Advances in

PARASITOLOGY

Edited by

BEN DAWES

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Professor Emeritus, University of London

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PREFACE

This volume contains reviews on various topics by experts, working in Leeds and London, England; Urbana, Illinois and Kansas City, Missouri, U.S.A.; Johannesburg, South Africa; and Adelaide, South Australia. J. B. Jennings has written about Parasitism and Commensalism in Turbellaria, Ivan G. Horak on Paramphistomiasis of Domestic Ruminants, Ralph Muller on *Dracunculus* and Dracunculiasis (hitherto known as Dracontiasis), Thomas A. Miller on Vaccination against the Canine Hookworm Diseases, and W. Grant Inglis on Speciation in Parasitic Nematodes. In the one updated review, Paul H. Silverman has been assisted by Miss Eder L. Hansen in dealing with *in vitro* Cultivation Procedures for Parasitic Helminths.

The origins of parasitism in helminths may be sought in turbellarians, for in every one of the five orders commonly recognized some representatives live in close association with other animals, mainly echinoderms, crustaceans and molluscs but less commonly annelids, sipunculids, xiphosura and coelenterates, teleost fishes and elasmobranchs, not to mention other turbellarians. Turbellaria participating in these close partnerships belong to at least 27 families, and only freshwater and terrestrial triclads are entirely free-living in habit. Notably, these associations often show host-type specificity, related forms of a single family tending to associate with one type of host, as most Umagillidae associate with echinoderms. However, in only a few out of many such associations are the turbellarians truly parasitic, the majority living as commensals. Parasitic turbellarians do not represent the climax of commensalism and Temnocephalids entered into an ancient association with crustaceans without developing parasitism. However, the wide variety of associations with other animals range from ecto- and endo-commensalism to true parasitism, and Jennings takes the five great groups of Turbellaria in turn in considering such relationships in some detail. The salient emergent conclusion is that remarkably few turbellarians are parasitic in the usually accepted sense of the term; most of them are Rhabdocoela such as the genera *Acholades, Fecampia, Glanduloderma, Kronborgia* and *Oikiocolax*. All these forms get all their nourishment from the host, and their alimentary system is much reduced by comparison with the typical rhabdocoele condition. *Kronborgia* and *Oikiocolax* bring about castration of the hosts, and the former is lethal to the hosts. Forms which live in the "kidneys" and their ducts (e.g. *Graffilla*) and subcutaneous tissue dwellers (e.g. *Ichthyophaga*) may also be parasitic, but more information must be sought about modes of life and metabolism of species which are apparently parasitic. Asexual reproduction such as occurs in trematodes and cestodes is little known in turbellarians, although *Microstomum* produces chains of zooids, and transverse fission is seen in *Dugesia* and other genera. The loss of epidermis and development of cuticle is worthy of study in greater (ultrastructural) detail in Temnocephalids, and it would no doubt be interesting to know why large deposits of glycogen occur in commensals such as *Syndesmis*. The various associations studied, we are told, probably arose from chance contacts which provided food and shelter, thus conveying selective advantage. Intensifications of such contacts could have given rise to many different degrees of commensalism and in some instances to parasitism.

Ivan G. Horak notes that paramphistomiasis is caused by massive infection of the small intestines of sheep, goats, cattle and water buffalo, and is characterized by sporadic epizootics of acute gastro-enteritis which may cause high mortality, especially in young animals. Various paramphistomes have been incriminated in this respect but most of our knowledge concerns *Paramphistomum microbothrium* in Africa and Israel, *P. ichikawai* in Australia and *Cotylophoron cotylophorum* in India. The disease is caused by sexually immature worms, and this adds to the difficulty of specific identifications. After dealing with outbreaks of disease in Africa, Asia, Australasia, Eastern Europe, Russia and the Mediterranean countries, Horak goes on to consider the life cycle characteristics of *P. microbothrium*, *P. ichikawai*, *Cotylophoron cotylophorum* and *Calicophoron calicophorum*, and then subsequent development in definitive hosts. One point made is that in cattle paramphistomes grow larger, migrate more rapidly, mature sooner, live and produce eggs for a longer period, and survive migration in greater numbers than occurs in either sheep or goats. Most readers will not need reminding about the outstanding difficulties of experimental work with such large hosts as these. Much field work has been carried out and is considered in the particular area of immunology, and it is shown that previous infection in adult cattle can supply a degree of resistance to subsequent massive infections such as produce paramphistomiasis in the field. Multiple infections in sheep result in partial immunity, but the worms can excyst and attach in the small intestines, whereas in cattle subsequent infections are eliminated. There is an interesting parallel, I might point out, with the elimination of flukes in cattle in fascioliasis. However, Horak has reported successful immunization of sheep, goats and cattle against massive infections of *P. microbothrium*. He has also shown that immunity to paramphistomiasis, especially in sheep, depends on such factors as the number of metacercariae ingested and thus the number of young flukes which excyst and attach themselves to the mucosa of the small intestines. Immunity does not depend on the number of worms present in the rumen, and cattle or sheep with numerous flukes in the rumen may be susceptible, while other hosts with smaller numbers of flukes in the rumen may be immune. This is true when X-irradiated metacercariae are used to produce immunity: many young flukes excyst and attach to the intestinal wall, but many are lost during or after migration to the rumen, leaving small fluke burdens in the rumen, and yet cattle are then completely immune to reinfection. In sheep, immunity seems to depend on the continued presence of flukes, and anthelmintic treatment lowers the degree of immunity achieved.

Horak also discusses the effects of immunity on the flukes, and one effect is retardation of growth in immune hosts. Some observations on serology have also been made and pathological studies include notes on clinical signs, clinical pathology and pathological anatomy. Pathogenesis is studied in relation to worm burden and fatal acute paramphistomiasis is produced in stabled sheep with *P. microbothrium* in numbers greater than 40 000: in stabled cattle the corresponding number is about 160 000 flukes. Epizootiology of the disease is also considered in detail: the intermediate snail hosts (*Bulinus tropicus* and *B. truncatus*) are prolific breeders found in streams, ponds, pools, water troughs, marshes and other locations at any altitude up to 6800 ft. They can produce more than sixteen eggs per day for an experimental period of thirty days. The eggs start hatching after seven days and young snails in turn lay eggs when about four weeks old. Within the snails a massive multiplication of *P. microbothrium* may occur, cercariae being shed for many months. In late African summer the grass seeds become unpalatable; only green grazing surrounds natural water masses where sheep, cattle and calves become heavily infected with amphistomes. In other countries conditions vary. Treatment is also considered and a number of anthelmintics are effectual against adult parasites, notably hexachlorophane, hexachloro-ethane-bentonite suspension, tetrachloridifluoro-ethane, bithionol and combinations of certain drugs. Since 1962, remedies against immature forms have been available and some are effectual in sheep but none has proved effectual in cattle. This problem is discussed in some detail, after which methods of control are considered, although methods for the prevention of paramphistomiasis have not yet been devised. Many of the measures used are based on practical observations which are treated in great detail. At present, control depends on keeping livestock away from potentially dangerous areas when climatic conditions produce massive concentrations of infected snails and myriads of metacercarial cysts.

Ralph Muller notes that *Dracunculus* has been known from ancient times as an agent of the disease dracontiasis (or, as he would prefer to call it, dracunculiasis). This is a disease characterizing human poverty mainly in tropical rural communities which lack suitable water supplies. In spite of the hideous culmination as the female's body emerges from an ulcer on arms, legs, breasts or other parts of the body, this is not a lethal disease when there are no pathological complications, although these are not uncommon and produce crippling effects. Muller first deals with the morphology of both sexes of the parasite, notes the paucity of our knowledge on physiology and then considers the life history. The mature female worm may liberate into water more than one half million embryos, and smaller numbers thereafter, about three millions being available in her body. Development continues in some species of *Cyclops*, in which two moults yield a third stage larva that can be activated by the action of acids. In experimental animals larvae occur in the duodenum four hours after infection in drinking water and are soon commencing a long migration through the tissues of the body to widely separated regions. The route of migration is difficult to determine, especially in the early stages when the young worms are microscopically small, and special techniques which can be used are noted. The female worms emerge, usually in the extremities, 10–14 months after infection, giving an approximately annual life cycle. Much useful information is given on maintenance of *Dracunculus* in the laboratory, in both the intermediate and definitive hosts. Various species are characterized and discussed in terms of the species problem within the genus. The greater half of the review deals with dracunculiasis, one section with epidemiology, geographical distribution, the economic effects of disease, the effect of climate and water sources on seasonal incidence in ponds and wells, and the species of *Cyclops* that serve as vectors of the disease. Another section is concerned with pathogenesis including sites of emergence, numbers of worms emerging, clinical symptoms, the simple course of the disease, secondary infection and the failure of worms to emerge. Diagnosis is considered from clinical, parasitological and immunological points of view, with information bearing on the surgical removal of adult females. Chemotherapy is not overlooked, and mention is made of the transformation of treatment brought about by the use of niridazole ("Ambilhar") and thiabendazole ("Mintezol"). Lastly, there is an account of methods of prevention and the control of dracunculiasis by various means, notably chemical treatment of ponds and wells and the general improvement of water supplies.

Thomas A. Miller considers that hookworm disease of dogs has been neglected by comparison with the same disease of Man, text book accounts agreeing with one another largely because of the deficiency of recent work. Yet there may be four species of hookworms which produce disease in dogs, namely *Ancylostoma caninum*, *A. braziliense*, *A. ceylanicum* and *Uncinaria stenocephala*. The three species of *Ancylostoma* are tropical or subtropical forms but *U. stenocephala* occurs in wild Canidae and Vulpidae north and south of the tropical hookworm belt and even in near Arctic regions. The life cycle of all species is direct, but transport hosts have been noted but are unnecessary, so enormous is the biotic potential of the canine hookworms. A heavily infected pup may pass five million eggs of *A. caninum* per day for more than four weeks. Miller describes the life cycles in detail in the dog, and he deals with prenatal-colostral infection although in experimental infections less than 2% of parasites were acquired by the intra-uterine route. The term "colostral" is also considered unsatisfactory for the reason that larvae have been recovered from the milk of bitches up to twenty days after parturition. There is also some information dealing with abnormal hosts; in the mouse, third stage larvae of *A. caninum* accumulate and persist almost throughout life. In discussing canine hookworm diseases (the plural indicates that it is necessary to qualify about the species concerned), the mechanisms by which anaemia is caused are various; intravascular haemolysis, myelotoxins and depressed erythropoiesis, intoxication from worm metabolic products, and secondary microbial infection. During the last decade only, it has been proved that one of these factors only (i.e. intestinal haemorrhage) can be regarded as the primary cause of pathogenesis. In dealing with specific hookworm disease, Miller shows that the signs of infection are related to its intensity, the age of the host, nutritional states, and the presence of acquired and age resistance. The question of immunity is dealt with in detail in respect of age, infection with normal and with attenuated larvae, and vaccination. One section of the review is devoted to the practical use of the newly instituted

Canine Hookworm Vaccine. Immunity against infection does not usually include destruction of the larvae or complete elimination of entire intestinal challenge infections. The demonstration of hookworm eggs in faeces should not be the prime criterion of diagnosis of clinical hookworm disease; more accurate diagnosis is based on haematological observations and clinical examinations.

The review of W. Grant Inglis, which contains ten sections between Introduction and Conclusions, is concerned with the extent to which speciation in parasitic nematodes has been dependent upon or independent of their hosts in the light of recent studies of speciation in free-living animals. He defines speciation as a process of multiplication by which one genetical population divides into two such populations between which genetic interchange is not possible. In this sense, speciation is the crucial process upon which evolution depends, and the problem is to explain the process by which or in consequence of which the genetic continuity between the members of one population can be broken, i.e. how the members of once interbreeding populations can become and remain distinct in reproductive processes and so protect their genetic integrity. After he has devoted a section to species, Inglis in later sections discusses species characteristics, speciation in free-living animals, speciation and the origin of parasitism, and the analysis of speciation in parasites. He then devotes other sections to speciation in the genus *Parathelandros* (parasites of reptiles and amphibians, but in consideration here are parasites of Australian frogs), speciation in the oxyuridae of primates, species flocks, speciation and host specificity, and general speciation. To try to outline here the ideas discussed by Inglis would be futile but is unnecessary, but final discussion is interpreted in terms of an hypothesis of sympatric speciation. As a general case Inglis assumes one parasite occurs in a range of diverse hosts characterized only by a common ecology and common feeding habits. If that host group divides and the parasite is also divided the parasites can speciate. If or when the host groups come together, the two parasites can divide the total host environment between them, either by each occupying a distinct part of the body of each host, or by each occupying a restricted range of hosts. By a continuous series of speciations and niche diversifications the host range of each species would become increasingly restricted and increasingly diversified taxonomically. However, the author does not depend on this model, and he considers less strict host-parasite parallelisms which give the impression that parasites have speciated and radiated to occupy each environment as it appeared. And, in conclusion, there is an interpretation of parasite speciation in terms of an hypothesis of allopatric speciation, which explains the presence of flocks of parasites and intra-host restricted distribution of taxonomically similar parasites, as well as explaining all those other features covered by an hypothesis of host-dependent speciation.

In bringing up to date his review on *in vitro* cultivation procedures for parasitic helminths (1965), Paul H. Silverman has been assisted by Miss Eder L. Hansen. Together and in respect of recently published works they have analysed closely all available data, indicating areas in which some additional research is desirable. They have also emphasized the application of *in vitro* methods to the elucidation of problems concerning parasite physiology and development. In applying *in vitro* techniques to helminths there are several limitations. So far, only very few species out of an enormous assemblage have been studied, and few of the studies made have been sufficiently sustained to warrant adequate generalizations, or even to certify the reproducibility of a particular technique. Marked differences in *in vitro* cultural requirements seem to exist, and no obligate helminth parasite has been cultured through successive generations. Because such limiting factors exist, the writers have considered axenic culture of free-living and insect or plant parasitic nematodes when necessary. Environmental conditions considered include host stimuli and trigger mechanisms, precise conditions that are required during successive stages of development, factors that influence development and organogenesis as distinct from maintenance or survival, immunological inhibition, the toxicity and elimination of metabolic waste products and protreatment factors acting on the parasite before cultivation. Separate sections deal with techniques, trigger mechanisms of various kinds, media and various conditions, recent studies concerning trematodes, cestodes and nematodes, and applications of metazoan *in vitro* cultivation procedures. In a concluding statement there is mention of considerable progress in recent years, "guideposts" having been set up to assist future researchers in this field. Experimental biologists can now utilize culture systems to obtain basic information on the parasite's development and interaction with the host, which could lead to new ideas concerning the host-parasite relationship.

Finally, I can once more express my gratitude and thanks not only to all the contributors to this volume who have set aside the excitement of research or their leisure hours for the tedium of writing, but also to the members of staff of Academic Press who attend to a thousand important details in the preparation of such a volume as this. I can only hope that they have produced another useful and informative book.

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December 1970

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Parasitism and Commensalism in the Turbellaria

J. B. JENNINGS

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I. Introduction

The Turbellaria are predominantly free-living predators but each of the five orders contains families with representatives living in association with other animals.

The commonest partners with which these associations have been established are echinoderms (Asteroidea, Ophiuroidea, Echinoidea, Holothuroidea and Crinoidea), crustaceans (Isopoda, Amphipoda and Decapoda), and mollus.s (Lamellibranchiata and Gastropoda). Less common are associations with annelids (Polychaeta), sipunculids and arachnids (Xiphosura), and a very few species have become associated with coelenterates (Anthozoa), other turbellarians (Alloeocoela) and lower vertebrates (Elasmobranchii and Teleostei).

The Turbellaria concerned in these associations come from at least twenty-seven different families and represent all the major subdivisions of the class, with the exception of the freshwater and terrestrial triclads which are entirely free-living in habit. One striking feature of the associations is the great extent to which they show "host-type" specificity, in that the members of one family tend to be associated with a single type of host organism. Virtually all of the rhabdocoel family Umagillidae, for example, are found in association with echinoderms, and the remaining members occur only in sipunculids.

Although a fairly large number of turbellarian species have entered into associations with other animals, relatively few have become parasitic. The others show a range of different types of relationships, and many of these are difficult to define in strict terms. As a general descriptive term "commensal" is perhaps the most convenient and generally applicable. In many instances the literal interpretation of the term, as implying the sharing of the same food by the turbellarian and its partner, is not entirely valid. In the temnocephalids, for instance, the food consists of various freshwater organisms in addition to particles of the host's food, and in species like the umagillids other commensal organisms such as ciliate protozoans may form a significant proportion of the diet. Nevertheless the concept of commensalism provides a useful background against which most turbellarian associations can be considered, and it will be used in this way in the present review.

It might be thought that the parasitic turbellarians represent a climax to the gradual intensification of the relationship between commensal species and their particular partners, and that the other types of relationship found represent stages in the evolution of the parasitic habit. This may well be correct, but on the other hand there can be no doubt that some of the associations between turbellarians and other animals represent nothing more than end points in the development of those particular associations. The temnocephalids, for example, occur principally on freshwater decapod Crustacea in Central and South America, Madagascar, New Zealand, Australia and some of the islands of the South Pacific. This distribution is interpreted by Baer (1951) as indicating the very ancient nature of the association between flatworm and crustacean since these habitats, originally united by the Palaeoantarctic continent during the early Cretaceous when ancestral parastacid Crustacea were appearing, were separated from each other by the oceans in the middle of the Tertiary period. Despite its long-standing nature, however, this particular association has not developed further towards parasitism.

The fact remains, however, that members of the Turbellaria have become involved in a whole variety of associations with other animals, ranging from ecto- and ento-commensalism to true parasitism. They are members of a phylum which is predominantly parasitic in habit, and even if some or all of the associations involving turbellarians are incapable of evolving further, a study of them may well indicate possible ways in which parasitism has become established as the principal mode of life in their phylum. In the present review, therefore, the occurrence of parasitism and commensalism in the Turbellaria will be surveyed systematically throughout the class, and particular attention will be given to any modifications in structure, physiology or life history which appear to be related to the transition from the basic free-living habit.

II. Acoela

The Acoela are small worms, one to several millimetres in length, exclusively marine, and generally regarded as the most primitive living turbellarians. Primitive features include the absence of an excretory system and of a permanent lumen to the gut. The food of free-living species consists of bacteria, Protozoa, unicellular algae and similar microscopic particles, and digestion occurs in temporary vacuoles within the syncytial endoderm (Jennings, 1957).

Only a few genera (summarized in Table I) have formed associations with other organisms and so little is known of their biology, and especially of their physiology, that it is impossible to define their exact relationship with the host. A single species, *Ectocotyla paguri*, is described by Hyman (1951) as living ectocommensally with hermit crabs on the Atlantic coast of North America. There is some doubt, however, whether or not this species is in fact an acoelan and De Beauchamp (1961) places it within the family Monocoelididae (order Alloeocoela) because of the arrangement of the reproductive system and the plicate form of the pharynx. Other salient features of *E. paguri* are a "degenerate intestine", which De Beauchamp admits is indicative of acoelan affinities, and a posterior adhesive disc reminiscent of that of the temnocephalid rhabdocoels. The caudal disc is clearly an adaptation for an ectocommensal, or at least epizoic, mode of life, but nothing is known of the diet or feeding mechanism. Thus until the systematic position of the genus *Ectocotyla* is clarified and more is known of its general biology it is impossible to say categorically whether or not the acoelan grade of organization has proved adaptable to ectocommensalism, whereas that of other turbellarian orders clearly has been capable of such adaptation.

TABLE I

Genera of Acoela living commensally with other organisms

Genus	Host	Authority
Fam. Anaperidae		
Avagina	Echinoidea	
A. glandulifera	*Spatangus purpureus*	Westblad, 1953
A. incola	*Echinocardium flavescens*	Leiper. 1902; 1904;
	S. purpureus	Westblad, 1953
A. vivipara	*Echinocardium cordatum*	Hickman, 1956
Fam. Convolutidae		
Aphanastoma	Holothuroidea	
A. sanguineum	*Chirodota laevis*	Beklemischev, 1915
A. pallidum	*Myriotrochus rinkii*	Beklemischev, 1915
Fam. Hallangiidae		
Aechmalotus	Holothuroidea	
A. pyrula	*Eupyrgus scaber*	Beklemischev, 1916
Fam. Otocelididae	Holothuroidea	
Otocoelis		
O. chirodotae	*Chirodota laevis*	Beklemischev, 1916
Acoela of uncertain affinities:		
Ectocotyla	Crustacea	
E. paguri	hermit crabs	Hyman, 1951
Suborder Nemertodermida		
Meara	Holothuroidea	
M. stichopi	*Stichopus tremulus*	Westblad, 1949

Entocommensalism, however, has arisen in a number of acoelan genera, usually with holothurian echinoderms as hosts. Such accounts as are available of these genera tend to be restricted to taxonomic descriptions, but the general impression gained from them is that the acoels are truly commensal and not parasitic forms. Westblad (1949) describes in some detail *Meara stichopi*, which he found in the intestine and body cavity of the holothurian *Stichopus tremulus* and, in one instance only, in the body cavity of the related *Mesothuria intestinalis*. He found no evidence of injury to the host's tissues, but observed the remains of copepods and diatoms in the acoel's gut and concluded therefore that *M. stichopi* is "a harmless commensal". From the appearance of fixed specimens he deduced that the acoel feeds by protruding a portion of the intestine through the mouth and engulfing its food in an amoeboid fashion, in precisely the same manner as described by Jennings (1957) for the free-living acoel *Convoluta paradoxa* (= *C. convoluta*).

M. stichopi differs from the free-living acoels in that the epidermis is thicker, lacks rhabdites and has a reduced complement of mucous glands. The brain is reduced also, and the intestine is cellular rather than syncytial. These differences cannot be related to the mode of life, however, since most are shared with the related free-living genus *Nemertoderma* (Westblad, 1937).

Other Acoela from holothurians include *Otocoelis chirodotae*, from the oesophagus of *Chirodota laevis*; *Aphanostoma sanguineum*, from the intestine of *C. laevis*; *A. pallidum*, from the intestine of *Myriotrochus rinkii*; and *Aechmalotus pyrula*, from the intestine of *Eupyrgus scaber* (Beklemischev, 1915). All four of these species appear to be commensal with their hosts and their presence does not cause any obvious damage.

Three species of Acoela are reported from echinoids. *Avagina incola* was described by Leiper (1902, 1904) from the intestine of *Echinocardium flavescens*, and later by Westblad (1953) from both *E. flavescens* and *Spatangus purpureus*. The latter echinoid also harboured *Avagina glandulifera*. No information is available as to the gut contents or feeding habits of these two species, so that no valid comment can be made as to their precise status within the host. In *A. vivipara* from the oesophagus of *Echinocardium cordatum*, however, the gut contains diatoms, indicating that the acoel is using the same type of food as free-living species (Hickman, 1956). These three species show no significant structural differences from free-living forms, but *A. glandulifera* does produce a much greater number of eggs—a feature which Westblad noted as "usual amongst parasites". *A. incola* in the same habitat, however, shows no such modification of its reproductive physiology.

III. Rhabdocoela

The rhabdocoel Turbellaria are small worms like the acoels, but somewhat more complex in internal structure. The gut is saccate, with a permanent lumen and with the anterior region differentiated into a pharynx (simple, bulbous or rosulate) which is an important component of the feeding mechanism. The food in free-living species ranges from protozoa through various small invertebrates, which are swallowed intact, to crustaceans on which species with an eversible bulbous pharynx feed by sucking out body fluids (Jennings, 1957). Feeding by this latter method may on occasion leave the prey alive and capable of recovery.

TABLE II

Commensal and parasitic genera of Rhabdocoela (excluding Dalyellioida: Umagillidae and the Temnocephalida)

Genus	Host	Authority
SUBORDER LECITHOPHORA: DALYELLIOIDA		
Fam. Acholadidae		
Acholades	Asteroidea	
A. asteris	*Coscinasterias colamaria*	Hickman and Olsen, 1955
Fam. Fecampiidae		
Fecampia	Decapoda and Isopoda	
F. erythrocephala	*Cancer pagurus*, *Pagurus bernhardus*, *Carcinus maenas*	Giard, 1886; Caullery and Mesnil, 1903; Southern, 1936; Southward, 1951
F. spiralis	*Serotis schytei*	Baylis, 1949
F. xanthocephala	*Idotea neglecta*	Caullery and Mesnil, 1903
Glanduloderma	myzostomid Annelida	
G. myzostomatis	*Myzostomum brevilobatum* *M. longimanum*	Jägersten, 1942
Kronborgia	Amphipoda and Decapoda (Natantia)	
K. amphipodicola	*Ampelisca macrocephala*, *A. tenuicornis*	Christensen and Kanneworff, 1964
K. caridicola	*Eualus machilenta*, *Lebbeus polaris*, *Paciphaea tarda*	Kanneworff and Christensen, 1966
Fam. Graffillidae		
Graffilla	Gastropoda and Lamellibranchiata	
G. brauni	marine lamellibranchs	Von Graff, 1904–08
G. buccinicola	*Buccinum undatum*	Dakin, 1912
G. muricicola	*Murex* sp.	Jhering, 1880
G. mytili	*Mytilus edulis*	Von Graff, 1904–08
G. parasitica	marine lamellibranchs	Von Graff, 1904–08
Paravortex	Lamellibranchiata	
P. cardii	*Cardium edule*	Hallez, 1909; Atkins, 1934
P. gemellipara	*Modiolus plicatulus*	Linton, 1910; Ball, 1916
Fam. Provorticidae		
Oikiocolax	Turbellaria	
O. plagiostomorum	*Plagiostomum* sp.	Reisinger, 1930
Fam. Pterastericolidae		
Pterastericola	Asteroidea	
P. fedotovi	*Pteraster* sp.	Beklemischev, 1916
SUBORDER LECITHOPHORA: TYPHLOPLANOIDA		
Fam. Typhloplanoidae		
Typhlorhynchus	Annelida	
T. nanus	*Nephthys scolopendroides*	Laidlaw, 1902