8. *On the* AFFINITIES *of the* ECHINOTHURIDÆ; *and on* PEDINOTHURIA *and* HELIKODIADEMA, *two* NEW GENERA *of* ECHINOIDEA.

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[PLATE VII.]

THE genus *Echinothuria* was founded by S. P. Woodward [1] in 1863 to include two Chalk fossils in the British Museum (Nat. Hist.). The specimen first discovered was found at Rochester, and it was regarded as a fossil cirripede until Darwin refused to accept it as a member of that class. Ed. Forbes then proposed to describe it as an holothurian, but finally declined this responsibility. It was not till the second specimen was found at Charlton by the Rev. J. N. Glass that the two fossils were recognized as probably fragments of an abnormal echinid. S. P. Woodward discussed the possibility of the fossils being holothurians or allied to Palæozoic echinids, such as *Protechinus*; but he rejected both ideas, and cautiously described the specimens as belonging to a new genus of echinoderm, of which the affinities 'are still matter for conjecture.' He remarked that 'the disciples of von Baer may regard it it as a "generalized form" of echinoderm'; but he shows that he realized one strong objection to this view, by pointing out the fact of the fossil 'coming, however, rather late in the geological day.'

The importance of the genus *Echinothuria* was not fully appreciated until 1873. In that year Sir Wyville Thomson [2] published an account of some recent echinids with flexible tests: for one series of these he proposed the name *Calveria*, but this has since made way for that of *Asthenosoma*, which had been given by Grube [3] in 1868. Thomson recognized the affinity of the deep-sea species with the Chalk fossil, and included both, with a third genus *Phormosoma*, in a new family—Echinothuridæ.

The possible affinity of these flexible echinids with the Palæozoic genera at once aroused the interest of palæontologists. Prof. J. Young,[4] in 1873, and Mr. R. Etheridge, Jun., in 1874, promptly called attention to the resemblances between them. The latter author welcomed the new genera as throwing light on the relationship between Palæozoic and recent Echini, and as serving 'to unite

[1] 'On *Echinothuria floris*, a New and Anomalous Echinoderm from the Chalk of Kent,' Geologist, vol. vi. (1863) pp. 327–330, & pl. xviii.

[2] 'The Depths of the Sea,' 1873, pp. 155–159; 'On the Echinoidea of the *Porcupine* Deep-Sea Dredging Expedition,' Phil. Trans. Roy. Soc. vol. clxiv. (1874) pp. 730–737.

[3] '*Asthenosoma varium*, n. sp.,' Jahresber. Schles. Gesellsch. Breslau, vol. xlv. (1868) pp. 42–44.

[4] 'On a Carboniferous Genus of Echinoderms with Overlapping Plates,' Geol. Mag. 1873, pp. 301–303.

the echini of the present seas with certain of those genera which existed during Palæozoic times.'[1]

The view of the close affinity of the Echinothuridæ with the Palæozoic 'Perischoechinidæ' was not allowed to pass unchallenged. It was denied by the late W. Keeping,[2] from a study of the fossil forms, and by Prof. F. J. Bell[3] in his classification of the recent families. Bell, however, still regarded the gap between the Echinothuridæ and other ectobranchiate echinids as very marked. He included the family in his Ectobranchiata, which he divided into two series: one of these, the Neoproctous, included all regular echinids except the Cidaridæ and Saleniidæ; it was subdivided into two subseries, the 'polylepid,' including only the Echinothuridæ, and the 'decalepid,' containing all the rest.

Prof. A. Agassiz, about the same time, also clearly recognized the affinity of the Echinothuridæ with the typical families of living ectobranchiate echinids. He even remarked[4] that 'it is difficult to separate this group of echinids as a distinct family from the Diadematidæ.' But he counteracted this advanced view and gave great encouragement to the older hypothesis by the remark 'that the Palæchinidæ are far more closely allied to the recent echinids than is usually supposed, and that we have in the recent Echinothuridæ structural features combining the characteristics of the normal Desmosticha and of the Palæchinidæ.'[5]

This view received its most definite exposition in an important memoir by the cousins P. & F. Sarasin,[6] published in 1888. These authors, impressed by many remarkable features in the anatomy of a new species of *Asthenosoma* (*A. urens*), claimed that the Echinothuridæ are the most primitive of living Echinoidea, and established the origin of this class from an holothuroid ancestor. They laid especial stress on the great size of the 'Stewart's organs,' on the presence of a series of powerful radial muscles, and on the absence of the supposed calycinal system of plates. Bell,[7] however, showed in 1889 that both the 'Stewart's organs' and radial muscles are absent or rudimentary in the genus *Phormosoma*, and that these organs therefore do not possess the importance attached to them by the Sarasins.

[1] 'On the Relationship existing between the Echinothuridæ, Wyv. Thoms., and the Perischoechinidæ, M'Coy,' Quart. Journ. Geol. Soc. vol. xxx. (1874) pp. 307–315, & pl. xxiv.

[2] 'Notes on the Palæozoic Echini,' *ibid.* vol. xxxii. (1876) p. 40.

[3] 'Observations on the Characters of the Echinoidea, pt. iv.: The Echinometridæ; their Affinities and Systematic Position,' Proc. Zool. Soc. 1881, p. 417.

[4] 'Report on the Echinoidea,' *Challenger* Exped., Zool. vol. iii. (1881) p. 71.

[5] *Ibid.* p. 81.

[6] 'Ueber die Anatomie der Echinothuriden u. die Phylogenie der Echinodermen,' Ergebn. naturw. Forsch. auf Ceylon, vol. i. (1888) pp. 83–151.

[7] 'Report of a Deep-Sea Trawling Cruise off the S.W. Coast of Ireland under the direction of Rev. W. Spotswood Green. Echinodermata,' by F. J. Bell, Ann. Mag. Nat. Hist. ser. 6, vol. iv. (1889) pp. 436–438.

Duncan, who carefully considered the Sarasins' arguments during the preparation of his 'Revision of the Genera and Great Groups of the Echinoidea,' did not accept their conclusions. He pointed out the differences between the Palæozoic echinids and the Echinothuridæ, and concluded that 'it appears more reasonable to place the Echinothuridæ near the Diadematidæ, granting some atavism, than to station them at the end of the Palæchinoidea.'[1] Like Bell, however, he separated them from the rest of his order, the Diadematoida (which included all Neozoic regular echinids except the Cidaridæ), as a special suborder, the Streptosomata.

Hence there have been, and still are, two opposite theories as to the affinities of the Echinothuridæ. According to one school, the characters of this family are primitive and ancestral; according to the other, they are degenerate and highly specialized. As it is impossible to progress with the phylogenetic classification of the echinids until it be known whether the Echinothuridæ are a root or whether they are a branch near the summit, I may be excused for again calling attention to this question.

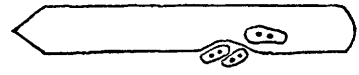
As we have already seen, it has been remarked by A. Agassiz, Bell, and Duncan—to whom Neumayr[2] may be added—that, in spite of the resemblances between the Echinothuridæ and the flexible Palæozoic echinids, this family is most closely allied to the Diadematidæ. It was natural first to compare *Asthenosoma* with *Astropyga*. But, as Wyville Thomson remarked in 1874, although 'some characters would seem to indicate a tendency to a passage from the Diadematidæ to the Echinothuridæ, through such forms as *Astropyga*, the resemblances are for the most part superficial, and very important anatomical characters maintain, according to our present knowledge, a broad line of distinction between the families.'[3] *Astropyga* is now recognized as a thin-tested member of the family Pedinidæ, with no special resemblances to any of the Echinothuridæ.

In most previous attempts to determine the origin of this family, the living echinothurids have been taken as the starting-point. The ancestry of the family is inferred from the characters of the latest and most specialized, instead of from those of the earliest and most primitive members. The best clue as to the origin of the Echinothuridæ is obtained from *Pelanechinus*, a Corallian genus founded by W. Keeping,[4] and ably described by T. T. Groom.[5] His account leaves no doubt that *Pelanechinus* is an echinothurid, of which family it is the oldest known form.

[1] 'A Revision of the Genera and Great Groups of the Echinoidea,' Journ. Linn. Soc., Zool. vol. xxiii. (1891) pp. 39–40.
[2] 'Die Stämme des Thierreiches,' vol. i. (1889) p. 377.
[3] Phil. Trans. Roy. Soc. vol. clxiv. (1874) p. 732.
[4] 'On *Pelanechinus*, a New Genus of Sea-Urchins from the Coral Rag,' Quart. Journ. Geol. Soc. vol. xxxiv. (1878) pp. 924–930.
[5] 'On some New Features in *Pelanechinus corallinus*,' *ibid.* vol. xliii. (1887) pp. 703–714 & pl. xxviii.

The Characters of the Ambulacra in the Echinothuridæ.—Since Duncan's classical paper on the 'Structure of the Ambulacra of some Fossil Genera and Species of Regular Echinoidea,'[1] it has been universally admitted that the characters of the ambulacral plates offer the best guidance in the classification of that section of the class. These plates in *Asthenosoma* and *Phormosoma* are very different from those of any other living echinid. It will be advisable therefore, in the first place, to endeavour to trace their gradual development. In the living echinothurids the ambulacral plates are all free; two-thirds of the pore-pairs occur in small plates ('klasma-plates') lying along the horizontal sutures between the remaining plates (fig. 1). Both characters remind us of the ambulacral plates of some Palæozoic echinids, which are multiserial, simple, and free. But in the living echinothurids every third plate is a large primary; and in spite of the apparent irregularity of the plates, they may be recognized as occurring in triplets. This is quite different from anything met with among the Palæozoic echinids, and they agree fundamentally with the typical Diadematoida. If the Echinothuridæ are to be regarded as descendants from the Palæozoic echinids, then compound ambulacral plates have been twice independently developed from the simple primary plates of the latter and of the Cidaridæ. This is not impossible, for heterogenetic homœomorphy unquestionably occurs sometimes. It is highly probable that echinids with 'arbacioid' ambulacral plates have developed from forms with simple ambulacral plates, through stages represented by the genera *Salenia* and *Acrosalenia*; while those with 'diademoid' ambulacral plates have developed through forms such as *Eodiadema* and *Archæodiadema*. It is conceivable that there may have been a third line along which the Echinothuridæ have developed; but there is no evidence of any such development, and we ought not to assume this origin in face of actual evidence for one which is inherently far more probable.

Fig. 1.—*Ambulacral plates of* Phormosoma Uranus. (*After A. Agassiz.*)



It will be remembered that the typical 'diademoid' ambulacral plates consist of three primary plates fused into one (fig. 9, p. 121). The middle primary is usually the largest. The gradual growth of this central plate may be traced until the adoral and aboral plates are cut off from the vertical suture-line, and thus become demi-plates (fig. 6*d*, p. 118). By a further progress in the same direction, the demi-plates are reduced to the condition of 'klasma-plates,'[2] detached

[1] Quart. Journ. Geol. Soc. vol. xli. (1885) pp. 419–452.

[2] A name suggested for the small, eye-shaped plates, which are cut off from contact with either the vertical suture running down the centre of the ambulacral area, or that between the ambulacrum and interambulacrum. They represent a stage of reduction further than that of demi-plates. From κλάσμα, a fraction.

from both of the vertical sutures, and lying only on the horizontal sutures (see fig. 1), as in *Phormosoma Uranus*. Now in *Pelanechinus* the ambital ambulacral plates (fig. 2) each consist of three primary ambulacral plates and three demi-plates and three klasma-plates, or nine constituents in all. This arrangement is apparently so complex that Mr. Groom suggests that it is to be regarded as a new type of ambulacral plate.[1] But the plates near the end of an ambulacrum consist of triplets, each composed of a central large primary with a demi-plate (or klasma-plate) above and below it (fig. 3). This is the arrangement of a typical 'diademoid' plate. If we follow along an ambulacrum of a *Pelanechinus*, we find a gradual passage from the simple diademoid triplets to the large compound plates of the ambitus. These plates may, therefore, be regarded as formed by the fusion of three diademoid plates.

Fig. 2.—*Ambital ambulacral plate of* Pelanechinus. (*After Groom.*)

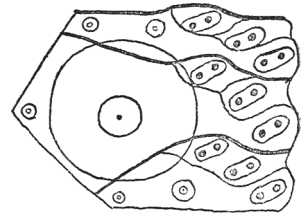
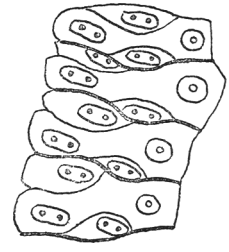
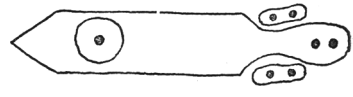


Fig. 3.—*Peristomal ambulacral plates of* Pelanechinus, *showing division into triplets of the diademoid type.*



In the living Echinothuridæ the ambulacral triplets are usually described as formed of a large aboral primary and two small demi-plates in the adoral suture of the primary (fig. 1, p. 115). This view obscures the diademoid structure of the plates. If we examine the ambital plates the usual view appears the natural one. But if we examine the ambulacral plates near the apex, we find that they are composed of a central primary between an adoral and an aboral primary, as, for example, in *Phormosoma bursarium* (fig. 4), and near the peristome the same arrangement recurs (fig. 5); that is to say, the plates are typically diademoid, and agree in arrangement with the equivalent plates of *Pelanechinus*. From these upper plates we may follow the series downward, seeing the gradual increase of the central plate, and the reduction of the demi-plates until they occur as small klasma-plates in the horizontal suture. The development of the plates shows, therefore, that the ambulacral plates

Fig. 4.—*Ambulacral plates of* Phormosoma bursarium *near the apex. (After A. Agassiz.)*

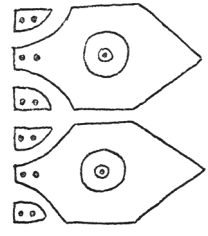


[1] Quart. Journ. Geol. Soc. vol. xliii. (1887) p. 707. The author, however, there regards the triplets as of the echinoid, and not of the diademoid type.

ought to be described as composed of a central primary between aboral and adoral demi-plates; and of the pair of pore-pairs below each primary, one belongs to the same triplet as the plate above, and the other to that of the plate below. The limits of the triplets in *Pelanechinus* are shown in fig. 5.

Pelanechinus and the living echinothurids, therefore, begin with plates of identically the same arrangement. In *Pelanechinus* three of the triplets fuse into a compound plate; while in *Asthenosoma* and *Phormosoma*, on the other hand, the triplets are broken up—owing to reduction in the calcification of the test.

Fig. 5.—*Ambulacral plates of* Phormosoma luculentum *near the peristome.* (*After A. Agassiz.*)



It appears, therefore, possible to explain the peculiar arrangement of the ambulacral plates of living echinothurids as due: 1st, to the fusion of three diademoid triplets; 2nd, to their dissociation *pari passu* with the reduction of the calcareous matter in the test, as the plates become thinner and the test flexible. If this view be correct, then the flexibility of the Echinothuridæ is a secondary character, and was not due to inheritance from a flexible, Palæozoic ancestor.

The structure of the ambulacral plates seems conclusively to prove that the Echinothuridæ are members of the order Diademoida. The question arises whether the members of this family have descended from a diademoid ancestor, or whether the rest of that order have descended from an echinothurid.

That the former alternative is the true one is rendered probable by several reasons:—1stly, the Echinothuridæ are younger than many of the Diademoida, for this order begins in the Lower Lias, while the family does not appear until the Corallian; 2ndly, the oldest form of echinothurid is more nearly allied to the nearest diademid than are the later, and apparently more primitive, members of the family. To accept the other alternative would make diademids found in the Lower Lias, and even some older forms occurring in the Trias, descendants from genera not known to occur earlier than the Corallian.

Let us therefore next enquire whether there be any member of the Diademoida, of Corallian or pre-Corallian age, from which *Pelanechinus* could have been derived.

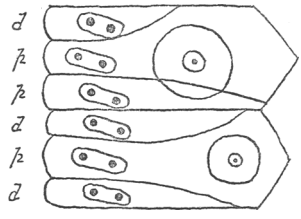
Neumayr [1] has already suggested that the evolution of the family was through 'a series from *Hemipedina* by *Pelanechinus* to the Echinothuridæ.' It is true that the only species of *Pelanechinus* was originally described as an *Hemipedina* [2]; and the two genera

[1] 'Ueber *Palæchinus*, *Typhlechinus*, und die Echinothuriden,' Neues Jahrb. 1890, vol. i. p. 85.

[2] *H. corallina*, Wright, 'Monogr. Brit. Foss. Ech. Ool.,' p. 163, pl. xii. fig. 1,

agree in having perforate, non-crenulate tubercles, and low, broad interambulacral plates, each with a row of tubercles. But the genera differ widely by the structure of the ambulacral plates. In *Hemipedina* the compound ambulacral plates are always formed of three primaries, and the pore-pairs are a simple vertical series. But in *Pelanechinus* the pore-pairs are triserial. We have therefore to look for its ancestor among the triserial Pedinidæ, and not among the uniserial Diadematidæ to which *Hemipedina* belongs.

Fig. 6.—*Ambulacral plates of* Pedina. (*After Duncan.*)



Before following this clue, however, we must remember that Duncan adopted a course which, if agreed upon, would prevent the derivation of the Echinothuridæ from such specialized Diademoida as the Pedinidæ. Duncan divided the order Diademoida into two suborders—the Streptosomata, including the Echinothuridæ, and the Stereosomata, including the rest of the order. He defined the Streptosomata as follows[1]:—'Test more or less flexible, with external and internal branchiæ. Ambulacral plates alone continued beyond the peristome to the stoma.' But all these characters also occur among the other suborder, the Stereosomata. In the pedinid *Astropyga* and the diademid *Helikodiadema* (see *infra*, p. 121) the test is more or less flexible. Both external and internal branchiæ are as well developed in *Diadema* as they are in *Phormosoma*.[2] In those of the Stereosomata which have plates on the peristomal membrane, these are always ambulacral.

Hence Duncan's diagnosis is useless, and there is no evidence to show that the Echinothuridæ diverged from the main diademoid stem at a very early period. We may search therefore among the triserial members of that order for a suitable ancestor for the echinothurids. Of all the Pedinidæ, *Pedina* is most like *Pelanechinus*. The interambulacral plates have the same tuberculation, for in both genera they are multiserial, perforate, and non-crenulate.

The ambulacral plates of *Pedina* show a series of stages between simple diademoid plates and those of *Pelanechinus*. The ambital plates of *Pedina* usually consist of three primaries, of very unequal size. In some cases the middle primary increases so much in size that it crowds out the other two constituents and reduces them to demi-plates (fig. 6). These demi-plates may even lose any connexion with the vertical suture between the ambulacral and interambulacral areas; they are thus reduced to the position of klasma-plates on the horizontal sutures between the primaries. Plates in this

[1] Journ. Linn. Soc., Zool. vol. xxiii. (1890) p. 25.
[2] F. J. Bell, Ann. Mag. Nat. Hist. ser. 6, vol. iv. (1889) p. 437.

condition are not common in *Pedina*; but they do occur, and they are identical in arrangement with the ambulacral plates near the apex of *Pelanechinus* and *Phormosoma*.

Thus *Pedina* suggests the point at which the echinothurid branch diverged from the main diademoid stem. The gap between *Pelanechinus* and the nearest member of the rest of the order Diademoida is bridged by a new echinid from the German Jura, which I have accordingly named *Pedinothuria*. Its test being small and rigid, it appears to be nearer to the Pedinidæ than to the Echinothuridæ.

Pedinothuria, gen. nov.

Diagnosis.—Pedinidæ with the test small, rigid, and turban-shaped.

Apical system large, its diameter about half that of the test. The arrangement of the plates is unknown.

Ambulacra.—Near the apex the plates are simple primaries. At the ambitus the pore-pairs are biserial, owing to the reduction of alternate primaries to demi-plates. Below the ambitus the pore-pairs are triserial, owing to the presence of a second demi-plate on the horizontal suture between two primaries.

Near the peristome the plates are not compound; they are all demi-plates, and occur in three series. Those of the median series are the largest, and they may bear a miliary granule.

There are no primary tubercles on the ambulacra; but two rows of small, regular granules run down each ambulacrum. Near the peristome they are small, and limited to the primary plate on which they occur.

Interambulacra.—The plates are unituberculate. Upon each there is a prominent, primary tubercle, which is perforate and crenulate. About seven in each vertical series. The mamelons are perforated. Near the peristome the ambulacra are broader than the interambulacra.

Peristome small; branchial slits very deep.

Distribution.—Jurassic, Germany.

Pedinothuria cidaroides, sp. nov. (Pl. VII. figs. 1–3.)

Diagnosis.—Test circular, depressed. Oral surface very flat; aboral half slightly tumid.

Apical system slightly more than half the width of the test in diameter.

Interambulacra.—Seven plates in each vertical series. Scrobicular areas confluent. Miliary granules scarce.

Ambulacra.—Structure as in generic diagnosis. The change from the uniserial to the biserial arrangement of the pore-pairs occurs at the 12th or 13th plate from the apex.

Dimensions.—Diameter, 12 millim.; height, 5 millim.; diameter of apical area, 7 millim.; diameter of peristome, 4 millim.; width of ambulacrum at ambitus, $2\frac{1}{2}$ millim.; width of interambulacrum

at ambitus, 5 millim.; width of interambulacral plates in each series, 7 millim.

Distribution.—Weisser Jura, Germany. Type, B. M., no. 34,724.

Affinities.—This specimen was sent to the Museum labelled *Diplocidaris*. Its deep branchial slits and compound ambulacral plates show that it cannot belong to the order Cidarida. There can be no doubt that it is a member of the order Diademoida, for the genus is regular and ectobranchiate. It is distinguished from the suborder Calycinæ (including the Saleniidæ and Acrosaleniidæ), in the absence of knowledge of the structure of the apical system, by the complexity of the ambulacral plates. From the suborders Arbacina and Echinina it differs in having the ambulacral plates diademoid, instead of on the arbacioid or echinoid type. The genus falls easily into the suborder Diademina, owing to the character of the ambulacral plates. In this suborder there are six families; of which the Orthopsidæ have simple ambulacral plates; the Diadematidæ and the Diplopedinidæ respectively have regularly uniserial and biserial pore-pairs; the Cyphosomatidæ have the pore-pairs in high curved arcs. This leaves only the two families of the Pedinidæ and Echinothuridæ, with both of which the genus agrees in some respects. Thus the ambulacral plates may consist of a central primary and two demi-plates, one or both of which may be further reduced to klasma-plates. The plates just below the ambitus of *Pedinothuria* agree exactly with those of *Asthenosoma*, except that they are thicker and solidly united to their fellows. They are more of the echinothurid type than of that of *Pedina*. Nevertheless, owing to the rigidity of the test, and the unituberculate, cidaroid character of the interambulacral plates, it appears advisable to include the genus in the family Pedinidæ.

The exact horizon whence the fossil came is unfortunately unknown. It is simply labelled 'Weisser Jura, Germany.' The test has apparently been washed in weak acid, and thus it may not be safe to guess its horizon from its appearance. But, as far as I can judge, it probably came from either Western Bavaria or Württemberg, and from the horizon γ of the Weisser Jura. In that case it would be older than the earliest echinothurid, which lived in the succeeding stage of the Weisser Jura ϵ.

As the main difference between *Pedinothuria* and *Pelanechinus* is that the latter had a somewhat flexible test, it is advisable to consider the value of this character. The evidence of *Astropyga* and of the deep-sea spatangids, such as *Calymne* and *Cystechinus*, shows that flexibility is not limited to a single family, and may be independently acquired; it is probably due to changes of environment leading to diminished calcification of the test. We must therefore be prepared to meet with imbricating-plates in any group of echinids.

In various Mesozoic rocks there occur isolated plates, with truncated margins, which, if imbrication and flexibility were limited to the Echinothuridæ, would have to be referred to that

family. S. P. Woodward called attention to these plates in his original description of *Echinothuria*. Spines had previously been figured by Forbes, first as belonging to *Micraster*[1] and then to *Cidaris*.[2] S. P. Woodward[3] and Wright[4] showed a truer appreciation of their characters by assigning them to *Diadema*. At this time, however, the echinid was known only from isolated plates. In Wright's 'Monograph of the Cretaceous Echinoidea' a better

Fig. 7.—*Ambulacral plates of* Helikodiadema *at summit of ambulacrum.*

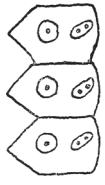


Fig. 8.—*Ambital ambulacral plate of* Helikodiadema.

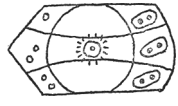


Fig. 9.—*Ambulacral plates of* Helikodiadema *adjoining peristome.*

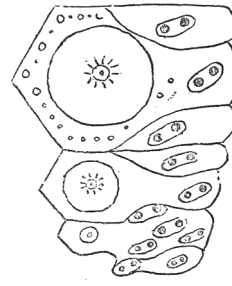


Fig. 10.—*Genital plate of* Helikodiadema.

specimen was figured, with the plates in their relative positions:[5] it was named *Pseudodiadema fragile*. The structure of the ambulacral plates was not shown; but the accompanying figure (7) of a specimen in the British Museum (B. M. 46,781) shows that the plates are diademoid.

The echinid is most nearly allied to *Pseudodiadema*, but the differences between it and that genus seem well worthy of generic distinction. I therefore describe it as follows:—

HELIKODIADEMA,[6] gen. nov. (Figs. 7–10.)

Diagnosis.—Diadematidæ with a large, flexible test, composed of thin, loosely-fitting plates. Peristome and periproct large. Perignathic processes slender.

[1] E. Forbes, in Dixon's 'Geol. Suss.,' Expl. of pl., p. x, pl. xxv. fig. 28.
[2] *Id.*, Dec. Geol. Surv. no. iii. pl. x. fig. 15.
[3] S. P. Woodward, *ibid.* no. v. pl. ii. p. 11.
[4] Wright, 'Monogr. Cret. Ech.' pl. xiv. fig. 2.
[5] *Ibid.* pl. lxxx.
[6] From ἕλικος, twisting.

Apical system apparently a single circle of ten plates. Genital plates pentagonal and large.

Ambulacra.—The plates near the apex are primaries. At the ambitus they are of three fused primaries. Near the peristome they are crowded, and demi-plates are numerous.

Tubercles perforate and crenulate.

Spines annulated, fluted, hollow.

Distribution.—Chalk, England.

Type Species.—*Helikodiadema fragile* (Wilts.), of which the synonymy is as follows :—

Cidaris, sp., Forbes, 1850, in Dixon, 'Geol. Suss.,' Expl. of pl., p. x, pl. xxv. fig. 28.

Micraster, sp., Forbes, 1850, Dec. Geol. Surv. no. iii. pl. x. fig. 15.

Diadema, sp., S. P. Woodward, 1856, Dec. Geol. Surv. no. v. pl. ii. p. 11 ; Wright, 1868, 'Mon. Cret. Ech.' pl. xiv. fig. 2 ; S. P. Woodward, 1878, in Dixon, 'Geol. Suss.' 2nd edit. p. 372, pl. xxv. [28] fig. 28.

Pseudodiadema fragile, Wiltshire, 1882, in Wright, *op. cit.* pl. lxxx.

Summary of Conclusions.

1. That the family Echinothuridæ is a member of the order Diademoida, and is derived from the Pedinidæ.

2. That the oldest member of the family is the genus *Pelanechinus*, and that the extreme flexibility and loose articulation of the plates of the living genera *Asthenosoma* and *Phormosoma* are due to diminished calcification of the plates.

3. That the apparently primitive features of the Echinothuridæ are secondarily acquired and are not primæval. The recent genera are therefore extremely specialized, instead of being primitive forms.

4. A new genus *Pedinothuria* is a connecting-link between the Pedinidæ and the Echinothuridæ.

5. A new genus *Helikodiadema*, which has a flexible test, is a modified form of *Pseudodiadema* ; it has probably arisen from the adoption of deep-sea life having resulted in diminished calcification of the test.

[For Explanation of Plate VII., see p. 134.]