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ART. XXXII.—*On a New Species of the Palinurid-Genus Linuparus found in the Upper Cretaceous of Dakota*; by ARNOLD E. ORTMANN, Ph.D.

THE Geological Museum of Princeton University has lately acquired two unique specimens of a hitherto unknown fossil species belonging to the family Palinuridæ, which are not only the first remains of this group of Decapoda found on the American continent, but which—as regards the completeness of preservation—surpass anything that is known of this group from the European deposits. It is true, Palinuroid-Decapods have been found in Europe, especially in England and Germany, in great numbers, and the systematic relations of these forms—as belonging to the family of Palinuridæ—are beyond any doubt. But there is hardly a form the affinities of which to the living genera of this family have been ascertained: accordingly, for most of them new genera have been created, and although the old generic name of *Palinurus* has been used for some of these European forms, there is nothing that indicates a closer connection of this *fossil* *Palinurus* with the *living* *Palinurus* “sensu strictiore.”

The American fossil here to be described not only shows all the chief characteristics of the family, but it is so well preserved that the writer has been enabled to make out its generic position, and he was exceedingly surprised that this fossil from the Upper Cretaceous is congeneric with a species living nowadays in the Japanese seas, namely with *Palinurus trigonus* of de Haan,\* the name of which stands at present as *Linuparus trigonus* (d. H.). The genus *Linuparus* created by Gray in 1848 for this Japanese form is—as far as we know—a monotypic genus, containing only that Japanese species just mentioned.

In order to make clear the systematic position of the new fossil, it will be well to give a brief sketch of the generic divisions of the family Palinuridæ, as accepted in modern zoology.†

The family Palinuridæ contains seven recent genera: *Palinurellus*, *Jasus*, *Palinurus*, *Palinustus*, *Linuparus*, *Panulirus* and *Puerulus*. Indeed, some of these genera have not been admitted by some modern carcinologists, but I should say that the differences of these genera are so striking, that one would amply be justified in arranging them into three or

\* See de Haan, *Fauna Japonica. Crust.*, decas 5, 1841, p. 157, pl. 39, 40.

† Compare Ortmann, in *Zoolog. Jahrb. Syst.*, vol. vi, 1891, pp. 13–38. I should mention here, that some of the generic names used by me in this revision do not comply with the rules of nomenclature accepted generally. Thus *Avus* should be *Linuparus*, *Senex* should be *Panulirus*, and *Puer* ought to be changed, since it has been preoccupied. (I should like to propose *Puerulus* for it.)

four different families. Only *Palinurus* and *Palinustus* on the one hand, and on the other *Panulirus* and *Puerulus* are more closely related to each other: the other genera differ so widely that they indicate as many lines of development within this family, which are separated since very old geological times. It may be possible to trace back the separation of these lines of development into the earlier Jurassic or even into the Triassic period.

There are three chief groups, namely: 1, that of *Palinurellus* and *Jasus*; 2, that of *Palinurus*, *Palinustus* and *Linuparus*; 3, that of *Panulirus* and *Puerulus*.

According to the morphological characters the first may be called the more primitive, the second the typical, the third the more advanced group. But perhaps it would be well to place *Palinurellus* and *Jasus* in separate groups, since both—although agreeing in some characters not found in the other genera—are so widely different, that no closer genetic relation seems to be present.

The most striking character of *Palinuridæ* is the connection of the frontal parts of the carapace with the so-called segment of the antennulæ as well as with the epistoma, and, on the other hand, the fusion of the basal points of the stalk of the antennæ with the epistoma. The frontal part of the carapace is always united with the segment of the antennulæ outside of the eyes, on either side, but in the two genera first named there is a median connection besides: the rostrum is bent downward and covers completely or partially the bases of the eyes, thus reaching and joining the segment of the antennulæ. These two genera—*Palinurellus* and *Jasus*—are further characterized by the lack of a stridulating apparatus, formed by the first free joints of the antennæ rubbing against the segment of the antennulæ, which seems to be present in all the other genera.

The second and third groups are more closely related to each other, but they are distinguished by one important character: in the second the epistoma is divided longitudinally by a deep furrow, which no doubt indicates the former separation of the basal joints of the antennæ fused into the epistoma. This furrow is wholly wanting in the third group, the epistoma being smooth and even medially. The disappearance of this indication of the primitive separation of the basal joints of the antennæ stamps the third group as a more advanced one than the second. Besides, there is another difference: in the second group the flagella of the antennulæ are always short, while in the third group they are very much longer.

Examining our fossil form, we see at once that it belongs to the second group. The larger specimen shows plainly the connection of the carapace with the epistoma and with the segment of the antennulæ, outside of the bases of the eyes, while

no median connection is present. The epistoma shows the median longitudinal groove characteristic of the second group. The flagella of the antennulæ, however, are not preserved.

There are three genera in the second group. The first is the type genus of the family, *Palinurus* (containing two living species); the others are *Palinustus* and *Linuparus* (containing only one species each). *Palinustus* was proposed by A. Milne-Edwards\* for a deep-sea form from the West Indies. The description of it is very poor and even incorrect in some respects, and no figure of it has been published. I am, however, enabled—through the kindness of Professor Alexander Agassiz, who lent me the type specimen for examination—to state, that *Palinustus* comes very near to *Palinurus*, and differs only in the weaker “frontal horns,” which are placed on the outer edge of two very peculiar plates projecting horizontally from the frontal margin and truncated squarely at the apex. In *Palinurus* these projecting frontal plates are wanting and the “frontal horns” are formed by two large, compressed, nearly falciform spines placed close to the frontal margin on either side of the rostrum. In all other respects *Palinurus* differs only slightly from *Palinustus*. The differences of both genera from *Linuparus* are the following. In *Palinurus* and *Palinustus* the carapace, especially the part behind the cervical groove, is evenly arched from side to side, i. e. of sub-cylindrical shape, and it is covered by a multitude of spines and spiny tubercles, becoming scaly in the hinder part. The frontal horns are compressed and separated by a wide space. In *Linuparus* the hinder part of the carapace is distinctly carinate, three keels being present, a median one and two lateral ones. The surface is covered with granules, and a few small spines placed chiefly on the anterior part, thus differing strikingly from the spiny appearance of the carapace of the first two genera, and, further, the frontal horns of the living *Linuparus* lie close together and are depressed (not compressed), forming two broadly triangular plates projecting from the middle of the frontal margin.

Our fossil form comes very near to *Linuparus* in the shape and armature of the carapace. There are three distinct longitudinal keels on the hinder part of the carapace, and only a few short spines distributed in a similar manner as in the living Japanese form. But there is a difference in the frontal horns. The latter are compressed, as in *Palinurus*, but nearer to the median line. The horns are smaller than in *Palinurus* and a little inclined, diverging from the bases outward, and thus they are exactly intermediate in shape and position between the living *Palinurus* and the living *Linuparus*: the distinct lateral compression comes near to that of the former genus, but the inclining direction looks like an incipient depression, and in

\* Bull. Mus. Compar. Zool., vol. viii, 1880, p. 66.

their closer position to the median line, the horns approach also the condition seen in *Linuparus*.\*

There is no doubt that we are to place the fossil form in the genus *Linuparus*, and although the frontal horns form in some degree a connection with *Palinurus*, there are a couple of other characters of minor importance exhibited by our fossil which occur only in the Japanese *Linuparus trigonus*, as will be pointed out in the following detailed description of the new fossil, which I propose to name

*Linuparus atavus*, spec. nov.

The two specimens of the Princeton Museum, both males, were collected by Mr. H. F. Wells in the Niobrara group (Upper Cretaceous) at the head of Cotton-Wood Creek, Mead Co., South Dakota. They were broken into numerous pieces, but have been put together again very skilfully by Mr. Gidley. The matrix being extremely hard, it was deemed dangerous to try to work out some parts of the body more completely; thus some parts in either specimen are still imbedded in the matrix: but luckily the specimens supplement each other in an admirable manner, so as to leave only a few details of minor importance unknown. See figures 1-4, p. 297.

MEASUREMENTS.

*Of larger specimen (a).*

From anterior frontal margin to hinder lateral corner of carapace .....	79 <sup>mm</sup>
Length of 4 posterior abdominal segments + telson (hinder part of the latter imbedded in the matrix) .....	77
Length of the three free basal joints of the antennæ (outer margin) .....	39
Breadth of frontal margin .....	38
Distance between the frontal horns, .....	8
Breadth of carapace, posterior end .....	36

*Of smaller specimen (b).*

Length of carapace .....	60 <sup>mm</sup>
Length of 4 anterior abdominal segments .....	31

Allowing, in the larger specimen, for the first two abdominal segments one and a half of the length of the third segment (14<sup>mm</sup>), the approximate total length of the body would be 177<sup>mm</sup>.

\* This intermediate shape of the frontal horns settles the question, whether the triangular frontal processes of *Linuparus* are a bilobed rostrum (as de Haan believes) or the homologues of the frontal horns found in other genera of *Palinuridæ*. They are frontal horns.

Specimen (*a*) shows beautifully the frontal margin, the segment of the antennulæ, the stalks of the antennæ and parts of the flagella, the basal joints of the antennulæ, the epistoma, and the hinder part of the abdomen. The upper surface of the carapace is much crushed, and the place of the sternum is occupied by a large hole. Of the abdomen, the four last abdominal segments and the telson are present; of the first and second segments only a few pieces are recognizable. In specimen (*b*) the upper surface of the carapace is nearly complete, there is only a hole occupying the gastrical region and a few smaller ones; the frontal horns are better than in the first specimen. The anterior part of the abdomen and the sternum are complete in specimen (*b*), but the anterior part of the body (beyond the frontal margin) is imbedded in the matrix, and the posterior part of the abdomen is wholly absent. Parts of the maxillipeds, pereopods, and pleopods are visible in both specimens.

*Description.* — *Carapace* nearly rectangular in outline. Frontal margin truncate, nearly straight, connected with the segment of the antennulæ on both sides of the eyes. Frontal horns approaching each other, compressed, but diverging from the bases outward, their anterior margin with a few small teeth, no median rostral spine being visible. Antero-lateral angles formed by spines. Cervical groove distinct. Anterior part of carapace (in front of the cervical groove) with two spines just behind the frontal horns, which are a little more distant from each other than the latter, and with three tubercles forming a triangle. A curved, longitudinal series of three spines between the median line and the lateral margins. Hinder part of carapace tricarinate, each keel bearing a number of small spines. Otherwise the surface of the carapace is only granulate and punctate. (The arrangement of the spines on the anterior part is very like to that of the living *Linuparus*!)

*Abdominal segments* in the median line provided with short, conical spines. (Similar spines are found in *Linuparus trigonus* on the anterior segments, but are wholly wanting in all other genera of *Palinuridæ*, except in one species of *Puerulus*: here, however, they are of a different character!) The first segment has only one spine, the second has two simple spines, on the third segment the posterior one is provided, in specimen (*a*) with one, in specimen (*b*) with two additional tubercles, one behind the other. The fourth segment has two double-spined tubercles; the tips of the spines are placed one behind the other. The fifth segment has two simple spiniform tubercles. On the sixth segment, however, are two low double spines, placed side by side each near the median line, and on the posterior margin are two small spines placed close to the median line. The segments from the second to the fifth have each two sharp tubercles on each lateral part; the sixth has only one. The epimera are spined on the margins, but the

exact number of the spines cannot be determined. Each abdominal segment has a transverse furrow passing across the back between the anterior and the posterior median spines; these furrows are very distinct on the second, third and fourth segments, while they are obsolete on the first, fifth and sixth. Of the telson only a small part of the anterior portion is exposed; the posterior end, which was probably—as usual in this family—soft, is imbedded in the hard matrix.

The segment of the *antennulæ* is very like that of *Palinurus* or *Linuparus*. It is narrow, elongate-triangular; the lateral borders form a blunt, elevated ridge. The *epistoma* has a deep median longitudinal furrow, which is bordered anteriorly by a strongly elevated, oblong tubercle on both sides. The phymacrite (opening of the green gland) is visible only on the left side of specimen (*a*). The *sternum*, exposed beautifully in specimen (*b*), is elongate-triangular in outline. The lateral borders have three spiniform tubercles near the insertions of the second, third and fourth pereopods, and a similar median tubercle a little in advance of the level of insertion of the fifth pereopods.

Of the *antennulæ* only parts of the basal joint are preserved. The *antennæ* show the stout and enlarged form usual in the family. The stems have three free joints, the basal one being greatly enlarged and dilated on the inner margin, thus forming, with the segment of the *antennulæ*, that peculiar "stridulating apparatus" found in the genera of group 2 and 3 of the family. The two other basal joints of the *antennæ* are narrower than the basal one, but still large and powerful. All three joints are furnished with a number of smaller and larger spines. Of the *flagella* only a couple of fragments are preserved, but these show a very peculiar feature only found, among the living genera, in *Linuparus*: there exists dorsally and ventrally a distinct longitudinal furrow, so as to render the cross section oval with a constriction in the middle.

Of the *mouth parts*, traces of the strong and powerful *mandibles* are seen in specimen (*a*), of the second maxillipeds in specimen (*b*), and of the third maxillipeds in both. Of the latter the distal joints, carpus, propodus, and dactylus, are broken away. The interior margin of ischium and merus is spiny. No traces of an exopodite have been discovered, but it is probable that it is broken away or still imbedded in the matrix.

Of the *pereopods* (thoracic legs) the first seems to be the stoutest, the second the longest. In specimen (*b*) all the joints of the latter are preserved on the right side (but partly covered by the matrix). The dactylus reaches as far as the end of the stalks of the *antennæ*, and it is long and slender. The dactylus of the first pereopods is nowhere visible, but in both specimens the propodus of the left sides, showing plainly that

no chelæ were developed, as required by the diagnosis of the family. The following pairs of pereopods decrease in size and thickness. The fifth pair shows plainly in both specimens the male sexual opening. The distal parts from the merus onward are not present in the fifth pair.

Traces of abdominal appendages (*pleopods*) are discernable in both specimens; the right one of the fourth segment in specimen (*a*) is the best preserved, consisting of an oval plate, which is finely striated. Sexual appendages are wanting.

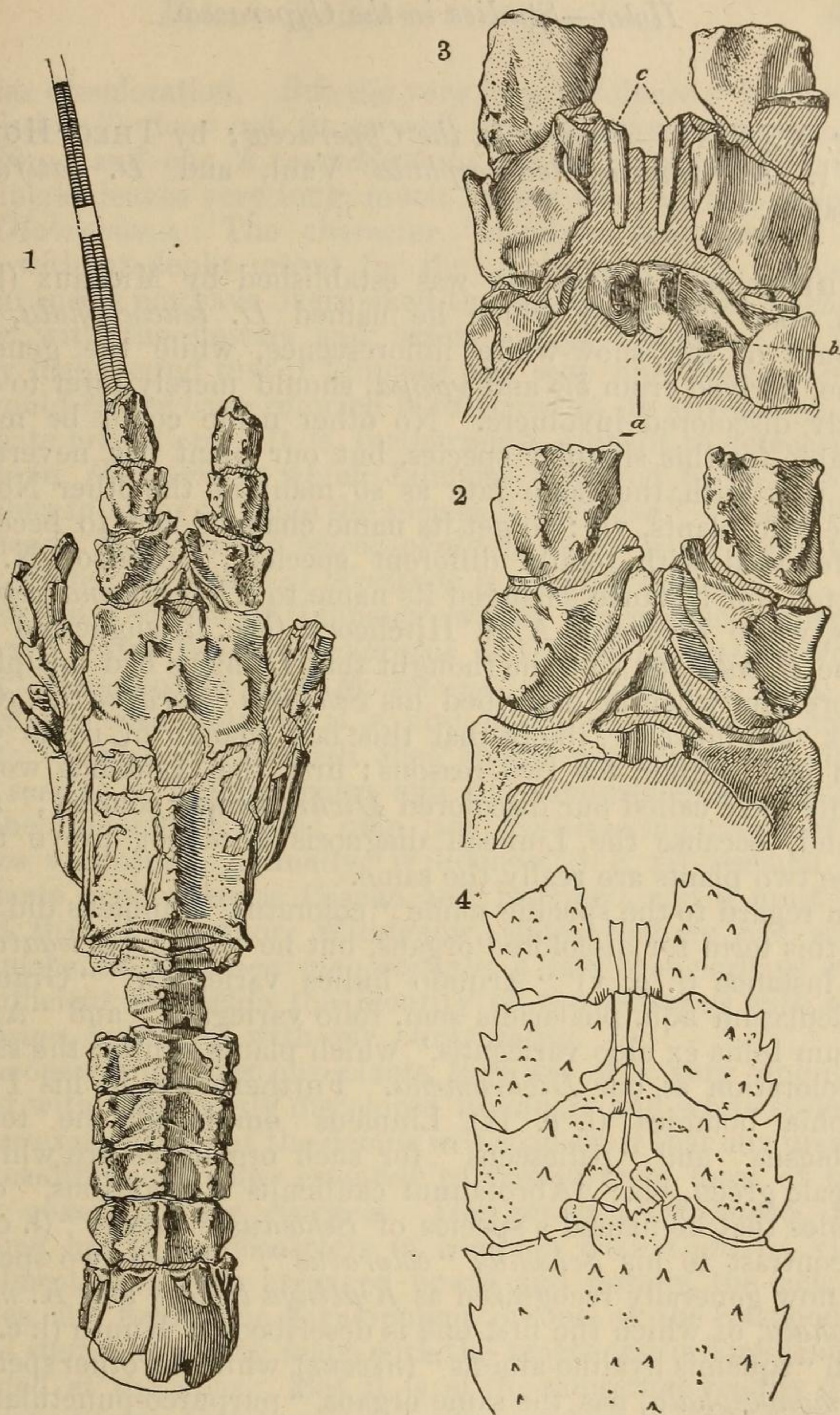
Thus we see that the position of this fossil form with the genus *Linuparus* is warranted not only by the tricarinate carapace, but also by other characters of minor importance, such as the distribution of spines on the carapace, the armature of the abdomen (which in its general plan is exactly like that of *Linuparus trigonus*, and differs from *Palinurus* as well as from the other genera of the family), and the peculiar shape of the flagella of the antennæ. Only the frontal horns differ from those of the living species, but, as I have shown above, they are intermediate between that species and the condition seen in *Palinurus*, and this difference should be regarded as of only specific value: I do not think the shape of the frontal horns justifies the creation of a new genus, and this would be the only way left, if we do not wish to unite this fossil generically with the living Japanese species.

Altogether, there is no doubt that the fossil described above is the nearest relation of the living *Linuparus trigonus*, none of the other living species coming so near to that Japanese Crustacean. This fact is extremely interesting, since it proves that the genus *Linuparus* only slightly modified existed as far back as the Upper Cretaceous time, and, indeed, one might be induced to regard *Linuparus atavus* as the direct ancestor of the living species.

In conclusion, this new fossil gives a hint as to the origin of the geographical range of the genus *Linuparus*. *Linuparus* is not—as might be supposed from its present exclusive distribution in the Japanese seas—a form indigenous to that part of the world: the Japanese seas are not the “center of origin” of this genus, but the living species is to be regarded as the only “relict” left from a former wider distribution. Probably this genus (like most of the other Mesozoic marine animals) possessed formerly a more or less cosmopolitan distribution, but it has been restricted gradually, and the only remnant left at the present time is the Japanese *Linuparus trigonus*, which is to be regarded, accordingly, as a very ancient type among the living Decapods.

Princeton University, February, 1897.





EXPLANATION OF FIGURES.

*Linuparus atavus.*

- FIGURE 1.—Upper view of larger specimen.  $\frac{1}{2}$  nat. size. (Some details of structure of the carapace are supplemented from the smaller specimen.)
- FIGURE 2.—Frontal parts of carapace and base of antennæ, viewed from above, and showing stridulating apparatus. Nat. size (large specimen).
- FIGURE 3.—do., viewed from below. Nat. size.—*a*. Longitudinal groove, dividing the epistoma; *b*. Phymacerite; *c*. Basal joints of antennulæ.
- FIGURE 4.—*Linuparus trigonus* (dH.), living Japanese form, the same parts as in fig. 3, copied from the "Fauna Japonica" for comparison.  $\frac{1}{2}$  nat. size.