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Achievements of Soviet Scientists in Investigations of the Helminthofauna of Marine Mammals of the World Ocean^{1,2}

S. L. DELAMURE and A. S. SKRIABIN³

ABSTRACT

During the last 40 yr (1940 to 1980), Soviet helminthologists have examined about 9,680 specimens of marine mammals in the Northern and Southern Hemispheres, using uniform or standard methods in most cases. As a result, 20 new species of trematodes [digeneids], 19 cestodes, 9 acanthocephalans, and 23 nematodes have been described. Also several new supraspecific taxa have been established. Systematic revisions of Campulidae, Tetrabothriidae, Pseudallidae, and Anisakidae have been undertaken.

The morphology, adaptation of helminths to their environments and to the host's mode of life, infection rates and characteristics, and the seasonal and age dynamics of the helminthofauna have been studied. Methods of distinguishing host populations using quantitative and qualitative differences as well as the geographic variability of the helminthofauna have been developed. Consequently local stocks of mammals have been revealed, as has the pathogenicity of several helminth species.

All of these data have been summarized from ecological, zoogeographical, and phylogenetic points of view. Results of these studies are now employed by zoologists interested in sea mammals.

In 1780 Fabricius published a scientific description of the cestode *Pyramicocephalus phocarum* (Fabricius, 1780), the first of the helminth species to become known to science as a parasite of marine mammals. Some time later Karl Rudolphi (Rudolphi 1802 to 1819) described another eight species (trematodes [digeneids], cestodes, and acanthocephalans) parasitizing these animals. Without becoming too immersed in the history of the development of knowledge of the parasites of marine mammals (for details see Delamure 1955), we wish to indicate that over the last 200 yr (1780-1980) some 276 species of helminths infecting marine mammals of the World Ocean have been discovered by Soviet and foreign scientists.

Today the parasites of these animals are of interest, not only to parasitologists but also to mammalogists studying marine mammals. They are attracted by the possibilities of using helminthological data for the purposes of studying the ecology, phylogeny, dynamical statistics [population dynamics?], and the population structure of the [various] species of marine mammals, including those of commercial importance.

Helminths of marine mammals are not without significance to medical and veterinary specialists, especially since it is known that there are pathogenic species common to pinnipeds, cetaceans, wild and domestic terrestrial mammals, and also to man: *Opisthorchis felinus* (see Kurochkin 1960); *Diphyllobothrium cordatum* (see Yamaguti 1959); *D. pacificus* (see Atias and Catton 1976); *Pyramicocephalus phocarum* (see Rausch et al. 1967); *Taenia solium* larvae (see Graff et al. 1980); *Trichinella spiralis* (see

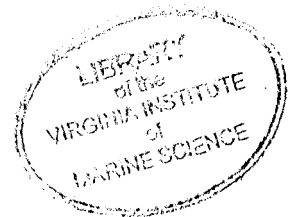
Rausch et al. 1956; Fay 1960; Smirnov 1963; Kozlov 1966, 1971; Treshev and Serdukov 1968; Arvy 1970); larval Anisakidae (Kurochkin and Mamaev 1972; Shiraki 1974; and others).

The interest which has developed in studying helminths of marine mammals will be illustrated by examining the dynamics of recent publications by 10-yr periods.

Before 1940 Soviet scientists had published eight works in this one area. Between 1941 and 1950 they published 15, from 1951 to 1960—31, from 1961 to 1970—91, and from 1971 to 1980—143 articles.

According to the summary of Scheffer and Rice (1963), the World Ocean is inhabited by 31 species of pinnipeds and 80 species of cetaceans. Not all of them have been studied in helminthological respects. Better known than others are the helminthofaunas of the walrus and long-eared seals of the Northern Hemisphere, the true seals and major commercial whales of temperate and cold waters of the Northern and Southern Hemispheres, and, likewise, certain species of small whales. This is due, in no small measure, to Soviet scientists who for the first time investigated the helminthofauna of the gray whale (Treshev 1966a); Bryde's whale (Skriabin 1970a); harbor seals inhabiting the Bering Sea (Yurakhno 1970); island seals (Nikolsky and Kazikanov 1970); small seals of the Baltic Sea and Lake Ladoga (Barysheva and Bauer 1957; Delamure et al. 1980); Caspian seals (Schupakov 1936; Kurochkin 1958; and others); and the Baikal seal (Sudarikov and Ryzhikov 1951; Delamure et al. 1979a; and others).

In this connection it should be indicated that in the last 40 yr Soviet helminthologists have examined 9,680 marine mammals from various zones of the World Ocean (pinnipeds—6,222 and cetaceans—3,458). The large majority of those examinations (8,432) were carried out using the same accepted methodology (Delamure and Skriabin 1965b), by colleagues of the chairman of Zoology of the Crimean Pedagogical Institute (since 1972, the Simferopol State University), by participants in the 33 expeditions to the Black, Azov, Caspian, Baltic, Greenland, Barents, White, Eastern Siberian, Chukchi, Bering, and Okhotsk Seas;



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Lakes Ladoga and Baikal; and expanses of the Southern Hemisphere—including the waters of the Antarctic. Regarding our waters, we have not as yet been able to investigate the marine mammals of the Karskogo Sea and the Sea of Laptevsk.

Turning now to the most common results of the efforts of Soviet scientists in faunal areas, it is interesting to compare them with analogous investigations performed abroad. Calculation has shown that until 1900 only 16 species of trematodes, parasitic in pinnipeds and cetaceans, were known, but now there are 72. During the last 40 yr 27 species have been described (principally of the families Campulidae, Notocotylidae, and Microphallidae). Of that number, 20 or 74% have been by Russian scientists (Skriabin 1944, 1947; Krotov and Delamure 1952; Gubanov V. Kh.: [in:] Delamure 1955;⁴ Delamure and Kleinenberg 1958; Kurochkin 1958, 1962; Skriabin 1959, 1969a, 1970a; Petrov 1963; Treshev 1966a, 1968; Yurakhno 1967, 1968, 1969; Treshev et al. 1969; Kurochkin and Nikolsky 1972. New taxa have been established—the genera *Oschmarinella* Skriabin 1947; *Leucasiella* Krotov and Delamure 1952; *Cetitrema* Skriabin 1969a; and the family Campuloidea (A. Skriabin 1976).

Significant progress has been made in the studies of the cestodes parasitizing marine mammals. Known at present are 71 species of cestodes (versus only 20 in 1900). These discoveries include interesting tetrabothriid species (of the genera *Tetrabothrius*, *Priapocephalus*, and *Trigonocotyle*) and diphyllobothriids (of the genera *Diphyllobothrium*, *Diplogonoporus*, *Tetragonoporus*, *Hexagonoporus*, and *Polygonoporus*). Of the 32 cestode species described in the last 40 yr, some 19 (or 59%) have been by Soviet scientists (Gubanov in Delamure 1955; Delamure 1955, 1971; Belopolskaya 1960; Skriabin 1961, 1967; Delamure et al. 1964; Delamure and Skriabin 1966; Delamure and Parukhin 1968; Muraeva and Treshev 1970; Yurakhno 1973). New genera have been established (*Tetragonoporus* Skriabin, 1961; *Hexagonoporus* Gubanov in Delamure 1955; *Polygonoporus* Gubanov in Delamure 1955; and *Polygonoporus* A. Skriabin 1968); and a subfamily, *Polygonoporinae* Delamure and Skriabin 1968. Occupying a special place is the discovery by A. Skriabin of a 30 m long diphyllobothriid, *Polygonoporus giganticus* A. Skriabin, 1967, parasitizing the cachalot, with strobilae about 5 cm wide, having some members [strobilae] with 14 gonads in the sexual complex.⁵ Diplo- and polygonadal diphyllobothriids have been the subject of special investigations which attempt to clarify their systematics and phylogeny (Delamure and Skriabin 1966, 1968). There have been studies of larval forms or stages of cestodes invading cetaceans (Delamure 1955; Skriabin 1965, 1970a, 1971).

Research has added significant information about acanthocephalans. At present, 35 species parasitizing pinnipeds and cetaceans are known (versus 8 in 1900). Since 1940, 19 species have been described (of the genera *Bolbosoma* and *Corynosoma*). Of these, nine have been described by Soviet scientists (Krotov and Delamure 1952; Gubanov in Delamure 1955; Skriabin 1959; Treshev 1966a, 1970; Nikolsky 1974a).

By 1900, 23 species of nematodes were known from marine mammals; at present there are 98. In the last 40 yr, 46 species have been discovered (of the families Pseudaliidae, Folaroididae, Crassicaudidae, Anisakidae, and Capillariidae), of which 23 (50%) were described by Russian scientists (Skriabin 1933, 1942; Delamure in Skriabin 1942; Delamure 1946, 1951a; Gubanov

1951; Mozgovoy 1951; Gubanov in Delamure 1955; Kurochkin and Zablotski 1958; Skriabin 1959, 1966, 1969a; Delamure and Alekseev 1966; Delamure and Kleinenberg 1968; Zablotski 1971; Yurakhno and Skriabin 1971; Nikolski 1974a). The new genera, *Otophocaenurus* Skriabin, 1942; *Skrjbinalius* Delamure in Skriabin, 1942, *Placentonema* Gubanov, 1951; and *Delamurella* Gubanov in Delamure 1955, were established. The discovery of the 9 m long nematode (*Placentotrema gigantissima* Gubanov, 1951), which parasitizes the placenta of cachalots by H. Gubanov deserves special attention.

At present 276 species of helminths parasitizing pinnipeds and cetaceans of the World Ocean are known. In addition to the Soviet scientists contributing significantly to knowledge of the helminth fauna during the last decade, one must acknowledge investigators from other countries, especially Baylis, Baer, Davey, Dailey, Dollfus, Dougherty, Margolis, Markowski, Rausch, Stunkard, Shultz, and Yamaguti.

The study of helminths of marine mammals has not been limited to discovery of new species, to redescription of old ones, to creation and revision of higher taxa, to studies of morphology and systematics, to development of better characteristics to clarify synonymies and permit more exact definitions, or to the discovery of principal hosts. In recent times there has been a change not only toward consideration of the morphological variables of the helminths of marine animals but also toward comparison of the factors of development, host-parasite relationships, zoogeography, and variables of routes and intensity of infection. Manifestations of the variability of different, separate indicators and also the causes of that variability have important meanings for the systematics of helminths and for the study of the population structure of their hosts—pinnipeds and cetaceans.

Study of the accumulated materials permitted revision of the taxonomic characteristics of marine mammals according to the taxa of helminths such as ampulids, tetrabothriids, pseudaliids, and anasakids (Skriabin 1942; A. Skriabin 1970a; Kontrimavichus et al. 1976; Temirova and Skriabin 1978; and others).

Helminths are not second in any respect to other animals in the number of their adaptations toward their environments and the life histories of their different hosts; e.g., those of the pseudaliid infecting the respiratory organs of dolphins (Delamure 1951a, 1955), as well as those of the crassicaudid nematode which infects the genito-urinary systems of whales (Skriabin 1969a). The origin of their adaptations is closely connected with those changes which the whales underwent in the course of their evolution.

The adaptations of gigantic cestodes and nematodes, which assure survival of the species over the wide expanses of the ocean, are very interesting (Delamure and Skriabin 1965a, 1968). Adaptation of the parasite to the anatomical and physiological peculiarities of the principal hosts together with the damage it causes have been studied by Skriabin (1960) using *Placentonema gigantissima* as a model or example. The importance of such investigations to the understanding of the host-parasite system is evident. Attempts have been made to study the life cycles of helminths of marine mammals. The studies of A. V. Uspenskaya (1960), who deciphered the life cycle of the nematode *Terranova decipiens*, and T. I. Popova, A. A. Mozgovoy, and M. A. Dimitrienko (1964), who devoted attention to the same question, are relevant. A. A. Mozgovoy, T. I. Popova, and V. I. Shakhmatova (1963) studied the life cycle of *Parafilaroides gymnurus* and B. E. Sudarikov and K. M. Rhyzhikov (1951) attempted to comprehend the cycle of *Contraecum osculatum baicalensis* under the conditions found in Lake Baikal. These investigations supplement the findings of H. M. Pronin et al. (1980). Incidentally, comparison of

⁴V. Kh. seems to translate best as "in the work" or "in the work of," which can be reduced to "in" as it has been throughout this translation.

⁵This phrase concerning the sexual complex was particularly difficult to translate. It is hoped that it is correct, but may not be.

the helminth fauna of the Baikal seal, *Pusa siberica*, with the helminth fauna of other seals disclose their similarity to the species of the genus *Phoca* inhabiting the Asiatic sector of the northern Pacific and the Arctic and in no way supports their similarity to the helminth fauna of the Caspian seal, *Pusa caspica* (Mozgovoy and Ryzhikov 1950; Delamure et al. 1978). Comparative studies of the helminth fauna of the Caspian seals over an extensive period of time confirm the thesis of V. A. Dogiel (1947) regarding the relict parasite fauna having adapted its patterns to those of the host (Delamure et al. 1964, and others).

Massive examination of pinnipeds conducted over the last few years allows us to approach, for the first time, study of the intensity and extensiveness [prevalence] of invasion or infestation, seasonality, and growth dynamics of the helminthofauna of commercial marine animals inhabiting the waters of the Soviet Union and adjacent waters. Walruses, polar bears, sea lions, greenland seals, ringed seals, common seals (harbor seals), island seals, ribbon seals, bearded seals, and hooded seals were investigated from these points of view (Delamure and Treshev 1966; Treshev and Popov 1970, 1975; Delamure and Popov 1975; Kovalenko 1975; Popov 1975; Delamure et al. 1968, 1976).

It was established that the harbor seals inhabiting the Bering Sea begin to be infected by helminths at about 1 to 1.5 m in size when they cease feeding from their mothers and proceed to live and acquire nourishment independently. By the age of 2 mo the seal is usually attacked by two to four species of helminths. Later the infections increase very quickly and by the age of 4 [yr] the seals are struck [infected] by up to 12 species of helminths. In animals older than 12 yr of age a certain decline can be detected (9 to 10 species) [down to 9 to 10 species], which can possibly be explained by the changing ecology of the host. It is characteristic that in several species, infections become more intensive and also extensive [prevalent] as the seals grow but they are especially great or large in the young and also in the very old animals (Delamure and Alekseev 1962; Delamure et al. 1978; Treshev 1969; Yurakhno 1970b).

The generalized methodology for differentiating the populations of marine mammals, based upon the study of the qualitative and quantitative differences in their helminthofauna and also the geographical variability of the helminths (Delamure et al. 1979a; Popov and Marichev 1979) by comparison of the helminthofaunas and the characteristics of infestation of the different populations of marine mammals, demonstrated localized herds of walrus, Greenland seal, ringed seal, harbor seal, bearded seal, and the striped whale of the northern Pacific. It has also unearthed or disclosed the boundaries of the summer habitations [ranges, grounds, or habitats] of a certain population of whales of the Southern Hemisphere (Skriabin 1958, 1970a, 1972, 1975, 1978; Shustov 1965; Treshev 1970, 1978; Yurakhno 1970a; Kosygin and Popov 1972; Delamure and Popov 1978, 1980; Delamure et al. 1978, 1979a). These investigations confirm the opinions of mammalogists that existing stocks of pinnipeds and cetaceans must be protected. A comparison of the character [or nature] of infection with the findings (or data) of mammalogists on the mortality of seals permitted the assumption that helminths are one of the causes of their deaths.

Combining these data with histopathological investigations confirms the fact that pinnipeds whose hearts are stricken by the nematode *Dipetalonema spirocauda* perish during the first years [first year or early years] of life (Delamure et al. 1965; Delamure and Treshev 1966; Treshev et al. 1967; and others). Intensive infections of Baikal seal by the nematode *Contracaecum osculatum baicalensis* lead to the formation of large ulcers and

fistulas in the walls of their stomachs and cause internal bleeding. Such a picture has been established from those animals which were killed during commercial harvesting and those which perished naturally and washed up on the shores of the lake by waves (Zhaltsanova 1980). Information on the damage which can be done to the health of sea animals is found in a number of other publications (Vsevolodov 1948; Chupakhina 1969; Zablotski 1971; Temirova and Usik 1971; Gurevich and Evdokimov 1972; Nikolski and Kandinski 1974; Popov 1975; Starostin 1975; Delamure et al. 1976; Kovalaeva et al. 1978; and others). The data which have been introduced unquestionably confirm that the helminths emerge as one of the primary factors in the mortality of marine mammals, a fact that must be taken into account when one is establishing or studying their numerical or population dynamics.

Having gathered and analyzed a large amount of material we naturally arrived at the necessity of forming generalizations about it from the viewpoints of ecology, zoogeography, and phylogeny (Delamure 1952, 1955, 1956; Delamure and Skriabin 1958; Skriabin 1958). The results established the rules [regularities] of the patterns of the helminth faunas of the pinnipeds and cetaceans and likewise the patterns of distribution of helminths in the animals of the World Ocean. This showed that among the species and genera of helminths there are some which are dispersed in bipolar, amphiboreal, and amphi-Pacific [fashion]. This was accomplished for the first time on the basis of helminthological material and it was also explained in light of the history of the free-living fauna of the World Ocean (Berg 1922, 1934; Andriashv 1939; Zenkovich 1947, 1951; and others).

Comparison between the helminthofauna and the large taxa of their hosts in light of their ecology and phylogeny is of great interest. Here it has been established that, though the helminthofauna of pinnipeds shows characteristics of independence, it was developed principally from ancestors derived from the helminthofauna of terrestrial animals. In contrast with that of pinnipeds, the helminthofauna of cetaceans possesses clearly expressed traits of independence; it includes such helminth families as Pholeteridae, Brauninidae, Crassicaudidae, Pseudaliidae, and Campulidae almost completely. Investigations of the composition of the helminthofauna clearly reflect fundamental differences in ecology and phylogeny of these unique animals (Delamure 1955).

Sharp differences were demonstrated also when comparing the helminthofauna of toothed and baleen whales. Because of the small number of species (11), narrow specialization and feeding only at the surface of the sea on the not very varied [on the relatively homogeneous] plankton organisms—sometimes on mollusks and sometimes on schooling fishes, and other peculiarities of baleen whales; they have developed in themselves a helminthofauna which has no marked originality. It is totally different with the toothed whales. The numerous species of these cetaceans (69 species), which have settled widely in the World Ocean—even in brackish and freshwaters, have won for themselves the most varied ecological niches and accustomed themselves to feeding at different depths on varied kinds of food. In the process of evolutionary development of the toothed whales, they had a much greater opportunity than the baleen whales to become specific hosts for numerous species and genera and even a few families of helminths. There are essential differences between the helminthofauna of toothed and baleen whales which result from the long process of ecological selection, and it is possible to use them to compare the phylogenetic differences between the sub-orders of whales and also to compare their relationships with other animals (Delamure 1970).

Comparing the helminths of dolphins and beaked whales with the helminths of the Viverridae family [civets] in the historical [evolutionary] aspects, allows us to conclude [postulate] that these groups of hosts are close in phylogenetic respects (Delamure 1960).

Helminthological workers have discovered many valuable and interesting answers in their investigations of native mammals, which have involved their comprehensive studies of the parasites and also the characteristics of pinnipeds and cetaceans indigenous to the waters of the U.S.S.R. and also [those from] beyond their borders (Kleinenberg 1956; Tomilin 1957; Kleinenberg et al. 1964; Berzin 1971; Yablokov et al. 1972; Fedoseev 1975; Geytner et al. 1976; and others). These publications utilize and also exemplify the scientific investigations of parasites of marine mammals. It is not possible to encompass the subject without their numerous works in this area.

We have presented the work of the last 10 decades by Soviet helminthologists before many All-Union scientific conferences as well as those of several republics and now before the Soviet-American conference, conducted within the framework of the agreement, in surroundings that provide immeasurable support and assistance.

From this accounting it is evident that studies of the helminths of pinnipeds and cetaceans are of notably practical importance. It is possible to report with confidence that study of the helminths of animals, especially those of industrial importance living in the waters of the Soviet Union, compare favorably with those of our friends, and that this is possible thanks to the support and assistance provided by the Laboratory of Helminthology of the U.S.S.R. Academy of Sciences, and the Ministry of Fisheries of the U.S.S.R., the Ichthyological Commission, VNIRO and the foundation related to it, the Zoological Institute of the U.S.S.R. Academy of Science, Vsesoyuznogo Institute of Helminthology, the Limnological Institute CO [SO] Academy of Sciences of U.S.S.R., the Astrakhan -Zapovyednika, Ministry of Enlightenment [or Instruction] of the U.S.S.R., and the administration of the Simferopol University and the institutions of our associates.

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