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Parasitology

OBSERVATIONS ON THE LOCALIZATION AND PATHOGENICITY OF *HAEMOBAPHES DICERAUS* WILSON, 1917 (*COPEPODA: LERNAEOCERIDAE*) IN THE GILLS OF *THERAGRA CHALCOGRAMMA* (PALLAS)

OBSERWACJE NAD LOKALIZACJĄ I PATOGENICZNOŚCIĄ *HAEMOBAPHES DICERAUS* WILSON, 1917 (*COPEPODA: LERNAEOCERIDAE*) W JAMIE SKRZELOWEJ *THERAGRA CHALCOGRAMMA* (PALLAS)

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The invasion of *Theragra chalcogramma* by the parasitic copepod *Haemobaphes diceraus* and the anatomo-pathologic changes induced by these parasites in the organs of the host are described. The data concerning *H.theragrae* Yamaguti, 1939 and *H.enodis*? Gusev, 1951 are also discussed and the supposition as to their synonymity with *H.diceraus* Wilson, 1917 is put forward.

INTRODUCTION

Haemobaphes diceraus has not hitherto been recorded from *Theragra chalcogramma.* It has been described by Wilson (1917) from *Chaeturichthys scistius* caught in the Pacific off the Asiatic coast (Japan, Hakodate) and by Kabata (1967) from *Cymatogaster aggregata* colllected in the East Pacific (Canada, British Columbia).

Gusev (1951), in addition, found 1 specimen on the gills of *Gadus morhua macrocephalus* off Sakhalin (Antonovo). Unfortunately, this specimen had its head broken off and therefore it could not be determined exactly and its identification as *H.diceraus* is only hypothetical.

As there are only few data concerning the occurrence and pathogenicity of this parasitic species, it seems expedient to discuss these questions on the basis of own material.

MATERIAL AND METHOD

A total of 100 specimens of *Theragra chalcogramma* were examined. The fishes, 31–49 cm long, were caught off the Asiatic coast of the North Pacific and imported from the USSR.

Twenty-seven per cent of the fishes examined were infested with *H.diceraus*, which occurred on the gills, being attached to different branchial arches, mostly a single specimen in a fish. More rarely, only in 6 cases, two parasites were found in one fish, on two different arches of the same side or one on each side of the head. Thus, 33 specimens were collected, 4 of which were removed whole from the fishes, which made it possible to identify them down to species. Several specimens were left in situ on the fish and some parasites partly sectioned to enable the investigation of the localization of the parasite.

In addition, transverse microscopic sections were made through the arterial trunk and arterial bulb with the parasite enclosed in them and, for comparison, through the same organs of non-infested *Th.chalcogramma*. Sections were stained with haematoxylin and eosin, the standard paraffin method being employed.

Since the material used for sections was derived from frozen fishes, it was unfit for its histological structures to be examined and was used only to investigate the localization of the parasite and the anatomo-pathologic changes.

The drawings of the anterior section of the parasite body were mady by hand.

DESCRIPTION OF PARASITE

H.diceraus was first described by Wilson (1917) and his description was next corrected and completed by Kabata (1967). The specimens from *Theragra chalcogramma* quite agree with Kabata's description and therefore there is no need for a detailed discussion of the morphology of this parasite.

Dimensions of specimens examined.

The trunk length, measured in the line of the abdomen, from its end to the farthest point of the dorsal curvature of the trunk, is 10–15 mm and the abdomen length 8 mm. The length of the "neck", from its junction with the trunk to the bend, is 16–21 mm, the length of the anterior part of the "neck", from the bend and including the head, 13–22 mm, the thickness of the "neck" about 1 mm and the length of the egg sacs 8–15 mm.

Localization of parasite and pathologic changes.

In the place where the parasite is attached to the branchial arch, between two rows of gill lamellae, the lamellae undergo a shortening or complete atrophy over the space filled

up by the parasite's thick S-shaped genital segment, from which the egg sacs, coiled in tight spirals, hang. These sacs sometimes stick out from below the opercle (Fig. 1).

Fig. 1. *Haemobaphes diceraus* on the gills of *Theragra chalcogramma*

The anterior part of the parasite body forms a very long slender "neck", which extends inside the afferent gill artery against the stream of blood. Along with this vessel it pierces through the ventral junction of the branchial arches and reaches the arterial trunk. Here the "neck" forms a sharp bend and, inside the arterial trunk, tends towards the heart to get to the bottom of the arterial bulb (Fig. 2).

The head and mouth-parts of the parasite are washed by the fish blood pumped by the heart to the gills. The head of the parasite is covered with a necrotic fibrous layer, produced by the tissues of the host and forming a big tumor. Only the mouth region of the parasite remains uncovered.

Two straight outgrowths, turned backwards, occur before the bend on the "neck", where it enters the arterial trunk. These outgrowths, leaning against the wall of the artery, probably prevent the pushing-out of the parasite by the pressure of the blood flowing from the heart. A diagram of the localization of the parasite in the branchial circulatory system is presented in Fig. 3a and b.

The length of the "neck" varies considerably according to the place in which the parasite settles in the gills.

Fig. 2. *Haemobaphes diceraus* on an isolated branchial arch with the arterial bulb, in which the cephalic section of the parasite body is visible

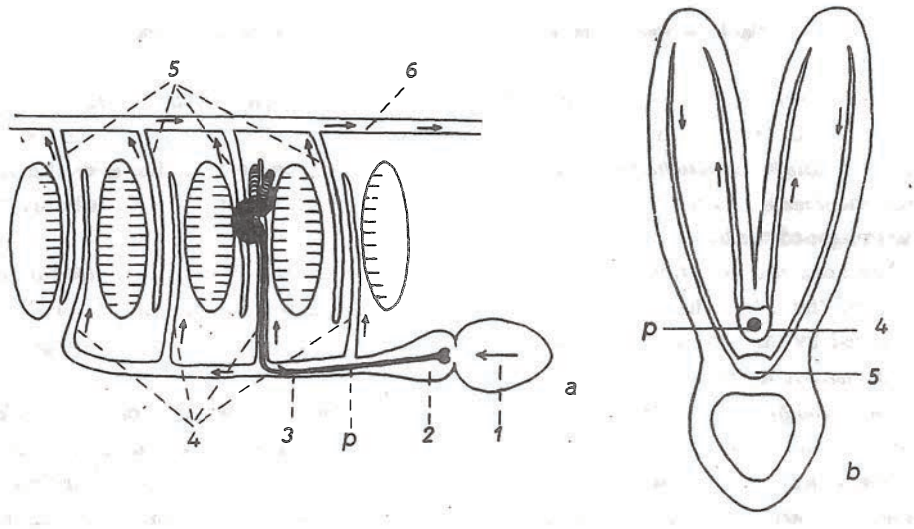

Fig. 3. A diagram to show the situation of the parasite in the branchial circulation system of the fish: a. longitudinal section; b. transverse section through a gill arch. 1. heart chamber, 2. arterial bulb, 3. arterial trunk, 4. afferent gill arteries, 5. efferent gill arteries, 6. dorsal aorta, p. parasite

If the gills are infested by two parasites, both of them stretch along the respective afferent gill arteries to the arterial trunk and enter it. They fill the arterial trunk to the extent that it undergoes a marked deformation (Fig. 4). It may be supposed that a third parasite would have no chance to develop on this fish.

Fig. 4. Isolated heart with the arterial bulb and two specimens of *Haemobaphes*, showing the deformation of the arterial trunk by the heads of the parasites which fill it

Even a single parasite nearly entirely fills the lumen of the arterial trunk and thus it undoubtedly impairs the blood circulation (Fig. 5). In the case of infestation with two parasites the obstruction of the arterial trunk is still greater. For all that, the blood circulates, which is probably due to the considerable elasticity and delatability of the vessel walls. Disturbances in the action of the heart, which must do more work because of the blockade of a long segment of the vessels by the parasites, no doubt have a noxious effect on the branchial circulation.

Moreover, the heads of the parasites may reach as far as the valves between the arterial bulb and the heart and pierce through them, thus adding to the impairment of the cardiac action and to the disturbances in circulation.

The parasite, having a strongly chitinized cuticle, not only blocks the artery and arterial bulb, but also damages the inner layer (*tunica intima*) of these vessels, which is particularly well seen in cross sections through the arterial bulb (Figs. 6 and 7). An analogous section through the bulb of a non-infested specimen of *Theragra chalcogramma*, and so with its inner layer uninjured, is given for comparison (Fig. 8).

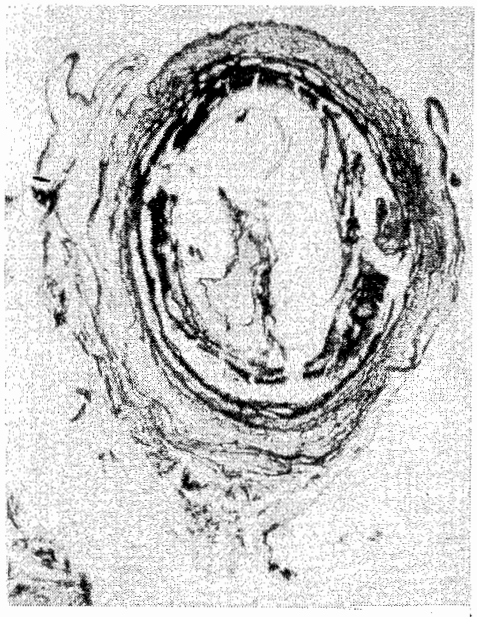

Fig. 5. Transverse section through the arterial trunk of *Theragra chalcogramma*. The parasite fills up the lumen of the vessel completely. Phot. J. Waluga

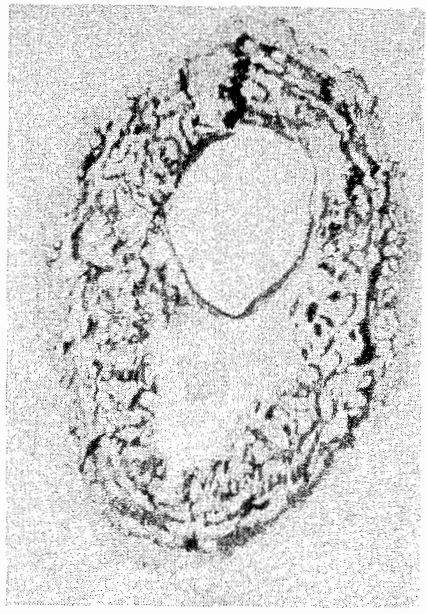

Fig. 6. Longitudinal section through the anterior part of the arterial bulb, showing the outlines of the parasite body in its lumen. Phot. J. Waluga

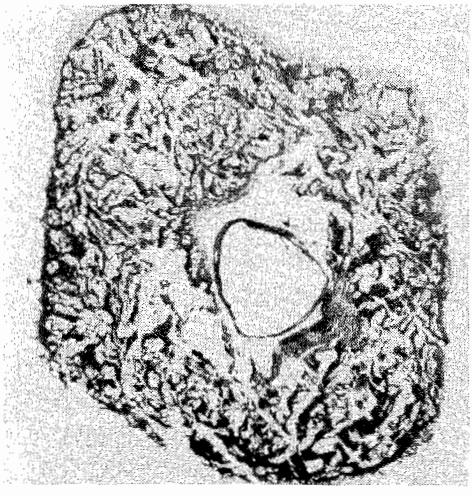

Fig. 7. Transverse section through the middle part of the arterial bulb with the parasite in it. Damage to the inner coat (*tunica intima*) of the bulb is visible. Phot. J. Waluga

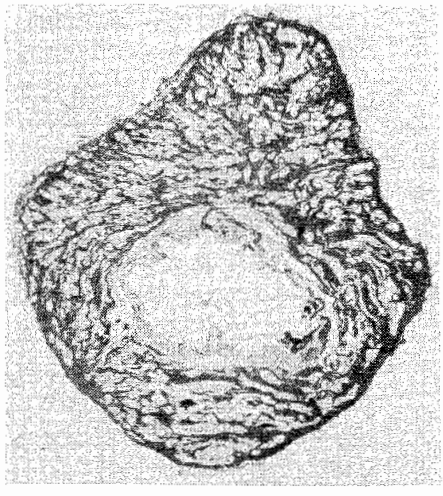

Fig. 8. Transverse section through the arterial bulb of a non-infested specimen of *Theragra chalcogramma*. The undamaged inner coat is well seen. Phot. J. Waluga

The penetration of the parasite into the heart valve induces also changes in the structure of the muscular layer of the valve, i.e. its marked loosening (Fig. 9).

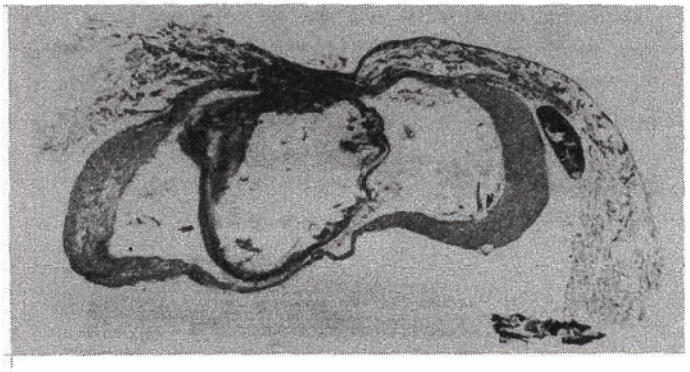

Fig. 9. Transverse section through the valve between the heart chamber and the arterial bulb, in the lumen of which the head of the parasite is visible. Phot. J. Waluga

DISCUSSION

In the available literature there is only very general information concerning the localization of *Haemobaphes* in the central circulatory system of the fish. On the other hand, close studies were made on a related species, *Lernaeocera branchialis,* parasitizing the cod *Gadus morhua.* This parasite, too, penetrates from the gill chamber into the pericardial cavity and attaches to the arterial bulb. Schurmanns Stekhoven's (1936) study shows that the head of *L.branchialis,* together with its outgrowths, sinks into the wall of the arterial bulb, causing its marked deformation, the thickening of the wall and the reduction in the vessel lumen, which must exert a far-reaching influence on the blood circulation of the host and its ability to survive. Some very great histopathologic changes appear in the tissue of the arterial bulb damaged by the parasite, as well.

According to Kabata (1970), *Lernaeocera* probably very rarely penetrates into the lumen of blood-vessels, for "the consequences of such penetration would be disastrous for the fish and parasite alike. Immediate thrombus formation would be inevitably followed by death of both".

The penetration of *H.diceraus* into the lumen of blood-vessels and arterial bulb is however a normal, regularly occuring phenomenon. Nowhere in cross sections did I observe a thrombus accompanying the occurrence of this parasite in the vessels, although the injury to the endothelium of the vessels was very extensive. The specimens of *Theragra chalcogramma* examined were derived from commercial catches and so they had been caught alive, which proves that the fishes do not die immediately after the

parasites have penetrated into their circulatory system. Presumably, *Haemobaphes* secretes enzymes that prevent blood from coagulation.

So far, parasites of the genus *Haemobaphes* have been found on the gills of *Theragra chalcogramma* by Yamaguti (1939) and Gusev (1951). Yamaguti found only one female in Toyama Bay (Japan) and described it as a new species *Haemobaphes theragrae*. Gusev also found only one specimen, which in addition was damaged, its anterior part of the trunk including the head being broken away. This made the exact determination of the species impossible and therefore the specimen was only hypothetically identified as *H.enodis* Wilson, 1917 on the basis of the structure of the genital segment devoid of characteristic swellings.

As may be judged from the description and the drawing of the whole animal, Yamaguti's specimen very much resembles *H.diceraus*, from which it differs, as has been emphasized by the author himself, only in that the first three thoracic segments following the cephalic part are not differentiated. In *H.diceraus* these segments are very distinctly marked (Fig. 10a and b). The swellings on the genital segment of *H.theragrae* are besides so poorly developed that they give the impression of one pair of swellings and not of two pairs as in *H.diceraus*. To be exact, in *H.diceraus* one pair of swellings is situated on the genital segment and the other one on the postgenital segment, corresponding to the abdomen.

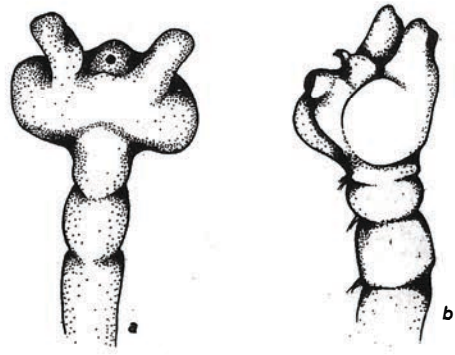

Fig. 10. The cephalic section of *Haemobaphes diceraus*: a. dorsal view, b. lateral view.

Delamare Deboutteville and Nunes Ruivo (1955) assume this occurrence of one pair of swellings to be a distinctive trait, characteristic of the species *H.theragrae* Yamaguti, 1939.

Because of its great similarity to *H.diceraus*, on the one hand, and the incomplete description and lack of precise drawings, on the other hand, the validity of *H.theragrae* was called in question (Gooding and Humes, 1963; Kabata, 1967). What is more, since the description of the species there has been no record of another find of *H.theragrae* on *Th.chalcogramma*. Only Yamaguti's (1939) original description is quoted and the drawing presented by different authors (Delamare Deboutteville and Nunes Ruivo, 1955; Markevič, 1956; Gooding and Humes, 1963; Yamaguti, 1963). On the contrary, *H.diceraus*

collected by me is a species that relatively often occurs on *Theragra chalcogramma* and it is rather hard to assume that the same fish species may be infested also by another species of *Haemobaphes* so similar to it.

The most essential taxonomic character of the genus *Haemobaphes* is the structure of the cephalic part of body, which has also been emphasized by Kabata (1967). The trait which makes us think that we are concerned with one and the same species is the presence of two outgrowths on the head of *H. theragrae* and *H. diceraus*. These outgrowths are turned to the front and give the head its characteristic "horned" appearance. Two straight outgrowths with blunt ends on the "neck" of these parasites are also identical. On the other hand, there are no major specific differences in the structure of the head appendages and thoracic limbs between the species known to me.

In my opinion, the conviction that there is one pair of swellings on the genital segment takes rise from the inexactitude of the drawing or from the fact that Yamaguti dealt with a relatively young and still incompletely developed specimen.

Although nothing else than a close analysis of Yamaguti's specimen, which constituted the basis for the erection of the species, is necessary to dispel the existing doubts definitively, yet, basing myself on the foregoing remarks, I venture the statement that *H. theragrae* should be considered synonymous with *H. diceraus*.

This is also true of the specimen found by Gusev (1951) and identified by him hypothetically as *H. enodis* Wilson, 1917. This form should also be included among the synonyms of *H. diceraus* under the name of *Haemobaphes enodis*? Gusev, 1951. It differs from *H. enodis* Wilson, 1917 in the presence of short straight outgrowths, characteristic of *H. diceraus,* on the "neck", whereas in *H. enodis* these outgrowths show a tendency to branch. Moreover, the genital segment of Gusev's specimen is more bent in the form of the letter "S" than it is in the specimen described by Wilson.

The absence of swellings from the genital segment of Gusev's specimen is, according to me, a hardly important character, because these swellings become more and more distinct only as the specimens of *Haemobaphes* get older.

The gradual development of the swellings on the genital segment and abdomen of female *H. ambiguus* has been demonstrated in Delamare Deboutteville and Nunes Ruivo's (1955) study. It may therefore by that the situation in the other species of this genus is similar and that Gusev's specimen was a young one.

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OBSERWACJE NAD LOKALIZACJĄ I PATOGENICZNOŚCIĄ *HAEMOBAPHES DICERAUS* WILSON, 1917 (*COPEPODA: LERNAEOCERIDAE*) W JAMIE SKRZELOWEJ *THERAGRA CHALCOGRAMMA* (PALLAS)

Streszczenie

Opisano dość znaczną inwazję pasożytniczego widłonoga *Haemobaphes diceraus* na mintaju (*Theragra chalcogramma*), pacyficznej ryby dorszowatej (*Gadidae*). Ekstensywność inwazji wynosiła 27%, intensywność po 1–2 pasożyty na jednej rybie.

Pasożyty uczepione były do łuków skrzelowych między dwoma rzędami płatków skrzelowych, przy czym na zewnątrz łuku wystawał esowato wygięty segment płciowy, odwłok i worki jajowe. Natomiast głowa i tułów pasożyta w postaci cienkiej. długiej „szyjki" przebiegały wewnątrz naczynia skrzelowego doprowadzającego, pnia tętniczego i sięgały do opuszki tętniczej. Głowa pasożyta może nawet przebijać się do zastawek serca.

Obecność pasożytów w świetle naczyń krwionośnych powoduje rozległe uszkodzenie błony wewnętrznej (*intima*) naczyń a także stanowi duży zator, utrudniający krążenie skrzelowe krwi. Ponadto uszkodzenie zastawek wywołuje niewątpliwie zaburzenia w krwiobiegu.

Prócz tego obecność pasożytów na łukach skrzelowych powoduje atrofię płatków skrzelowych.

Przedyskutowano przynależność gatunkową okazów uprzednio znalezionych na mintaju i wyrażono przypuszczenie, że *Haemobaphes theragrae* Yamaguti, 1939 i *Haemobaphes enodis*? – Gusev, 1951 są synonimami *Haemobaphes diceraus* Wilson, 1917.

НАБЛЮДЕНИЯ НАД РАЗМЕЩЕНИЕМ И ПАТОГЕННОСТЬЮ HAEMOBAPHES DICERAUS WILSON, 1917 (COPEPODA: LERNAEOCERIDAE) В ЖАБЕРНОЙ ПОЛОСТИ THERAGRA CHALCOGRAMMA (PALLAS)

Р е з ю м е

Описана довольно значительная инвазия паразитирующего веслоногого рачка Haemobaphes diceraus на минтае (Theragra chalcogramma), тихоокеанской тресковой рыбе (Gadidae). Экстенсивность инвазии составляла 27%, интенсивность - по 1-2 паразита на одной рыбе.

Паразиты прикреплялись к жаберным дугам между двумя рядами жаберных пластинок, при чём наружу выступали s-образно изогнутый половой сегмент, брюшко и яйцевые мешки, голова же и туловище паразита в виде тонкой длинной „шейки" проходили внутри жаберного приводящего сосуда, артериального ствола и доходили до артериального окончания. Голова паразита иногда проникала даже до сердечных клапанов.

Присутствие паразитов внутри кровеносных сосудов вызывает сильное повреждение внутренней оболочки (intima) сосудов, а также является большим пренятствием, затрудняющим жаберное кровообращение. Кроме того, присутствие паразита на жаберных дугах вызывает атрофию жаберных пластинок.

Рассмотрена видовая принадлежность особей, ранее обнаруженных на минтае, и высказано предположение о том, что Haemobaphes theragrae Yamaguti, 1939 и Haemobaphes enodis? Gusev, 1951 являются синонимами Haemobaphes diceraus Wilson, 1917.

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