ANNUAL REPORT 1960

Invertebrate Studies

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November 10, 1960

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The writer started full-time employment with the department September 1, 1959. Active field work was not undertaken until the start of the new field season in May, 1960. Accordingly, all of the projects to be discussed below are in their preliminary stages. Prior to the start of the field season, the writer was occupied with the planning of projects and an extensive search for all of the published information pertinent to the projects and responsibilities of the position.

The projects to be discussed fall into two separate research areas in invertebrate zoology: parasitology and the physiology of crustaceans. They will be discussed in their relative order of nearness to completion, starting with the projects on which work has progressed the furthest.

1. Review of the Literature on Parasitology.

A. Regional (Alaska).

At the present time, 178 separate scientific articles concerned with the parasites of Alaskan animals have been located in the very extensive world-wide literature. The articles cover a very broad range of Alaskan animals including relatively important game mammals, fish and birds; commercially important fish and a variety of aquatic and terrestrial animals which are secondarily important as food for the preceding groups of animals or which may be involved in the spread of parasitic diseases. Thus far the number of kinds of animals known to the writer to be parasitized is in excess of 171 species. The corresponding number of parasite species now stands at 312. It is perhaps pertinent to state that the work of the present investigator, even though initiated quite recently, has revealed a number of additional parasite species to be present, some previously unknown to science. The articles also span a relatively long period of time and have been published in scientific journals of countries relatively remote from Alaska. William H. Dall, a well-known, early day Alaskan naturalist, was the first to publish on this topic when in 1872 he described some species of whale parasites in the "Proceedings of the California Academy of Science". Although most of the reports have been published in American scientific journals, articles have appeared in some relatively unexpected places, Mexico, France, Germany, Russia, India, Pakistan, and Ceylon, to mention a few.

It is the intention of the writer to complete the bibliography and an abstract of it through 1960. This host-parasite catalog will then be published in order that various

interested persons or agencies will have relatively easy access to the extensive information already available. Furthermore, the permanent bibliography in the laboratory files will be kept as up-to-date as possible in order that the writer will be able to provide complete technical data on this subject when it is required for the efficient management of wildlife resources in Alaska.

B. Non Regional.

The effectiveness of modern science in dealing with problems of all kinds is related in part to the availability of previously established scientific results. Often one can effectively apply information obtained on another, but similar, animal from another part of the world to research problems at hand (e.g. pod formation, similar to that of the Alaskan King Crab, has been reported for at least one European species of crab). For this reason, the writer has spent some time compiling bibliographies on game animals, etc., found outside of Alaska. It is intended to eventually make available to department personnel detailed listings of articles on the diseases and parasites of the big-game animals of Alaska and closely related species over their entire geographical distribution. The first of these will be one on the black-tail deer which at present includes 228 articles and will be incorporated in a larger publication being sponsored by the Wildlife Disease Association. This larger bibliography will include all known references on cervid mammals (deer, elk, moose, caribou, etc.) and is being compiled by a number of reviewers of which the writer is one. One of the biggest problems confronting scientists at the present time is that of keeping up with the ever increasing store of new information much of which is published in relatively obscure foreign journals of difficult access and in languages many are not prepared to read.

2. Marine Mammal Investigations.

Marine mammals may be of importance as part of a wildlife resource in a number of ways. In some areas they are valuable sources of food for humans. Most of them are predators, frequently on commercially valuable fish to a greater or lesser extent. They also have value as game animals and/or fur bearers. Their predatory habits however are the primary focus of research at the present time. Any predator can influence prey populations in a number of ways. The writer is primarily concerned with only one of these. Most, if not all, predator-prey relationships can be shown to involve parasites common to both the predator and prey species. In this situation the prey animal harbors the immature or larval stage of the parasite which becomes established in, and a parasite of the predator species when it eats the prey. The parasite frequently is of greatest potential harm to the

prey species. In this case a predator could influence prey populations both by eating the prey and by transmitting parasites harmful to the prey. In some cases the parasite may reduce the commercial value of the prey species (e.g. the commercial value of whitefish and cod fillets from eastern Canada have been lowered by the presence of larval worms which have to be removed manually (50% efficient) in order to avoid consumer rejection of the product).

The past years work in this area of research was carried out in conjunction with that of Mr. Calvin Lensink of this department. We made two joint field trips, one to Bristol Bay to work on the Beluga and one to Prince William Sound to study sea lions and sea otters. Mr. Lensink studied the life history of these animals and without his aid in collecting, etc., the writer would have encountered much greater difficulty in his own work.

A. Beluga Studies: Bristol Bay.

Preliminary studies on the parasites of the Beluga in Bristol Bay have yielded only four species of parasites from this animal: 2 species of nematodes (round worms) and one species each of acanthocephala (thorny-headed worm) and trematoda (fluke). These are treated separately below.

1) Hadwenius seymori (intestinal fluke).

Two of seven Belugas harbored about 10-60 specimens respectively of this relatively large fluke (1 inch long x 1/8 inch diameter). There were no signs that the infections observed were of more than very slight harm, if any, to the host. The life cycle of this kind of fluke is unknown and therefore one can not even speculate whether or not a valuable prey species may be involved. This is a relatively common Beluga parasite in both Alaskan and Siberian waters.

2) Corynosoma sp. (?) (intestinal thorny-headed worm).

Acanthocephala have not been previously recorded from the Beluga in Alaska waters. The species found (as yet not definitely identified) was of common occurrence. All of the animals examined harbored many specimens of this parasite, a heavy infection amounting to approximately 500-1,000 individuals. Even in a heavy infection it was not obvious that the host animal was seriously infected. However, in a very heavy infection, perhaps 5,000-10,000 individuals, the host would probably suffer severe intestinal disorder, possibly death.

It was possible to make some observations on part of the larval development of this worm which suggests the probable means where by the Beluga acquires the parasite. Knowing that other species of Corynosoma undergo the latter part of their larval growth in various species of fish, plus the observation that the Belugas were then feeding extensively on the spawning runs of Rainbow Smelt (Osmerus dentex) in the Kvichak River, prompted the writer to examine the smelt for larval acanthocephala. Larval specimens of what appears to be the same species of Corynosoma as that in the Beluga were found regularly in the body cavity of the smelt. Based on information available on the life cycle of other Corynosoma, it is anticipated that the early larval development of this worm takes place in some small crustacean (planktonic) found in Bristol Bay or its watershed.

Unfortunately the opportunity to examine sockeye smolts did not present itself. Since the Beluga is commonly infected with Corynosoma and there is no reason to believe that the sockeye smolt could not be infected by the larval stage, there is a possibility that under certain conditions the smolts could acquire heavy enough infections of this parasite to reduce to some unknown degree their marine survival. This is strictly a hypothesis, but nevertheless one which would be worth looking into further. In any case, this potential problem could be circumvented, at least in part, by harassment of the Beluga. The opportunity for infection of the smolts would be greater in the confines of the Kvichak River than in the much broader expanse of Bristol Bay.

3) Anisakis sp. (?) (stomach roundworm).

Various species of this genus of parasitic roundworms are commonly found in marine mammals without geographical limits. Although they have never previously been recorded for the Beluga in Alaskan waters they are known from this host species elsewhere. Anisakis physeteris Baylis, 1923, has been reported from the Sperm Whale in the Aleutians and the larval stage of an undetermined species of this genus has been commonly found in adult Red and Pink salmon throughout Alaskan waters.

The writer observed this kind of parasite commonly in the Belugas examined in the Bristol Bay area. Although what could be considered heavy infections were not encountered, nevertheless infections in excess of 200-300 worms were observed. It appears likely that this parasite damages the stomach lining of the host, but only to a limited extent in the relatively light infections observed. However, female worms of this general category of roundworms can produce large numbers of eggs over extended periods of time and thus even light host infections could result in extensive infection of the intermediate host species (prey animal: fish) in which

the worm's larval development takes place. It appears likely that under certain conditions, infection of the intermediate host (e.g. Red or Pink salmon) could reach a level at which the "vitality" of the fish were definitely impaired, perhaps interfering with marine survival and/or spawning activities. Since no one has ever examined the effects of larval roundworms on the "vitality" of fish this possibility is an entirely open question. However, it is known that various larval roundworms do affect mammalian hosts, sometimes being the direct cause of death of the host.

The writer encountered an undetermined species of larval nematode in the Rainbow Smelt. It is likely that, as in the case of the Corynosoma species discussed in the preceding section, that the smolt, which apparently is an important food animal for the Beluga at certain times, is also one of the intermediate hosts for the Anisakis sp.(?) found in the Beluga. Although sockeye smolts from the Bristol Bay watershed have been extensively examined by others for parasites, and larval Anisakis species have not been reported, this does not in itself rule out the possibility that the smolts might actually be an important intermediate host in the marine environment. Apparently all of the smolts examined have been collected at F.R.I. smolt traps in fresh-water areas not frequented by the Beluga. Smolts trapped in the lower reaches of Bristol Bay streams or in the upper parts of the bay should be examined in order to settle this question.

4) Stenurus arcticus(?) (Cobb, 1888) (lung roundworms).

Lungworms were found only in one animal and are probably of relatively low occurrence. The species encountered has only been tentatively identified, but it appears likely that it is the same one reported by Cobb in 1888 from the Beluga in eastern Canadian waters. The life cycle of this kind of worm is unknown, but judging from the known cycles of more or less closely related forms, it does not appear likely that fish are involved as an intermediate host.

Considering the known affects of various other species of lung worms on other species of animals, it is possible that the one encountered in the Beluga is of greater potential damage to the Beluga than any of the other parasites found. One of the most important kinds of parasites of big-game and domestic animals are lung worms of various kinds.

B. Sea Lion and Sea Otter Studies:

Prince William Sound

The writer and Mr. Calvin Lensink camped at Patton Bay on Montague Island from where it was a short run by skiff

out to the Sea Lion rookeries on the Wooded Islands. On our first reconnaissance on the rookery it was evident to Mr. Lensink that the rookery had been recently disturbed. The finding of many empty cartridge cases clearly suggested the nature of the disturbance. In any case, the Sea Lions were unusually wary and as a result only three animals could be collected.

Three species of parasitic worms were found in these animals, one each of cestode (tapeworm), nematode (roundworm) and acanthocephala (thorny-headed worm). None of the infections were considered to be severe. Two of these worms are quite similar, if not identical, to parasites of the Beluga considered in the preceding section. Undetermined species of Anisakis and Corynosoma were present in all three of the sea lions examined. The general remarks previously made about these worms fit equally well Sea Lion infections and therefore will not be repeated.

Unlike the Beluga the Sea Lion all harbored a few tapeworms. These are a species of Diphyllobothrium, which like other Diphyllobothrium spp., undoubtedly utilize some kind of fish in which the latter half of the worms' larval development takes place. There was no opportunity to determine which local species of fish were serving as intermediate hosts in that area for the Sea Lion worm. However, sea-run Dolly Varden Trout from the Nellie Marten River were commonly infected with a larval Diphyllobothrium which might be the one recovered from the Sea Lions. Elsewhere in Alaska, both Red Salmon adults and smolts are known to carry larval tapeworms of this kind. In the Karluk Lake area of Kodiak Island, the Brown Bear becomes infected with Diphyllobothrium ursi Rausch, 1954, when they eat adult Red Salmon which commonly harbor the larval stage of this worm.

There is good evidence that under certain circumstances, Diphyllobothrium larvae can have decimating effects on fish populations. Large numbers of Rainbow and Eastern Brook Trout are killed every fall in certain of the larger, high lakes in the Oregon Cascade range by severe infections of Diphyllobothrium. The writer has observed fish in all size classes dying from this kind of parasitism in that area. In this particular case, the Ring-billed Sea Gull, which frequents the larger lakes of the area mentioned, carries the adult worms which are the sources of infection. Whether or not Diphyllobothrium infections are one of the factors limiting salmon production in Alaska is unknown. However, this is not outside the realm of possibility in local spawning or fry rearing areas where there are concentrations of fish-eating birds and mammals.

While Mr. Lensink was in the Prince William Sound area, but prior to the time the writer joined him for the Sea Lion studies, Mr. Lensink collected a female and a pup Sea Otter for the Hastings Museum in Nebraska. The carcasses

were frozen and saved for the writer to examine at a later date. Although the parasites of Sea Otters from the Aleutian Chain are relatively well known, only one animal from the Sound area has been previously examined. The acanthocephalan, Corynosoma villosum Van Cleave, 1953, also found in other common Alaskan marine mammals, is the only recorded parasite of the Sea Otter in the Sound. Two species of trematoda (flukes) and one of acanthocephala (thorny-headed worm) were found in the two animals examined. These will be discussed below.

1) Microphallus pirum (Afanas'ev, 1941) (intestinal fluke).

This fluke was first found in Sea Otters taken at the Commander Islands of the Aleutian Chain. It was more recently implicated in the die-off of numbers of Sea Otters at Amchitka. Both the adult and juvenile Sea Otters examined by the writer were infected with large numbers (1000?) of this very small (less than 1mm.) fluke. There were no obvious signs of intestinal damage, although in the Amchitka specimens pathologic damages in the intestinal lining were reported. It appears most likely that this parasite is potentially most harmful when local areas become overpopulated with otters resulting in increased opportunity for infection and poorer nutrition.

2) Orthosplanchnus fraterculus Odhner, 1905
(gall-bladder fluke)

This worm, first reported from the Atlantic Walrus in Norway, is a common parasite of Sea Otters in the Aleutians particularly in older animals. It was observed in relatively large numbers (60) in the adult otter from Prince William Sound. Infection by this fluke results in a typical host reaction in which the walls of the gall bladder become very thick and much less elastic resulting in reduced bile storage capacity. This does not appear to be of serious consequence to the otter.

Although not previously reported from the Pacific Walrus, this fluke was recently taken by Mr. Lensink from a walrus collected by he and Mr. Sam Harbo at the Walrus Islands. Apparently the gall bladder of the walrus does not undergo any gross structural changes when infested by this parasite.

3) Corynosoma sp. (intestinal thorny-headed worm).

From the adult otter examined by the writer, sixty specimens of a new species of Corynosoma were recovered. This worm is distinctive among the 28 species of this genus so far known to science in its relatively large size and various other characteristics. The addition of this new species will raise to nine the number of species of Corynosoma known from Alaska marine mammals. The specific details of the life cycle

of the worm are unknown but, like other Corynosoma, undoubtedly involve crustaceans and fish as the first and second intermediate hosts respectively. There were no obvious signs of pathology in the one case observed.

3. The Parasites of the Sitka Black-tail Deer: Southeastern Alaska. P-R Project #M-2.

This project is being coordinated with that of Mr. David Klein who is studying the nutritional and physical condition of deer in three study areas in Southeastern Alaska. These areas are Coronation Island, Woronkofski Island and the Horn Cliffs area opposite Petersburg on the mainland. Thus far it has been possible to sample only the first of these study areas. The data have not been completely analyzed and only a very preliminary statement of progress and conclusions can be made.

Two species of parasitic worms are more or less common in Coronation deer: Dictyocaulus viviparus (lung roundworm) and Oesophagostomum venulosum (caecum roundworm). Both of the species can be quite detrimental to the welfare of deer and are widely found in big-game and domestic animals throughout North America and elsewhere. There have been frequent instances where both species have been associated with the death of deer. None of the infections observed on Coronation Island were judged to be more than slight in nature. However, it is likely that the crucial time for deer harboring these parasites would be in early spring when deer usually are in poorest shape. Furthermore, at this time the deer are generally concentrated in wintering areas increasing the likelihood of transmission from one animal to another.

Two other species of parasites were encountered in Coronation deer. A larval tapeworm cyst of what is probably a species of Taenia (wolf or dog parasite) was found on one occasion. Since the island is uninhabited and has not had wolves in the past or at the time of study, the finding of a single cyst is unexplainable in the usual manner. A single specimen of an unidentified species of tick was found on another deer. While ticks are quite common on black-tail deer elsewhere (e.g. Oregon) they have not been recorded from Alaska.

In spite of what appears to be a poorer nutritional state, the deer of Coronation Island seem to be in relatively good condition even though they are smaller on the average than elsewhere. However, it is likely that from time to time when conditions are difficult that some deer die from parasitic infections.

4. Kitoi Bay Fish Project.

In recent years the department has undertaken the experimental rehabilitation of certain lakes in the vicinity of the Kitoi Bay Research Station. After poisoning, these lakes have been stocked with Red Salmon, a species not previously present in the lakes being studied because of natural barriers preventing their access to spawners. Smolts from at least one of these rehabilitated lakes have been of exceptionally large size. There are many biological factors which may be involved in the production of these smolts. One of these may be the elimination or depression of natural Red Salmon parasites in the poisoned lakes. In order to evaluate this possibility, a study of the endemic salmonid parasites of the fresh-water lakes of the Kitoi region has been initiated. In this study particular attention will be paid to the fish parasites of Upper Jennifer and Ruth Lakes which were poisoned and to Lower Jennifer which was not. Thus far, only Lower Jennifer has been studied. Seven species of salmonid parasites have been encountered. These include one species of trematode (fluke), two of cestode (tapeworm), three of nematode (roundworm) and one of acanthocephala (thorny-headed worm). All of these have not been definitely identified at this time. The known and tentatively identified species are as follows:

1) Crepidostomum transmarinum (Nicoll, 1909) (intestinal fluke)
2) Proteocephalus arcticus Cooper, 1921 (intestinal tapeworm)
3) Eubothrium salvelini (Schrank, 1790) (intestinal tapeworm)
4) Dacnitis laevis Zschokke & Heitz, 1914 (intestinal roundworm)
5) Philonema salvelini Fujita, 1939 (body cavity roundworm)
6) Nematode species (?) - (intestine)
7) Neoechinorhynchus rutili (Mueller, 1780) (intestinal thorny-headed worm)

The effects of these species of parasites, singly or in combination, on the growth and vitality of salmonid fish is unknown. However, it is reasonable to predict that under conditions of lowered nutrition, heavy parasitism, etc., that the well-being of salmonids would be definitely depressed. In the case of Red Salmon this could result in stunted smolts having a reduced marine survival, etc., and resulting in spawning migrations composed of smaller adults. Unfortunately, relatively little is known with certainty about the various biological factors involved in the survival and growth of salmon in their fresh-water and marine environments. Accordingly, in the absence of direct evidence, one can only advance what appear to be reasonable speculations (based on observations on other host-parasite combinations) regarding the pos-

sibilities. The Kitoi Bay study should provide some of the facts needed to evaluate the role of parasitism in the life history of the Red Salmon and other salmonids.

5. Kodiak King Crab Project.

Proper management of the King Crab resource of the state requires among other things, a detailed knowledge of the population structure and growth of this animal in various Alaskan waters. The present project is designed to supplement the information obtained on growth by the study of natural populations with additional information obtained from laboratory observations on the crab.

In order to grow, the crab must molt. Since the molting process of all the many kinds of crustaceans thus far studied has in every case been shown to be controlled by hormone-secreting glands, it is reasonable to predict that the King Crab is no exception in this regard. Most crustaceans increase to a maximum size by means of a series of molts and then cease to grow. In many cases, the immature animal will molt frequently during a period of time in which the adult molts only once or not at all. This is apparently the case with the King Crab. The study of these variations in molting time (season) and frequency in natural populations has yielded much information. However, in order to be able to predict with maximum certainty that, for example, a particular animal has reached maximum size or that it will molt at a particular time, requires a more detailed knowledge of molting and its physiological control. At the present time it is only possible to study molting of adult crabs during two or three months of the year (April-June). This suggests that there is inherent in the crab some physiological mechanism which determines the time of year at which the crab will molt. Such a mechanism in crabs would be the biological equivalent of known seasonal activities of other kinds of animals (e.g. breeding periods, etc.) which have been shown to be physiologically regulated to some environmental factor which varies with the time of year. The environmental variable which has been implicated in many seasonal activities of plants, as well as animals, is length of daylight. By responding to the length of daylight in the natural environment the animal carries out certain biological processes at specific times in the year. It is anticipated that this is the case of the King Crab. If length of light period times the seasonal molting of the crab, then it should be possible to induce non-seasonal molting by simply exposing the animal to artificial light periods of appropriate duration. An experiment to determine whether or not this is the case is being initiated at the present time. Once one can induce molting when desired it should be possible to effectively study under controlled laboratory conditions the factors inherent in the crab and in the environment which together

determine the growth rate in natural populations. Furthermore, it may be possible to develop a method whereby animals taken from natural populations can be more accurately graded as to the nearness of the next molt. This would be quite useful in the study of natural populations.

6. Caribou Project. (P-R Project #M-3)

Caribou are the most numerous big-game animal in Alaska. They are known to be infested more or less commonly by a number of parasitic worms and the like. Although there is reason to believe that they are rarely killed outright by acute parasitism, we have no knowledge whatsoever of the effects of less severe, longer term chronic parasitism on their general well being.

The present project was initiated to determine what, if any, observable effects parasitism (to the extent it is encountered) has on the vitality (running endurance) of caribou. Of primary interest in this study will be the relationship between chronic parasitism and susceptability to predation by wolves. The theory has been advanced that one of the "so-called" benefits of wolf predation on caribou is the removal of diseased and/or parasitized animals. Although there is no doubt that this does, on occasion happen, there appears to be relatively little direct evidence for or against the idea. It is anticipated that this study should provide data which will allow a more detailed and objective evaluation of caribou - wolf relationships.

At the present the writer has not had the opportunity to examine enough animals to make any definite statements based upon his own observations.

7. General Parasitology. (P-R Project #M-1).

Most of the species of fish, birds and mammals of Alaska, or any other region, are generally of little, direct economic value. For this obvious reason, it is not always readily apparent why time should be spent studying such animals as mice or squirrels or any of the other "unimportant" animals. However, it can be stated unequivocably that there is no animal which does not exert some degree of influence on its surrounding environment. In many, if not most, instances the effect is negligible or at least appears that way. However, the seemingly insignificant mouse or kingfisher or shag does transmit parasites which are known to be very detrimental to other wildlife or man under certain circumstances. Therefore, although it would not be advisable to devote great amounts of time and money to the exhaustive, short-term study of such animals and their parasites, it is worthwhile to make observations on them whenever it can be

done in conjunction with other activities. Accordingly, the writer has examined a number of non-game animals in the various areas in which he has worked. Many species of parasites have been encountered, most of which are yet to be identified during the non-field season. With few exceptions, none of the infections observed appeared to be of a severe nature.

The writer expects to continue this project in the future on a limited basis, whenever time allows.