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Authors: Conlogue, G. J., Ogden, J. A., and Foreyt, W. J.

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PARASITES OF THE DALL'S PORPOISE (*PHOCOENOIDES DALLI* TRUE)

G. J. Conlogue,[1] J. A. Ogden,[2,3] and W. J. Foreyt[1]

ABSTRACT: The prevalences of three helminths, *Campula oblonga, Halocercus dalli* and *Crassicauda* sp., recovered from Dall's porpoises which were net-entrapped incidentally in the vicinity of the western Aleutian Islands in the northwest Pacific are reported. Specimens of *Campula oblonga* were found within the bile ducts of 46% of 127 livers examined. The prevalence of hepatic trematodiasis increased with the age of the host. Pulmonary nodules associated with *Halocercus dalli* were noted in 71% of the Dall's porpoises. Adult *H. dalli* were recovered from the main stem bronchi of heavily infected lungs. Younger animals exhibited a relatively higher prevalence. Specimens of *Crassicauda* sp. were found within the main lactiferous canal of 69% of 29 mammary glands examined. The prevalence was highest in mature porpoises. Possible detrimental effects and the modes of transmission of the three species of parasites are also considered.

INTRODUCTION

Helminths have been documented from a number of cetaceans including Dall's porpoise (Yamaguti, 1951a, b; Ridgway, 1966; Johnston and Ridgway, 1969; Neiland et al., 1970; Dailey, 1971; Dailey and Walker, 1978) and True's porpoise, *P. truei* (Machida, 1974). However, few reports attempt to relate parasite prevalence to age, morbidity or mortality of the host (Dailey and Perrin, 1973; Geraci et al., 1978; Perrin and Powers, 1980).

Cowan (1968) indicated that most studies on the pathology of whales have been conducted on animals obtained from pelagic whaling ventures. The primary goal of such operations, the expedient processing of tissue into commercially marketable products, usually precludes quantitative pathologic analysis. Cowan felt that the methods of pelagic harvesting yielded animals that were generally healthy, and prevalence of disease would approximate that found in any random sampling of a wild population.

Strandings and net-entrapment provide another major source of cetacean tissue for examination, especially smaller animals such as dolphins and porpoises. These studies have been more extensive, though usually only listings of the parasites have been reported. Animals obtained from this source, however, may not always be representative of the population. Although trauma may have been the primary cause of death, an underlying pathologic condition might have predisposed the animal to injury (Ogden et al., 1980).

Recently, attempts have been made to relate parasite intensity to the age of the host (Dailey and Perrin, 1973; Perrin and Powers, 1980). Our study reports the prevalence of three endoparasites and relates the findings to the relative age of the host. The possible detrimental effects and the modes of transmission are also considered.

MATERIALS AND METHODS

A total of 127 Dall's porpoises was examined at necropsy during the summer of 1979. These were among 682 Dall's porpoises which were caught accidentally by the Japanese salmon fisheries fleet in the northwest Pacific, south of

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[1] Departments of Veterinary Microbiology and Pathology, and Zoology, Washington State University, Pullman, Washington 99164, USA.
[2] Departments of Surgery (Orthopaedics) and Comparative Medicine, Yale University School of Medicine, and the Yale University Marine Mammal Stranding and Study Center, 333 Cedar Street, New Haven, Connecticut 06510, USA.
[3] Present address: Shriners Hospital for Crippled Children, 3500 East Fletcher Avenue, Suite 106, Tampa, Florida 33612, USA.

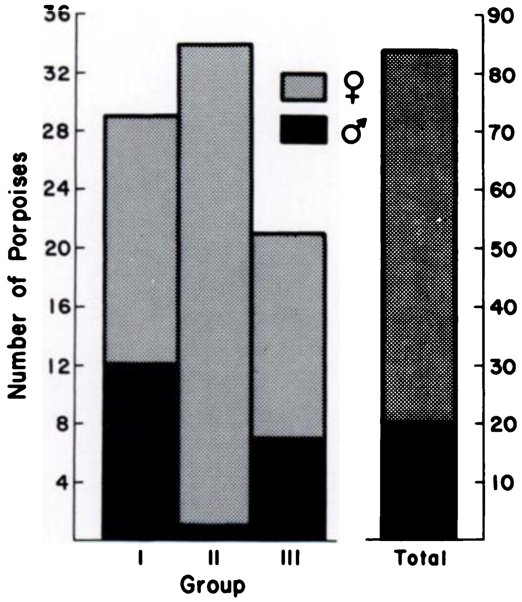

FIGURE 1. Age distribution of entrapped male and female Dall's porpoises into the three radiographic age groups.

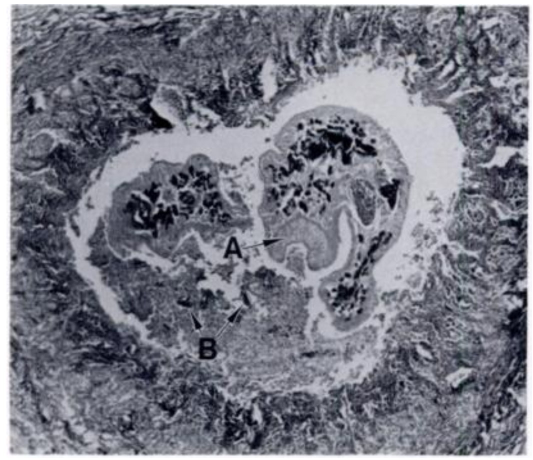

FIGURE 2. *Campula oblonga* within the bile duct of a Dall's porpoise. A = ventral sucker. B = operculated eggs, ×25.

the Aleutian Islands. Teeth were collected from all animals examined, and were sectioned at the National Marine Mammal Laboratory, Seattle, Washington, to determine the relative age of each animal. Flippers were saved from 84 porpoises which were selected randomly and later radiographed at Yale University to assess chondro-osseous maturity. These data were compared to the relative ages determined from tooth sections. The radiographic technique, described by Ogden et al. (1981), was modified to establish three groups: Group I (stage 1 in the original scheme), animals which were immature or just attaining sexual maturity; Group II (stages 2–4), sexually mature individuals; Group III (stages 5 and 6), older mature porpoises demonstrating the onset of degenerative bony changes associated with aging. Mammary glands of females, and lung and liver of both sexes were examined for parasites and lesions. Helminths and tissues were frozen due to the lack of appropriate tissue fixatives aboard ship. When frozen samples were thawed, tissues were fixed in 10% buffered formalin and helminths in 70% ethyl alcohol. Lung, liver and mammary gland specimens were sectioned at 7 μm and stained with Mayer's hematoxylin and eosin Y. Whole mounts of trematodes were made following staining with Semichon's carmine. Nematodes were mounted in glycerine. Contingency tables were compiled and the expected cell frequencies were calculated for the prevalence of each species of parasite. Representative specimens of *Halocercus dalli* (No. 78253) and *Campula oblonga* (No. 78254) have been deposited in the U.S. National Parasite Collection (Beltsville, Maryland 02705, USA).

RESULTS

Based on histologic tooth sectioning and radiographic analysis of flippers (n = 84), average dentine layers for the three radiographic groups (Fig. 1) were 3.9, 6.6 and 8.5 layers, respectively. The number of dentine layers observed by histologic sectioning of the teeth ranged from 0 to 19 layers.

Trematodes, *Campula oblonga,* were recovered from the bile ducts of 58/127 (46%) of the livers examined. Histological examination of the tissue demonstrated the parasite and the extent of fibrosis and hyperplasia of the epithelial lining of the duct due to the presence of the parasite (Fig. 2).

Small white nodules, less than 1 cm in diameter, were observed on the surface of all infected livers. Extensive hepatic involvement with large cysts (Fig. 3), measuring up to 2 cm in diameter and filled with reddish-brown granular debris, were

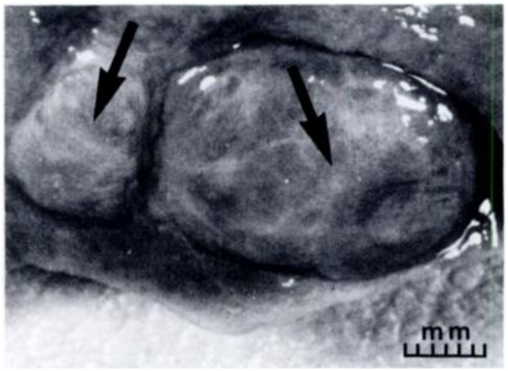

FIGURE 3. Large composite cysts (arrows) on the margin of the liver of a Dall's porpoise. Cysts contain eggs of *Campula oblonga*.

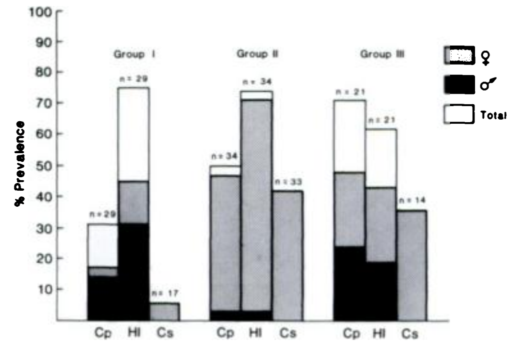

FIGURE 4. Prevalence of parasites in male and female Dall's porpoises within each radiographic age group. Cp = *Campula oblonga*, Hl = *Halocercus dalli*, Cs = *Crassicauda* sp.

noted in 7/58 (12%) of the parasitized porpoises. Operculated eggs were observed in the small and large lesions. In the latter, eggs were more numerous and lodged in the walls which were composed of concentric layers of dense collagen.

The prevalence of hepatic trematodiasis significantly increased ($\alpha = 0.025$) with age (Fig. 4), although the parasite was detected in one immature animal with no dentine layers. Infections appeared to be most numerous in animals with four to five layers and were not present in porpoises with more than 11 layers. The prevalence in Group I and III was 31% and 71%, respectively.

Adult nematodes, *Halocercus dalli*, were collected from the main stem bronchi or subpleural nodules of 60/84 (71%) of the porpoises that were radiographed. The parasite was noted at significantly higher prevalence ($\alpha = 0.05$) in relatively younger animals (Fig. 4). All immature porpoises (7/7) with two or less dentine layers were infected. Group I demonstrated a prevalence of 76%, Group II, 74%, and Group III, 62%.

Yellow-white, subpleural nodules, ranging up to 1 cm in diameter, were noted in 90/127 (71%) of the lungs (Fig. 5). Nodules covering at least half the surface of one lung were present in 48/90 (53%) of the infected animals. Histologic sections of all representative lesions revealed multiple sections of nematodes. Adult *H. dalli* were present in both alveoli and the bronchial tree (Fig. 6). Distortion of the tissue from freezing and autolysis precluded a more accurate description of the lesions.

Nematodes were found within the main lactiferous canals of 20/29 (69%) of the mammary glands examined (Fig. 7). Due to the advanced state of autolysis and subsequent difficulty in removing intact parasites, only fragments were recovered. The parasite could only be identified as *Crassicauda* sp. based on previous reports of its location (Dailey and Walker, 1978) and general appearance (Geraci et al., 1978). The relative age distribution indicated that nematodes were recovered in significantly greater numbers ($\alpha = 0.05$) from mature female porpoises (Fig. 4). The parasite was not detected in animals with less than three dentine layers. Group I females had a prevalence of 5%, Group II, 42% and Group III, 36%. Nodules were found in the blubber around the mammary gland and in the abdominal wall of all animals from which the nematodes were recovered. Similar nodules were noted in other porpoises in the sample, both male and female; however, the prevalence of

FIGURE 5. Subpleural nodules (arrows) over the surface of both lungs of a Dall's porpoise which contained metastrongyloid nematodes.

FIGURE 6. Sections of adult *Halocercus dalli* (arrows) in the terminal bronchioles of a Dall's porpoise, ×25.

infection was only recorded for porpoises where worms were recovered. Milk collected from infected females contained nematode eggs resembling those of *Crassicauda*. Histological sections of the mammary gland revealed cellular infiltrates. The duct lumen was filled with concentric layers of thin, pale, basophilic, fusiform cells judged to be fibroblasts. Amorphous eosinophilic debris was also present.

DISCUSSION

The prevalence of hepatic trematodiasis in the present study was less than that reported by other investigators. Specimens of *Campula* spp. were reported from the pancreatic duct of 4/4 Dall's porpoises and 23/37 (62%) of the common dolphin, *Delphinus delphis* (Dailey and Walker, 1978). Woodward et al. (1969) reported *C. palliata* in the liver and pancreas of 29% of an unreported number of the bottlenosed dolphins, *Tursiops truncatus*. These reports did not consider the relationship between the prevalence of the parasite and morbidity or mortality of the host. An assessment of the pathologic effects was not possible in the present study due to autolysis of the liver. However, chronic hepatic trematodiasis can produce progressive weakness through impairment of liver function. Severely parasitized animals may therefore suffer some degree of debilitation.

The life cycle of *C. oblonga* has not been documented, but it has been suggested that transmission is by ingestion of infected fish (Delyamure, 1968). If porpoises acquire the parasite in this manner, one would expect an increase in the infection rate following weaning. Data from the present study tended to support this theory.

Radiographic aging indicated an increase in the prevalence relative to the increase in skeletal maturity. This increased prevalence relative to age was more evident with the tooth section data. Twenty-one percent of porpoises with up to three dentine layers were infected. This increased to 61% in the group with four to six layers and 86% in the group with 10 to 12 layers. However, the parasite was not found in any porpoises examined with more than 13 layers. This might indicate an increased mortality among parasitized animals prior to the deposition of 13 layers or the decrease in prevalence related to completion of the life span of the parasite with no further acquisition of parasites due to immunity or change of diet.

Other reports of pulmonary nematodiasis in cetaceans ranged from 40% in the common dolphin (Tomilin and Smyshlyayer, 1968), and 79% in the bottlenosed dolphin (Woodward et al., 1969), to 98% in the common pilot whale, *Globicephala melaena* (Cowan, 1966).

There is disagreement concerning the pathogenicity of the lungworms of cetaceans. Tomilin and Smyshlyayer (1968) stated that the parasites are capable of causing death in small cetaceans. Anderson (1966) attributed eight out of 12 deaths in captive harbor porpoises, *Phocoena phocoena*, to parasitic bronchitis. Woodward et al. (1969) reported that both wild and captive dolphins are heavily infected, but generally asymptomatic. Cowan (1966) suggested the resulting subacute and chronic inflammatory process did not cause functional impairment. What may be considered minimal respiratory functional impairment in a terrestrial mammal may be more significant in cetaceans. The respiratory mechanisms of cetaceans are adapted to retain air during deep dives and to exchange air rapidly. These aquatic adaptations include muscular sphincters between the bronchus and terminal bronchioles, and cartilagenous structures extending almost to the alveoli (Simpson and Gardner, 1972). Additional modifications include a lack of three characteristics and structures: a cough reflex, mucous glands and significant pulmonary lymphoid apparatus (Cowan, 1968).

Parasites entrapped in the lungs initiate an immune response with resulting inflammation and hypertrophy of the muscular sphincters of the terminal bronchioles and progressive occlusion of the airway. Cowan (1968), reversing his earlier opinion (1966), stated that the results of such processes were either dense fibrotic nodules or scar formation with localized, destructive, secondary emphysema. No significant tissue response was noted during examination of lung sections in the present study although assessment of lesions was difficult due to tissue distortion.

FIGURE 7. Adult *Crassicauda* sp. in the main lactiferous canal of the mammary gland of a Dall's porpoise.

The radiographic index indicated that 76% of immature animals were infected, and the dentine layer index revealed that all five porpoises examined (5/5) with less than three layers were parasitized. This would indicate the infection was acquired early in life.

Caldwell and Caldwell (1968) and Woodward (1968) reported the air passages of a 2½-mo-old bottlenosed dolphin were occluded with specimens of *Halocercus* sp. The animal had been conceived in the wild and born in captivity. Prior to death, the dolphin only received milk from its dam and was kept in a pool with copper-treated water void of live fish. Milk, blood, fecal, and blowhole swab samples examined from the dam following the death of the calf were found to be negative for larvae. Colostrum, however, was not available for examination. Caldwell and Caldwell (1968) therefore felt no intermediate host was necessary and transmission could have been direct by inhalation of infected spray or taken in alive from infected water. Arnold (1973) reviewed the Caldwell and Caldwell report and suggested that the parasite was transmitted transplacentally. However, he felt that the use of some intermediate host was the usual mode of transmission (Arnold and Gaskin, 1975).

Specimens of *Crassicauda* sp. were found in 71% of the mammary glands examined in the present study. This compared with reports of 47% in the Atlantic white-sided dolphin, *Lagenorhynchus acutus* (Geraci et al., 1978) and one of two in the Dall's porpoise (Ridgway, 1966). Milk from several infected animals contained eggs. Similar findings have been reported from other studies (Ridgway, 1966; Geraci et al., 1978). However, milk from the present study and that reported by Ridgway (1966) was not discolored nor blood tinged as noted by Geraci et al. (1978).

Geraci et al. (1978) speculated that *Crassicauda* sp. might affect milk production in the Atlantic white-sided dolphin, since the degree of damage exceeded the functional reserve of the gland. Fibrosis, noted in severe infections, might impair the ability of the abdominal muscles to forcibly eject the milk and milk production might be reduced by the presence of parasites, eggs, tissue debris and inflammatory cells. Decreased milk production might therefore result in a nutritionally deprived calf and reduced calf survival.

Although the life cycle of *Crassicauda* sp. from the Dall's porpoise has not been documented, the presence of mature female parasites in the lactiferous canals and eggs recovered from the milk may indicate direct transmission between cow and calf. If this is the mode of transmission, maturation of the parasite appeared to be delayed until the porpoise reached sexual maturity. In our study, only one immature porpoise was infected with an adult nematode, whereas the prevalence in mature animals (Group II) was 38%. The onset of infection did not occur until dentine layer three was present. The prevalence was 39% in porpoises with between three to eight dentine layers.

The three parasites reported in this paper may contribute to debilitation of porpoises and thereby affect herd productivity. Several considerations must be taken into account before conclusions can be made from net-entrapment studies. If porpoises are randomly entrapped, then prevalence of parasites and possibly other diseases can be determined. However, this method of sampling may be biased because a higher percentage of debilitated animals may be entrapped. If this is the case, our prevalence figures overestimate the prevalence in the actual population. However, animals which succumbed to disease or predation prior to this study were obviously not represented in our data. The condition of porpoises which avoid the nets cannot be determined.

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