

GENERAL RESULTS OBTAINED FROM AN EXAMINATION OF THE GASTROPODOUS FAUNA OF THE SOUTH INDIAN CRETACEOUS DEPOSITS, BY FEED. STOLICZKA, Ph. D., F. G. S., Palaeontologist, Geol. Survey, India.

The second volume of the "*Palaeontologia Indica*," recently completed and published, contains the descriptions of 237* species of Gastropoda from the cretaceous deposits of South India. The fauna is very rich and varied, though probably not quite so extensive as might have been expected relatively to the large number (146) of Cephalopods which were described from the same beds. Still as many species, only represented by specimens in the state of casts, have been laid aside, further examinations of the ground will no doubt furnish large additions.

Taking a general review of the fauna of the Gastropoda, it will be interesting to point out some of the more important families and genera which were found to be represented.

The first family which in this respect is deserving of special attention is that of the *HELICIDÆ*, represented by four species, three of which belong to the genus *Angustoma* and one to *Macrocyclus*. Nearly all are found in the uppermost beds, stated by Mr. H. F. Blanford to have been deposits in shallow water. The extremely rare occurrence of land shells in cretaceous rocks increases the interest connected with those four species, especially as they mostly belong to types which are still found living in the same or neighbouring districts.

The sub-order PROSOBRANCHIA counts 174 species, of which the larger number belongs to the SIPHONOSTOMATA CTENOBRANCHIATA. Among the *ALATA* the genus *Pugnellus*, which up to the present has only been found in cretaceous rocks of North America, has yielded three very interesting species; it is in the recent fauna represented by species like *Strombus gallinula*. The *CYPRÆIDÆ* are remarkably numerous, being represented here by almost as many species as were previously known from cretaceous deposits in general, in which, as a rule, they are very rare. Among the types described are some which belong to *Cypræa* proper, several to *Luponia* and others to *Aricia*, *Epona*, &c. From the large number of *CYPRÆIDÆ*, as also from that of the *VOLUTIDÆ*, the peculiar forms of the *MURICIDÆ* and of the *PURPURIDÆ*, I draw the conclusion that the genera and species belonging to these families were already during the cretaceous time somewhat more numerous in the eastern than in the western hemisphere, or, in other words, that the present distribution of a portion of the Gastropoda, at least, was already indicated at that remote period.

The *OLIVIDÆ* are represented by a species of *Dipsacus*, the *CASSIDIDÆ* by a very interesting small species of *Oniscia*, the *PLEUROTOMIDÆ* by *Cythara* and *Pleurotoma*, the *CONIDÆ* by that peculiar form *Gosavia*, intermediate between this and the next family. Of the *VOLUTIDÆ*, 18 species are described belonging to the genera *Scapha*, *Melo*, *Ficulopsis* (n. gen.), *Fulguraria*, *Athleta*, *Volutilithes*, *Lyrta*, *Volutomitra*, *Mitreola* and *Turricula*.

* Including some new specific forms, which on account of the imperfectness of the specimens have not yet received specific names, though acknowledged as distinct from other known species.

Of the *MURICIDÆ* I would particularly mention *Polia Pondicherriensis*, because it so much recalls the form of our common, recent *Polia melanostoma*, and a species belonging to the genus *Trophon*.

The *TRITONIDÆ* have representatives in species belonging to *Hindsia*, *Tritonium* and *Lagena*; the *BUCCINIDÆ* in those of *Nassa* and *Pseudoliva*; the *PURPURIDÆ* in *Tudicla*, numerous species of *Rapa* and one of *Rapana*. Not less interesting are also two species of *Trichotropis* and five species of the *CANCELLARIIDÆ*, representing the genera *Cancellaria*, *Euclia* and *Narona*. No *TEREBRIDÆ* have occurred, and the *PYRAMIDELLIDÆ* offer no peculiarities, nor are they very rich in species or genera.

The *CERITHIIDÆ* mostly belong to marine sub-generic types, the absence of the very large number of *POTAMIDINÆ*, occurring in the deposits of the Alpine-Gosau formation, being remarkably conspicuous as one of the most important differences between the two faunas. The same applies to the *MELANIIDÆ*, their absence in Southern India being equally due to the apparent want of brackish or fresh water deposits, so far as they are known at the present. The *TURRITELLIDÆ* have yielded five forms identical with European ones, *T. multistriata* being probably the best known, *T. nerinea*, *nodosa*, *affinis* and *Neptuni*. The rest of the species peculiar to the Indian deposits do not differ in general character from European types. Of the *SCALIDÆ* three out of four are identical with European species. Of the *VERMETIDÆ* two interesting species have been referred to a new genus *Tubulostium*, being very characteristic for the Ootator beds, which are the lowest of the series. Of the *LITTORINIDÆ*, the occurrence of which in cretaceous rocks was always disputed, six different species have been met with. Of the *RISSOIDÆ* I may draw attention to two rather large species of *Rissoa*, one smooth *Rissoina* and three species of that peculiar genus *Keilostoma*, differing from *Rissoina* by the great thickness of the apertural margins. The *NATICIDÆ* are characterized by the usual large number of species belonging to the genus *Euspira*; three genera, *Naticina*, *Velutina* and *Amplostoma* of the *VELUTINIDÆ* also deserve specially to be noticed.

When speaking of the family *NERITIDÆ*, the *UMBONIDÆ*, *TURBINIDÆ* and *TROCHIDÆ*, &c., I had occasion to remark that most of the recent so called sub-generic forms are already to be found during the cretaceous period. Some of the generic types are very interesting and new to the fauna, as, for instance, *Velates*; *Teinostoma* and *Vitrinella*; *Oxytele*, *Gibbula*, *Euchelus*, *Cantharidus*, &c.

The *PLEUROTOMARIIDÆ* are not very varied in genera, but one species of the peculiar type *Leptomaria* (*L. indica*), is very common, occurring almost through all the successive groups from the lowest to the highest; it greatly resembles several of the European forms.

The *OPISTHOBRANCHIA* are also worthy of notice, being represented by 24 species; these belong to *Acteonina* (2), *Acteon* (6), *Trochacteon* (3), *Bullina* (2), *Bullinula* (1), *Avellana* (4), *Ringinella* (1), *Ringicula* (2), *Euptycha* (3) and *Cyliclona* (1). This unusually large number of species of that sub-order is the more interesting, as the recent species are far from common shells. The genera *Trochacteon*, *Avellana*, *Ringinella* and *Euptycha* are chiefly cretaceous forms, and therefore in comparison with the present fauna of very great importance. *Acteonina* is one of the oldest genera, but I believe there are a good number of species of recent shells which ought to be transferred to that genus. Of the *DENTALIIDÆ*, being the only representatives of the *PROSOPOCEPHALA*, merely four species of the genera, *Dentalium*, *Antale* and *Fustiaria* (n. gen.) were recorded.

After this general review of the fauna I may now enter upon the distribution of the species in the different groups which, beginning with the lowest, are the *Ootator*, *Trichinopoly* and *Arrialoor* in the Trichinopoly district, and the *Valudayur* and *Verdachellum* groups near Pondicherry. These last two are equivalent to the first and third named one, respectively. Geological details respecting these groups and their fauna will be found in Mr. H. F. Blanford's Report in the IVth Volume of the Memoirs of the Geological Survey of India. The present remarks regarding the distribution of the species of *Gastropoda* will therefore be very general.

The 237 species of *Gastropoda*, described from the cretaceous deposits of South India, divide themselves into the different groups, thus: 113 species are peculiar to the *Arrialoor* group, 59 to the *Trichinopoly* and 36 to the *Ootator*; 20 species are common to the *Trichinopoly* and *Arrialoor* groups, 4 to the *Ootator* and *Trichinopoly*, none, however, with sufficient certainty to the *Ootator* and *Arrialoor* solely. Only five species, *Fulguraria elongata*,

Ampullina bulbiformis, *Gyrodes pansus*, *Solariella radiatula* and *Leptomaria indica* are common to all the three divisions of the deposits. The Gastropodous fauna of the different groups is therefore tolerably well defined, the distinction between the Ootator and the Arrialoor groups being especially prominent. The large number of species common to the two higher groups is principally due to the uncertainty of the geological boundary between them. When this point has been more satisfactorily settled, it may show that an equal distinction exists in the Gastropodous fauna between them, as does between the two lower groups. All the species occurring in the Arrialoor group belong to such genera as are now commonly found living in shallow water, while many of those of the Ootator group are littoral forms, living on rocky coasts or on coral reefs.—The fauna, as a rule, is purely marine, and there is a remarkable absence of the *POTAMIDINÆ*, of the *MELANIIDÆ* and others which are very characteristic for some of the beds of the Alpine cretaceous deposits. The comparison of our rocks with those of the Alps only applies, therefore, to the purely marine fauna. The Arrialoor beds were probably deposited over a large, very slightly undulating ground in from 2-10 fathoms of water, but at some distance from the coast.

In point of comparison of our fauna with that of other countries I must direct attention to the following table, giving a list of those species which are also found elsewhere:—

No.	Name of Genus and Species.	GEOLOGICAL POSITION.		REMARKS.
		In India.	Not in India.	
1	<i>Alaria Parkinsoni</i> , Mant.	Oot. and Trich. ...	Gault and Greensand, (Cenomanien).	(Middle Planer).
2	„ <i>papilionacea</i> , Goldf.	Trich. and Arr. ...	Turonien	
3	<i>Cyprea Kayei</i> , Forbes, (<i>Globioconcha ovula</i> , d'Orb.)	Trich. and Arr. ...	Senonien.	
4	<i>Pleurotoma subfusiformis</i> , d'Orb.	Trich. (Arr. ?) ...	Turonien.	Cenomanien and Turonien.
5	<i>Fulguraria elongata</i> , d'Orb.	Oot. ? Trich. and Arr.		
6	<i>Fasciolaria rigida</i> , Bally	Trich. ...	Middle cret. of Sth. Africa	(Probably Cenomanien).
7	<i>Neptunea rhomboidalis</i> , Zekeli	Arr. ...	Turonien	(Gosau-deposits).
8	<i>Tritonidea Requieniana</i> , d'Orb.	Trich. ...	Turonien	
9	<i>Trichotropis Konincki</i> , Müll.	Trich. ...	Senonien near Aachen.	
10	<i>Nerinea inaeqvata</i> , Bronn	Oot. ...	Turonien	Gosau and Transylvania. } I have observed these two species in Prof. Heber's collection.
11	<i>Cerithium inauguratum</i> , Stol.	Trich. and Arr. ...	„ <i>Craie pisolitique</i> near Paris.	
12	„ <i>Arcotense</i> , Stol.	Arr. ...	Ditto.	
13	„ <i>trimoniae</i> , Mich.	Arr. ...	Gault and Grès verts, (Cenomanien)	
14	<i>Turritella affinis</i> , Müll.	Trich. ...	Senonien near Aachen.	
15	„ <i>Neptuni</i> , Münst.	Trich. ...	Turonien	(Middle Planer).
16	„ <i>nerinea</i> , Röm.	Oot. ...	Senonien	(Upper Planer).
17	„ <i>nodosa</i> , Röm.	Oot. ...	Cenomanien	(Lower Planer).
18	„ <i>multistriata</i> , Bss.	Trich. and Arr. ...	Turonien	(Middle Planer).
19	<i>Scala</i> (?) <i>Clementina</i> , Mich.	Oot. ...	Gault.	
20	„ <i>subturbinata</i> , d'Orb. (<i>Haidingeri</i> , Binkh.).	Arr. ...	Senonien of Maestricht. [Aachen.	
21	„ <i>striatocostata</i> , Müll.	Arr. ...	Senonien near Chalk (Turonien).	
22	<i>Burtinella concava</i> , Sow.	Arr. ...	Senonien near Aachen.	
23	<i>Rissoina acuminata</i> , Müll.	Arr. ...	Senonien near Aachen.	
24	<i>Euchrysalis gigantea</i> , Stol.	Trich. and Arr. ...	Cretaceous beds in Sth. Africa.	Probably Cenomanien.
25	<i>Ampullina bulbiformis</i> , Sow.	Oot., Trich. and Arr.	Turonien beds of the Alpine cretaceous deposits.	Probably also occurring in Texas.
26	<i>Euspira rotundata</i> , Sow.	Arr. ...	Chalk (Turonien).	
27	„ <i>lirata</i> , Sow.	Arr. ...	Turonien.	
28	<i>Ziziphinus Geinitzianus</i> , Bss.	Trich. and Arr. ...	Turon. beds of Germany.	
29	<i>Solariella radiatula</i> , Forbes, (<i>Trochus glaber</i> , Müll.).	Oot., Trich. and Arr.	Senonien near Aachen.	
30	<i>Avellana elongata</i> , Guér.	Oot. ...	Cenomanien.	

Of these 30 identical species, forming very nearly one-eighth of the entire fauna, 10 species occur in the Senonien, 12 in the Turonien, 4 in the Cenomanien (including 2 species from the South African deposits); 1 species is common to the first and second, 1 to the second and third, and 3 are quoted from the Gault, 2 of which, however, are also found in the Cenomanien. Applying these results in detail to the groups distinguished by Mr. Blanford among the South Indian cretaceous deposits, it will be found that they do not correspond exactly. Thus, species which in Europe occur in the Cenomanien are in India occasionally found in the Arrialoor beds, not as would be expected in the Ootatoor beds only; and again there are Senonien and Turonien species found in the Ootatoor as well as in the Trichinopoly beds. As a rule most of the species from our Arrialoor beds are identical with those from the Senonien; but there appears to be an equal difficulty experienced in India in separating the Arrialoor and the Trichinopoly group, as is felt in Europe in distinguishing properly between the Senonien and the Turonien. The general conclusion, therefore, derivable from the examination of the Gastropoda regarding the age of the South Indian cretaceous deposits is that they represent *only the beds above the Gault, that is, the Cenomanien, Turonien and Senonien.*

It is possible that the Ootatoor beds represent the Cenomanien, but the number of fossils obtained from these beds is, in one respect, comparatively as yet very small; in other respects the boundaries between this and the other groups may not have been sufficiently worked out. It appears more justifiable to regard the Trichinopoly beds as the representatives of the Turonien, and (as already stated) the Arrialoor as those of the Senonien. Stratigraphically this tri-division has also great probability.

When reviewing the Cephalopoda of the same rocks (Quart. Jour., Geol. Soc., Lond., 1865, p. 407, etc.), I have stated that the largest number of the identical species of Cephalopoda occurs in Europe in the middle cretaceous strata and especially in the Gault; thus I placed the lowest beds of our South Indian cretaceous rocks as equivalents of the Gault. After having gone over the Gastropoda I found that no Gault species were represented, and conferring with some of my friends at home on this point, Prof. Hebert specially directed my attention to several species of the Cephalopoda which are strictly speaking not typical Gault fossils. I had already occasion to mention* that the identification of *Am. Beudanti* (now *Am. Yama*, Forb.) was found incorrect; but several other species which undoubtedly appear to be identical with European fossils, like *Nautilus elegans*, *N. sublavigatus*, *Am. rostratus*, *Am. Rotomagensis*, *Am. Candollianus*, *Am. navicularis*, *Am. Mantelli*, *Am. peramplus*, *Am. Timotheanus* and *latidorsatus*, *Turrilites costatus* and *Bergeri* and others, are such species as pass from the Gault into the Cenomanien and the Grès verts. Prof. Hebert† is of opinion that the true Gault beds must be considered as the uppermost group of the Neocomien or lower cretaceous series, all the beds above being included in the upper cretaceous series. There appears to be a relation of several of our species to such Gault species as *Am. Beudanti*, *serratus*, *lautus*, *denarius*, *splendens* and to some Neocomien forms, but, on the other hand, the numerous *Cristati* and *Ligati* of our rocks are strongly marked upper cretaceous types. The fauna of the Gault is undoubtedly an intermediate one, and possibly when the stratigraphy of the rocks has been better studied many corrections in points of identifications, at present doubtful, may be made. Some of the species like *Nautilus pseudo-elegans* and *Neocomiensis*, and *Am. Rouyanus* and *Velledæ* I am still unable to distinguish satisfactorily from the typical Neocomien species; the number of these species is, however, so small that they cannot outweigh the other facts which would place the cretaceous deposits of South India higher in the series.

Considering, therefore, that most of the so-called Gault species of our Cephalopoda are equally common in the Cenomanien, and that the Gastropoda have not yielded any undoubted Gault forms, I believe I am more justified in stating that the South Indian cretaceous deposits only represent the *upper cretaceous strata, beginning with the Cenomanien.* The larger number of representative species were found to agree with the Turonien, which is a very wide spread formation, though its limits must be considered rather different from those given to it by d'Orbigny. I have reason to suppose that the present statement regarding the age of our cretaceous deposits will also be supported by the examination of the

* Records Geol. Surv., India, I. pt. 2, 1868, p. 35.

† Bull. Soc. Geol., France, 2d ser., t. XXIV, p. 323, etc.

Pelecypoda, especially the various *Inoceramus*- and *Hippurite*-types. Thus the original notion of representatives of Neocomien beds in South India more and more loses support, as already pointed out by me in the first volume of the "Palæontologia Indica."

In conclusion I should like to draw attention to a parallel of our cretaceous deposits with those of Bohemia, Saxony, North Germany, etc.; this parallel being indeed a very remarkable one. Dr. Gümbel, who has lately (Sitzb. Gesellsch. Isis, Dresden, 1867, p. 72, etc.), devoted a little time to the study of the Bohemian and Saxon cretaceous deposits, states that they generally begin with a kind of fresh-water deposit containing numerous plant remains, and being sometimes represented by a coarse conglomerate, both filling up cavities in the older rocks, which in many instances are metamorphic or crystalline. Immediately above these plant beds follows the series of Quader- and Plæner-beds, the oldest of which are characterized by *Am. Mantelli*, *Inoceramus striatus*, *Ostrea bivauculata*, *Exogyra columba*, etc., as Cenomanien or the Upper Greensand of English Geologists; the highest beds are the equivalents of the upper chalk with *Inoceramus Cuvieri* and *Crispi*, *Rhynchonella octoplicata*, etc., or Senonien. Dr. Gümbel consequently acknowledges an upper, middle and lower Plæner, which may approximately be called Senonien, Turonien and Cenomanien. Dr. Schlönbach, in a very valuable paper, printed in the Official Report of German Naturalists, etc. (Hanover, 1865, p. 160, etc.), expressed similar opinions on the French equivalents of cretaceous beds in Hanover. Zittel, in his admirable work on the Bivalves of the Gosau-deposits (Denksch. Akad., Wien, XXV, 1866, part. II, p. 174, etc.) enters upon the question of parallelism of those deposits with others in great detail and corroborates the opinion of most of his predecessors that they principally represent the Turonien and the Senonien. Were it to give at this early stage of examination of the fauna an opinion regarding the parallelism of our South Indian cretaceous rocks, I could, as I stated, only compare them with those of North Germany (Aachen, Saxony, Hanover) and Bohemia, but it is impossible to say which of our beds exactly correspond to the Cenomanien, Turonien, and so on; probably the parallel must remain only a general one. To the Gosau-deposits our Trichinopoly and Arrialoor beds appear to form a correlate. What characterizes the Cenomanien of our beds are the Cephalopoda; these are, however, very scarce in the Gosau-deposits. Those lately described by F. v. Hauer have fully the character of Cenomanien species.

There is one point which deserves special attention during any subsequent examination of the ground of the South Indian cretaceous deposits, and this is respecting the plant beds, which underlie all the undoubted cretaceous rocks. Some time ago the Geologists, engaged in the survey of the Madras Presidency, have sent numerous plants and a large number of bivalves, etc., from these strata in the neighbourhood of Sripematoor. A few small Ammonites belong to the Dentati group, but they are insufficiently preserved for identification. Of bivalves there is a large number of species belonging to *Leda*, *Yoldia*, *Tellina*, *Psammobia*, *Lima*, *Pecten* and others; all forms with a remarkably thin shell and the allies of which are at present usually found living on sandy ground in from 8-10 fathoms of water. Several exhibit a resemblance to species from the cretaceous rocks of Trichinopoly, but none appear to be specifically identical. At another locality, fragments of an *Inoceramus*, which belong to a flattened ribbed species like *I. mytiloides*, have been found with the same plants. Of the plants there have been several species (*Palæozamia Cutchensis* and *acutifolium*, and a *Dyctyopteris*?) recognized as identical with those from the Rajmahal beds and again with those found associated with the jurassic Cutch fossils. Thus this would distinctly prove that the South Indian plant beds below the cretaceous rocks are jurassic. I cannot express the slightest opinion on this matter, but in pointing out the parallelism existing between the Indian and North German cretaceous beds, the similar structure of those whitish clay plant beds underlying, in both countries, the above formation appeared to me deserving of marked notice. Special attention must at any subsequent examination be devoted to tracing out the relations of those plant-bearing beds to the cretaceous beds of the Trichinopoly district.

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