assemblage of Leaiid estheriids. The bed underlies a pebbly sandstone, white and lavender clay horizon (=Parsora Formation in the adjacent Johilla Coalfield in the west). The horizon is tentatively placed at the top of Middle Pali (=uppermost member of Raniganj Formation) Formation. Scanty exposures do not permit to assign a definite stratigraphic position to this bed. However, the fossil assemblage, described below, indicates Upper Permian age:

a. *Leaia* (*Hemicycloleaia*) sp. abundant (Pl. 1, figs 5, 7)
b. *Leaia* (*Leaia*) sp. scarce (Pl. 1, fig. 4).
c. *Cycloleaia* sp. frequent (Pl. 1, fig. 6)
d. *Rostroleaia* sp. rare (Pl. 1, fig. 8)
e. *Monoleaia* sp. frequent (Pl. 1, fig. 3B).

Associated biota include insect wing, fish scale and fronds of *Glossopteris*, seeds and root burrows. Further detailed study of the fauna is being carried out.

The *Leaia* (*Hemicycloleaia*) dominated biozone during the Late Permian all over the world strongly suggests it to be a Pangean fauna (Chang *et al.*, 1976; Shen Yanbin, 1984). India played a major role in Late Permian palaeogeographic set up for the dispersal of *L.* (*Hemicycloleaia*) from Australia, through Antarctica to India and possibly to south-east China (Table 3a).

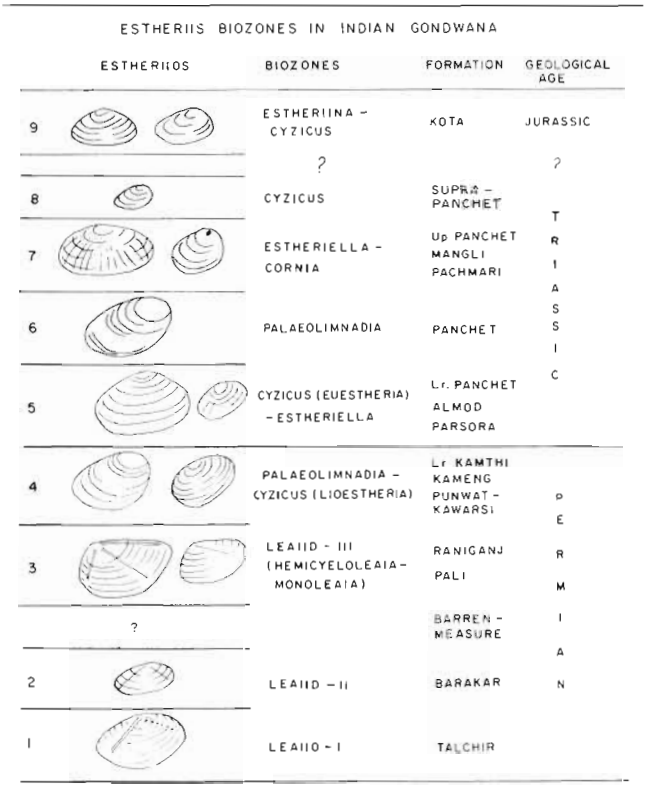
Palaeolimnadia-Cyzicus (Lioestheria) Biozone

The uppermost Permian biozone within the Damuda Group is developed in Raniganj, Ib River and Wardha basins and the Gondwana of Kameng District, Arunachal Pradesh.

A red shale unit belonging to the upper part of Middle Kamthi Formation of Ib River Coalfield, Orissa (S. Mukhopadhyay) has yielded a horizon containing high concentration of estheriids identified as *Palaeolimnadia* sp. (Pl. 1, fig. 10). Another associated larger form *?Pseudoasmussiata* is still under examination. This horizon possibly marks the uppermost biozone within the Permian Gondwana (=Raniganj Formation).

This horizon in Ib River Coalfield is specially noteworthy in containing trail marks of estheriids on the bedding plane (Pl. 3, fig. 5) indicating the beds being the site of dwelling of the fauna. Associated biota include fragments of *Glossopteris*.

The horizon is probably correlatable with the Upper Raniganj *Cyzicus* sp. subzone met with in the bore-hole RNM-3 in Andal area at a depth of about 30 m below the Raniganj-Panchet conformable boundary and about 10 m above the youngest coal seam (R-X) of Raniganj Formation (Ghosh *et al.*, 1987). There is a record of *Cyzicus* (*Lioestheria*) sp.



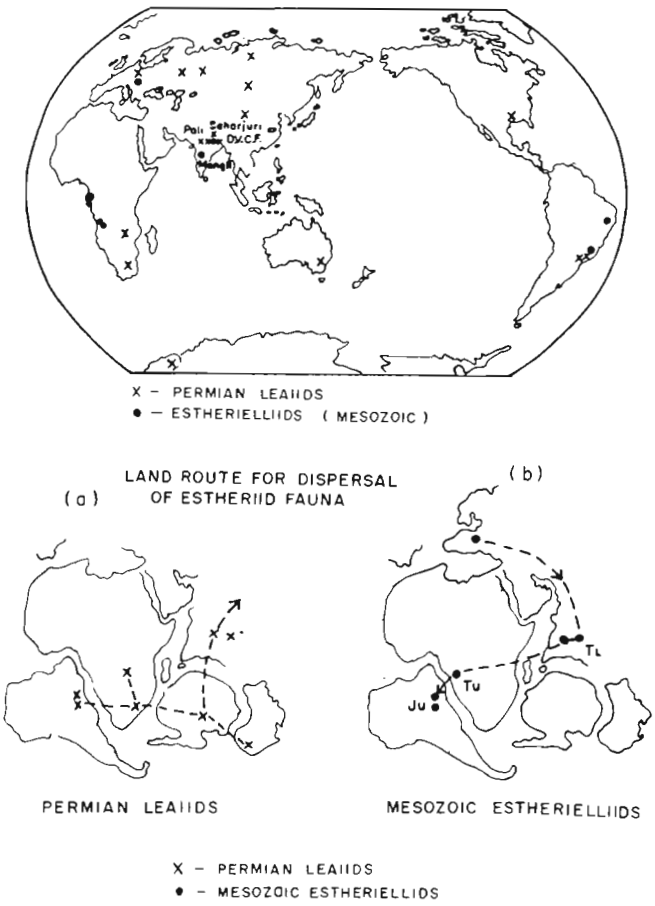
Text-figure 1—Estheriids biozones in Indian Gondwana.

from Punwat-Kawarsi area, Maharashtra in Wardha Basin which possibly belongs to this biozone (Pl. 1, fig. 9). The fauna obtained from eastern Himalaya (Acharyya *et al.*, 1975) also correlatable with this biozone (Pl. 1, fig. 11) alongwith *Estheriina* (pers. comm. : P. P. Satsangi).

Cyzicus (Euestheria)-Estheriella Biozone

The advent of Triassic marks the culmination of leaiids and appearance of estheriellids while other taxa continue (Text-fig. 2). Plant fossils associated with these horizons also corroborate this subdivision. *Glossopteris* is often found to occur with the underlying biozone while *Dicroidium* is associated with this basal Triassic biozone. The biozone is developed in Damodar Valley, Satpura and Johilla basins.

At the base of the Panchet Formation a very well-defined conchostracan zone mainly comprising *Cyzicus* is met with in Raniganj Coalfield (Pl. 2, fig. 9) both in outcrop (Banspetali *nala*, Nunia *nala*, Kanyapur *nala* and other outcrops) and in the bore-holes in Andal area. However, in bore-hole RNM-3 a fragment of *Estheriella* sp. was also found. This horizon marks the basal Panchet Formation and is found in North Karanpura and East Bokaro coalfields and occurs about 20 m above the Raniganj-Panchet boundary. Association of *Estheriella* sp. assigns an



Text-figure 2—Distribution of Leaiids and Estheriellids.

Early Triassic age to this horizon. This horizon extends even beyond the realm of Damodar Valley basins and is met with in Parsora Formation (Pl. 2, fig. 1) in Johilla Coalfield (A. Nandi), and Almod Bed in Satpura Basin where *Cornia* occurs alongwith the *Cyzicus* (*Euestheria*) (Pl. 2, fig. 3). Associated conchostracan genera are *Cycloestheroides* and *Pseudoasmussiata* (Text-fig. 2).

Though the genus *Estheriella* is of singular occurrence in Andal area it has been included in naming the biozone due to its significance as an index fossil for Lower Triassic.

Palaeolimnadia Biozone

This horizon occurs about 50 to 70 m above Panchet-Raniganj boundary and is well developed in Damodar Valley basins. *Cornia* appears in Panchet Formation for the first time in this horizon in Raniganj Coalfield. In North Karanpura Coalfield *Lystrosaurus* fauna occurs alongwith this biozone about 70 m above the Raniganj-Panchet boundary (Chakraborty & Ghosh, 1973).

Estheriella-Cornia Biozone

The biozone is best developed at the top of Panchet Formation, i.e. about 250 m above Raniganj-Panchet boundary in Dhardharwa *nala*, East Bokaro Coalfield, Bihar. There are several species of *Estheriella* of which *E. sastryii* Ghosh 1983 is dominant (Pl. 2, fig. 11; Pl. 3, fig. 8). *E. taschi* (Ghosh & Shah, 1977) has been assigned to a new genus *Cornutestheriella* (Tasch, 1987). The other dominant genus is *Cornia* (Pl. 2, fig. 7) which is represented by several species (Novojilov, 1970). This same horizon, though without *Estheriella*, is also met with in Andal group of bore-holes at a level of about 200 m above the basal *Cyzicus-Estheriella* biozone. Vertexiid group represented by *Cornia, Gabenestheria* and *Vertexia* (Ghosh, 1980) occurs in this horizon in Andal bore-hole (Pl. 3, figs 1, 2). The biozone is again very well-developed in Mangli Bed, Wardha Basin (Ghosh, 1983). *Cyzicus* is found in large numbers besides the captioned *Estheriella* (Pl. 2, fig. 10) and *Cornia* (Pl. 2, fig. 6). The Pachmari Formation in the type area contains this biozone represented by fragmentary-*Cornia* (Pl. 2, fig. 5) and *Cyzicus* (courtsey Dr S. Chanda).

Cyzicus (Euestheria) Biozone

The only estheriid biozone encountered within the Supra-Panchet sediments comprises mainly

PLATE 1 →

1. Leaiid conchostraca, Talchir Formation, Saharjuri Coalfield, Bihar. Umbonal part broken, nodose posterior rib prominent. Magnification × 22, SEM photo.
2. Leaiid conchostraca, Barakar Formation, Jharia Coalfield, Bihar (Bore-hole core sample, courtsey Dr S. Chanda). × 15.

3A. *Monoleaia* sp., Raniganj Formation, Raniganj Coalfield, SEM photo. × 20.

3B. (?)*Monoleaia* sp., Pali Formation, Sohagpur Coalfield. × 12.

4. *Leaia (Leaia)* sp., Pali Formation, Sohagpur Coalfield, SEM photo. × 22.
5. *Leaia (Hemicycloleaia)* sp., Pali Formation, Sohagpur Basin. × 12.
6. *Cycloleaia* sp., Pali Formation, Sohagpur Basin. × 12.
7. *Leaia (Hemicycloleaia)* sp., Pali Formation, Sohagpur Basin. × 12.
8. *Rostroleaia* sp., Pali Formation, Sohagpur Basin. × 15.
9. *Cyzicus (Lioestheria)* sp., Kawarsi area, Wardha Basin. × 10.
10. *Palaeolimnadia* sp., Kamthi Formation, Ib River. × 10.
11. *Cyzicus (Lioestheria)* sp., Kameng Gondwana (courtsey Shri P. P. Satsangi). × 15.

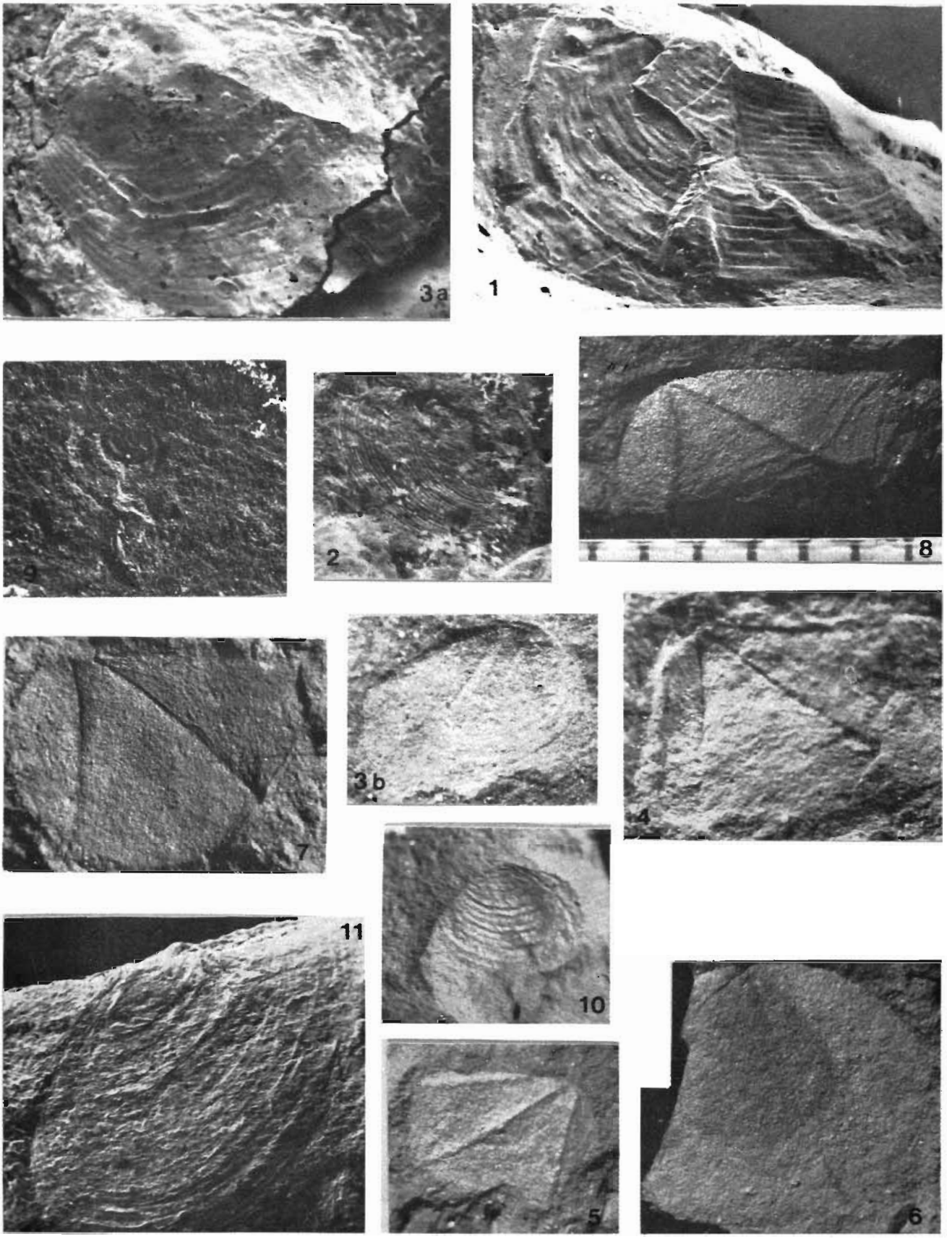
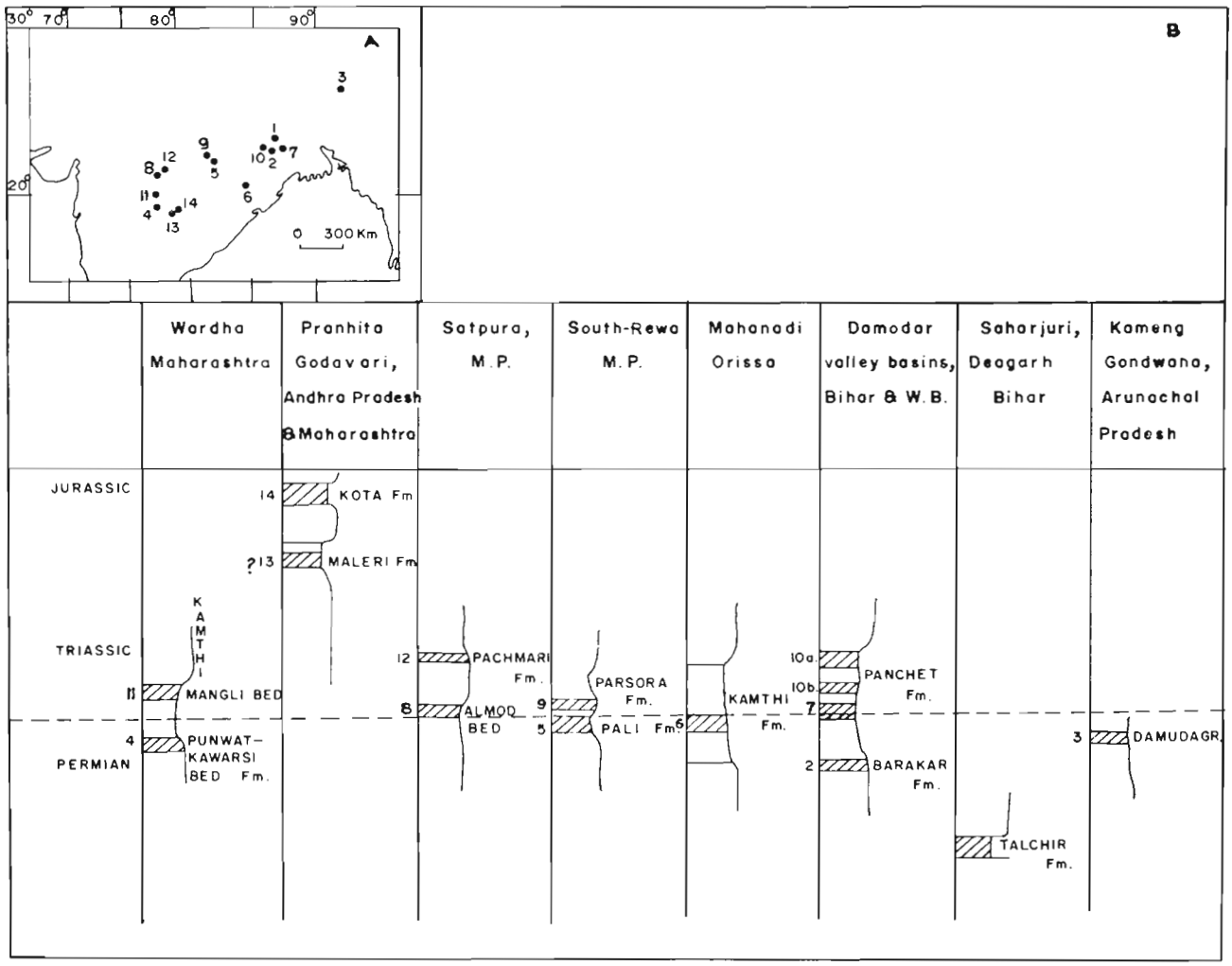


PLATE 1

Table 1—Lithostratigraphic sequence showing distribution of estheriid-biozones in Indian Gondwana



Cyzicus (*Euestheria*) sp. It is about 50 cm thick and occurs about 50 m above the base of Lugu Hill in East Bokaro Coalfield (Ghosh & Shah, 1977).

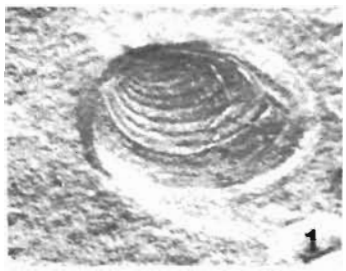
It may be noted that there are several subzones comprising *Cyzicus* and *Palaeolimnadia* in the Panchet Formation (Tasch, 1973) in Damodar Valley basins. These are helpful for intrabasinal correlation.

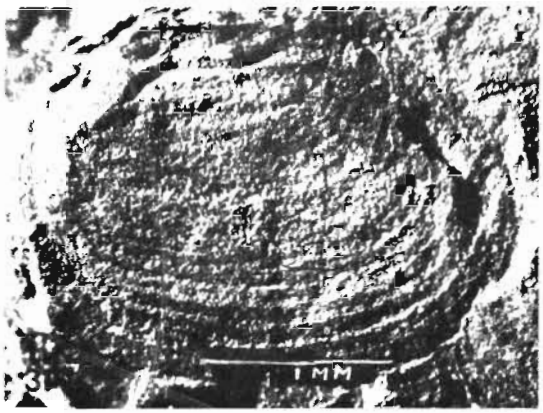
Estheriina-Cyzicus Biozone

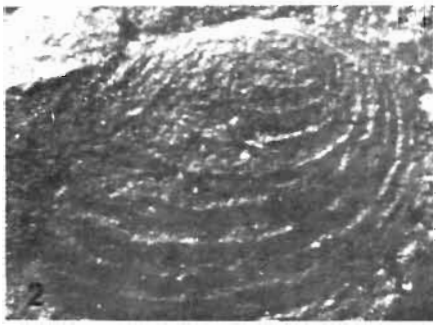
There is a large gap in estheriid biozone within the rocks above the Supra-Panchet and the Kota Formation. This biozone is very well developed in Kota Formation, Pranhita-Godavari Basin. The fauna comprises *Estheriina, Cyzicus, Pseudoasmussiata*

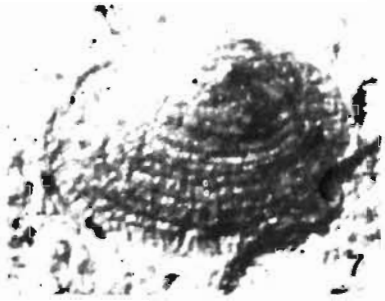
PLATE 2 →

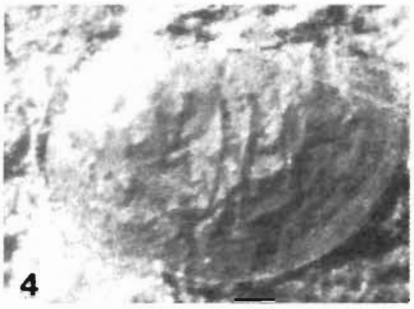
1. *Cyzicus (Euestheria)* sp., Parsora Formation, Johilla Coalfield. × 10.
2. *Cyzicus (Euestheria)* sp., Supra-Panchet Formation, Lugu Hill. × 12.
3. *Cyzicus* sp., Almod Bed, Satpura Basin (scale given). × 25.
4. *Palaeolimnadia* sp., Panchet Formation, Raniganj Coalfield. × 12.
5. *Cornia* sp., Pachmari Formation, Satpura Basin (courtsey Dr S. Chanda). × 25.
6. *Cornia* sp., Mangli Bed. × 10.
7. *Cornia panchetella* Tasch 1987, Panchet Formation, East Bokaro Coalfield. × 10.
8. *Pseudoasmussiata* (?) sp., Panchet Formation, Raniganj Coalfield. × 18.
9. *Cyzicus* sp., Panchet Formation, Raniganj Coalfield. × 8.
10. *Estheriella* sp., Mangli Bed. × 25.
11. *Estheriella sastryii* Ghosh, Panchet Formation, East Bokaro Coalfield. × 20.

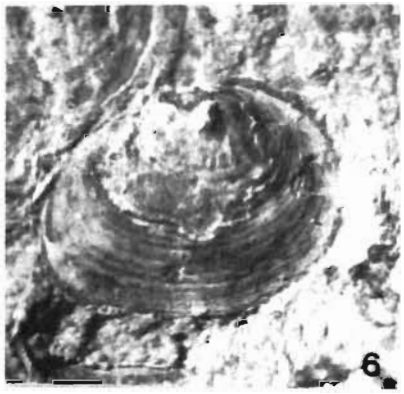


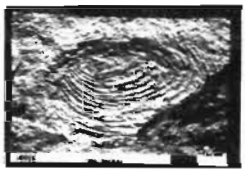


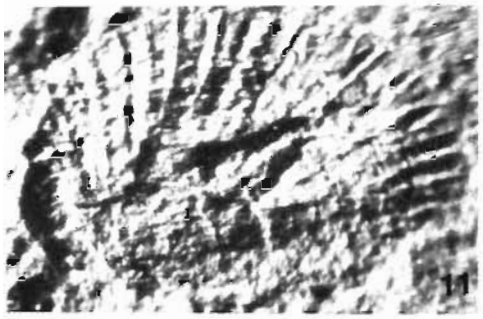












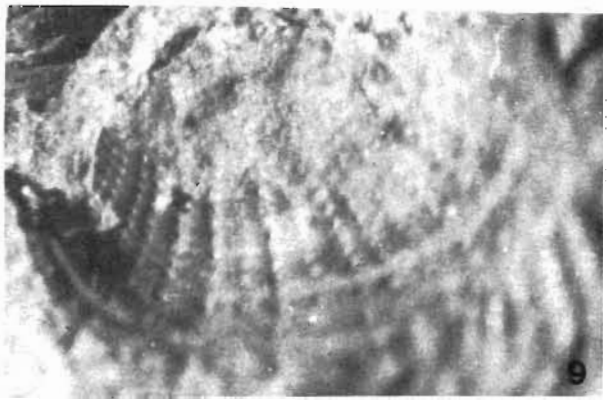
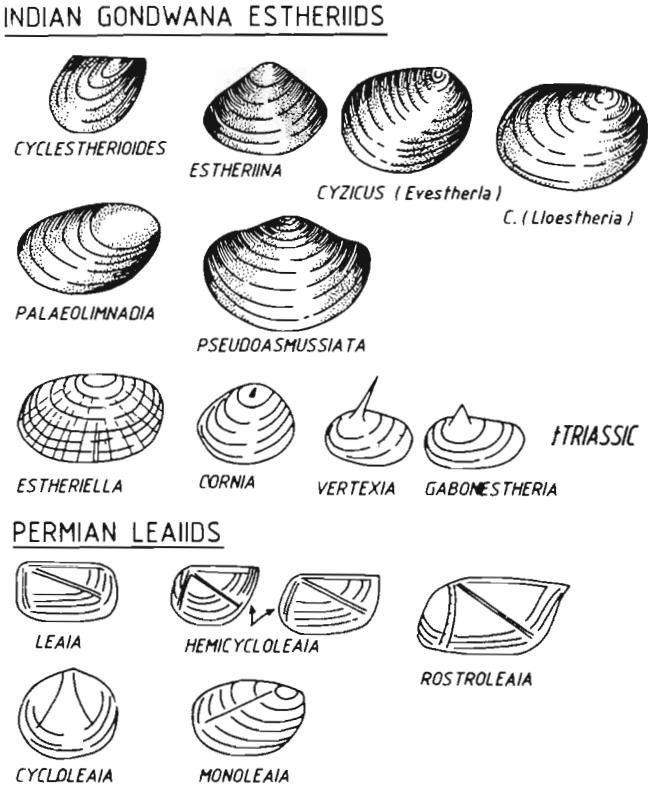


PLATE 2



Text-figure 3—Indian Gondwana Estheriids and Permian Leaiids

and *Palaeolimnadia* (Pl. 3, figs 3, 4). This Early Jurassic biozone is very well traceable for tens of kilometers in the basin and there are about 6 to 7 subzones (Tasch *et al.*, 1973). There is no equivalent bed outside the basin.

FAUNAL ANALYSIS

Discovery of leaiids from the Talchir, Barakar and Pali formations now establishes the fact that during the Permian time wide dispersal of the fauna occurred amongst all the Gondwana continents. The leaiids alongwith some *Cyzicus* and *Estheriina* define the Lower Gondwana conchostracan population. Further search and detailed identification up to species level is required for refining the biozones.

The basal Panchet member is dominated by *Cyzicus* (*Euestheria*) *minuta* and permits interbasinal correlation. The overlying *Cornia panchetella* Tasch 1987 and *Estheriella sastryii* Ghosh 1983 again offer another interbasinally correlatable horizon. *Palaeolimnadia* and *Gabonestheria* occur alongwith *Vertexia* in the same horizon. The Lower Jurassic Kota Bed with *Cyzicus* (*Lioestheria*) *kotahensis*, *Pseudoasmussiata*, *Palaeolimnadia* and *Estheriina* is of unique occurrence in India.

The major and characteristic genera are figured in Text-figure 1 to show main taxonomic features while their distribution through different Gondwana formations is explained in Table 2.

Cyzicus and *Palaeolimnadia* dominate the Indian population. Radially ribbed forms like *Leaia* and *Estheriella* indicating specific age offer an excellent opportunity for and emplacement of Permian-Triassic boundary (Table 3). Detailed distribution of Indian etheriids fauna, bed-wise, is listed as under:

I. Permian

A) Talchir Formation, Saharjuri Basin
?Leaia sp.

B) Barakar Formation, Jharia Coalfield
Leaia sp.
Estheriina sp.

C) Pali Formation, Sohagpur Basin
Leaia (Leaia) sp.
L. (Hemicycloleaia) sp.
Cycloleaia sp.
Rostroleaia sp.
Monoleaia sp.

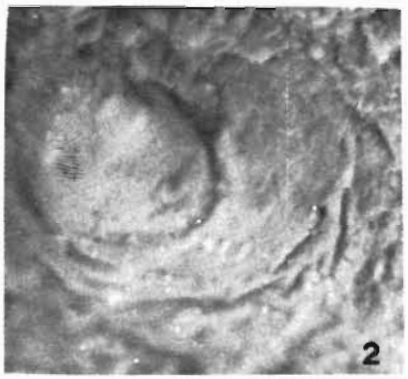
D) Kamthi Formation, Ib River Coalfield
Palaeolimnadia sp.
Cyzicus sp.

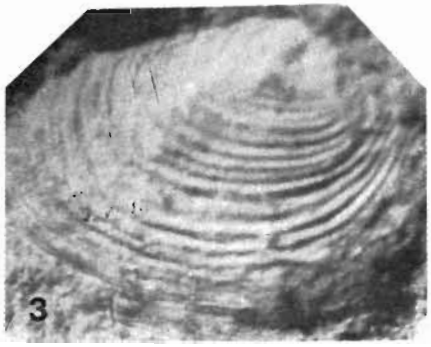
E) Punwat - Kawarsi area, Kamthi Formation, Wardha Basin
Cyzicus sp.
C. (Lioestheria) sp.

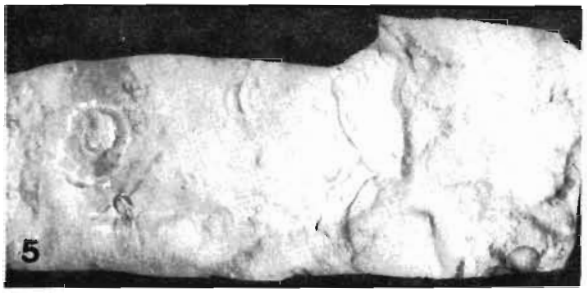
F) Raniganj Coalfield (Andal area)
Monoleaia sp.
Cyzicus sp.

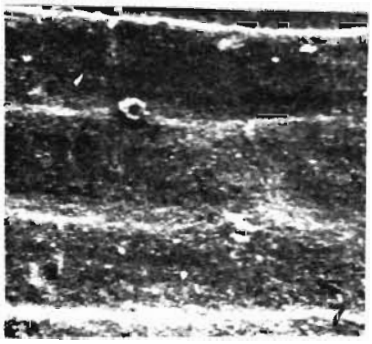
PLATE 3 →

1. *Vertexia* sp., Panchet Formation, Bore-hole RNM 4 (depth 106 m), Raniganj Coalfield, SEM photo. × 85.
2. *Gabonestheria* sp. Panchet Formation, Bore-hole RNM 4 (depth 106 m), Raniganj Coalfield, SEM photo. × 30.
3. *Estheriina* sp., Kota Formation, Pranhita-Godavari Basin. × 10.
4. *Pseudoasmussiata* sp. × 30.
5. Burrow trails and tracks on bedding plane of red shale, Kamthi Formation. Ib River Coalfield.
6. Hopper crystals of Halite on carapace of *Cornia* (Bore-hole RNM 4), Panchet Formation, Raniganj Coalfield. × 10,000, SEM photo.
7. Carapace ultrastructure between growth lines of Talchir Leaiid, SEM-photo. × 155.
8. Shell ultrastructure between growth lines of *Estheriella* sp., SEM photo. × 135.









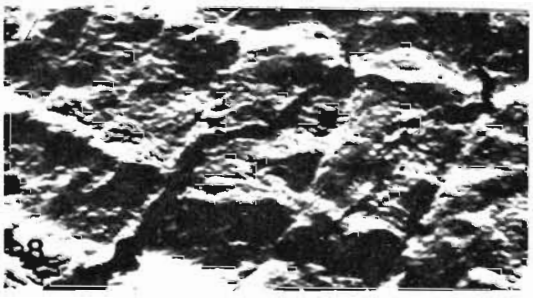
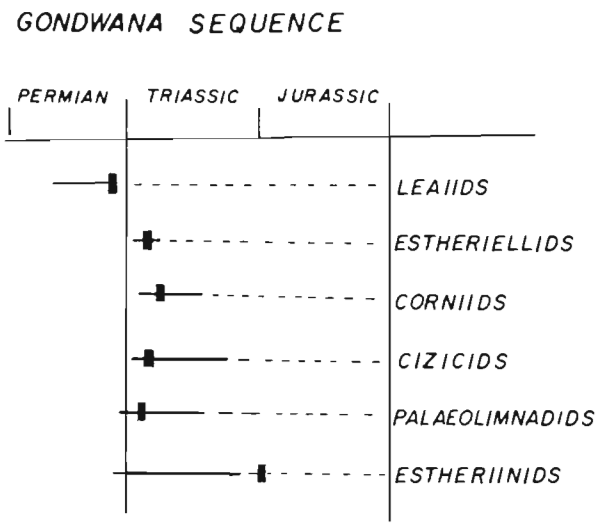


PLATE 3

Table 2—Distribution of major estheriid families of Indian Gondwana with acme of development.



G) Kameng Gondwana, Arunachal Pradesh
Estheriina sp.
Cyzicus (Lioestheria) sp.

II. Triassic

A) Panchet Formation, Raniganj Coalfield
Cyzicus (Euestheria) bengalensis Tasch 1987
Cycloestheroides (Sphaeroestheria) sp. Tasch 1987
Pseudoasmussiata bengalensis sp. Tasch 1987
Cyzicus (Lioestheria) miculis Tasch 1987
Cyzicus (Euestheria) raniganjensis Tasch 1987
C. (E.). mangaliensis Jones 1862
Cornia panchetella Tasch 1987
Cycloestheroides (Cycloestheroides) machkendaensis Tasch 1987
Cyzicus (Euestheria) dualis Tasch 1987
Palaeolimnadia sp.
Estheriella sp.
Gabonestheria sp.
Cornia sp.
Vertexia sp.
Cyzicus (Euestheria) sp.

B) North Karanpura Coalfield
Palaeolimnadia sp.
Cyzicus (Euestheria) sp.

C) East Bokaro Coalfield
Estheriella sastryi Ghosh 1983
Estheriella sp.
Cornutestheriella taschi Tasch 1987, Ghosh & Shah 1977
Cyzicus (Lioestheria) bokaroensis Tasch 1987
Palaeolimnadia sp.
Cornia sp. cf. *C. bengalensis* Tasch 1987

D) Parsora Formation, Johilla Coalfield
Cyzicus (Euestheria) sp.

E) Almod Bed, Satpura
Cyzicus (Euestheria) sp.
Cornia sp.

F) Pachmari Formation, Satpura Basin
Cornia sp.
Cyzicus (Euestheria) sp.

G) Mangli Bed, Wardha Basin
Cyzicus (Euestheria) mangaliensis Jones 1862
Pseudoasmussiata indicycloestheria Tasch 1987
Cornia panchetella Tasch 1987
Estheriella sp.

III. Jurassic

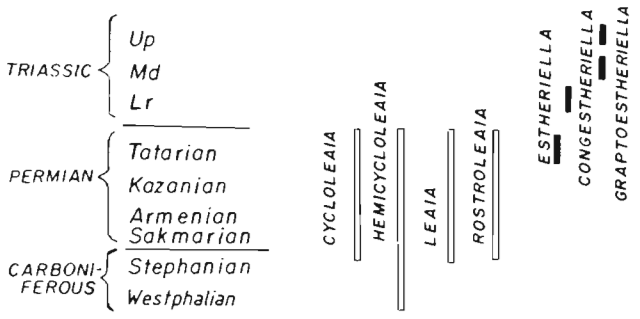
Kota Formation, Pranhita-Godavari Basin
Cyzicus (Lioestheria) kotahensis Jones 1862
C. (L.) sp.
C. (Euestheria) crustabundis Tasch 1987
Pseudeasmussiata andhrapradeshia Tasch 1987
Palaeolimnadia (Grandilimnadia) sp.
Estheriina (Nudusia) adilabadensis Tasch 1987
E. (N.) indijurassic Tasch 1987
E. (N.) bullata Tasch 1987
Estheriina (Estheriina) pranhitaensis Tasch 1987

GONDWANALAND EXTENSION

With the new Leaiid records from the Indian Gondwana Sequence a major lacuna has been filled up. The group originally evolved in China (Chang *et al.*, 1976) and subsequently dispersed to all the available land masses through land routes. During Gondwana sedimentation it appeared in Australia and by late Permian it spread to Antarctica, Africa, South America and through India probably to China (Shen Yanbin, 1984) (Text-fig. 3a).

The earliest record of Early Triassic *Estheriella* is from the Panchet Formation, India where from it dispersed to Africa (Upper Triassic) and South America (Jurassic) during the Mesozoic Period (Tasch, 1980). Similarity of Indian fauna with that of Bundenstein estheriellids (Weiss, 1875) suggests, direct land-route between India and Western Europe

Table 3—Distribution of ribbed estheriids through geological ages.



during Early Triassic Period (Text-fig. 3b.) *Cyclestheroides* and *Pseudoasmussiata* are found in Indian, African and South American Triassic Gondwana deposits as the continental contiguity offered non-marine dispersal routes.

Gobonestheriids and corniids recorded from the Triassic sequences of India (Andal, Raniganj), Africa (Lesotho) and South America (Brazil), indicate spread of the bioprograms for these taxa due to proximity of continents (Gondwanaland).

Similarity between the Kota estheriids and those of Antarctic Nunatak assemblage, alongwith the insect fauna, suggests divergence from the same parent stock specially for estheriinids.

Palaeoecology played major role in evolutionary changes (Ghosh, 1980, 1982a). Proliferation of vertexiids in the Panchet Formation in Andal area, eastern Raniganj Coalfield is noted in bore-holes. Pseudomorphs of halite and gypsum are found closely associated in the sediment as well as inside the fossils (Pl. 3, fig. 26). Desiccation leading to hypersalinity possibly led to endemic forms with variety of umbonal spines (Ghosh, 1984). Such information associated with the conchostracan fauna will be of immense importance for better understanding of Gondwana palaeogeography.

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