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With their very limited fauna, coral atolls are remarkably free of "dangerous animals". There are of course no large mammals, and no carnivorous or poisonous reptiles except for an occasional sea-snake. The only macroscopic animals which can be described as dangerous in themselves are sharks and poisonous fish, the Conus shells, and the black-widow spider (Latrodectus mactans) introduced on Kwajalein. With these and a few other exceptions, the animal pests have mostly a nuisance value, or cause painful, but not dangerous stings. Such are ants, wasps, scorpions, centipedes, flies, mosquitoes, and even birds when they form large colonies. Some of these pests, of course, are dangerous as carriers of disease-producing organisms, or parasites. A few can be rather harmless individually but dangerous if met with in great numbers: the Portuguese Man o'War for instance causes such painful stings that encountering a great many of them may render a swimmer panicky and quite helpless.

Two kinds of animals occur on most atolls which inspire often unwarranted fears in the various parts of the world where they are found: these are the centipedes and scorpions. A few species of the former cause very painful bites, and some scorpions are even deadly, but the dread they inspire is often out of proportion with the actual danger. The species of these which occur on atolls are not at all dangerous, and not too abundant, either. However, it seemed worthwhile to assemble the information on one of these groups, the scorpions, as a zoological summary with practical aspects.

In spite of their formidable appearance and their sting, scorpions are rather fascinating for various reasons. The group is rather homogeneous, and all scorpions look much more alike than different spiders, for instance. They are often found in pairs, the couple apparently going about together for a long time before fertilization takes place, at which time they go through a remarkable courtship and what is called a mating dance. These have been described in great detail by J. Henri Fabre, for the scorpions which live in the south of France, and observed in various other species. After these extraordinary performances, fecundation takes place, and the female eats up the male, at least in some species. When the young are born they look just like adult scorpions, and are simply enclosed inside a thin membrane. They break out of it at once and promptly climb onto the back of their mother. They are rather easy to observe thus, because they are white and almost translucent, while adult scorpions are yellow to black.

These are just a few of the peculiarities of these animals. Another, of a different order, but very interesting, too, is that scorpions are one of the oldest groups of living animals: in other words, fossil scorpions are found in very ancient (Silurian, about 400 million years old) deposits, and look astonishingly like modern scorpions. These must be extremely successful animals, therefore, which is only partly explained by the fact that they have few enemies.

This brief account is no attempt to exhaust the interesting facts known or suspected about scorpions, but aims to render the idea of these animals less formidable and dreadful before discussing them in more detail.

Scorpions are arthropods, which means that they belong to the phylum of invertebrates whose legs are jointed and whose skeleton is an external armor of chitin. Other arthropods are crustaceans, for instance, and insects. The group to which scorpions belong, and which corresponds in the classification to crustaceans or insects is that of the Arachnida. Scorpions are one of the groups of arachnids, spiders are another; there are several others, which are not so commonly known, although one contains the mites and ticks.

The different groups of arthropods are classified mostly according to the number and arrangement of their legs and other appendages. Arachnids have only four pairs of legs, insects three, and crustaceans more. Besides their walking legs, scorpions have two pairs of pincers. The larger pair looks rather like the claws of a crab or lobster and are used to seize food, usually living prey, and bring it to the smaller pincers, which have the role of jaws and teeth, and tear up the food before it is swallowed.

Arachnids, once recognized by the number of their legs, are further classified according to the nature of their bodies. While insects have three main parts to their body, arachnids have only two, the cephalothorax, which contains the mouth, eyes and various other organs, and to which are attached all the legs, and the abdomen. The soft rounded abdomen of the spiders is quite different, for instance, from that of the scorpions, which is made up of segments, terminating in a narrow tail with a last segment modified into a sting.

More characteristic of scorpions than their pincers, therefore, is their tail with its stinging apparatus. The tail of the scorpion, which is really a narrow part of the abdomen, is made up of 5 narrow segments and followed by a sixth, which is the sting. It is very mobile, and is usually curved back above the rest of the body bringing the sting near the front of it, its extremity pointing forward; the scorpion stings by driving the tail and the sting forward and upward or upward and backward. This sting is pear-shaped, with a curved needle-like extremity. In the pear-shaped part are two venom glands, and they open by two small holes slightly below the extremity of the curved needle: this arrangement functions just as does a hypodermic, in which the sharp needle point breaks the skin and protects from obstruction the opening of the needle which is just behind it.

The venom produced by the glands and injected by the sting varies with different species; not all have been studied in detail. In regions of the world which happen to be well-equipped for research, and rich in deadly scorpions, much work has been carried on to analyze the venoms, understand their toxic effect; and find remedies. In North Africa, for instance where there are various dangerous species, including one which causes some deaths every year, the Pasteur Institute in Algiers has been studying these scorpions for many years, and is manufacturing anti-scorpion serum, in just the same way that sera are prepared to help victims of snake bites. In Arizona, the Poisonous Animals Research Laboratory of the State College, at Tempe, studies the local deadly scorpions, and advises on treatment of stung persons (Stahnke, 1949).

The effect of a scorpion's sting is quite independent of the size of the species, some of the deadly scorpions being rather small; the giant scorpions of tropical Africa, Pandinus, which can be as much as 180 mm. long and the Palamnaeus or Heterometrus of the East Indies which come next in size, are relatively harmless. They must be rather formidable animals, and some Pandinus species have formidable names: P. imperator, and P. dictator. However, the scorpions that occur on atolls are rather small, and relatively harmless. Their sting is painful, but the pain vanishes after some hours, leaving no after-effects.

Generally six families of living scorpions are recognized by zoologists, and atoll scorpions represent two of them. In the family Scorpionidae (the same to which the above-mentioned giants belong) is the species Hormurus australasiae (Fabr.); the family Buthidae is represented on atolls by Isometrus maculatus de Geer, two species of Lychas (Archisometrus of Kraepelin), and perhaps others. It must be borne in mind, of course, that on atolls, scorpions are not very abundant or conspicuous, and that, since collecting there has almost never been carried on intensively, there must be many atolls from which they have not been recorded, though present. There also may be more species present on some atolls, especially those near high islands or continents; for instance a species of Lychas is known from the Duizend Eilanden, which are very close to Java, just outside the Bay of Batavia, and not, so far as records are available, from other atolls.

Family SCORPIONIDAE.

1. Hormurus australasiae (Fabr.)

(Scorpio australasiae Fabr. Syst. Ent. 399, 1775)

This scorpion has a wide range of occurrence, and is found all over the islands of the Pacific, Malaysia and some parts of the Indian Ocean.

It is found in the woods and coconut plantations; most authors who record it do not indicate the exact habitat, but we have some information on the specimens collected in the Marshall Islands by F. R. Fosberg in 1951-52. One, on Lae Atoll, was found in the crotch of a split, partially decaying breadfruit tree. Otherwise, the specimens were observed under sticks and stones, in coconut trash, and especially under the bark of dead logs, in coconut plantations and in the various types of forest and scrub found in the Marshalls. Also in the Marshalls, on Arno, Usinger (1953, p. 27) cites scorpions as predators in the fallen log stratum of the canopy woodland community. This most probably refers to Hormurus. It certainly would be interesting to have more information on this scorpion, and its habits: Does it burrow at all, or just hide under loose material? Does it give chase to prey, or, as reported for Mediterranean scorpions, mostly wait with extended pincers, ready to grasp an unwary spider or other animal? Does it exhibit the same courtship behavior?

Chamisso (1821, p. 159) recorded this under the name Scorpio australasiae from the Marshalls "of which the natives did not appear to be afraid; and the sting of which, according to Kadu [his informant], produces a local swelling which is of short duration". Since then, all reports agree

that the sting of this scorpion is not to be feared.

Marshall Islands:

Ailuk Atoll; Lae Atoll, Lae Islet, Lwejap Islet, Enemanman Islet; Wotho Atoll, Wotho Islet; Ujae Atoll, Bock Islet; all collected by F. R. Fosberg in 1951-52.

Ailinglaplap Atoll, Bigatyelang Islet, collected by H. K. Townes in 1946; other specimens, collector unknown, collected in 1948.

Arno Atoll, collected by J. W. Wells in 1950.

Bikini Atoll, Romuk Islet, collected by L. P. Schultz in 1946; Namu Islet, and Bikini Islet, collected by J. P. E. Morrison in 1946.

Caroline Islands:

Ulithi Atoll, Mogmog Islet; Kapingamarangi Atoll, Hare Islet; Nukuoro Atoll, Nukuoro Islet; all collected by H. K. Townes in 1946.

Tuamotu Islands:

Rarua Atoll, Ngarumaoa Islet, Oteteu Islet, Opakea Islet; all collected by J. P. E. Morrison in 1952.

The above records are hitherto unpublished, and were kindly furnished by Dr. E. A. Chapin, of the U. S. National Museum, who identified the specimens and transmitted the information in time to include these many recent records in this paper. His help and advice are here gratefully acknowledged. The species had been previously recorded from the Marshall Islands: by Karsch 1881, p. 15 (as Liocheles australasiae), collected by O. Finsch, and by Chamisso (see above).

Ellice Islands:

Funafuti, Pocock 1898 p. 323 (see discussion of Buthus brevicaudatus Rainbow, below); many specimens were collected by Sollas and Gardiner during the Funafuti survey and boring work; Kopstein, 1921 p. 136 (specimens apparently available in Dutch museums, but no record of collection).

Ellice Islands, Buxton, 1927 p. 13; collected by O'Connor, determined by Hirst.

Duizend Eilanden:

Edam Island, Kopstein 1921 p. 119, 135.

Noordwachter Island, Kopstein 1923 p. 185, 186.

Kopstein in his 1921 paper, p. 135, also records this species from "Kokos Inseln". Unfortunately, this is not quite clear, and although it may be supposed that this refers to Cocos Keeling Atoll, extending the range of

the species to this Indian Ocean atoll, it may well also be one of the many other Cocos Islands, especially those in the Andaman Islands.

Family BUTHIDAE

2. Isometrus maculatus (de Geer)

(Scorpio maculatus de Geer, Mem. Hist. Ins. 7:346, 1778)

Unlike the above species, this scorpion is found in and around human habitations, and is transported by human agency. It is not native to the islands. It has managed to travel all around the world, and is found practically everywhere in the tropics, as shown by the following atoll records:

Marshall Islands:

Karsch, 1881 p. 15, collected by O. Finsch; Schnee, 1904 p. 406, determined by Dahl.

Jemo Island, collected by F. R. Fosberg in 1951, on the floor of the only house on this tiny island, which is uninhabited, except when visited occasionally to prepare copra. Only one individual was seen.

Phoenix Islands:

Canton Island, Van Zwaluwenburg, 1943 p. 303 "found occasionally in buildings".

Pratas Island (China Sea):

Cambridge 1871 p. 617 (as Lychas maculatus); collected by Collingwood, who says (1868 p. 27) that small scorpions were abundant in an abandoned Chinese temple on Pratas.

Cocos-Keeling:

Hirst, in Wood-Jones 1910 p. 366. Wood-Jones, p. 306 says that wounds are painful and dreaded, but not fatal. Gibson-Hill, 1950, p. 101: "Plentiful on all the larger islands. Local name, Kala Jengking. It does not appear to be seasonal. In the plantation it is found at the base of the fronds of the coconut palms, and under the piles of fallen nuts. On Pulo Selma and Pulo Tikus it occurs fairly freely in the buildings. It moves about mostly at night."

Seychelles:

Bird Island, Hirst, 1913 p. 32.

Dennis Island, Hirst, l. c.

Astove Island:

Hirst, l. c.

Maldives:

North Mahlosmadulu Atoll, Fainu Islet, Male Atoll, Huhule Islet, Suvadiva Atoll, Havaru Tinadu Islet, Pocock, 1904, p. 798, as L. europaeus (L.), collected by J. S. Gardiner.

Minicoi, Pocock, l. c.

3. Lychas scutatus Koch Arach. 12: pp. 3, 163, 1845. [indicated as L. scutillus on p. 3, apparently typographical error].

Cocos-Keeling Atoll:

Kopstein, 1921 p. 122.

4. Lychas mucronatus (Fabr.)
(Scorpid mucronatus Fabr. Ent. Syst. suppl. 294, 1798)

Duizend Eilanden:

Edam Island, Kopstein 1921 p. 123.

5. Buthus brevicaudatus Rainbow, Austral. Mus. Mem. 3: 107, 1897.

Ellice Islands:

Funafuti Atoll; Rainbow, created this new name for Funafuti scorpions, but Pocock, 1898 p. 323, severely criticized this determination, and placed the specimens in the species Hormurus australasiae, see above. Rainbow's plate, however, does not much resemble Hormurus australasiae, so this reduction may quite possibly be incorrect.

These are available records of identified scorpion species from atolls. In addition to these, there are a number of records of "scorpions", from various other islands; some of these for instance are found in lists of native names for various atolls.

Gilbert Islands:

Abemama Atoll: Woodford, 1895 p. 347 records a small species.

Onotoa Atoll: E. T. Moul (ined.) collected some scorpions among packing cases (probably Isometrus, possibly just introduced).

Caroline Islands:

Kapingamarangi, Miller, 1950 p. 6 records a small scorpion.

Nukuoro, Eilers, 1934 p. 193 cites native name.

Ifaluk, Burrows, 1949 p. 19 says that nothing was heard or seen of scorpions.

Marshall Islands:

Kraemer and Nevermann 1938 p. 297 give native names.

Luangia and Nukumanu Atolls:

Sarfert and Damm, 1929, p. 31, give native names.

There are undoubtedly other such records of scorpions scattered throughout the non-systematic literature on atolls, and it is hoped that more of them will become known, and that more collections and determinations will help clarify them. New records are always interesting even though of the same species as they enable us to follow the spread of the species, especially that of Isometrus maculatus, to new islands. Only a great many observations on atolls can lead to such results. As mentioned above, in addition to distribution records and specimens, data on the biology and ecology of scorpions on atolls are meager and such observations would be a valuable addition to our knowledge of atoll biota. To make such information of maximum value, it should always be accompanied by specimens.

As this summary was nearing completion, Dr. Waldo L. Schmitt kindly called attention to a very recent paper on scorpions (Vachon, 1953). It consists of brief general notes on their biology, and has no mention of atolls, but has a short list of useful references, and is illustrated with some beautiful color plates, including one of the giant African scorpion (see p. 5 of this paper), and several of one of the deadly North African species, showing various postures. A lengthy, and much-praised work by the same author, "Etudes sur les scorpions", published by the Pasteur Institute of Algiers in 1952, unfortunately could not be consulted.

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