Number of Counties Containing National Forest Land	30
Acreage of Federal Refuge (Big Levels)	30,000
Acreage of State Game Refuge	7,000
Estimated Game Populations—White-Tail Deer	60,000-80,000
On National Forest Land —Black Bear	1,500
—Turkeys	3,000
Number Deer Stocked on National Forest Land Period 1932 through 1943	1,790
1954 Deer Kill (National Forest Counties)	7,460
1954 Bear Kill (National Forest Counties)	253
1954 Turkey Kill (National Forest Counties)	500
Number National Forest Stamps Sold 1939	11,000
Number National Forest Stamps Sold 1954	65,000
Number of Cooperative Game Management Units	23
Size of Management Units—10,000 to 80,000 acres	
Number of Game Managers	23
Acreage in Game Management Units on Virginia's National Forests	750,000
Number of Wildlife Clearings to Date	5,000
Number of Wildlife Roads and Trails (Miles)	500

SESSION ON WETLAND RESOURCES

WINTER LOSSES OF CANADA GEESE AT PEA ISLAND, NORTH CAROLINA

By A. B. COWAN and C. M. HERMAN
U. S. Fish and Wildlife Service, Laurel, Maryland

Mortality of Canada geese (*Branta canadensis*) wintering along the Outer Banks of North Carolina was reported as early as 1901. Since 1931 there have been yearly losses of varying intensity with peaks appearing to occur every 7-9 years. The last severe mortality was in the winter of 1948-49 and was reported to be centered on the Pea Island National Wildlife Refuge.

Following heavy losses during the winter of 1931-32, a number of short-term investigations were made. Unpublished reports covering these investigations indicated that heavy parasitism, malnutrition, adverse weather conditions, and wounding of birds by hunting were possible contributing factors, but they did not explain the recurent excessive mortality. The present attempt to determine the cause or causes of losses was begun in the winter of 1949-50 and has centered primarily at Pea Island.

Initial work concentrated on examination of sick geese collected at Pea Island and control geese trapped at Pea Island, Mattamuskeet, Back Bay, Blackwater, and Bombay Hook National Wildlife Refuges. Results suggested that gizzard worm (*Amidostomum anseris*) infections and malnutrition were probably important factors in causing sickness. Renal coccidiosis, an early suspect, was ruled out as a primary factor because it occurred in only approximately 50 percent of the sick geese and was equally prevalent and intense in the controls. On the whole, parasitic infections were markedly heavier in the sick geese than in the controls; and, with few exceptions, the controls from Pea Island were usually more heavily infected than controls from other areas. At least 29 species of internal parasites were found in Pea Island geese; but only the gizzard worm caused readily apparent pathology, evident as erosion of the gizzard lining. It was also found most frequently, occuring in 98 percent of the sick, 98 percent of the Pea Island controls, and 74 percent

of the other controls. Average gizzard worm burdens were overwhelmingly heaviest in sick birds.

Sick birds were obviously suffering from malnutrition. They were emaciated and weakened to the point that they were incapable of sustained flight, if they could fly at all. Most of those captured were run down. Some which could barely fly were shot. Such geese often weighted only 3-3½ pounds.

From this beginning subsequent investigation has been directed toward evaluating the separate and joint significances of gizzard worm infections and malnutrition as probable causes of mortality. Field work has included analysis of habitat, feeding and behavior of Canada geese at Pea Island, and migration. Collections of both sick and normal geese have been made at Pea Island as well as of controls from other areas. The occurrence, development, and survival of gizzard worm larvae in the soils at Pea Island were studied, and an experiment was undertaken to determine the possibility of gizzard worm transmission on Pea Island during the winter months.

Early in the investigation it was discovered that the geese were infected with gizzard worms when they arrived at Pea Island. Each year a few died shortly after arrival. The major losses occurred during January, February, and early March. Whether or not transmission and increased infections occurred on Pea Island during the winter was an important point to determine.

All the sick birds examined were devoid of fat and were extremely emaciated. Autopsy data indicated that these geese carried an average burden of 119.58 gizzard worms, while the infected controls carried an average of only 24.67 worms.

The extent of juvenile losses which gizzard worms may cause in the wild is unknown. However, goslings become infected quite early in life. A group captured when only a few days old at Seney Refuge in Michigan and shipped to Patuxent Research Refuge were carrying mature gizzard worms when autopsied three weeks later.

Birds of the year have comprised only about 30 percent of the total sample trapped during the five years of this study, but over 75 percent of the losses have been juvenile birds. Adults autopsied for control data have harbored large numbers of gizzard worms without apparent ill effects.

Once established, gizzard worm infections persist for a considerable time. Canada geese collected at Pea Island and held at Patuxent Research Refuge for source material have exhibited infections for nearly two years. Experimental infections are still persisting 14 months after establishment. However, there has been a very apparent tapering off in the intensity of the infections in these captive birds. They have been held under sanitary conditions which should preclude the chances of reinfection.

In the winter of 1954-55 a series of 31 soil plots in six different site classifications were seeded at different times with approximately 1,400 gizzard worm eggs each. One pound coffee cans, with tops and bottoms removed, were pressed into the soil until only about ½ inch remained above the surface to prevent the feces containing the eggs from being washed away by rains. At varying post-seeding intervals the top ½ to 1 inch of soil was collected and processed to recover any gizzard worm larvae present.

Larvae were recovered from 11 of the 31 plots, but the rate of recovery was very low, varying from 1 to 16. However, no gizzard worm larvae were found in 80 control plots, which were located in the immediate vicinity of the seeded plots. This appears to negate the possibility of transmission occurring during the winter months, but this did not prove to be the case.

In December, 1954, at the same time soil studies were begun, 36 juvenile Canada geese which had been raised from goslings and kept free of gizzard worms, were released on Pea Island. They were wing-clipped, banded, and marked with white plastic neck bands. During the first week of freedom 12 disappeared and the remaining 24 were under observation regularly until the middle of March, 1955, when they moved from a fresh water impoundment to Pamlico Sound. An air search then became necessary to locate them for collection, and fifteen were recovered. At autopsy all were infected with gizzard worms in numbers ranging from 2 to 108, but all were in excellent condition.

These experimental geese appeared to spend most of their time on the water, loafing along the shoreline and periodically coming ashore to feed on grain spread to keep them localized. The fact that they did not range much on land, plus the results of the soils study, indicate that the water might be the media through which the infective gizzard worm larvae are obtained.

Laboratory studies show that gizzard worm larvae develop and hatch from eggs just as well when incubated in brackish water as in fresh water and that larvae survive equally well in either. Charcoal cultures of feces from infected geese, the technique used for obtaining large numbers of larvae, are just as productive when moistened with brackish water as with tap water. Therefore, it is possible that transmission at Pea Island may occur on the Sound as well as on the freshwater impoundments. The historical records support this hypothesis in that heavy gizzard worm infections were noted in sick geese in that area before the Pea Island National Wildlife Refuge was established and before freshwater reservoirs were built.

Gizzard worm larvae hatched in 24 to 48 hours when eggs were incubated in water at room temperature. At 6° centigrade (normal refrigeration temperature) larval development continued to completion, but the larvae remained quiescent and did not break out until warmed to room temperature. Larvae were observed to shed their first sheath at time of hatching, but it has not been determined that they are infective at that time. However, experimental geese have been infected with larvae obtained from six-day-old charcoal cultures, the shortest time used to date. Infective larvae, frozen solid in ice, have been observed to again become active upon thawing and warming to room temperature. Their ability to infect geese is presently under investigation.

All experimental infections have been established by introducing infective larvae orally, using a transfer pipette or rubber tubing inserted to the level of the crop. In goslings up to 4 weeks old the parasite may develop to maturity and be shedding eggs within 14 days. In older goslings this period extends to as much as 25 days and the resultant infections appear lighter in intensity than in the younger birds. Attempts to infect birds over one year old have not significantly successful.

John Steenis, Biologist at Patuxent Research Refuge, U. S. Fish and Wildlife Service, who conducted the major portion of the field work, collected a series of plants which observation and stomach analysis indicated to be the principal foods of Canada geese at Pea Island. These were chemically analyzed by James V. Derby, Jr. Almost all were low in crude protein content. The only common foods available throughout the wintering period (November to April) were rootstocks of widgeongrass (*Ruppia maritima*), saltmarsh cordgrass (*Spartina alterniflora*), and threesquare (*Scirpus americanus*), the plant foods with the lowest percentage of crude protein and among the highest in crude fiber. Foods of higher protein content are available early in the winter but are rapidly depleted by the geese. New growth in the spring again provides added protein. This may be a factor in the recovery of some weakened individuals that have survived to that time.

A study of the effects of low protein diets on the survival and general welfare of gizzard worm infected geese is currently in progress at Patuxent Research Refuge.

The cause or causes of mortality of Canada geese at Pea Island has not been fully clarified. The results of our studies to date, however, indicate that the gizzard worm is an important factor. Poor physical condition brought about, at least partially, by malnutrition also contributes to the losses.