

LIX.—*On Contrasts in the Marine Fauna of Great Britain.*

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I HAVE drawn together some of the impressions made by an examination of the littoral fauna, and that within a few miles of the shore, at the four points of the compass in the British area, leaving out, however, on the present occasion all reference to Ireland. Thus, for the north Shetland, for the south the Channel Islands, for the east St. Andrews, and for the west the Outer Hebrides have been selected. As, however, a long stretch of English coast on both sides would have been left out, it has been thought desirable to supplement these in certain cases by similar investigations at Scarborough, the Tees, the Humber, and the Orwell on the east, and at Southport and the Isle of Man on the west; whilst on the south the Isle of Wight and Plymouth give some useful data.

The whole British marine area is included in the Celtic province of Edward Forbes, the Shetland Islands alone in the north having an admixture of boreal forms, while the Channel Islands present an admixture of southern types, or, as Forbes called them, Lusitanian forms. I may explain in passing that this accomplished naturalist grouped the seas of Western Europe into five provinces, viz. the Arctic, Boreal, Celtic, Lusitanian, and Mediterranean, each of these being one of his centres of creation, for he believed that nowhere do we find a province repeated—"that is to say, in none except one centre of creation do we find the same assemblage of *typical* species, or, in other words, no species has been called forth originally in more areas than one." The vast advances which have been made in marine exploration, however, since the publication of his 'Natural History of the European Seas' (1859) have levelled some of his barriers and have shown how wide the distribution of many species is. Yet even in so limited an area as that of the seas of Britain we shall find certain interesting facts underlying the generalizations of Forbes.

In the brief compass of a more or less simple introductory lecture it is, of course, impossible to give a detailed or complete view of the four points selected. It becomes necessary, therefore, to choose only the most salient features for review and discussion, a preference, moreover, being given for those which in one way or other bear on problems of general interest.

* The Introductory Lecture to the Class of Natural History, University of St. Andrews, 9th October, 1896.

Without further introduction, therefore, we shall at once proceed to examine the conditions at St. Andrews, which during the present generation has come to be a zoological centre for the east coast, though in former years other places, such as the Forth in the days of Professors Forbes and Allman, Berwick-on-Tweed in the time of Dr. George Johnston, and the northern shores of England under the fostering influence of Joshua Alder and Albany Hancock, attained great prominence.

If we take a general glance between tide-marks at St. Andrews the great abundance of the crumb-of-bread sponge (*Halichondria panicea*) is noteworthy, covering as it does several square feet in certain places, and it is equally abundant in the Laminarian region. Where an admixture of fresh water, moreover, occurs, as in the estuaries of the Forth and the Tay, the growth of this species is remarkable. With the exception, perhaps, of *Chalina* other sponges are not conspicuous, though they are by no means absent.

Of zoophytes we have *Clava multicornis* under stones and on *Cynthia*, and *Gonothyræa Lovéni* in vast profusion on the finely grown submerged mussels of the Eden, forming a network upon which the pelagic young mussels settle as minute points or grains in summer, and, after growing a little, are swept off by the annual decay of the zoophyte at the end of autumn. The frequency of *Sertularia pumila* and of *Sertularella rugosa* near low-water mark is another feature, as also is the occurrence of large *Corymorphæ* in a limited inshore area, and of large *Lucernariæ* on *Fuci* at the tidal rocks. The striking pelagic members of this group are *Halistemma* and *Lesueuria*, while the common *Beroë* and *Pleurobrachia* are very abundant amidst swarms of *Hydromedusæ*, including *Aglantha* and *Hybocodon*. The common sea-flowers (*Actinia mesembryanthemum* and *Tealia crassicornis*) are plentiful, or, rather, I should say, were plentiful, for the fishermen have found them so attractive as bait for cod that they have in several places almost exterminated them. The sandy bay is likewise the home of *Peachia* and its allies—*Edwardsia* and *Cerianthus*. The deeper water, again, is characterized by the rare *Hormathia* and by the sea-pens *Pennatula* and *Virgularia*.

The most interesting starfish between tide-marks is the little *Asterias Mülleri*, which is found under stones in pools, and in the early months of the year it carries its eggs over the mouth and hatches them there, as does also the purple *Cribrella* which accompanies it. Larval starfishes are plentiful in summer and autumn, including the remarkable one of *Luidia*.

Amongst the worms the abundance of the spoon-worm (*Echiurus Pallasii*) is a striking feature, together with the prevalence of sand-dwelling forms, such as *Magelona*, *Ophelia*, and *Nephtys*. The occurrence of the gigantic epitocous form *Alitta virens* is also noteworthy. In the tow-nets the larval types *Tornaria* and *Mitraria* occasionally appear, along with *Polygordius*.

The crabs exhibit no very marked diagnostic characters, but the edible, shore, and masked crabs are common, the two former between tide-marks, the latter in the inshore sand, along with *Portumnus variegatus* and *Portunus holsatus*. The northern stone-crab is not uncommon in the deeper water. *Mysis* is abundant and *Boreophausia* and *Nyctiphanes* occasionally in great profusion in the inshore water, along with *Parathemisto*.

The Lepraliæ and Alcyonidians are fairly numerous between tide-marks. In the adjoining sea the most characteristic are *Bugula purpurea* and *Flustra Murrayana* with the larval *Cyphonautes*.

Of shell-fishes the mussel is the most conspicuous, along with *Mya arenaria* and the cockle on the beach, whilst between tide-marks amongst the rocks *Trochus cinerarius* and *Tapes pullastra* are characteristic. Only a single rock-oyster is occasionally met with. In the pelagic fauna mussels are likewise the most prominent in summer. The pteropods *Spirialis* and *Clione* also occur, the former often in great numbers, the latter a pigmy in comparison with the arctic examples.

Ascidians, with the exception of *Styela rustica*, are not common between tide-marks; but in the adjoining waters *Ascidia scabra* is abundant on the tangles. In the deeper water *Molgula* occurs, and, in certain areas, the remarkable *Pelonaia*. Myriads of the pelagic Appendicularians fill the tow-nets.

The fishes between tide-marks are those usually observed all along the coasts, viz. shannies, gunnels, long-spined sea-scorpions, gobies, fifteen-spined sticklebacks, and sand-eels, while the flatfishes and thorn-backs are characteristic of the margin of the sandy bay beyond. Soles are occasionally procured. The ordinary round fishes are abundant, but the conger is less common than on the west and south. The characteristic young fishes at the margin of the rocks in summer and autumn are young green cod, cod, ling, lump-suckers, and sand-eels, with pleuronectids, herrings, and gunnels in the adjoining area.

The marine mammals include the seal—still present in

considerable numbers at the mouths of such salmon-rivers as the Tay—and a few porpoises. The rorqual and lesser rorqual are occasionally seen, and also scattered pairs of the ca'ing whale. Killers are rare.

Turning now to the extreme west, to shores more or less influenced by warm currents both of air and water, the first feature of note is the comparatively small rise and fall of each tide, and, in bays like Lochmaddy, the great abundance of mud; but it must not be thought that the latter is absent from the eastern shores, for a great deposit occurs east of the Island of May and at many other parts of the coast. Before proceeding to the consideration of the fauna of the west, we may, indeed, glance briefly at this deposition of mud, a question which has often been before marine zoologists. Thus, during the 'Porcupine' Expedition of 1870 Dr. Carpenter broached the idea that the deposit of fine mud in the deeper parts of the basin of the Mediterranean was devoid of life because of the turbidity of the bottom-water. He held, indeed, that such fine particles diffused through the water would produce asphyxia in the marine animals. Further, he pointed out the bearing of his explanation in regard to the vast azoic deposits of the geologists. I showed at the time* that such a theory should only be built on well-ascertained facts, and, moreover, that, so far as my experience went, the facts were not favourable. For example, many littoral sponges are found on extremely muddy ground, while the siliceous sponges all over the world affect a muddy bottom. Muddy ground is the favourite haunt of zoophytes, sea-pens, and other Cœlenterates. Certain starfishes and *Synaptae* are found only in mud. *Terebellæ* and *Gephyrea* in vast numbers are characteristic of muddy beaches; not only these, but many other annelids, are found nowhere else than amongst mud or muddy sand, and this is often of such a nature that the sea-water which covers them must always be loaded with minute particles, which may also coat the littoral sea-weeds. Some of the most delicate and beautiful of these annelids, with the finest branchial plumes, live amongst tenacious chalk-mud, yet they are so sensitive to other impurities that a very slight admixture of fresh water is instantly fatal. Those familiar with the habits of the shore-crab (*Carcinus maenas*) will be cautious in attributing a deleterious influence to mud of any description. Others of the higher crustaceans burrow in it. In muddy sand various mollusks live and thrive, such as *Scrobicularia*, *Corbula*, *Crenella*, and even an occasional oyster; while ascidians and mussels are not only powdered

* Ann. & Mag. Nat. Hist., January 1872, p. 10.

on their respective sites, but the latter are often almost imbedded in it. The witch (*Pleuronectes cynoglossus*) is partial to muddy ground, mud is the home of the hag-fish, and even the delicate young flounders, on descending after their pelagic existence and metamorphosis to the bottom, skim through and hide (all but the eyes) in it along our muddy shores. Referring to the tidal and adjoining area, the conclusion then (1871) was:—"In general, muddy ground is found to be much more productive in marine life of all kinds than where the rocks, sea-weeds, and sands are pure." The barrenness of such regions in the Mediterranean, therefore, was not proved to be due to the muddy character of the water *per se*. The greatly extended researches of a quarter of a century have only confirmed these opinions.

This question of the muddy deposits has again, and quite recently, been brought forward by Dr. John Murray, who, in the 'Challenger' publications*, established what he calls a mud-line, which he fixes everywhere at or about 100 fathoms. He considers this line the great feeding-ground of the ocean, citing, in proof, the capture of myriads of young and adult crustaceans, many of them phosphorescent, and nearly all of the red or brown colour characteristic of deep water. These, again, he says, furnish food for migratory fishes, such as the herring and the salmon†, while the stomachs of whales are crowded with cuttlefishes and crustaceans from considerable depths. His views were criticized last year by Prof. Herdman in his address to the Zoological Section of the British Association, and he differed so much as to hold that the deep-sea mud supports "a comparatively poor fauna as compared with other shallow-water deposits." He contrasts the hauls of small trawls in shallow water with those of the 'Challenger' in the deep-sea mud, and shows that the number of species and genera is greater in the former. It must be borne in mind, however, that some of the finest fishing-grounds are those in muddy areas, which abound in marine life of all kinds. The selection of more or less pelagic crustaceans as the test of the correctness of Dr. Murray's theory appears to be of doubtful import, though the latter himself is perhaps responsible for it. Such forms often fill the tow-nets over pure sand, or in midwater or near the surface far from mud. They are, indeed, found in great numbers under very diverse circumstances. The more minute, however,

* 'Deep-sea Deposits,' p. 184 *et seq.*, 1891; Summary, vol. ii. p. 1433, 1895.

† It would be interesting to give in detail the food of the salmon in the offshore waters.

frequently occur in swarms just over the muddy ground of certain fishing-banks, in the midst of multitudes of post-larval fishes which feed on them. But muddy ground is to be tested as much by the forms which live in it and on it as by those which, it may be, are only temporarily above it. From rhizopods to fishes there is no scarcity. Dr. Murray is inclined to think that "in the present period and not very remote geological past" his mud-line has played an important part in the spread of marine animals. Prof. Herdman, on the other hand, considers that the fauna of the Laminarian region is richer than that of the mud-line, and that there life "is most abundant, growth most active, competition most severe," that "evolution of new forms by natural selection has been most active," and that "migrations have taken place downwards to the abysses, outwards over the surface, and upwards on to the shore." Both the able naturalists just mentioned have doubtless good grounds for their views, so that the one theory may be as good as the other. It is doubtful, however, if we are yet in a position to speak decisively as to how and whence marine life radiated, either in the present or in the past.

Returning to the condition of the marine fauna on the extreme west, it is found that, instead of the soberly tinted sponges of the east, bright yellows and purples are met with, while the firm rounded *Geodia* grows on stones between tide-marks. The crumb-of-bread sponge, again, is partial to tangle-roots and stems, while *Grantia ciliata* abounds near low-water mark.

Foremost amongst the Coelenterates is the stony coral (*Caryophyllia Smithii*), which studs the hard gneiss stones near low-water mark, especially where, piled on each other, they form little caverns, in which the corals hang, grow upright, or project horizontally. Equally characteristic in certain creeks is *Anthea cereus*, which has a brownish or ash-coloured body and long large tentacles of greenish and magenta. Truly arborescent in habit, it is found only on the blades of the *Fuci* and tangles, though a few float freely with the very mobile disk uppermost and the long trailing tentacles hanging in the water. Indeed, it loosens hold of its site more readily than most of the group, and its tissues are comparatively delicate, so that when tearing tangle-blades, to separate them, the rent sometimes severs the anemone as well as the tangle. No sight could be more beautiful than to glance along the surging sea-weeds and watch the large tentacles with their hues of green and red nodding with each wave. Instead of *Clava multicornis*

of the east we have the tufted *Clava squamata* on the littoral *Fuci*. One of the characteristic zoophytes is *Sertularia operculata*, which grows in dense tufts on the stems of the tangles. The Siphonophore, *Diphyes* (or *Muggicea*), occurs in the inshore waters, moving towards the surface with lively jerks, and dragging its trailing hydrosome with the orange polypites behind it, through a maze of the rich blue *Pelagia* and the pale or milky *Salpæ*. The abundance of *Velella* is another striking feature of the region, and, indeed, of the western coast-line generally, while the rarer *Physalia* occasionally is met with in fine condition. *Funiculina* for the most part takes the place of *Pennatula*.

In the creeks and bays the rosy feather-star (*Antedon*), in both pale and dark red varieties, is abundant, clinging by its dorsal arms to the tangles, and moving with considerable rapidity. Between tide-marks *Asterias Mülleri* is occasionally procured; while Ophiuroids and two species of *Synapta* abound in the mud, viz. *Synapta Gallienni* and a new species (*S. tenera*), found nearly simultaneously with Canon Norman, who got his examples in Shetland, and the symmetry and beauty of the anchor-plates of which are diagnostic.

Several rare Nemerteans, such as *Tetrastemma Robertianæ* and *Carinella linearis*, occur between tide-marks; and of characteristic Annelids *Spinther*, *Lepidonotus clava*, *Nephtys Hombergii*, the richly tinted and lively *Ophiodromus vittatus*, *Myrianida* with its long chain of bright orange buds, *Nereis Dumerilii*, *Owenia filiformis*, *Travisia Forbesii*, and *Trichobranchus glacialis*. The western shores of England produce the rare *Achloë astericola* and *Panthalis Ærstedii*, the latter, however, extending to Shetland; also a wealth of *Terebellæ*, especially *Terebella nebulosa*, Mont., with its commensal *Polynoë scolopendrina*, which here attains a much larger size than in the Channel Islands.

A prominent feature near low-water mark is the comparative abundance of the armed tubes of *Pomatocerus triqueter*, a Serpulid which covers the under surface of the hard gneiss boulders and wounds the fingers by the sharp anterior spine.

The most noteworthy crustacean is the large purple swimming-crab (*Portunus puber*), which is frequently found under the broad blades of the tangles in some of the creeks (as at Armaddy); and though its carapace is considerably thinner, it is as active in movement and fierce in defence as the shore-crab. Yet it has little of the hardihood of the latter, none surviving a night's confinement in a moist vasculum. *Sphæroma* is common in the fissures of the gneiss rocks, and rolls itself into a ball—head to tail—when inter-

ferred with. Its back is speckled brown and white, while the border of each segment is reddish. The eyes are prominent, large, and black. When crawling it presents a strange appearance indeed, as if it had a crinoline.

The occurrence of pigmy forests of *Crisia eburnea* under stones between tide-marks instead of the zoophyte *Sertularia pumila* at St. Andrews forms a contrast, as also is the frequency of *Retepora Beaniana* in the deeper water.

The abundance of borers in wood and the comparative absence of borers in rocks is another marked feature. The only examples of rock-borers lurked between stones that had been fixed by a Laminarian root, in the interstices of the latter on rocks, and in peat, never in an independent tunnel in the rocks. The drift-wood is almost universally perforated by the ship-worm (*Teredo norvegica* and *T. megotara*), and since his barren country compels the islander to depend on such for almost every available purpose to which wood is applied, the investigator may well be conversant with the labours of these shell-fishes. Other notable bivalves between tide-marks are *Tapes decussata*, *Arca tetragona*, and *Pecten varius* var. *nivea*, while the frequency of oysters fixed to stones is characteristic. *Lima hians*, so often met with in the Clyde area, is absent, the rarer *Lima subauriculata* alone being procured by the dredge. The valves of *Pecten maximus* cast ashore by storms are still used for skimming milk and scooping butter*.

Between tide-marks *Trochus zizyphinus* in fine condition abounds at the verge of low water, hanging on the blades of the *Fuci*, but it is not so often met with in dredging as *T. cinerarius*. *Trochus umbilicatus* is rather less common than at Tobermory and other parts on the west coast, but it is not rare between tide-marks. All these places, however, differ materially from St. Andrews, where *Trochus cinerarius* is the only one met with in the same region. *Doris proxima* is often seen on the floating blades of the *Fuci* at low water. The prevalence of *Fissurella* and *Emarginula* between tide-marks, of the *Rissoæ*, *Akera bullata*, and *Phasianella* in the inshore waters, and of the pelagic *Ianthina* with its peculiar float, is noteworthy.

No greater contrast to the eastern shores exists in any group than in the Ascidians. On the latter only the compound forms and a few solitary ones under stones occur between tide-marks; here in the tidal region are large compound forms, such as *Aplidium*, *Amouroucium*, bright orange *Leptoclini*, *Botryllus*, and *Botrylloides*, and numerous solitary

* Further south, as at Southport, *Ceratisolen legumen* is diagnostic.

Ascidians stud the blades of the *Fuci* and tangles at low water, while very large species grow in the quiet parts of the inland seas. Other interesting forms are *Clavelina*, *Cynthia echinata*, *C. (Forbesella) tessellata*, and *Molgula*. Moreover, the surrounding seas occasionally swarm with Salpæ, both solitary and in the remarkable chains. So far as known no Salpæ have hitherto been found on the north-eastern shores, and such, at any rate, like the occurrence of the Physophores, must be very rare. In the offshore waters of the west *Doliolum* is now and then captured, and thus the west and the south agree in this respect.

In the department of fishes the contrast is sufficiently marked. Thus in the loch salmon and salmon-trout frequently leap above the surface close inshore. Young wrasses swim in shoals at the margin of the rocks, or lurk under the sea-weeds of the rock-pools. Bimaculated suckers are prevalent in the Laminarian region, and green cod and conger are more abundant than on the east.

Of the marine mammals seals are much more numerous than on the east, the headquarters of this species being in the Sound of Harris. A few great grey seals haunt the rocks at Hashkeir. Finners and porpoises are likewise more frequently observed, and the same may be said of the killer (*Orca*).

When we come to the extreme north of Scotland, viz., the Shetland Islands, we encounter a very rich marine fauna—not so much between tide-marks as in the voes and in the deep water beyond.

A wealth of large sponges, including perhaps the “grandest” British sponge (*Phakellia ventilabrum*), is diagnostic. Besides the foregoing another cup-sponge (*Isodyctia infundibuliformis*) is common, and this region is also the home of the remarkable turnip-sponge (*Oceanapia Jeffreysii*, Bow.), with branched processes of considerable length growing from both poles of the sphere, while the interior, into which those fistulæ pass, is filled with sarcode, to the extent, as its discoverer, Canon Norman, says, of nearly a pint. The interesting *Geodia zetlandica* and the yellow sea-apple (*Tethea cranium*) are also present.

Of the Coelenterates between tide-marks the abundance of *Coryne pusilla* and *Gonothyræa*, and of *Tubularia indivisa* with *T. larynx* parasitic on it at low water, merit notice, both of the latter being characteristic of the deeper water in the east and west. Between tide-marks also the anemones *Actinoloba dianthus* and *Corynactis viridis* are found; while *Corymorpha* occurs in the sandy voes. Moreover, in the latter and in the sounds in July immense numbers of a

Beroë (*Idyia cucumis*) swim amidst swarms of *Arachnactis albida* of Sars, a pelagic stage of an anemone (*Cerianthus*), and they are also sometimes accompanied by *Diphyes* and *Physophora*.

In the off-shore waters, again, we have the zoophyte *Aglaophenia*, a genus characteristically southern. Of anemones *Bolocera eques*, *B. Tuediæ*, *Stomphia*, and *Adamsia* occur, all, however, passing further south along the east coast. The stony corals are more characteristic, such as *Caryophyllia Smithii*, var. *borealis*, and, in small numbers, *Paracyathus* and *Ulocyathus*. *Epizoanthus* appears to be almost typical and in great profusion, one form (*E. incrustans*) being inhabited by a hermit-crab.

The characteristic Echinoderms are two species of rosy feather-star in considerable numbers, *Asterias glacialis* and *Asterias Mülleri*, the latter being only met with in deep water, whereas at St. Andrews it occurs between tide-marks. The sea-urchins are represented by the piper (*Cidaris papillata*), *Echinus Flemingii*, *E. norvegicus*, *Toxopneustes pictus*, *Brissopsis lyrifera*, and a specially southern form *Spatangus meridionalis* of Risso. Of Holothurians or sea-cucumbers, one of the most striking is *Cucumaria frondosa*, which has been familiar to zoologists since the days of Edward Forbes, but *Thyonidium hyalinum* and species of the genus *Thyone* are also common.

Amongst the Annelids are the rare *Eurythoë borealis* of Sars, swarms of a small sea-mouse (*Lætmatonice filicornis*), the northern *Eunoa nodosa*, Sars, *Sthenelais Buskii* (found nowhere else), *Panthalis Örstedii*, *Nothria conchylega* in abundance, *Eumenia Jeffreysii*, *Trophonia glauca*, *Rhodine Lovéni*, *Axiothea catenata*, *Ampharete arctica*, *Amphicteis Gunneri*, *Pista cristata*, *Trichobranchus glacialis*, and *Euchone analis*. The remarkable *Polygordius* is in great profusion amongst the coarse gravelly bottom formed of *Melobesia*. There are likewise some peculiar Nemerteans, such as *Amphiporus hastatus*, *A. bioculatus*, *Meckelia asulcata*, and *Valencinia lineformis*.

Of the Crustaceans, *Pagurus tuberculatus*, Risso, and *Xantho rivulosus*, Risso—both Mediterranean forms,—*Pagurus tricarinatus*, *Crangon serratus*, and *Lophogaster typicus* (Stomatopoda) are noteworthy*. As a rule the remarkable forms lean to northern types.

Amongst the Polyzoa the free growths of *Cellepora*, and the occurrence of such species as *Flustra Barleei* and *Hornera*, are interesting.

The Brachiopods are frequently met with.

* For these and some other references I am indebted to the late Dr. Gwyn Jeffreys's and Canon Norman's papers.

The most noteworthy bivalve mollusks are *Pinna rudis*, *Isocardia cor*, *Solecurtus*, *Pandora inæquivalvis*, *Siphonodentalium*, and *Cadulus*.

Amongst the univalves it is difficult to give forms specially Zetlandic, though species of *Odostomia*, *Trochus helycinus*, *T. grænlandicus*, and *Trichotropis borealis* are very abundant amongst the tangle-roots. The list includes *Puncturella noachina*, *Aporrhais Macandreae*, Jeff., *Columbella haliæti*, *Lyonsia*, *Lepeta*, *Trochus amabilis*, the *Jeffreysiæ*, *Pleurotoma nivalis*, *Scaphander librarius*, *Philine angulata*, *P. nitida*, and *Rossia papillifera*. A large number are common to the Mediterranean.

Of the Hemichordates perhaps the most characteristic is *Rhabdopleura Normanni*, Allman, which has not been found in any other area in Britain.

The Urochordates (Tunicates) are represented by an occasional example of *Pelonaia*, a form only got in profusion in our own neighbourhood, and by great numbers of ascidians, chiefly of a common type.

Salpa runcinata, Chamisso, again, is now and then met with in the tow-nets, with *Diphyes* and *Physophora*, as well as a few Appendicularians.

Amongst fishes one of the most characteristic is the torsk (*Brosmius brosme*), which is nowhere (in Britain) met with in greater numbers or of larger size. Cod, haddock, and green cod are of large size and abundant, and large pollack are more common than in the south. Conger, again, are especially numerous on the western shores. *Chimæra* is not uncommon. The large size of many of the forms—both elasmobranch and teleostean—is in contrast with the eastern and southern fish-fauna.

Of mammals the most conspicuous are the finners and the ca'ing whales (*Globiocephalus melas*), but small numbers of rarer forms, such as *Mesoplodon*, are occasionally met with. Porpoises are often remarkably numerous, but seals are less common than in the Outer Hebrides.

In considering the relations of this our most northern area with the arctic fauna, some remarks of Dr. Murray's in the last volume of the 'Challenger' summary may here be noticed. He says*:—"In polar waters a marked peculiarity of the tow-net gatherings is the almost total absence of pelagic larvæ belonging to benthonic organisms, and we know that many of the Echinoderms and other shallow-water animals of the Arctic and Antarctic regions are furnished with pouches in which the young are reared; the same appears to be true of the animals living about and deeper than the mud-

* Summary of Results, vol. ii. p. 1459.

line in all parts of the world. In temperate zones, where there is a wide range in annual temperature, the pelagic larvæ of benthonic animals appear only in the spring and summer seasons; in the tropics they are present at all times in the surface-waters. If there were once a nearly universal climate over the whole ocean, we may suppose that the same species of benthonic animals were nearly everywhere present in the shallow-water zones. When cooling at the poles set in, those animals with pelagic larvæ would be killed out or be forced to migrate towards the warmer tropics. By being able to limit the reproductive process to the summer season, some of these organisms with free-swimming larvæ have been able to live on in the temperate regions, but in the tropical and coral-reef regions we have the remnants of a once universally distributed shallow-water fauna. With the disappearance of this shallow-water fauna from the polar regions its place would be occupied by the organisms from the deeper mud-line, very few of which possess pelagic larvæ."

With respect to the first part of this quotation it is doubtful if the actual facts connected with the polar fauna bear out this interpretation. In the first place, well-known deep-sea (or, as he calls them, benthonic) arctic animals have pelagic larvæ, such as sponges, zoophytes, star-fishes, and annelids. The condition of the latter alone would prove fatal to the argument. Further, the mere examination of surface-organisms in the tow-nets is no proof that swarms of pelagic larvæ do not exist near the bottom. The pelagic larvæ of the pteropods and hydromedusæ that abound in the "whale-food," and the pelagic eggs and larvæ of fishes, would be quite as likely to suffer as the ciliated young of the benthonic forms previously mentioned. Again, while it is true that certain polar forms have hollows or pouches in which the young are reared, the same holds good with *Asterias Mülleri* and *Cribrella sanguinolenta* of the tidal rocks, and the *Autolytus* of the inshore waters of St. Andrews. The number of these forms in the polar waters, moreover, is out of proportion to those which have no such provision, and in which the larvæ are free-swimming. So far as present knowledge goes the same remarks apply to "animals living about and deeper than the mud-line in all parts of the world."

Some modification is also necessary in regard to the statement that "In temperate zones the pelagic larvæ of benthonic animals appear only in the spring and summer seasons," whereas "in the tropics they are present at all times at the surface." Now in climates like our own it is well known that delicate pelagic forms like ciliated larvæ prefer the surface only in mild and calm weather, but their

absence from the surface is no proof that they are not in the lower regions of the water. Rough or, in winter, cold weather generally causes even adult pelagic forms to seek the lower regions of the water, and it is unlikely that delicate larvæ would be less sensitive. If in temperate regions it should happen that these mild, calm days were frequent throughout the year, such organisms would appear in the surface-waters during a considerable part of the year, if not throughout it, since from January to December pelagic larval forms (benthonic) of one kind or other are present. It is true the numbers of such forms would constitute a spindle with the bulky region in the warmer months, but, nevertheless, a considerable number occur in what are called the colder months.

It is thus doubtful how far we can accept this theory, viz., that the "cooling at the poles killed off the animals with pelagic larvæ or forced them to migrate to the warmer tropics." Considerably stronger evidence is yet required before we can assert that towards the poles deep-sea animals have no pelagic larvæ.

In surveying the tidal fauna of the Channel Islands, such as Guernsey, Herm, and Sark, one of the most prominent features is the abundance of the Protozoan *Noctiluca*, which here and in the south of England causes the sea to be brilliantly phosphorescent, whereas, so far as known, it never occurs in the northern part of Britain, the phosphorescent *Ceratium* there taking its place. The ravages of the boring-sponge (*Hymeniacidon celata*) are everywhere visible in the oyster-beds in the inshore waters, and especially in the beautiful arborescent patterns in many of the dead bivalves and limpets on the shell-beach at Herm. The same form affects the calcareous rocks on the southern shores of England.

Of zoophytes the most noteworthy are *Aglaophenia pluma* and *A. pennatula*, and the presence of *Tubularia indivisa* in the Gouliot Caves of Sark at low water. Yet we have seen that this likewise occurs occasionally in Shetland.

Between tide-marks the gaudily-striped *Sagartia parasitica* is carried about on shells inhabited by hermit-crabs, while in the deeper water the richly-tinted *Adamsia palliata* is common on shells inhabited by *Eupagurus Prideauxii*.

Rosy feather-stars are frequent between tide-marks, as are also fine examples of the bluish or purplish *Asterias glacialis*, and in the adjoining area are the purple, Flemings's, and the silky-spined urchins, together with *Synapta Gallienni*. In no other area is there such a combination.

In the same way richly-coloured Planarians like *Eurylepta vittata*, and Nemerteans such as *Borlasia Elisabethæ*, *Drepa-*

nophorus, and the viviparous *Proserpinche*, are characteristic. The Euprosynidae amongst Annelids have their headquarters as tidal forms in this region. Instead of the northern sea-mice (*Aphrodite* and *Læmatonice*), we have in abundance the southern *Hermione hystrix*, with its naked scales and long barbed spines, in water from 10 to 20 fathoms. The occurrence of *Harmothoe areolata*, Grube, *H. marphysæ*, of the *Nereis* (*Eulalia*) *nebulosa* of Montagu, of *Nereis Marionii* and the general prominence of Nereids, of the Eunicidae, Lumbriconereidae, *Staurocephalus*, *Chætopterus*, *Sabellaria alveolata*, *Lepræa* and other Terebellids, *Sabella saxicava*, and *Protula* and *Filigrana* between tide-marks, are diagnostic.

In no group is the contrast greater than in the higher crustacea. The huge spiny lobster off rocky shores, velvet-crabs, *Pirimela* and *Ebalia* under stones between tide-marks, *Alpheus ruber* and *Pagurus cuanensis* in rock-pools, *Pagurus Prideauxii*, *Maia*, *Dromia*, and *Polybius* are all more or less characteristic. In the same way the presence of *Cymodocea truncata* and *Sphæroma Prideauxianum* in the fissures of rocks between tide-marks and *Dynamene* in rock-pools, the large *Cymothoa* on fishes, and other sessile-eyed crustaceans are noteworthy.

The extraordinary beauty and profusion of the Polyzoa, such as the Escharidæ and the Lepraliæ, between tide-marks, together with the finely spiral tufts of *Bugula turbinata* and the free growth of *Amathia lendigera* and *Flustra chartracea* (the two last from the inshore water), are also southern features, as also is the occurrence of *Argiope*.

The molluscan fauna is characterized by the presence of extensive beds of large oysters in the inshore waters, with the somewhat rare borer, *Gastrochæna*, perforating the upper valve of many; whilst amongst them are large *Anomia*. Other typical species are *Mactra glauca*, *Triton nodifer*, *T. montacuti*, *Cardium papillosum*, and *Murex aciculatus*.

Between tide-marks we have *Pecten varius*, *Mytilus barbatus*, *Arca tetragona*, and *Galeomma Turtoni*, a lamelli-branch which opens its valves and adheres to the under surface of stones. Only here does *Haliotis* (the ear-shell or "ormer") occur between tide-marks; and in the rock-pools no sight can be more striking than to watch *Lima* nimbly moving through the water with its bright orange tentacles forming an ornamental fringe. *Trochus lineatus*, *Murex erinaceus* and *M. aciculatus*, *Aplysia*, *Cerithium*, and *Cerithiopsis* are likewise characteristic of the tidal area, and *Calyptræa* of the adjoining waters, along with numerous *Octopi*, which have their homes under the larger stones.

Balanoglossus is found between tide-marks, and ascidians are numerous and large in the same region. In the surrounding waters swarms of *Salpæ* occasionally appear, now and then accompanied by *Doliolum*.

Amongst fishes, eels are abundant between tide-marks, and wrasses at the margin of the rocks, gliding here and there like dark shadows under the tangles. Black gobies are frequent in the tidal region; while in the inshore waters whiting-pout, red mullets, *Hippocampi*, gattoruginous blennies, rainbow, cook, and other wrasses, *Serranus*, small blue sharks and congers, are common. "Schools" of pilchards break the surface of the water like a heavy shower of hail in certain areas, and mackerel are abundant.

The marine mammals, viz. seals and cetaceans, are much less common than in the north and north-west.

Each of the four areas has certain forms common to all, but at the same time each has species that occur sparingly or not at all in the others, though it is true great caution is required in regard to the latter statement.

The eastern coast is distinguished rather by the absence of forms that are present in other areas, though the abundance of such as *Lucernaria*, *Hippasterias*, *Echiurus*, *Magelona*, *Pelonaia*, and the remarkably persistent profusion of food-fishes are also features of moment. Towards the north, as in the Moray Frith, again, we encounter southern forms that show no connecting links along the eastern shores, but the distribution of which seems to point to the view of Canon Norman that such may have travelled from the west round the north of Scotland, or in some cases may have passed from the northern shores of Europe in a westerly direction.

The western coast is in the main southern in its fauna, though the abundance of *Caryophyllia* and *Pomatocerus triqueter* within tide-marks, and of *Verella*, *Ianthina*, and the *Salpæ*, together with the frequency of seals and whales, are distinguishing features. The invertebrate marine fauna and fishes may have spread from the south and the west.

That the warm currents of air and water along the western shores are the main factors in accounting for the special fauna of the region is evident, and they carry that fauna to the Shetland Islands, and, passing through the various gaps, lave both sides of the land, so that the eastern fauna of the latter more resembles that of the west. Thus the southern types like *Adamsia*, that are found in the Moray Frith, may have spread from the same centres, though the commingling of northern species (for example, *Lumpenus*) proves that other centres along the northern shores of Europe must have contributed.

Contrasted with other regions, the richness of Shetland in cup-, apple-, and turnip-sponges, its swarms of *Arachnactis albida* and *Echinus norvegicus*, the occurrence of *Cidaris papillata*, the huge *Cucumaria frondosa*, *Eurythoë borealis*, *Lætmatonice*, the Ampharetidæ, the peculiar mollusca, the large size and frequency of the torsk, the presence of *Chimæra* and its many Cetaceans, give it characters of its own. The majority of these appear to have come from the north and east. Forms, again, which occur in deep water in Shetland appear between tide-marks in the Channel Islands, and occasionally in diminished bulk. The presence of Mediterranean forms—*Xantho rivulosus*, *Pagurus tuberculatus*, and *Pinna rudis*—show how difficult it is to explain the centres of origin or the lines of migration.

Boldly mapping out the warmer southern area is the distribution of *Noctiluca*, of the silky-spined urchins, the brightly coloured *Eurylepta*, and *Drepanophorus* amongst Nemerteans, of the southern sea-mouse (*Hermione*), of the crustaceans *Alpheus*, the spiny lobster, *Polybius* and *Dromia*, the mollusks *Gastrochæna*, *Galeomma*, *Mactra glauca*, *Haliotis*, and the frequency of the cuttles between tide-marks, of *Balanoglossus*, the finely coloured wrasses, the red mullets, and the pilchards. Almost all these forms are essentially southern, and they show no stragglers leading northwards, such having probably been checked more by the diminished annual temperature than by the absence of favourable currents.

In conclusion, limited as the area we have been considering is, it is apparent that while some forms are common to all, certain restraining influences check the spread of others, so that they become more or less characteristic of the several regions. Moreover, the mixed nature of the fauna shows that we have to do with several sources of origin, some of which date back to geological periods marked by a different arrangement of the land, and a consequent change in the temperature of the water.

LX.—On Excretory Organs and Sexual Conditions in certain Isopoda. By BOHUMIL NÈMEC, of Prague*.

IN the course of my investigations upon Isopods I have arrived at certain interesting results relating to their excretory and genital organs, of which I here furnish a short résumé.

* Translated by E. E. Austen from the 'Zoologischer Anzeiger,' Bd. xix. no. 507 (July 6, 1896), pp. 297-301.



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