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The cestode community in northern fur seals (*Callorhinus ursinus*) on St. Paul Island, Alaska

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ABSTRACT

The diversity and ecology of cestodes from the northern fur seals, *Callorhinus ursinus* (NFS), were examined using newly collected material from 756 humanely harvested subadult males between 2011 and 2014. NFSs were collected from five different haul-outs on St. Paul Island, Alaska. A total of 14,660 tapeworms were collected with a prevalence of 98.5% and intensity up to 107 cestodes per host (mean intensity 19.7 ± 16.5 SD). Three species of tapeworms were found: *Adenocephalus pacificus* (Diphyllobothriidea) was the most prevalent (prevalence 97.4%), followed by *Diplogonoporus tetrapterus* (49.7%), and 5 immature specimens of *Anophryocephalus* cf. *ochotensis* (Tetrabothriidea) (0.5%). Most of the cestodes found in the NFS were immature (69.7%). However, only 0.9% of cestodes were in larval (plerocercoid) stages. The species composition, prevalence and intensity of cestodes from these NFSs were not statistically different between the five separate haul-outs. Significant increases in the intensity of NFS infections were observed during the study period.

1. Introduction

The northern fur seal, *Callorhinus ursinus* (Linnaeus) (NFS), has been documented as a host for more than 35 species of helminths (Delyamure, 1961; Dailey and Brownell, 1972; Margolis and Dailey, 1972; Yurakhno, 1998; Atrashkevich, 2008).

The first tapeworm described from NFSs was *Bothriocephalus* sp. by Stiles and Hassall (1899) from the Pribilof Archipelago (St. George Island) (Fig. 1). Nybelin (1931) later described that species as *Adenocephalus septentrionalis* Nybelin 1931, as the second species of his newly erected genus *Adenocephalus* Nybelin 1931 with the type species *A. pacificus* Nybelin 1931, from the Juan Fernández fur seal *Arctocephalus philippii* Peters. Stunkard (1948) studied NFS cestodes from St. Paul Island, Alaska, and recorded two unidentified species (reported as species Nos. 2 and 3) which corresponded with *A. pacificus* and *Diplogonoporus tetrapterus* (Siebold, 1848) (Delyamure et al., 1985; Hernández-Orts et al., 2015). Later, several authors reported *A. pacificus* from NFSs on St. Paul and St. George Islands, Alaska (Markowski, 1952; Margolis, 1956), but also from Honshu Island (Sanriku), Japan (Yamaguti, 1951; Machida, 1969) and Far East Russia from Sakhalin and Tyuleniy Islands (Krotov and Delyamure, 1952; Chupakhina, 1971) (Fig. 1). *Adenocephalus pacificus* was also reported under different names as *Diphyllobothrium glaciale* (Cholodovsky, 1915), *Diphyllobothrium pacificum*, *Diphyllobothrium hians* (Diesing, 1850) or *Diphyllobothrium krotovi* Delyamure, 1955 (Rausch et al., 2010), but recently, Hernández-Orts et al. (2015) transferred *D. pacificum* back to the genus *Adenocephalus* based on molecular and morphological evidence. *Diplogonoporus tetrapterus* was reported rarely in NFSs off St. Paul Island and Valdez, Alaska (Stunkard, 1948; Rausch, 1964) (Fig. 1). Yurakhno (1986) described a new species, *Diplogonoporus violettae* Yurakhno, 1986, collected from a Steller sea lion, *Eumetopias jubatus* (Schreber), from Karaginsky Gulf, Russia, and concluded that diplogonids reported from NFSs by Wardle et al. (1947), Margolis (1956) and Rausch (1964) belonged to this new species (Fig. 1).

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Fig. 1. Map showing the areas at which helminths of the northern fur seals (*Callorhinus ursinus*) have been studied by previous authors (gray circles) and the present authors (black circle) in the Bering Sea. The detailed map of St. Paul Island, Alaska with sampling sites (rookeries) is enlarged.

Additionally, four other tapeworm species have been reported from NFSs: *Anophryocephalus ochotensis* (Delyamure, 1955), *Diphyllobothrium hians*, *Diphyllobothrium lanceolatum* (Krabbe, 1865), and *Pyramicocephalus phocarum* (Fabricius, 1780), as well as phyllobothriidean plerocercoids *Scolex pleuronectis* Müller, 1788 (Delyamure, 1955; Dailey and Brownell, 1972; Margolis and Dailey, 1972; Yurakhno and Taikov, 1986; Yurakhno, 1998; Kamo, 1999). However, most of these taxa are not specific parasites of NFSs (such as *D. hians*, *D. lanceolatum*, or *P. phocarum*), and may represent misidentifications of the morphologically variable *A. pacificus* and *D. tetrapterus* (Delyamure et al., 1985; Hernández-Orts et al., 2015).

Studies of several aspects of NFS biology on the Pribilof archipelago have been undertaken regularly since 1944 (Scheffer et al., 1984; Ream, 2008), but only few parasitological surveys, mainly on hookworms, anisakid nematodes and acanthocephalans, have been published (Stiles and Hassall, 1899; Olsen and Lyons, 1962; Keyes, 1964, 1965; Lyons et al., 2000, 2003, 2011; Ionita et al., 2008; Kuzmina et al., 2012, 2014). Cestodes have been superficially mentioned in a few reports (Stiles and Hassall, 1899; Stunkard, 1948; Yamaguti, 1951; Krotov and Delyamure, 1952; Markowski, 1952; Delyamure, 1955; Machida, 1969; Kamo et al., 1982; Scheffer et al., 1984; Yurakhno, 1998; Ionita et al., 2008). Despite the thousands of seals slaughtered every year from the Pribilof archipelago (Scheffer et al., 1984; Ream, 2008), detailed studies on the diversity and prevalence of cestodes from NFSs have not been performed.

The objective of the present study was to characterize the species composition of cestodes from NFSs based on newly collected material from St. Paul Island, Alaska, including re-examination of type- and voucher material from several helminthological collections (see Hernández-Orts et al., 2015). Comparison of the species composition, prevalence and intensity of cestodes among five subpopulations of NFSs inhabiting different rookeries on St. Paul Island also was performed (Fig. 1).

2. Materials and methods

This study was carried out on St. Paul Island, Alaska (57°09′ N, 170°13′ W) in July–August, 2011 to 2014 (Fig. 1). The gastrointestinal tracts of 756 humanely harvested subadult NFS males (3–4 years old) were collected during four annual Aleut subsistence harvests at haul-out areas on five rookeries: Polovina (n = 164), Morjovi (n = 120), Zapadni (n = 182), Lukanin (n = 165) and Gorbatch (n = 125) (Fig. 1). The research was done under the authority of the Marine Mammal Protection Act Permit Number 14327 issued to the National Marine Mammal Laboratory.

The gastrointestinal tracts of freshly killed NFSs were collected in the field and placed in separate plastic bags, delivered to the laboratory, dissected and examined by classical methods (Bowman and Lynn, 1995). The age of NFS examined was estimated according to the size of their stomachs – stomachs were significantly larger in 4-year old NFSs than in 3-year old seals. All helminthes (more than 7700 specimens of nematodes, 14,660 cestodes, 1200 acanthocephalans and 3700 trematodes) were collected manually from the intestines. The cestodes were washed in saline and fixed in hot (>90 °C) tap water and stored in 70% ethanol. The cestodes were identified based on morphological characters according to Delyamure (1955,1985) and Hernández-Orts et al. (2015), and compared with type- and voucher specimens deposited in several helminthological collections [see Hernández-Orts et al. (2015) for material of *A. pacificus*; type material of *D. tetrapterus* from the Natural History Museum, London, UK (BMNH Nos. 51.7.24.58 and 51.7.24.27); and one specimen from type series of *D. violettae* deposited at the Helminthological collection of the Institute of Parasitology, Czech Academy of Sciences, České Budějovice, Czech Republic (IPCAS C-683)]. Current identifications were also supported by phylogenetic analyses based on molecular data (LSU and *cox*1) (Hernández-Orts et al., 2015; Kuchta unpublished data).

Whole-mounted specimens were stained with Schuberg's hydrochloric carmine and mounted in Canada balsam. A total of 45 scoleces and segments were prepared for scanning electron microscopy (SEM) following the procedure outlined by Kuchta and Caira (2010).

Studied material has been deposited in the parasitological collection of the Schmalhausen Institute of Zoology NAS of Ukraine, Kyiv (Nos. SAM 0-1-SAM 22-16), IPCAS (Nos. IPCAS C-497 and C-682) and National Museum of Natural History, Smithsonian Institution (Nos. 1241612 and 1241613).