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A SURVEY OF THE RESULTS OF STUDIES ON GYRODACTYLUS KATHARINERI MALMBERG, 1964 (GYRODACTYLIDAE: MONOGENEA)

R. ERGENS

Institute of Parasitology, Czechoslovak Academy of Sciences, Prague

Abstract. The hitherto obtained information on *Gyrodactylus katharineri* Malmberg, 1964 is summarized, concerning particularly its localization, host species spectrum and distribution in Eurasia. The morphogenesis and morphological-metrical variability of hard parts of opisthaptor are dealt with in detail. The pathogenicity of the parasite is stressed and methods for its control in fish-breeding farms are proposed.

An intensive breeding of carp cannot progress without production of a sufficient quantity of a well developed and healthy fry. In this respect, however, the results are not always satisfactory and profitable due to great losses occurring during the development of the fry caused partly by various parasitic diseass. One of these diseases is gyrodactylosis induced by several species of viviparous monogeneans of the genus *Gyrodactylus* Nordmann, 1832, particularly *G. katharineri* Malmberg, 1964. I assumed therefore that it would be useful to summarize all available data on this parasite which might serve for its better identification and to add some new information necessary for timely and effective prophylactic and therapeutic measures regulating its occurrence, distribution and the resulting losses.

MATERIAL AND METHODS

The presented data on the measurements and morphology of the hard parts of opisthaptor and their morphogenesis were obtained during the author's studies of more than 1200 specimens of parasites fixed in 4 % formalin or in a mixture of glycerine and ammonium picrate and mounted in glycerine jelly or Canada balsam. They are deposited in the collections of the Institute of Parasitology, Czechoslovak Academy of Sciences, Prague and Zoological Institute, USSR Academy of Sciences, Leningrad. In order to complete the data on the localization, occurrence and distribution of *G. katharineri*, information published by other authors were also considered.

The illustrations were prepared with the aid of a camera lucida and the measurements were made according to the procedure of Ergens and Lom (1970).

The specimens for scanning electron microscopy were thoroughly washed in 0.1 M cacodylate buffer and fixed in 10 % neutral formalin. After subsequent washing in distilled water the material was removed, dehydrated through an ethanol series and amylacetate and subjected to critical point drying. The material was then coated with gold and examined in a TESLA BS-300 scanning electron microscope.

RESULTS

Nomenclature

Kathariner (1895) published the first detailed characterization of *G. katharineri*, but he assumed that the species *G. elegans* Nordmann, 1832 was involved. Just this fact was the reason of a series of determination errors for more than a half of a century and led to many misunderstandings among the authors of not only systematical, faunistical and zoogeographical papers, but also of those destinated to veterinary service and practical fishery.

The error of Kathariner was noticed as late as in 1957 by Bykhovsky, who wrote: "...if the rules of the zoological nomenclature* are considered, then the name *G. elegans* should be used only for the species occurring on *Abramis brama*, since this fish is given as the first one in the host series in Nordmann's description". Unfortunately, the author did not recommend to suit the demand of ICZN in this case for the following reason: "... in the literature, the name *G. elegans* is so much associated with species parasitic on *Cyprinus carpio* that, in our opinion, its changing would result in a confusion which would be hardly justifiable. For this reason we recognize the name *G. elegans* for the species parasitizing on gills and fins of *C. carpio* L.".

On the basis of a detailed analysis of Nordmann's data also Malmberg (1957) came to the conclusion that *A. brama* and not *C. carpio* should be considered the host of *G. elegans*. In contrast to Bykhovsky, however, he respected the rules of ICZN and rather easily enforced the name *G. elegans* exclusively for the species parasitizing *A. brama*. In 1964 he published a paper in which he named the species characterized by Kathariner from *C. carpio* as *G. katharineri*. However, he committed an error in attaching the abbreviation "n. nom." after the name, since according to the ICZN (point 21, general regulations) this abbreviation should be used only for the substituting names usually used for younger homonyma. In this case the author should have used "sp. nov.". It is also not evident from the above-cited paper whether the species *G. katharineri* was established only on the basis of Kathariner's description and illustration (in the sense of article 49 of ICZN) or on the basis of specimens obtained from *C. carpio* from Schreventeich, Kiel (Federal Republic of Germany). In 1970, the same author reported that the type material deposited in the Department of Invertebrates, Riksmuseum, Stockholm, were the "above mentioned specimens of *G. katharineri* Malmberg, 1964". In this case, however, the material consisted not only of specimens coming from Schreventeich, Kiel, but also of specimens coming from a small stream in fish-culture Bokelholm, Kreis Rendsburg, Schleswig-Holstein.

Nevertheless, in spite of the more or less formal imperfections, Malmberg succeeded in solving essentially the problem of the name of the parasites determined by Kathariner as *G. elegans*. Unfortunately, the situation was somewhat complicated by Kollman (1968), who described a new species *G. cyprini* from skin, gills and fins of fry of *C. carpio* from the ponds near Erlangen (Federal Republic of Germany). However, owing to the detailed description and illustrations of the parasite it could be stated that it was conspecific with *G. katharineri* and that its name was a younger homonym of *G. cyprini* Diarova, 1964.

I assume that this brief outline of the rather complicated history of *G. katharineri* will help to a better orientation of the authors intending to use some data on this parasite published in older papers.

Description

The total length of massive anchors in 0.070–0.112** and length of their basal part 0.051–0.079. The point measures 0.027–0.052 and process 0.020–0.035. The ventral bar is characterized by well developed lateral processes, the length of which (0.014–0.034) exceeds the length of the bar proper (0.008–0.014). The width of this bar is 0.033–0.053 at the level of posterior margin and 0.041–0.070 at the level of lateral processes. Its shield is 0.018–0.031 long. The size of the dorsal bar is 0.002–0.006 × 0.019–0.043. The total length of marginal hooks is 0.036–0.052, the hook proper measures 0.008–0.010 (Plate II).

The cirrus is oval to spherical, 0.020–0.025 in diameter and its spines are arranged in one row. Pharyngeal processes are long.

Hosts and temporary substratum*

The results of long-term studies on the occurrence and distribution of *G. katharineri* indicate that the host of this parasite is not only *C. carpio*, as it was originally supposed, but also *Varicorhinus capoeta heratensis* natio *steindachneri* (Kessler), *V. capoeta gracilis* (Keyserling), *Barbus barbus* (L.), *B. lacerta cyri* Filippi, *Gobio gobio* (L.), *Alburnus alburnus* (L.), *Ctenopharyngodon idella* (Valenciennes) and *Hypophthalmichthys molitrix* (Valenciennes). Moreover, in the localities where the population of some of these hosts is strongly infected, occasional specimens of *G. katharineri* may occur also in *Rutilus rutilus* (L.), *Leuciscus leuciscus* (L.), *L. cephalus* (L.), *Scardinius erythrophthalmus* (L.), *Schizopygopsis stoliczkai* Steindachner, *Carassius carassius* (L.) and *Lota lota* (L.). These fish species, however, in no case can be considered hosts, but only "temporary substratum", on which the parasite only temporarily survives.

It would be quite premature and in this paper also purposeless to try to submit a similar classification of hosts as was that published by Malmberg (1970) (true host, wrong host, temporary host). From the viewpoint of a possible distribution of *G. katharineri*, particularly in intensive breeding of *C. carpio*, not only all the host fish species, but also the fishes serving as the "temporary substratum" are of the same importance (see below).

Localization

G. katharineri is usually localized on the skin and fins, but in case of massive infection it may be found also on gills, in mouth cavity and in pharynx.

Morphogenesis of hard parts of opisthaptor

As it is shown in Fig. 1, the anlages of anchors and marginal hooks appear first of all the hard parts of opisthaptor. The anchors are two threadlike structures and each of them represents the future point. During the further development they grow in length and in width. At the time when they are of about the same length as the point of fully developed anchors, they bend and their basal part starts to grow. As soon as this part is longer than the point, the base of the process starts to form and somewhat later grows also the process itself. Thus the development of anchors is terminated.

The marginal hooks, arising at the same time as anchors, appear first like fine arched structures and in the following phase of development the base and handle of hook grow. The development of marginal hooks is completed at the time when the hook proper and its handle get their definitive shape and size.

The ventral bar first appears at the time when the base of anchor processes is forming. It is membranous and its lateral processes represent two oval, independent

* Further ICZN.
** All measurements are in mm.

* Terminology after Malmberg (1970).

structures, directed anteriorly. During the further development the bar becomes thicker and connected with lateral processes. The development of this bar terminates by the formation of the membranous process. The dorsal bar, ontogenetically the youngest structure, is a simple rod appearing at the time when the anchor process is growing. Its further development is very simple, since it only increases in size.

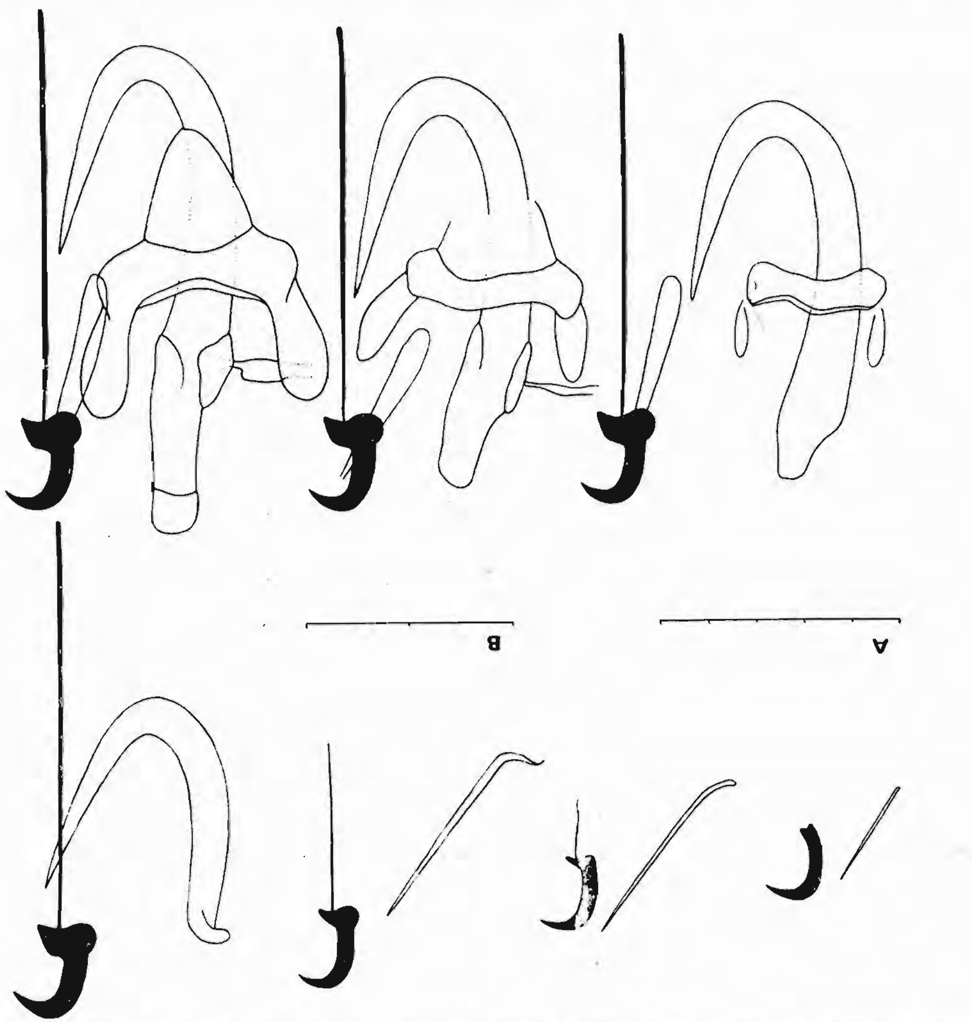

Fig. 1. Morphogenesis of hard parts of opisthaptor of *Gyrodactylus katharineri* Malmberg, 1964. Scales (1 part = 0.01 mm) A — for anchors and bars, B — for marginal hooks.

It should be noted that the morphogenesis of ontogenetically older hard parts of opisthaptor (anchors and marginal hooks) ceases at the stage when the daughter specimen is still in the mother organism and that, vice versa, the ontogenetically younger hard parts of opisthaptor (both bars) complete their morphogenesis mostly as late as at the stage when the daughter specimen has already left the mother organism and is capable of an independent existence.

Variability of hard parts of opisthaptor

Table 1

As it is evident from the above description, there is a great metrical variability in individual hard parts of opisthaptor. The smallest sizes were recorded in specimens collected in summer season, the largest in specimens obtained in winter. It may be therefore supposed that the changes in the sizes of these structures, like in *G. macronychus* Malmberg, 1957 or *G. aphyae* Malmberg, 1957 (Ergens 1976), are associated with regular and periodical (seasonal) changes in the temperature of the environment. No effect of the localization or age and species of the host was observed in this relation.

Table 1. Metrical variability of hard parts of opisthaptor of *Gyrodactylus katharineri* Malmberg, 1964

		from *Cyprinus carpio*	from other hosts	from temporary substratum	Total
Anchors	Total length	0.070—0.110	0.072—0.112	0.073—0.089	0.070—0.112
	Length of shaft	0.053—0.079	0.051—0.078	0.052—0.063	0.051—0.079
	Length of point	0.027—0.052	0.028—0.051	0.033—0.042	0.027—0.052
	Length of root	0.020—0.035	0.022—0.035	0.022—0.028	0.020—0.035
Length of ventral bar		0.008—0.013	0.009—0.013	0.009—0.010	0.008—0.013
Width of ventral bar		0.034—0.048	0.033—0.053	0.039—0.042	0.033—0.053
Length of shield		0.018—0.031	0.018—0.030	0.022—0.028	0.018—0.031
Width of dorsal bar		0.019—0.035	0.023—0.043	0.030—0.033	0.019—0.043
Total length of marginal hooks		0.036—0.052	0.036—0.051	0.039—0.045	0.036—0.052
Length of hook proper		0.008—0.010	0.008—0.010	0.008—0.009	0.008—0.010

The morphological variability of the hard parts of opisthaptor is minimal in comparison with their metrical variability (Fig. 2). The greatest morphological stability was observed in marginal hooks, which is another confirmation of the results obtained in previous papers (Ergens 1965a, b) dealing with the taxonomic value of specific determination criteria of members of the genus *Gyrodactylus*. Also the basic shape of anchors is relatively stable and is only slightly affected by the intensity of bending of their processes. A more pronounced morphological variability can be observed only in both bars, particularly in the proportion between their length and width, and in case of the ventral bar, also the shape and sizes of lateral processes are variable.

It should be noted in this respect that there is a marked metrical and morphological similarity in hard parts of opisthaptor in *G. katharineri* and *G. mizellei* Kritsky et Leiby, 1971. The latter species was found in North Dakota (USA) on *Stizostedion canadense* (16 specimens) and *S. vitreum* (6 specimens). In my opinion, this fact is a sufficient reason for a detailed comparative study of the two species.

Occurrence and distribution

G. katharineri occurs in most of the above fish hosts in both natural and artificial water reservoirs. An exception are the introduced species *Ctenopharyngodon idella* and *Hypophthalmichthys molitrix*, which were reported to harbour this parasite (even several hundreds of specimens per fish) only in ponds with intensive fish breeding in the Volgorechensk fish farm (USSR) where they were placed together with *C. carpio* (Kudentsova and Solomatova 1978).

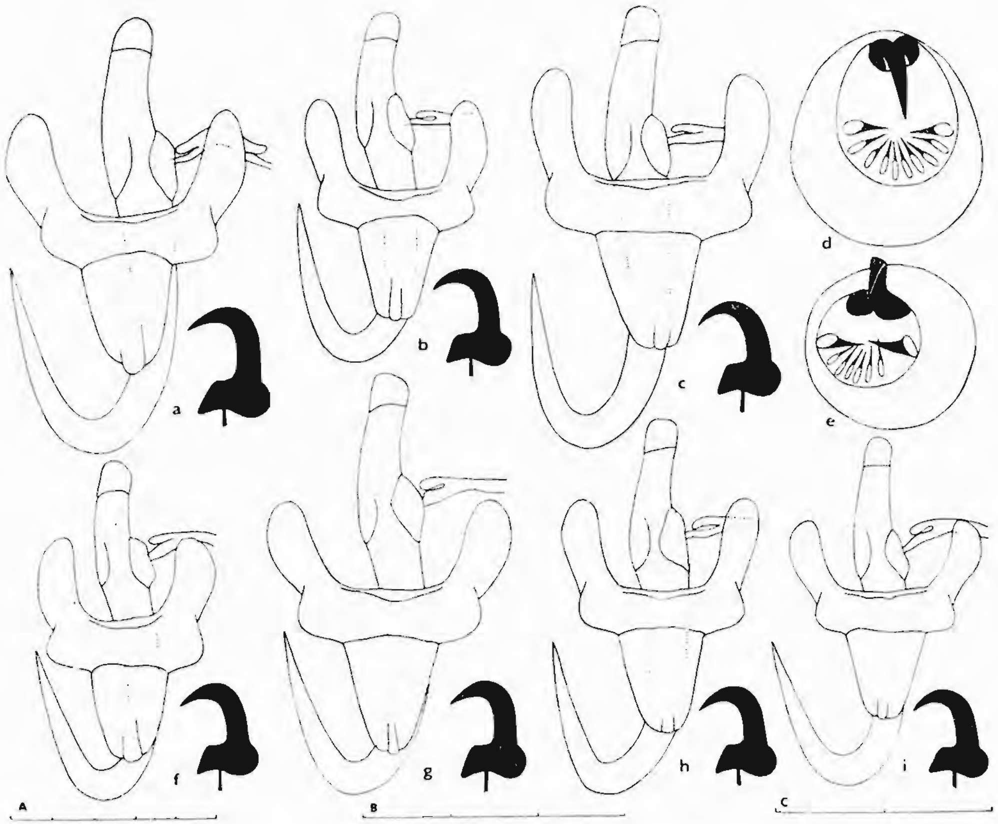

Fig. 2. Morphological variability of anchors, bars, marginal hooks and cirrus of *Gyrodactylus katharineri* Malmberg, 1964. a, b, f — from the fins of *Cyprinus carpio* L., the pond near Kamenec—Podolsk USSR, 1950 (lgt. Nagibina), the River Vltava near Prague, Czechoslovakia, 24th May 1967 and the Lake Irdyagi, USSR, 8th July 1967 (lgt. Kashkovsky); c, d — from the fin of *Varicorhinus capoeta gracilis* (Keyserling), the River Lenkoranka, Azerbaijan SSR, 31th July 1975 (lgt. Ibragimov); g — from the fin of *V. capoeta heratensis* natio *steindachneri* (Kessler), the "44 chashma", Tajik SSR, 31th May 1973 (lgt. Daniyarov); h — from the fin of *Barbus lacerta cyri* Filippi, the River Lenkoranka, Azerbaijan SSR, 20th July 1975 (lgt. Ibragimov); e, i — from the fin of *Alburnus alburnus* (L.), the River Želivka, Czechoslovakia, 18th May 1967. Scales (1 part = 0.01 mm) A — for anchors and bars, B — for cirrus, C — for marginal hooks.

Young fishes (fry and one-year-old fishes) are infected most frequently and to a greatest extent. Under natural conditions (rivers and lakes), the intensity of infection, as well as the incidence, are usually low and no symptoms of the disease appear in the hosts. However, another situation is encountered in the systems of water reservoirs in fish-breeding farms. The incidence of infection is often 100 % and even several thousands of parasites may occur on one fish. The infected fishes exhibit marked symptoms of a disease which are similar to the symptoms of chilodonellosis or trichodinosis: the body surface gets a dull blue colour, the fish loses weight and eventually dies.

Of interest is the fact that *G. katharineri* prefers the scaled form of *C. carpio*. Only occasional and always very low infections were recorded on mirror carp and in no case they were accompanied by clinical symptoms of a disease.

The problem of seasonal occurrence of *G. katharineri* has not yet been solved. All available data were obtained only from fish farms where the incidence and intensity of infection with this parasite is associated not only with the season, but primarily with the present physiological condition and concentration of hosts. This is supported also by the fact that a massive reproduction of *G. katharineri* and the resulting infection of fish in ponds with intensive fish breeding occur in any season of the year.

Also the knowledge of *G. katharineri* distribution is not yet quite complete. Due to the fact that this parasite, as well as many other species of the genus *Gyrodactylus*, was for more than 50 years erroneously named *G. elegans*, the older records, if they are not documented by a description and illustrations of the hard parts of opisthaptor, are practically inapplicable. With regard to the present state of research it may be demonstrated that this species occurs on the territory of Kazakhstan, Middle Asian and European parts of the USSR, Bulgaria, Hungary, Czechoslovakia, Poland, German Democratic and German Federal Republics.

Pathogenicity

The pathogenicity of *G. katharineri* consists particularly in a mechanical damage of the host tissue (Plates I, II) induced by the functional activity of the complex of opisthaptoral hooks. In addition to the pathological changes proper and the associated direct effects (abundant elimination of slime, general impairment etc.), the infected fishes become more sensitive also to non-specific diseases, mainly those caused by moulds and bacteria, since their non-specific immunity produced by body covering is reduced.

Control of occurrence and distribution

Under natural conditions, i.e. in rivers, lakes etc., where *G. katharineri* does not cause any serious damage, its occurrence can be decreased or maintained at a low degree only by looking after the newly stocked fish specimens, which must be at a good health condition and parasite-free (in Czechoslovakia this function is performed by two fishery organizations),

In the systems of various types of water reservoirs in fish breedings the occurrence and distribution of *G. katharineri*, as well as of other species of this genus, is limited by antiparasitic baths and by at least basic prophylactic measures.

Since the antiparasitic baths are made from water solutions of chemical substances producing toxic effect not only on the parasites but also on their hosts, it is necessary to keep carefully the prescribed concentration and time of application. If these parameters are not kept, the treated fish may be damaged or even killed, or, in an opposite case, the effect on the parasites is insufficient. In order to prevent any unfavourable consequences it is recommended to test the efficiency of the bath on a small sample of fish before application on a large scale.

Of the great number of hitherto known antiparasitic baths, particularly the "short-time" baths are used in the control of gyrodactylids. The most effective was that consisting of 0.01—0.05 % ammonia and 0.01 % formalin (Pasovsky 1953, Shcherbina 1960, Bauer et al. 1981 and others). A prerequisite of their application, however, is the possibility to manipulate with the fishes and therefore the treatment is performed particularly at the time when the fishes are transferred from one pond category to another.

It should be noted that the antiparasitic baths can be used for the liquidation of not only acute gyrodactyloses, but also feeble infections as prophylactic measures. The following conditions should be then observed.

1. The fishes should be kept at a good condition. That means that they should be fed only with valuable food, corresponding in the quality and quantity to the demands of individual age-groups of fishes. In the opposite case, in case of a bad quality or insufficient amount of food, alimentary disorders may occur inducing weakening of the fish organism and following decrease in the resistance against infective and invasive diseases.
2. It is necessary to prevent an excessive increase in fish concentration in individual reservoirs. According to Maslenikova (cit. in Bauer et al. 1981), if, for example, the number of fish fry is increased three times, then the intensity and incidence of *G. katharineri* infection increases three times as well.
3. The fishes imported from other breedings should be subjected to a thorough parasitological examination still at their original locality and specimens manifesting symptoms of a disease or suspected infection must not be transported in any case.
4. It is necessary to keep the imported brood fishes, in which the parasitological examination usually cannot be made, in separate quarantine reservoirs perfectly isolated from the system of other water reservoirs.
5. The health condition of fishes should be controlled regularly.
6. All fish species serving as hosts or temporary substrate for *G. katharineri* should be removed from the reservoirs destinated to carp breeding, particularly to carp fry breeding. The same concerns also the entire network of uniting canals.

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ОБЗОР РЕЗУЛЬТАТОВ ИЗУЧЕНИЯ *GYRODACTYLUS KATHARINERI* MALMBERG, 1964 (GYRODACTYLIDAE: MONOGENEA)

Р. Эргенс

Резюме. В работе подытожены все до сих пор полученные данные о *Gyrodactylus katharineri* Malmberg, 1964, касающиеся особенно локализации, спектра видов хозяев и распространения в Евразии. Подробно описаны морфогенез и морфо-метрическая изменчивость твердых частей прикрепительного диска. Подчеркивается патогенность паразита и предлагаются методы борьбы с этим паразитом в прудовых хозяйствах.

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R. E., Parasitologický ústav ČSAV,
Na sádkách 702, 370 05 České Budějovice,
ČSSR

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M. L. Sood, J. Kapur: Haemonchus of ruminants — A bibliography of titles. *Shikha Publications, Ludhiana 198?. 431 pp. Price Rs 150.00 (India), £ 12.00.*

The bibliography includes all papers dealing with nematodes of the genus *Haemonchus* which were cited in Helminthological Abstracts in the years 1932—1980. More than 4000 authors are cited; some of them studied this topic in detail, others only mentioned it in their papers. The diligence of the authors of the book should be highly appreciated, since the bibliography will facilitate the work of other authors engaged in the study of this most dangerous parasite.

The book is divided into 12 parts concerning hosts, morphology and taxonomy, immunology and serology, pathogenesis and pathology, biochemistry, ecology, geography, epidemiology and epizootology, life cycle, cytology and evolution. This enables the readers a rapid and exact orientation in the comprehensive set of citations. The last chapters include also books, dissertation papers and references, in which the authors deal with problems associated with nematodes of the genus *Haemonchus*.

The bibliography of papers on this parasite of ruminants, which is the most widely distributed all over the world, is of a great importance at the present time. Almost all laboratories engaged in the studies of serious gastrointestinal nematodoses, as well as those devoted to basic research will get into contact with *Haemonchus* spp. The bibliography will certainly become an indispensable tool for all of them.

Dr. B. Kotrlá, D.Sc.

Fig. 1. Scanning electron micrographs of *Gyrodactylus katharineri* Malmberg, 1964. a — on fin of *Cyprinus carpio* L. (× 130); b — opisthaptor (dorsal view) (× 1500); c — "trace" of opisthaptor (× 1500).

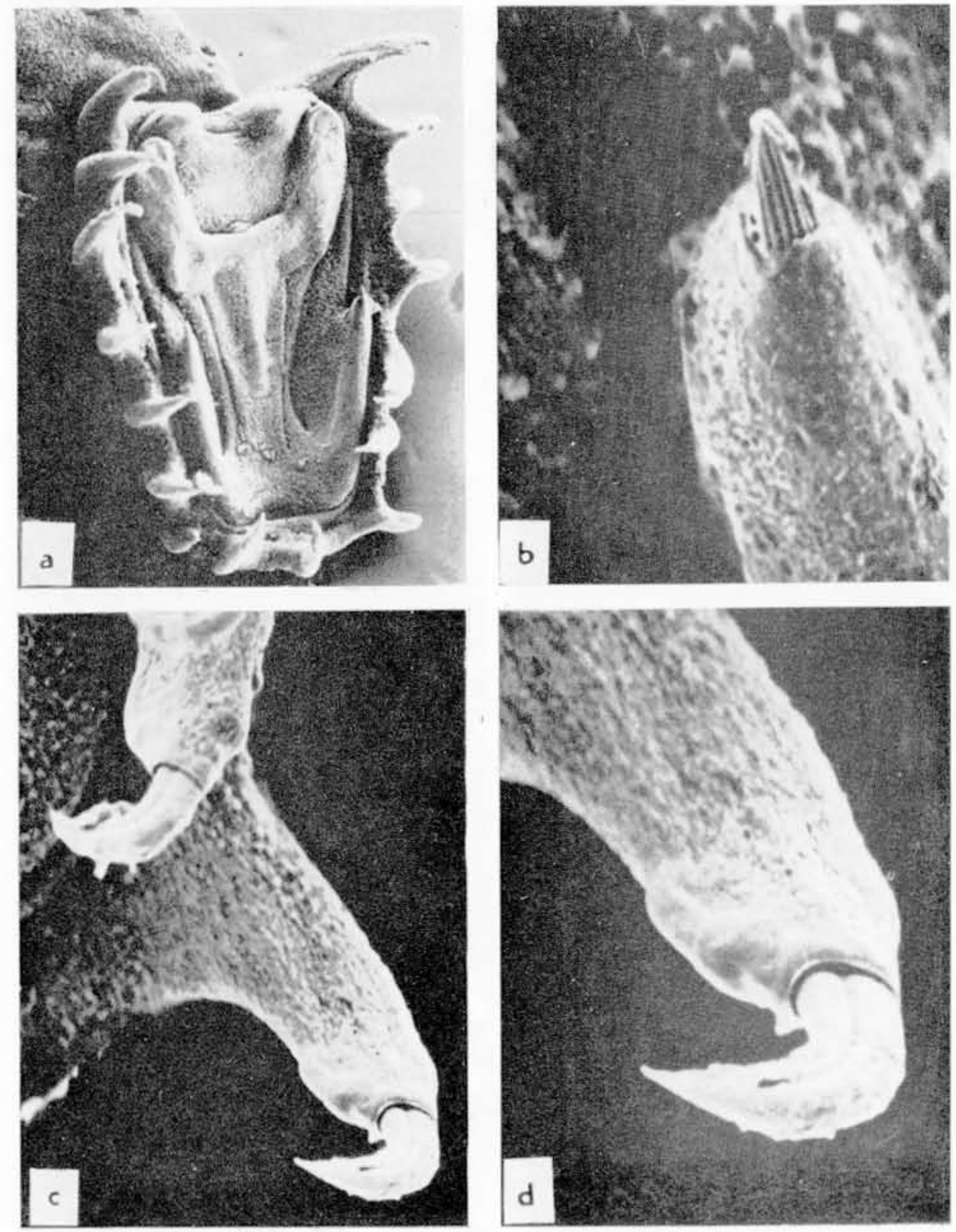

Fig. 1. Scanning electron micrographs of *Gyrodactylus katharineri* Malmberg, 1964. a — opisthaptor (ventral view) (× 720); b — free end of anchors (× 5800); c — detail of opisthaptor margin with marginal hooks (× 3200); d — point of hook proper (× 5800).