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LIST OF ILLUSTRATIONS

Fig. 1.—Junction of the Tazin and Taltson Rivers, Mackenzie, from the north. The rocky, sparsely timbered hills in the distance are very characteristic of the Tazin Highlands. The larger and heavier growth on a level area in the foreground includes jack pine (*Pinus Banksiana*), white spruce (*Picea canadensis*), black spruce (*Picea mariana*), canoe birch (*Betula papyrifera*), and aspen poplar (*Populus tremuloides*). July 31, 1914.

Fig. 2.—South shore of Great Slave Lake at Grant Point, Mackenzie, ten miles west of Taltson River. The trees on this rocky point are white spruce (*Picea canadensis*). August 20, 1914.

Fig. 3.—A muskeg on the east side of Athabaska River about ten miles below McKay, Alberta, with characteristic vegetation of black spruce (*Picea mariana*), Labrador tea (*Ledum grœnlandicum*), and sphagnum (*Sphagnum* sp.). May 31, 1914.

(*Photographs reproduced by courtesy of the Geological Survey of Canada.*)

MATING AND OVIPOSITION IN PANDALUS DANAE[1]

By ALFREDA BERKELEY NEEDLER

ON THE British Columbian coast there are five species of shrimps that commonly occur in the markets. Four of these species belong to the genus *Pandalus* and one to the closely related genus *Pandalopsis*. Of the five, *Pandalus danæ* is the most important species near Vancouver and so was given most attention in the study of the life history of these forms. The following account deals with some observations made during the autumn of 1929 on one phase of the life history of *Pandalus danæ*, namely the mating and oviposition. The investigation was carried out at the Pacific Biological Station, Nanaimo, and thanks are due to the Biological Board of Canada for providing facilities for the work.

The accounts hitherto given of the mating and egg-laying habits of Decapods have been rather scanty. These habits have been described in some detail for various crayfish, for the American lobster, for the crabs *Carcinus moenas* and *Cancer pagurus*, and for the prawn *Atyephira compressa*. For this last species Ishikava (1885)[2] gives a short but good account of the process of oviposition, which appears to be similar to that of *Pandalus danæ*, but he does not mention the mating habits.

In order to study the mating habits of *Pandalus danæ*, a number of specimens were placed in aquarial tanks early in October. At this time the males have the organs of copulation on the first pleopods and the appendices masculinæ on the second much enlarged and covered with heavy spines. This has been called the "active" male condition, and is a sign that the vasa deferentia are packed with ripe sperms. In the females the ovaries are filled with blue-green eggs and are very conspicuous through the clear integument.

About fifteen members of each sex were taken and at first the sexes were kept in separate tanks. When desired (usually after a female had moulted) a few males were placed in the tank with the females. In this way it was possible more conveniently to watch the entire process. Later, however, all the shrimps were kept together in one tank and their uncontrolled, presumably natural, actions were observed.

The process of mating and oviposition is always preceded by a moult on the part of the female. At this moult the pleopods develop the long numerous setae charactersitic of ovigerous females. Sexually active males display no interest in hard-shelled females and practically none in soft-shelled ones that have not undergone this final moult before oviposition. On one occasion a female moulted in the tank but was not ready for egg deposition. For some hours afterwards the males showed more interest in this female than in her hard-shelled comrades, but made no attempt to mate. Thus it seems probable that some substance is secreted by all females (perhaps all shrimps) that have recently moulted, but that this is much stronger in those that are ready to mate.

If a sexually active male be placed in a tank where there is a female recently moulted ready for the ovigerous condition, his first reactions are similar to those shown in the presence of food. There is, to begin with, only a vague uneasiness,

[1] This work was carried out with the aid of a scholarship from the National Research Council.

[2] ISHIKAVA, C.—On the development of a freshwater crustacean *Atyephira compressa*, de Haan. Quart. J. Micr. Sci. 2, Ser. 25, 1885.

but in a little while the male begins to feel about in the water with the antennæ, the third maxillipeds and the first pereiopods. He then advances, obviously feeling rather than seeing his way, towards the female and usually travels the last few inches very quickly. Having reached the female the male attempts to run up on her back. Frequently he is immediately shaken off by the female which is almost always larger than the male, but, if successful, he swings himself under her so that the anterior part of his abdomen is under the posterior part of her thorax. Sometimes the female rolls over and the two shrimps lie side by side. As a rule this mating process takes only from fifteen seconds to one minute, but on one occasion it lasted for fifteen minutes. After mating the female will be found to have a loose mass of sperms tucked in between the bases of the last two pairs of pereiopods. A male examined just after mating will be found to have the organs of copulation on the first pair of pleopods hooked together by their cincinnuli, and the appendices masculinæ of the second pleopods lying in between. It is easy to see how these two pairs of appendices with their long spines serve very effectively to guide the sperms from the vasa deferentia to the thorax of the female.

As a rule the female moults at night, and, as far as could be ascertained, the eggs are usually laid about thirty-six hours after this moult. Evidently mating can take place any time within this thirty-six hours. One female moulted at 1.45 p.m. and was continuously watched from 9.00 the next morning until she laid her eggs. According to observations of other females it is believed that her actions were fairly typical, so that they will be described in some detail. The whole of the day after moulting this shrimp was very quiet, ate nothing, and only moved at intervals to clean herself. This cleaning was mainly devoted to the abdomen and pleopods, and was often accompanied by one or two circular movements of the last pair of pereiopods similar to those made in oviposition. About 11.00 p.m. she assumed a vertical position clinging to one of the corners of the tank, and cleaned her pleopods more and more frequently. At 1.45 a.m. she suddenly descended to the floor of the tank and began the process of oviposition. The third pereiopods were almost straight, so that the shrimp was perched on these pereiopods, and the tip of the telson. Meantime the fourth and fifth periopods were bent with their tips held under the mid-line of the body. Throughout oviposition the fifth pereiopods were in constant motion and the fourth also moved from time to time. This motion was very reminiscent of a man elbowing his way through a crowd and, presumably, is designed to help the eggs in their passage down the oviducts. The pleopods were also seen to move gently but continuously. After leaving the oviducts the eggs passed in a steady stream between the thoracic appendages to the abdomen, and were deposited on the anterior pleopods first. The whole process of oviposition occupied about half an hour, but it was almost another half hour before the female resumed an ordinary position and began to walk about the bottom of the tank.

It is believed that in the main the above would be the procedure followed in a state of nature, but obviously something was not quite right in the artificial environment. This was shown by the fact that none of the females succeeded in fixing the eggs to the pleopods, and they were always shaken off within an hour or two of laying. Ordinarily the eggs after deposition are surrounded by a clear membrane, threads of which attach them to each other and to the pleopods. Now this membrane of egg cement was not present round any of the eggs laid in captivity, and it is probable that some unfavourable condition prevented the action of the glands which usually secrete it. Just where these glands are situated and how they act is still a matter of conjecture.

In going from the oviducts at the base of the third pereiopods to the abdomen the eggs would pass over the aforementioned mass of sperms tucked in between the bases of the fourth and fifth pereiopods. Now each of these sperms is shaped something like a tin-tack with a three-rayed head, each ray ending in a soft mass of protoplasm, while the rest of the sperm is quite rigid. The sperms with their sharp points are easily collected by the eggs as the latter pass over them and the points tend to penetrate into the eggs. A number of eggs were examined after being laid and in many cases a sperm could be seen stuck into the egg. In most of these the contents of the sperm appeared to have passed into the egg leaving the somewhat collapsed "shell" on the outside. Owing to the large quantity of yolk material and consequent opacity of the egg, it was impossible to see more of the process of fertilization without sectioning the eggs.