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Note on a Gregarine (*Aggregata inachi*, n. sp.) which may cause the parasitic castration of its host (*Inachus dorsettensis*).

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With plate 26.

1. The effect of the parasite on its host.

The fact that the presence of a parasite may profoundly modify the sexual development of its host was first made known by Giard, and in a series of papers (see especially **1** and **2**) this author has from time to time notified the wide spread occurence of what he calls "castration parasitaire". It appears from his observations that a number of different parasites belonging to widely different classes of animals can have this effect on their various hosts, so that it is evident that we are dealing with a general process of deep meaning. The castration brought about by these various parasites is found to affect the primary and the secondary sexual characters of the hosts, causing the gonad to be reduced or even totally to disappear in infected individuals, while externally the infected males assume characters proper to the female, and the infected females show a degenerate condition of their secondary sexual characters. No clear case has as yet been adduced of the female assuming distinctively male characters under the influence of parasitic castration.

The degeneration of the gonad may be brought about directly by the parasite attacking this organ, but in the great majority of cases the parasite is situated in a different part of the body to the gonad, and affects this organ indirectly in some unknown manner.

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The object of this paragraph is to describe a new instance of parasitic castration brought about by a Gregarine in a species of spider-crab, *Inachus dorsettensis*. The chief interest of this case is that it is the first clear instance of parasitic castration caused by a Sporozoan parasite. GIARD in his list of cases (2) gives *Capitella capitata* as influenced by the presence of the T-shaped gregarine, *Ancorella*, but I can find no other reference to this case in the literature of the subject.

The Gregarine which causes the parasitic castration of *I. dorsettensis* belongs to the genus *Aggregata*. The members of this genus, which have been described by FRENZEL, LÉGER etc. (3, 4, 5 and 6), in the adult or trophozoite stage inhabit the intestine of various Decapod Crustacea, but the encysted stage when spore-formation takes place is passed through in the body cavity of the host, the cysts being attached to the outer surface of the intestine, when they appear as opaque white bodies of a large though varying size (Plate 26, Fig. 1). I have only studied *Aggregata inachi* in the encysted and sporozoite stage: cysts indistinguishable from one another in appearance occur on the intestine of *Inachus scorpio* and *dorsettensis*, but in the former they are never present in great numbers, while in the latter species during the last half of May 1905, more than half the specimens collected contained a great number of cysts.

Inachus dorsettensis is distinguished from its congeners by the following characters (Plate 26, Figs. 2 and 3). The carapace is longer than it is broad: there are present 4 small tubercles on the gastral swelling of the carapace: the other tubercles are large and pointed but not greatly swollen at the base: the chelae of the male are swollen and oval: the legs of the female are shorter than in other species: the colour is light reddish brown.

Now of fifty males examined seven specimens were clearly distinguished by having the flat chelae characteristic of the females, while the abdomen was much broader than is the case in normal males of a corresponding size, thus converging on the female condition (Figs. 4 and 5). In one specimen (Fig. 6) there was present on the under side of the abdomen a pair of swimmerets which are characteristic of the female, these appendages being altogether absent in the normal males (Fig. 7).

On dissecting all these crabs of hermaphrodite appearance, the intestine was found to be covered with the cysts of *Aggregata*

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inachi, the body cavity was also full of liberated sporozoites, the haemolymph having a milky appearance due to the crowded presence of these bodies. The testes were in all cases disintegrated, only the vesiculae seminales remaining. Unmodified males were also found to contain the cysts of *Aggregata inachi*, but in none of these males were there large quantities of sporozoites in the haemolymph, so that it appears that the hermaphrodite external characters are assumed by the infected male at the moult which follows the liberation of a large quantity of sporozoites.

It is impossible to prove from the instances before us that the presence of the parasite is the cause of the castration, but that this is the case is certain from the analogy of other instances, a detailed analysis of which I hope to furnish in a forthcoming work on the *Rhizocephala*.

With regard to the effect of this parasite on the female I am unable to furnish any facts, owing to the rarity of the female in general.

2. Life history of Aggregata inachi.

It will be remembered that the Aggregatidae together with the Porosporidae form a separate sub-tribe Gymnosporea, distinguished from all other Gregarines by the fact that the ripe cyst contains naked sporozoites which are not invested in special sporocysts but are irregularly grouped round residual masses of nutritive matter. The mature cysts of the Gymnosporea thus come to have an extraordinary resemblance to the cysts of the Malarial parasite found in the Mosquito. This resemblance is brought out in Fig. 12, Plate 26.

In the adult trophozoite stage, however, the Gymnosporea are typical septate Gregarines, as there seems to be no doubt that observers are correct who associate the septate Gregarines found in the gut of the Crustacea with the coelomic cysts situated on the outer surface of the gut in the body cavity.

The life history of these Gregarines is exceedingly obscure: nothing is known of the means of infection or whether the sporozoites are taken up by an intermediate host before infecting another crab, though this appears highly probable from the observations of Frenzel (3) that the parasites seem to be absent from the crabs at certain times of the year.

The question to the solution of which I wish to contribute some fairly definite evidence relates to the occurrence or non-occurrence

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of conjugation in these forms. The examination of numerous cysts at different stages in development makes it apparent that a conjugation of the kind described by Cuénot for *Monocystis* and which with variations is held to be typical of the Gregarines in general, does not occur. Each cyst, whatever may be its size, at the beginning of development is found to contain a single nucleus, the chromatin of which is aggregated into a central reticular mass (Fig. 8). Before dividing it gets rid of the greater part of its chromatic substance and the nucleus loses its staining reaction with alum-haematoxylin (Fig. 9); it then proceeds to divide and forms a ring of nuclei round the periphery of the cyst (Fig. 10), which at first do not stain with nuclear dyes, but as they go on increasing in number they regain their staining properties. When a complete investment of small nuclei is formed round the cyst, invagination occurs at various points (Fig. 11), and in this manner rings of nuclei are formed within the cyst surrounding islets of residual matter. From these rings the sporozoites are formed (Fig. 12), and by the rupture of the cyst are set free in the body cavity of the crab. The sporozoites, while in the cyst, differ from those that have been set free in the body cavity in shape and in the form of the nuclear matter (Figs. 13a and b).

There is no trace in this history of the occurrence of conjugation, nor are two nuclei ever found together in one cyst at the beginning of development. It is clear therefore that if conjugation does occur at all in the life history it must take place at some different period to that which is usual for Gregarines. I have noticed among the sporozoites found free in the body cavity of the crab a tendency to fuse and to form associations (Fig. 13c) but of any definite process of conjugation at this stage I can obtain no evidence.

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Explanation of Plate 26.

Fig. 1. Mid-gut of *Inachus dorsettensis* with cysts of *Aggregata inachi*. × 40.
Fig. 2. Male of *I. dorsettensis*. Ventral view. Nat. size.
Fig. 3. Female of *I. dorsettensis*. Dorsal view. Nat. size.
Figs. 4 and 5. Infected males of *I. dorsettensis*, showing parasitic castration. Nat. size.
Fig. 6. Abdomen of infected male. × 4.
Fig. 7. Abdomen of normal male. × 4.
Figs. 8, 9, 10, 11, 12. Stages in development of *Aggregata inachi*. × 350.
Fig. 13. Sporozoites of *A. inachi*. 13a sporozoites in cyst. 13b free sporozoites. 13c associated sporozoites. × 1300.

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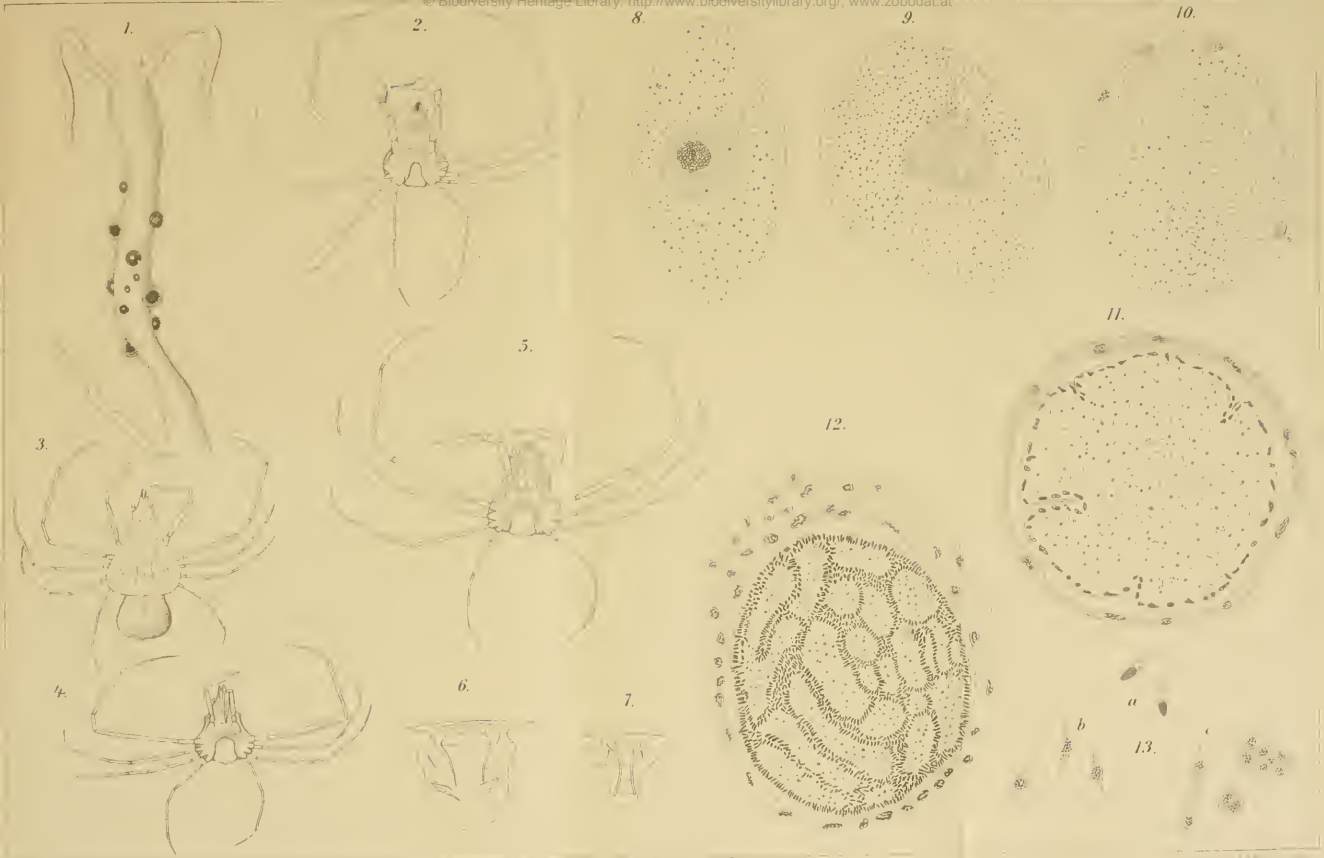

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Digitale Literatur/Digital Literature

Zeitschrift/Journal: Mittheilungen aus der Zoologischen Station zu Neapel

Jahr/Year: 1906

Band/Volume: 17

Autor(en)/Author(s): Smith Geoffrey

Artikel/Article: Note on a Gregarine (Aggregata inachi, n. sp.) which may cause the parasitic castration of its host (Inachus dorsettensis). 406-410