Fossile Gattungen:

Neorthophlebia Handl. 1908.

Handlirsch, Fossile Ins. 1906—1908. S. 479. Taf. 42. Fig. 15—18.

Unterscheidet sich von *Bittacus* Latr. durch den 3ästigen hinteren Ast der Media, der sich aber dem ersten Cubitalast angefügt hat und so scheinbar der Gabelast des 1. Cubitus ist.

4 Species im oberen Lias.

Pseudopolycentropus Handl. 1908.

Handl. l. c. S. 482.

Eine eigenartige Form, durch die sehr kurze Subcosta und den 3ästigen vorderen Medianast von *Bittacus* Latr. ausgezeichnet.

1 Species im oberen Lias.

Stettin, 5. Oktober 1909.

7. The Building of Atolls.

By F. Wood-Jones, Manchester University.

eingeg. 8. Dezember 1909.

1) The reasons why Darwin's theory of Subsidence will not explain the origin of such a structure as the Cocos-Keeling atoll.

Since the year 1825 the history of the atoll has been well recorded, and in that time the steady tendency of the atoll has been to increase its lagoon shores at the expense of the lagoon water. The lagoon has steadily become more shallow since 1825. Besides this known tendency of atoll building, the structure of the reef and the islands demonstrates that no sinking has taken place in the whole history from the time when the wave washed reef first reached the surface of the sea. The islands are mere débris piles thrown up at intervals upon the level surface of a crescentic reef, — this level rim of the submarine bank I have named the breccia platform. The breccia platform runs under the islands and stretches from the wave-washed barrier edge to the lagoon margin. Since its internal, or lagoon, edge is its oldest part, and in its extent to the seaward edge it represents the building during an enormous period of years, it follows that its lagoon edge should be lower than its seaward edge, if the structure had been sinking. This is however not found to be the case.

The undermining of coconut palms, and the denudation of shore lines, which Darwin took to be a sign of subsidence, are inconstant features, the outcome of temporary alterations of wind and tide. An area of denudation is always compensated for by a neighbouring area of building.

2) The reasons why Murray's theory of Solution will not explain the origin of the atoll.

The reasons are numerous, for the theory is faulty from beginning to end.

It has to be explained why, when solution may develop an atoll lagoon, it will not much more readily dissolve the bank on which the atoll is situated. For Murray has shown that the powers for solution increase with the depth.

It is everywhere to be seen that deposition of calcium carbonate takes place in the lagoon area, and that coral sand is constantly being accumulated in the lagoon.

It has to be explained why banks below the sea are already basin-shaped for none of Murrays arguments apply to these submarine lagoons. The features of atolls (the undermining of coconut palms, and the situation of the islands on the lagoon edge of the reef) which Murray relied on as demonstrating the workings of Solution are the results of entirely different causes.

The arguments of the Theory of Solution are fallacious, and the method of its investigation erroneous. No feature of a completed atoll, no stage of a developing atoll, and no picture in the closing scenes of the story of a mature atoll demonstrates its workings, or is explained by its suppositions. In Cocos-Keeling lagoon are large areas occupied by dead coral, killed in 1876, and these dead corals are standing intact after 30 years exposure to the effects of sulution. The many fanciful embroideries that have been appended to the original theory by Stanley Gardiner do not conceal the poverty of the original fabric but rather accentuate it.

3) The Funafuti bore has added nothing to the knowledge of the method of atoll formation, — except perhaps that atolls grow outwards on their own talus slopes. The bore was driven on the windward side of a bank ten miles across, and if the original bank had advanced only half a mile to windward in its whole life-history, the bore in such a site must have necessarily been confined to this talus slope.

4) Suggestions put forward by the Author to explain the development of Coral structures. As an outcome of observations made on the Cocos-Keeling atoll, it is suggested that the process of "Sedimentation" takes the largest share in the production of most of the stages of an atoll's history. The bed of the open ocean is composed of matter that has fallen from the surface; sedimentation is always taking place all over the ocean. In certain places, sometimes owing

perhaps to the influence of oceanic currents, sometimes to the presence of an already existing elevation upon the ocean bottom, this sediment will tend to make ridges or banks. Many such banks are known to exist in the depths of the sea.

What may be the nature of the original elevation that has become covered by this deposit of Globigerina and Pteropod ooze, we do not know. Whatever their original nature they become essentially "Sedimentation" banks.

The question then arises as to where beneath the surface of the sea will the building of banks by sedimentation become arrested. The answer may be partly given by determining where wave action ceases to be felt below the surface of the sea, and the data to be derived from published observations on this point show the level to be somewhat inconstant. Its variability would be confidently expected, for waves vary enormously in their size and in their power to stir the underlying water. Yet we know that there is some point between the surface of the ocean and the bottom, above which the action of waves is felt and sediment will not come to rest in open ocean, and below which there is no wave stirring and sediment may rest and build banks and raise the ocean bottom. This point is considered important; and the plane in which this line of stasis occurs is named the limiting line of sedimentation. It is therefore to the limiting line of sedimentation that banks formed by sediment may be raised. A bank so raised would rise to such a plane, but could not go beyond it, for the wave motion would keep the particles moving, and thus level out the top of the bank and flatten it, so that it formed a plateau at the level of the limiting line of sedimentation. It is claimed that the bathymetrical limit of the reef-building corals is intimately associated, if not coincident, with the limiting line of sedimentation, and that it is therefore a variable plane depending on the local conditions of the sea. The reasons for this coincidence are to be found in the study of the living corals themselves; and I have come to the conclusion that the presence of matter suspended in the water is the most potent factor in determining the unsuitability of an environment for coral life. Where sediment is at all times liable to fall upon the living zooids, reef-corals will not flourish: we would therefore not look for their luxuriant presence below the limiting line of sedimentation. In the wave-stirred area above this line, however, they can and do flourish. We therefore arrive at the presumption that sediment can build banks up to this hypothetical line, and reef-corals can build banks from this line up to the surface of the sea. There is therefore no reason why coral colonies should not settle upon the bank and start the development of a reef. As a matter of fact several other forms of life which possess calcareous skeletons outrun the reef-corals in bathymetrical range, and it is likely that they (calcareous algae, deep water corals, &c.) first populate the summit of the bank.

The process now becomes less a matter for hyopthesis and more one for actual observation, for the growth tendencies of reefs and of colonies may be more easily studied. It is claimed that the tendency is for such reefs to become "basin-shaped reefs," and to develop as flat banks, with edges raised from their general surface and abundantly covered with coral colonies. The chief factor in this process is again the action of sedimentation. The surface waters still drop their burden of suspended matter over the reef, and it is deposited upon the uneven surface of the coral colonies, for, though it could no longer come to rest upon the open sedimentation bank, it more easily finds a lodgment upon the broken coral surface of the reef. At the edges of the reef the sediment becomes more easily washed off by wave action, and the corals of the circumference of the reef flourish most.

To obtain a concrete picture of the process it is only necessary to turn to the colonies to be found any day in quiet pools in which sediment is accumulating. A colony of Porites grows as a spherical mass. In time it develops to such a size that its rounded upper surface becomes sufficiently flat to afford a lodgement for sediment. Then the activity of its central zooids wanes, and, by the upgrowth of the peripheral ones, the flattening increases. At length the central area dies — the zooids choked by sediment,—and a raised ring of active living zooids surrounds a central depressed area—an atoll in miniature.

That this process is not due to the colony reaching tide-level (Darwin, Semper) is proved by the abundant finding of such colonies developed many feet below the level to which the tide ever falls.

The process that may be seen any day in the myriad colonies around an atoll, is presumed also to occur on the reef as a whole, for it is merely a question of substituting colonies for individual zooids to picture the development of the submerged basin-shaped reef.

The basin-shaped reef continues to grow upwards until tide limit arrests the growth of its margins. At this stage the waves begin to act upon it and hammer fragment against fragment with the production of a quantity of coral débris at the point of maximum intensity of the waves. This débris becomes cemented into solid breccia by the deposition of calcium carbonate around the particles that compose it. This is the beginning of the breccia platform, and its origin may be looked for upon the windward side; and on that side it will always remain best developed.

The breccia platform follows the raised rim of the reef in its development, and forms a level, solid, conglomerate crescent, upon which the waves break at low tide. Upon this platform some waves of unusual violence will hurl fragments broken from the reef margin, and these masses will be left stranded upon the platform when the force of the waves can trundle them no further.

This is the beginning of the island, and this process also may be expected to originate at the windward side and to be always most perfectly developed there. Any fragment thrown upon the breccia platform is potent to bring about an important change, for it initiates a process that may be seen anywhere when an obstacle is placed in the line of a current of water that carries any sediment in its stream. The current impinges on the impediment and its burden of sediment is deposited in stream lines from its extremities (Hedley and Dr. Guppy). In this way the form of the island tends to become that of a crescent.

The piling up of fragments will follow the line of the breccia platform, and so will take place as a part of the circumference of a circle or a horse-shoe. At the lee side, the waves will not have sufficient force to construct a breccia platform or pile débris upon it, so the lagoon entrance is situated upon this side. When the wind blows in opposite directions for two definite seasons, as in the Monsoon area, the action may be equalised all round the reef edge, and so the atoll be a completed ring and each of its constituent islands be perfect atollons. In the Trade area, however, the uniformity of the wind will produce a horseshoe-shaped atoll, elongated in the line of the wind, with crescentic islands on its windward side. When the atoll structure is once developed, the enclosed lagoon tends to become the resting-place of a vast amount of sediment, formed by the disintegration of coral fragments by the force of the waves. The method of the deposition of this sediment is important.

As waves rush over the breccia platform in the intervals between adjacent islands, the current becomes slowed at the sides of the inlet, and sand is deposited in stream lines from the extremities of the islands, helping to increase their crescent form. In the middle of the interval between two islands the inrushing current sweeps on farthest, and its burden of sand is dropped in the lagoon opposite the gap in the island ring.

This process accounts for the existence of those atolls that have the most land upon their leeward side, and an entrance guarded by a breccia platform upon their windward side. The sand swept in at their windward side is deposited upon the lee side of the lagoon (if it be a small one) and comes to rest in the original lagoon entrance. The entrance becomes blocked up, and a wide belt of land is formed upon the lee side of the atoll; but no barrier reef exists upon the lee side.

As sand is deposited in the lagoon it tends to obliterate the coral growth, and so a lagoon, that at first tended to become shallow by the upgrowth coral colonies, ultimately becomes devoid of living coral, and to shoal entirely by the deposition of sediment. In the Cocos-Keeling atoll, the history since 1825 shows a steady filling-in of the lagoon. The continuation of the process that formed the perfect atoll, therefore, tends to obliterate the lagoon. The lagoon shores gain on the lagoon water, and banks rise up in its shallower parts; the windward side of the lagoon, if it be of large size, being the first portion to become obliterated.

The explanation of the origin of fringing reefs follows the same lines. On any platform that lies above the limiting line of sedimentation, reef-corals will develop, when the conditions of the water are suitable. Fringing reefs are merely reefs taking origin upon the submarine slopes of oceanic land, when these slopes afford a foothold in the wave-stirred area.

Barrier-reefs were explained in 1856 by Prof. Le Conte as being fringing reefs of which the growth was "limited on one side by the muddines of the water, and on the other by the depth." In 1884 Dr. Guppy independently furnished the same explanation. This explanation, which is an isolated and discordant thing when "Subsidence" or "Solution" is taken as accounting for atoll formation, becomes of consequence, and falls into line with other ascertained facts, when the importance of "Sedimentation" is appreciated. (For permission of republishing certain parts of this article I am indebted to the Zoological Society of London.)

8. Über die sogenannte metamere Segmentierung des Appendicularienschwanzes.

Von J. E. W. Ihle, Zoolog. Institut Amsterdam.

eingeg. 8. Dezember 1909.

Zu Anfang dieses Jahres erschien eine schöne Abhandlung von E. Martini über »die Konstanz histologischer Elemente« (Zeitschr. f. wiss. Zool. Bd. XCII), worin er einen sehr wichtigen Beitrag zur Kenntnis der Anatomie und Histologie von *Oikopleura longicauda* liefert. In dieser Schrift untersucht er auch ausführlich den Bau des Schwanzes und kommt (S. 611) in bezug auf die Segmentierung zu dem Ergebnis, daß, »wenn man selbst bei Appendicularien eine Segmentierung fände, sie doch so verschieden von der des *Amphioxus* sein würde, daß es zweifelhaft wäre, ob man sie mit der Segmentierung der Vertebraten in phylogenetischen Zusammenhang bringen könnte«.

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