ON THE OCCURRENCE OF *CARCINUS MAENAS* (LINNAEUS) AND ITS PARASITE *SACCULINA CARCINI* THOMPSON IN BURMA, WITH NOTES ON THE TRANSPORT OF CRABS TO NEW LOCALITIES

by

H. BOSCHMA
Rijksmuseum van Natuurlijke Historie, Leiden

From time to time crabs have been found in localities at great distances from their normal area of distribution, owing to their being transported by ships in ballast water tanks or on the hulls. Much attention has been paid to a report by Catta (1876), who examined the Crustacea taken from the hull of a ship that had made the voyage from India to Marseilles. Among these, four species of crabs of the family Grapsidae were represented, one of which, named by him *Plagusia squamosa*, being present in hundreds of specimens. Catta saw here the possibility of an extension of the area of distribution of the crab, but apparently the conditions of life were not favourable in the new locality, and the crab did not become established here. Stebbing (1893: 99) remarks that the correct name of the crab referred to above is *Plagusia depressa* (Fabricius) and adds that "The point of special interest, however, lies, as Catta explains, in showing the effects on distribution that may be produced by unconscious human agency." The data mentioned above were recorded again by Chilton (1911). According to Bennett (1964: 87) lists as given by Stebbing and Chilton of species transported on the hulls of ships are not lists of accidental acclimatisations, for it does not follow that the crabs could establish themselves in their new homes.

Another case of unsuccessful transport of a crab to a new locality is the record of great numbers of *Pilumnus spinifer* H. Milne Edwards at Uddevalla harbour on the west coast of Sweden in 1826 (Christiansen, 1969: 77). Here undoubtedly the crab disappeared because it could not stand the cold in its new locality.

A diligent search in the literature certainly would reveal numerous other cases of temporary settlement of crabs in new surroundings.

Some species of crabs, however, after having been transported to new localities, succeeded to establish themselves in their new surroundings. Four cases of immigration in this manner are dealt with in the present paper,

viz., *Carcinus maenas* (Linnaeus), *Callinectes sapidus* Rathbun, *Eurypanopeus depressus* (Smith) and allied species, and *Eriocheir sinensis* H. Milne Edwards. It is interesting to note that the rhizocephalan parasites of three of these crabs have also been transported to the new localities.

1. *Carcinus maenas* (Linnaeus) with *Sacculina carcini* Thompson.

In the collection of the Indian Museum, Calcutta, there are four specimens of the crab *Carcinus maenas* (Linnaeus), each bearing a specimen of the rhizocephalan parasite *Sacculina carcini* Thompson. As noted on the label, the crabs were collected by F. J. Meggitt at Maungmagan, Burma, the date of collecting is not mentioned. Thanks are due to Dr. L. B. Holthuis for the specific identification of the host crabs as *Carcinus maenas*, completely corresponding with specimens from the European Atlantic coast region.

The crabs and their parasites are of fairly large size, two of the parasites had the following dimensions: 18 × 11 × 4½ mm, and 20 × 12 × 6 mm (dorsoventral and anteroposterior dimensions and thickness from left to right side, respectively). These two specimens were longitudinally sectioned. Examination of the internal organs and of the peculiarities of the external and the internal cuticle of the mantle proved that they did not differ in any respect from specimens of *Sacculina carcini* from the European Atlantic coast region. The specific characters as noted in a previous paper (Boschma, 1937: 221) are as follows:

Male genital organs in the visceral mass, partially united, dorsal parts completely separated. Testes more or less cylindrical, gradually passing into the vasa deferentia, which, at least in their ventral part, are narrow tubes. Dorsal parts of the testes with a comparatively thick wall. Parts of the male genital organs with ridges on their inner walls. Colleteric glands with numerous canals (as a rule more than 30 of these canals in longitudinal sections of the most strongly divided part). External cuticle of the mantle with small hairs or papillae which as a rule are not longer than 12 μ (generally shorter), and possess minute lateral hairs. The chitin of the excrescences is of the same kind as that of the main layers of the cuticle. Internal cuticle of the mantle with numerous retinacula, which are more or less evenly distributed on its surface. Each retinaculum consists of a basal part and 4 to 10 barbed spindles, which have a length of about 15 μ.

More details on the complicated structure of the male organs were noted as follows: The two vasa deferentia are narrow canals; in their dorsal ends they unite and gradually the contour of the two united male genital organs becomes more or less circular. The two cavities remain separate for some distance, although the septum formed by the fused median parts of the walls

of the organs becomes more and more irregular. At last the septum is pierced by a large opening. Towards the dorsal region the opening through which the two cavities communicate gradually closes, and the two testes regain more and more their individuality. In their extreme dorsal part the testes are completely separated; the wall of this part of the male organs is rather thick (cf. Boschma, 1937: 222).

Especially in the older literature the name *Sacculina carcini* was given to the rhizocephalan parasites of a great number of crabs, without attempts to determine the specific characters of the parasites. After examination of the internal structure it appeared that in reality the number of host crabs of *Sacculina carcini* had to be restricted to fourteen (Boschma, 1955: 18-20):

Carcinus maenas (Linnaeus), *Macropipus marmoreus* (Leach), *M. corrugatus* (Pennant), *M. depurator* (Linnaeus), *M. pusillus* (Leach), *M. puber* (Linnaeus), *M. holsatus* (Fabricius), *M. arcuatus* (Leach), *Portumnus latipes* (Pennant), *Bathynectes longipes* (Risso), all belonging to the family Portunidae; *Pirimela denticulata* (Montagu), of the family Pirimelidae; *Pachygrapsus marmoratus* (Fabricius), *Brachynotus sexdentatus* (Risso), both belonging to the family Grapsidae; and *Pisa armata* (Latreille), of the family Majidae.

In the literature there are several records of the occurrence of *Sacculina carcini* as a parasite of *Carcinus maenas* in the Mediterranean and in the Black Sea. Holthuis & Gottlieb (1958: 85) have shown that the crabs from these regions belong to the species *Carcinus mediterraneus* Czerniavsky; this name therefore must be added to the list of hosts of *Sacculina carcini*.

Hesse (1867) gave the name *Sacculina gibbsii* to a parasite of *Pisa armata* (= *Pisa gibbsii* Leach) from Brittany. He remarked that the parasite was of squarish shape with rounded corners and noted as measurements 22 by 20 by 10 mm. Hoek (1878) gave the name *Sacculina pisae* to a parasite of *Pisa armata* from Naples. Guérin-Ganivet (1911) examined parasites of *Pisa armata* from the northern Atlantic coast of France, noting that in their external appearance they differ strongly from the parasite of *Carcinus maenas*, the dorsoventral diameter being only slightly larger than the anteroposterior, leading him to the conclusion that, at least provisionally, the parasite of *Pisa armata* has to be regarded as a separate species with the name *Sacculina gibbsii*. As the differences in the external appearance of the species of *Sacculina* are not altogether constant I became convinced that *S. gibbsii* was not specifically different from *S. carcini*, the two forms having a completely similar structure of the internal organs (Boschma, 1927).

The problem of the specific status of the parasite of *Pisa armata* has been definitely solved by Veillet (1964), who observed that the female cypris

larvae of this parasite (named by him *Sacculina pisae)* attach themselves in the branchial cavity of their host and here give rise to the kentrogone stage, a slender elongated sac, about five times as long as broad, with a very long dart. He could further fully confirm the observations by Delage (1884) on *Sacculina carcini,* in which the female cypris larvae attach themselves to the base of a plumose seta on the carapace and especially on the last pair of legs; here the kentrogone stage is much shorter, about three times as long as broad, with a shorter dart, of about half the length of the dart in *Sacculina pisae.* Bourdon (1967) briefly mentioned Veillet's discoveries, correctly using the name *Sacculina gibbsii* for the parasite of *Pisa armata.*

The parasites of *Pisa nodipes* (Leach) from Jugoslavia (Boschma, 1961 a) and of *Pisa muscosa* (Linnaeus) from the Mediterranean coast of Spain (Boschma, 1961 b) now also must be regarded as belonging to the species *Sacculina gibbsii.* It is interesting to note that in the sectioned specimen of the parasite of *Pisa nodipes* and in the two sectioned specimens of the parasite of *Pisa muscosa* the colleteric glands are found in the extreme anterior end of the visceral mass (Boschma, 1961 a, fig. 2 e, f; 1961 b, fig. 4). This peculiarity, however, cannot form a specific character, for Guérin-Ganivet (1911: 53) remarks that in his material of *Sacculina gibbsii* the situation of the colleteric glands is like that in *Sacculina carcini,* in or near the central parts of the left and right sides of the visceral mass.

In connexion with the fact that the parasites of crabs of the genus *Pisa* (family Majidae) are specifically different from the parasites of Portunidae, it would not be surprising if also the parasites of the two Grapsid crabs mentioned above would prove to be different from *Sacculina carcini*; then the name *Sacculina benedeni* Kossmann would become available for the parasites of the Grapsid crabs. It seems altogether safe to assume that the parasite of *Pirimela denticulata* is conspecific with *Sacculina carcini,* the family Pirimelidae being closely allied to the Portunidae.

Alcock (1899: 14) gives the following account of the geographical distribution of *Carcinus maenas*: "The species has been found at various places on the Atlantic coast of the Northern United States and off the coast of Pernambuco (Brazil): it is the common shore-crab of the British Islands, and occurs in the North Sea almost up to Arctic limits, in the Baltic, and on the Atlantic coasts of the European continent: it is common in all parts of the Mediterranean, and has been found in the Black Sea and the Red Sea: it is an Indian species, though evidently a very rare one, and has been reported from the Hawaiian Islands, from the Bay of Panama, and — though there is doubt about this locality — from Australia". On the cited

page Alcock also notes that in the Indian Museum there is a single male from Ceylon.

These notes give occasion to the following comments, mostly based on data in later publications. The records from Brazil and the Hawaiian Islands are based on misidentified or accidentally introduced specimens, not resulting in definite establishment (Almaça, 1962; 1963). The records of the species in the Mediterranean and in the Black Sea are based on *Carcinus mediterraneus* Czerniavsky (cf. Holthuis & Gottlieb, 1958). The occurrence of the species in the Bay of Panama is recorded by Christiansen (1969) as the only locality on the Pacific coast of America. The presence of *Carcinus maenas* in Australia has been considered doubtful; Stephenson & Campbell (1960: 81) remark, however, that the species is abundant at Port Phillip and Port Melbourne in Victoria, showing the characters of Atlantic specimens (the occurrence of the species at Port Phillip was already noted at a much earlier time, by Fulton & Grant, 1900). Christiansen (1969: 51) mentions Madagascar as an additional locality for the species. In the present paper Burma is recorded as a new locality.

The occurrence of *Carcinus maenas* in several localities in the Indo-West Pacific area (Red Sea, Madagascar, India, Ceylon, Burma, Australia) and in the Bay of Panama without any doubt is the result of transport by ships, in ballast water tanks or on the hulls. According to Almaça (1963) it is probable that the occurrence of *Carcinus maenas* on the east coast of North America is due to transport by ships in comparatively recent times.

It is interesting to note that the parasites of *Carcinus maenas* from Burma do not differ in any detail from those occurring on the same host in the Atlantic region of Europe. Taking into account that the rhizocephalan parasites of all other crabs in the Indo-West Pacific area (as far as they have become known) are specifically different from *Sacculina carcini,* it is safe to conclude that once upon a time at least one male and one female of *Carcinus maenas* and one specimen infected with *Sacculina carcini* have been transported by ships from Europe to Burma and have found there favourable conditions for further establishment.

Bennett (1964: 87) remarks that the crab *Cancer novaezelandiae* (Jacquinot) has been transported from New Zealand to Australia, by the introduction of New Zealand oysters to Tasmania about half a century ago, and observes that in this case the new locality is in the same latitude as the old and acclimatisation in the strict sense of the word is not called for; he concludes (l.c.): "This is a simple matter in comparison with the passage through the tropics and the finding of a favourable latitude in the same hemisphere (*Eriocheir*) or almost at the antipodes (*Carcinus*)". The speci-

mens of *Carcinus maenas* that have found favourable conditions of life in Burma also have reached their new locality after having withstood a passage through the tropics.

2. *Callinectes sapidus* Rathbun with *Loxothylacus texanus* Boschma.

The original description of *Loxothylacus texanus* Boschma, the rhizocephalan parasite of the crabs *Callinectes sapidus* Rathbun and *Callinectes marginatus* (A. Milne Edwards), reads (Boschma, 1933: 237):

Male genital organs in the posterior half of the visceral mass. Testes (at least in full-grown specimens) partially united into a common wide sac. Colleteric glands in the anterior half of the visceral mass, not far from the centre of the lateral surfaces, with a large number of tubes. External cuticle of the mantle with excrescences (short hairs or papillae), which have a length of 4 to 9 μ. Internal cuticle of the mantle with numerous retinacula, which consist of a basal part and several barbed spindles. The latter have a length of 14 to 18 μ.

In the cited paper there are figures of the external cuticle and the retinacula; a later paper (Boschma, 1950) contains figures of the external appearance of the parasites, their male organs and their colleteric glands, these glands showing a strong division of their system of tubes, the average number in four specimens being 124 in a section of the most strongly divided part.

Callinectes sapidus (including the subspecies *acutidens* Rathbun) has a wide range of distribution in America. Rathbun (1930) reports the crab from several localities in the Atlantic coast region (Massachusetts to Uruguay), from the Gulf of Mexico (Mississippi, Louisiana, Texas), from the Caribbean Sea (Nicaragua, Panama), and from the West Indies (Cuba, Jamaica, Porto Rico); Christiansen (1969) further mentions as American localities Nova Scotia and the Bermudas. Specimens infected with the rhizocephalan parasite *Loxothylacus texanus* are known from the coastal region of Texas (Boschma, 1955: 46, 47). This parasite also occurs on the crab *Callinectes marginatus* in the Canal Zone and other localities in Panama (l.c.: 46).

In comparatively recent time the crab *Callinectes sapidus* has been found in European localities. At first incidental records were reported from the Atlantic coast region of Europe and from Italian waters; it later appeared that the crab has become firmly established in several localities of the eastern part of the Mediterranean and even forms an object for extensive fishery (Holthuis, 1969).

Kinzelbach (1965) states that the crab *Callinectes sapidus* is sold at the

fish-markets of Thessaloniki and other towns in Greece, and remarks that the crab is often infected with a parasite of the genus *Sacculina*, causing the housewives to reject the parasitized specimens for food. No specimens were preserved to determine the specific characters of the parasites, but Professor Kinzelbach intended to obtain material during a later visit to Greece, unfortunately without results. In a letter dated 15 September 1971, he wrote to me that attempts to obtain specimens of *Callinectes sapidus* with rhizocephalan parasites had not met with success, because the crab has become rare in the north of Greece, owing to over-fishing.

As long as no specimens of the parasite of *Callinectes sapidus* from the eastern part of the Mediterranean become available for examination of the internal organs, their specific status cannot be definitely determined. As long as no proof to the contrary becomes available it appears, however, safe to take for granted that the parasite from these regions is *Loxothylacus texanus*, to all appearances corresponding in every detail with the American specimens. In this connexion it is important to point to the case of *Sacculina carcini*, dealt with above, which has been transported to Burma with its host *Carcinus maenas*.

3. *Eurypanopeus depressus* (Smith) and allied species with *Loxothylacus panopaei* (Gissler).

The specific characters of the sacculinid parasite *Loxothylacus panopaei* (Gissler) may be defined as follows:

Male genital organs in the posterior half of the visceral mass, strongly curved, completely separated. Vasa deferentia straight, narrow canals. Testes with comparatively thick walls and narrow cavities. Colleteric glands with a great number of tubes. External cuticle of the mantle with spines, usually without lateral hairs, of a length of up to 20μ, rarely longer, up to 35 μ. Internal cuticle of the mantle with retinacula consisting of a basal part and 3 to 9 barbed spindles of a length of 6 to 12 μ (cf. Boschma, 1928; 1931).

The parasite has been reported from several localities in the West Indies, in the Gulf of Mexico, and in the Caribbean Sea, on the hosts *Panopeus herbstii* H. Milne Edwards, *Panopeus occidentalis* Saussure, *Eurypanopeus depressus* (Smith), and *Tetraplax quadridentata* (Rathbun), from southern California on the host *Lophopanopeus diegensis* Rathbun, and from British Columbia on the host *Lophopanopeus bellus* (Stimpson) (cf. Boschma, 1955: 36). The specific status of the parasite on *Tetraplax quadridentata* remains somewhat doubtful as its host is not a Xanthid but a Goneplacid crab and the spines of the external cuticle are much longer than usually in *Loxothylacus panopaei* (Boschma, 1931, fig. 49 b); also the identity of the parasite

on *Lophopanopeus bellus* is not absolutely certain as the spines of the external cuticle are covered by minute lateral hairs, not smooth as in the other specimens (l.c., fig. 49 d).

Behre (1950) reported upon a specimen of *Rhithropanopeus harrisii* (Gould) with the parasite *Loxothylacus panopaei* from Louisiana; Reinhard & Reischman (1958) also examined specimens of the parasite on the same host from Texas. Van Engel et al. (1966) noted the occurrence of numerous specimens of *Eurypanopeus depressus* bearing the parasite *Loxothylacus panopaei* in the southern part of Chesapeake Bay, obviously introduced from the Gulf of Mexico. Dillon & Zwerner (1966) give an account of the biology of the parasite *Loxothylacus panopaei* with accurate figures of the external appearance, the nauplius, the cypris, the internal organs, the excrescences of the external cuticle, and the retinacula.

Maitland (1874) described the species *Pilumnus tridentatus* from the brackish water of the Zuiderzee and from near Haarlem in North Holland; De Man (1892) changed the name of the crab to *Heteropanope tridentata*, and up to 1949 the species was referred to under this name, the crab being regarded as endemic to the brackish water of the Netherlands. In 1936 the crab was for the first time observed in a locality in the north of Germany; soon afterwards it appeared that it had become very abundant in the region of the western Black Sea coast, and had incidentally also been found in various localities in western Europe. A detailed history of the settlement of the Zuiderzee crab in European localities was published by Buitendijk & Holthuis (1949); these authors further could prove that this crab is specifically identical with *Rhithropanopeus harrisii* (Gould), known from several brackish water localities on the Atlantic coast of North America and the Gulf of Mexico. It appears, therefore, that at least a century ago the crab was transported from America to the Zuiderzee and found here favourable conditions of life. After the closure of the Zuiderzee, in 1932, the water in this basin gradually turned from brackish to fresh, leading to the extinction of the crabs.

It is interesting to note that *Rhithropanopeus harrisii* also occurs on the west coast of America, in San Francisco Bay and in Coos Bay, Oregon (cf. Christiansen, 1969: 83), obviously also transported by ships.

Van Engel et al. (1966) state that in the vicinity of Gloucester Point, Virginia (at the southern end of Chesapeake Bay) a collection of 595 *Eurypanopeus depressus* (Smith) contained 54% parasitized crabs (the parasite being *Loxothylacus panopaei*). They further observe (l.c.: 112): "This appears to be a clear example of an introduced species. Since 1960 ... a substantial quantity of live oysters has been imported from the Gulf of

Mexico each year in refrigerated tanks. The practice is new and is a highly probable source of sacculinid-infected mud crabs." The data given above indicate that the parasite seems to be firmly established in the new locality. Van Engel et al. remark, however, that the parasite may normally require warmer waters than are found in western North Atlantic estuaries, and add that it will be interesting to observe whether *Loxothylacus panopaei* survives the winter and becomes definitely established. As far as I know the question of survival of the parasites has not yet been settled. In this connexion the attention may be drawn to a remark on a previous page concerning the occurrence of *Loxothylacus panopaei* in British Columbia, where in winter the water is also cold. This argument is, however, not altogether conclusive because there is some doubt concerning the specific identification of the parasite.

4. *Eriocheir sinensis* H. Milne Edwards.

The Chinese mitten crab, *Eriocheir sinensis* H. Milne Edwards, originally was known to occur only in the coastal region of China, from the province Fukien in the south to the Korean peninsula in the north (Christiansen, 1969: 98). In 1912 a single specimen was found in a river in Germany, and in the following years the crab became widely distributed in a large part of western Europe; Christiansen (1969: 98) records the following localities: "In the Baltic along the Finnish, Swedish, Russian, Polish, German, and Danish coasts and adjacent rivers; W. coast of Sweden; coasts of Denmark; German North Sea coast and coasts of Netherlands, Belgium, and France and adjacent rivers; once in the River Thames, London."

In their extensive studies on the morphology, the biology, and the distribution of *Eriocheir sinensis,* Peters & Panning (1933: 59) give as their opinion that the crab has been brought from China to Germany in the young stage in ballast water tanks of commercial vessels. This, indeed, seems to be the only possible manner of transport over such a distance, as *Eriocheir sinensis* lives in fresh water to the time of egg-laying and the hatching of the larvae; transport on the hulls of ships with exposure to salt water would rapidly kill off the crabs.

Eriocheir sinensis is not known to become infected by sacculinid parasites. It is interesting to note that the Japanese fresh water crab *Eriocheir japonicus* (De Haan) is the host of *Sacculina gregaria* (Okada & Miyashita), a parasite with numerous external sacs.

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