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FEEDING HABITS OF STRIPED BASS FROM THE SURF WATERS OF LONG ISLAND[1]

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ABSTRACT

The diet of striped bass in the south shore surf of Long Island consisted of both vertebrate and invertebrate organisms whose relative proportions and occurrences as food items fluctuated according to size of fish and season of capture. Relative occurrence of invertebrate foods decreased significantly between spring and fall but exhibited no significant differences according to fish size. Relative occurrence of vertebrate foods increased significantly between spring and fall, as well as with corresponding increases in fish size. Amphipods and mysids were the dominant invertebrate foods encountered, whereas the bay anchovy was the most common vertebrate form. Observed differences between feeding habits and traditional angling methods for striped bass in the surf during the summer are offered as a partial explanation for the generally poor catch rates recorded in that season.

The striped bass (*Morone saxatilis*) has been considered one of the most popular sport fishes of surf areas along the middle Atlantic coast. Briggs (1962, 1965) recently confirmed the popularity of the species among surf sport fishermen in New York and noted that it constituted a major portion of their catches. Schaefer (1967) further established that the striped bass was among the most abundant of all species encountered in seine hauls made along the south shore barrier beach of Long Island during each of three consecutive years (1961-1963). In spite of its high relative abundance both in sport fishery catches and in the surf zone environment, the average catch per unit of effort for the species has been low, generally less than one fish per angler trip (Briggs, 1962, 1965). Prompted by the popularity of the fish and the apparent disproportion between abundance and catch rate, the present investigation was undertaken to study the feeding habits of the species in the surf environment. It was hypothesized that the disproportion might possibly be attributable to differences between natural food preferences and traditional angling methods.

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Much has been written about the feeding habits of the striped bass. Raney (1952), in his extensive publication on the life history of the species, listed no less than 21 references for the Atlantic coast and 12 for the Pacific coast which presented data on its food and feeding habits. Similar studies since that time have provided additional information. Heubach *et al.* (1963), Stevens (1966) and Thomas (1967) recently reported on the diet and feeding habits of striped bass in the Sacramento-San Joaquin River drainage of California, while Stevens (1957) and Goodson (1964) conducted similar researches on fresh-water populations. On the Atlantic coast, Trent and Hassler (1966) reported on striped bass feeding behavior in the Roanoke River of North Carolina as it related to sexual maturity, and deSylva *et al.* (1962) listed the occurrence of food items in the stomachs of striped bass from the Delaware River estuary. Dovel (1968) suggested a relationship between striped bass feeding habits in Chesapeake Bay and the recent decline of the Atlantic croaker (*Micropogon undulatus*) population on the northeastern coast of North America. So far as can be determined, however, none of these reports, including those listed by Raney (1952), contains feeding observations on striped bass from an ocean surf environment.

METHODS

Striped bass were captured in a 1,300-foot modified commercial haul seine operated in the Great South Beach surf near Smith Point Park in Suffolk County (N.Y.) between April 27 and November 24 in 1964. A detailed description of the collecting site, capture gear and netting techniques was given by Schaefer (1967). Sampling was scheduled twice weekly, i.e., on the first two dates which permitted safe operation of the collecting gear. During some weeks, inclement weather and adverse surf conditions prevented sampling either on one or both of the scheduled collecting dates.

After each haul of the net, captured specimens were measured to the nearest 5 millimeters in fork length and each was assigned to one of three arbitrary size classes, i.e., small, 399 millimeters or less; medium, 400-599 millimeters; large, 600 millimeters or more. When sorting was completed, a maximum of 20 specimens were randomly selected from each size group for stomach examination. In hauls that produced less than 20 specimens in any one of the three size categories, all fish in that category were used. This procedure was repeated until the maximum weekly number of desired specimens (20) was accumulated for each size group, or until the two weekly seining dates were completed.

The visceral cavities of specimens selected were opened, and the stomachs, from the esophagus to the pyloric constriction, were removed intact. Stomachs were placed individually in suitably labeled polyethylene bags and sealed. Each bag was then punctured with one or two small holes and placed in a large plastic pail containing 10 per cent formalin. When submerged, the air in each bag was released and replaced by preservative. The stomachs were stored in 10 per cent formalin at the laboratory until needed.

At the laboratory, each stomach was opened and its contents removed for examination. Food items were identified as precisely as the stage of digestion would permit. The volumetric displacement of each item was measured in graduated cylinders containing tap water. From these observations, frequency of occurrence and total volume were determined for each food encountered. Data were treated and analyzed according to fish length and season[2] of capture.

RESULTS

A total of 367 stomachs were examined, including 61 from small fish, 183 from medium fish and 123 from large fish. Stomach contents data (Tables 1 to 3) are presented according to fish size. Percentage frequencies of occurrence relate only to stomachs that contained food rather than to the total number of stomachs examined.

SMALL FISH

Small fish fed heavily on invertebrates, as indicated by their occurrence in nearly 80 per cent of the 49 stomachs that contained food (Table 1). Invertebrates also constituted 85 per cent of all food items by volume. Vertebrates were of relatively little importance, occuring in only nine stomachs (18 per cent) and comprising 14 per cent of the total food by volume. Twelve (25 per cent) of the 61 stomachs were empty.

The most frequently encountered invertebrates and those which displaced the greatest volume were amphipods and mysids. These organisms occurred, respectively, in 57 and 43 per cent of the stomachs, and constituted 45 and 33 per cent of all food items by volume.

MEDIUM FISH

Of the 183 stomachs from medium fish, 145 contained food. Invertebrates occurred in more than half of them and constituted more than half the total food volume (Table 2). As observed for the small fish, amphipods comprised the bulk (99 per cent by volume) of all invertebrate organisms and occurred in 75 (52 per cent) stomachs.

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[2] According to celestial calendar, i.e. spring = March 21-June 21, etc.

TABLE 1. STOMACH CONTENTS OF 61 SMALL (275 TO 399 MILLIMETERS IN FORK LENGTH) STRIPED BASS COLLECTED AT GREAT SOUTH BEACH BETWEEN APRIL 27 AND NOVEMBER 24 IN 1964

Food item	Frequency of occurrence	Relative frequency (per cent)	Volume (milliliters)	Relative volume (per cent)
		Spring*		
Invertebrates	28	93.3	241.4	93.3
Arthropoda				
Crustacea				
Amphipoda§	25	83.3	117.3	45.4
Mysidacea†	13	43.3	101.0	39.1
Decapoda				
Macrura				
Crangon septemspinosa	2	6.7	2.6	1.0
Isopoda‡	3	10.0	0.5	0.2
Mollusca				
Pelecypoda				
Spisula solidissima	1	3.3	20.0	7.7
Vertebrates	6	20.0	16.7	6.5
Pisces				
Anchoa mitchilli	2	6.7	12.0	4.6
Apeltes quadracus	2	6.7	2.4	0.9
Anguilla rostrata	1	3.3	0.3	0.1
Unidentified remains	2	6.7	2.0	0.8
Miscellaneous debris•	3	10.0	0.5	0.2
Empty	4	11.8	xxx	xxx
Total	34	xxx	258.6	100.0
		Summer*		
Invertebrates	9	81.8	15.0	91.5
Arthropoda				
Crustacea				
Amphipoda§	1	9.1	9.0	54.9
Mysidacea†	8	72.7	5.0	30.5
Decapoda				
Brachyura				
Unidentified	1	9.1	1.0	6.1
Annelida				
Chaetopoda	3	27.3	Tr.	Tr.
Vertebrates	1	9.1	1.0	6.1
Pisces				
Unidentified remains	1	9.1	1.0	6.1
Miscellaneous debris•	5	45.5	0.4	2.4
Empty	3	21.4	xxx	xxx
Total	14	xxx	16.4	100.0

Table 1. (*continued*)

Fall*				
Invertebrates	2	25.0	21.0	41.8
Arthropoda				
Crustacea				
Amphipoda§	2	25.0	21.0	41.8
Vertebrates	2	25.0	29.0	57.8
Pisces				
Anchoa mitchilli	1	12.5	2.0	4.0
Menticirrhus saxatilis	1	12.5	4.0	8.0
Unidentified remains	3	37.5	23.0	45.8
Miscellaneous debris•	4	50.0	0.2	0.4
Empty	5	38.5	xxx	xxx
Total	13	xxx	50.2	100.0
Total				
Invertebrates	39	79.6	277.4	85.3
Arthropoda				
Crustacea				
Amphipoda§	28	57.1	143.3	45.3
Mysidacea†	21	42.9	106.0	32.6
Decapoda				
Brachyura				
Unidentified	1	2.0	1.0	0.3
Macrura				
Crangon septemspinosa	2	4.1	2.6	0.8
Isopoda‡	3	6.1	0.5	0.2
Annelida				
Chaetopoda	3	6.1	Tr.	Tr.
Mollusca				
Pelecypoda				
Spisula solidissima	1	2.0	20.0	6.2
Vertebrates	9	18.4	46.7	14.4
Pisces				
Anchoa mitchilli	3	6.1	14.0	4.3
Apeltes quadracus	2	4.1	2.4	0.7
Menticirrhus saxatilis	1	2.0	4.0	1.2
Anguilla rostrata	1	2.0	0.3	0.1
Unidentified remains	6	12.2	26.0	8.0
Miscellaneous debris•	12	24.5	1.1	0.3
Empty	12	24.5	xxx	xxx
Total	61	xxx	325.2	100.0

*Spring = April 27 to June 17; summer = June 23 to September 4; fall = October 14 to November 24.

§Primarily *Gammarus* sp. and *Haustorius canadensis*.

†Primarily *Neomysis americana*.

‡Primarily *Idotea metallica*.

•Mostly mollusc shell fragments, sand grains and pebbles and fragments of plant material including *Ulva* sp., *Spartina* sp. and *Zostera marina*.

TABLE 2. STOMACH CONTENTS OF 183 MEDIUM-SIZED (400 TO 599 MILLIMETERS IN FORK LENGTH) STRIPED BASS COLLECTED AT GREAT SOUTH BEACH BETWEEN APRIL 27 AND NOVEMBER 24 IN 1964

Food item	Frequency of occurrence	Relative frequency (per cent)	Volume (milliliters)	Relative volume (per cent)
Spring*				
Invertebrates	10	58.8	80.7	37.2
Arthropoda				
Crustacea				
Amphipoda§	9	52.9	76.6	35.3
Mysidacea†	4	23.5	4.1	1.9
Vertebrates	7	41.2	136.5	62.8
Pisces				
Menidia menidia	3	17.6	24.5	11.3
Stenotomus chrysops	2	11.8	99.0	45.6
Unidentified remains	2	11.8	13.0	6.0
Miscellaneous debris•	1	5.9	Tr.	Tr.
Empty	7	29.2	xxx	xxx
Total	24	xxx	217.2	100.0
Summer*				
Invertebrates	48	70.6	656.3	85.2
Arthropoda				
Crustacea				
Amphipoda§	43	63.2	647.4	84.0
Mysidacea†	3	4.4	7.0	0.9
Decapoda				
Macrura				
Crangon septemspinosa	2	2.9	1.8	0.2
Annelida				
Chaetopoda	1	1.5	0.1	Tr.
Vertebrates	13	19.1	108.5	14.1
Pisces				
Syngnathus fuscus	1	1.5	0.5	0.1
Unidentified remains	12	17.6	108.0	14.0
Miscellaneous debris•	23	33.8	5.8	0.8
Empty	20	22.7	xxx	xxx
Total	88	xxx	770.6	100.0

TABLE 2. *(continued)*

Fall*

Invertebrates	24	40.0	519.5	37.5
Arthropoda				
Crustacea				
Amphipoda§	23	38.3	517.5	37.4
Decapoda				
Macrura				
Unidentified	1	1.7	2.0	0.1
Vertebrates	46	76.7	840.5	60.7
Pisces				
Anchoa mitchilli	32	53.3	637.8	46.1
Menidia menidia	2	3.3	75.0	5.4
Brevoortia tyrannus	1	1.7	25.0	1.8
Bairdiella chrysura	1	1.7	2.2	0.2
Unidentified remains	16	26.7	100.5	7.3
Miscellaneous debris•	25	41.7	24.3	1.8
Empty	11	15.5	xxx	xxx
Total	71	xxx	1384.3	100.0

Total

Invertebrates	82	56.6	1256.5	53.0
Arthropoda				
Crustacea				
Amphipoda§	75	51.7	1241.5	52.3
Mysidacea†	7	4.8	11.1	0.5
Decapoda				
Macrura				
Crangon septemspinosa	2	1.4	1.8	0.1
Unidentified	1	0.7	2.0	0.1
Annelida				
Chaetopoda	1	0.7	0.1	Tr.
Vertebrates	66	45.5	1085.5	45.8
Pisces				
Anchoa mitchilli	32	22.0	637.8	26.9
Menidia menidia	5	3.4	99.5	4.2
Stenotomus chrysops	2	1.4	99.0	4.2
Syngnathus fuscus	1	0.7	0.5	Tr.
Brevoortia tyrannus	1	0.7	25.0	1.1
Bairdiella chrysura	1	0.7	2.2	0.1
Unidentified remains	30	20.7	221.5	9.3
Miscellaneous debris•	49	33.8	30.1	1.3
Empty	38	26.2	xxx	xxx
Total	183	xxx	2372.1	100.0

*Spring = April 27 to June 17; summer = June 23 to September 4; fall = October 14 to November 24.

§Primarily *Gammarus* sp. and *Haustorius canadensis*.

†Primarily *Neomysis americana*.

•Mostly mollusc shell fragments, sand grains and pebbles and fragments of plant material including *Ulva* sp., *Spartina* sp. and *Zostera marina*.

TABLE 3. STOMACH CONTENTS OF 123 LARGE (600 TO 940 MILLIMETERS IN FORK LENGTH) STRIPED BASS COLLECTED AT GREAT SOUTH BEACH BETWEEN APRIL 27 AND NOVEMBER 24 IN 1964

Food item	Frequency of occurrence	Relative frequency (per cent)	Volume (milliliters)	Relative volume (per cent)
Spring*				
Invertebrates	12	75.0	410.5	39.8
Arthropoda				
Crustacea				
Amphipoda§	10	62.5	219.5	21.3
Mysidacea†	4	25.0	136.0	13.2
Decapoda				
Brachyura				
Ovalipes ocellatus	2	12.5	47.0	4.6
Macrura				
Crangon septemspinosa	1	6.3	7.0	0.7
Unidentified	1	6.3	1.0	0.1
Vertebrates	11	68.8	617.0	59.8
Pisces				
Anchoa mitchilli	1	6.3	8.0	0.8
Menidia menidia	2	12.5	12.0	1.2
Stenotomus chrysops	2	12.5	248.0	24.0
Syngnathus fuscus	2	12.5	93.0	9.0
Apeltes quadracus	1	6.3	0.2	Tr.
Cyprinodon variegatus	1	6.3	1.5	0.1
Tautoga onitis	1	6.3	136.5	13.2
Unidentified remains	6	37.5	117.8	11.4
Miscellaneous debris•	2	12.5	4.0	0.4
Empty	7	30.4	xxx	xxx
Total	23	xxx	1031.5	100.0
Summer*				
Invertebrates	21	58.3	456.2	46.8
Arthropoda				
Crustacea				
Amphipoda§	8	22.2	127.8	13.1
Decapoda				
Brachyura				
Ovalipes ocellatus	11	30.6	300.0	30.8
Unidentified	4	11.1	27.8	2.9
Macrura				
Emerita talpoida	1	2.8	0.6	0.1
Vertebrates	20	55.6	509.0	52.2
Pisces				
Anchoa mitchilli	1	2.8	0.5	0.1
Urophycis chuss	2	5.6	37.5	3.8
Stenotomus chrysops	1	2.8	65.0	6.7
Sphaeroides maculatus	2	5.6	102.0	10.5
Unidentified remains	14	38.9	304.0	31.2
Miscellaneous debris•	6	16.7	9.2	0.9
Empty	4	10.0	xxx	xxx
Total	40	xxx	974.4	100.0

TABLE 3. (*continued*)

Fall*				
Invertebrates	17	39.5	289.9	20.1
Arthropoda				
Crustacea				
Amphipoda§	13	30.2	280.4	19.4
Decapoda				
Brachyura				
Ovalipes ocellatus	1	2.3	1.0	0.1
Unidentified	2	4.6	3.1	0.2
Isopoda‡	4	9.3	5.4	0.4
Vertebrates	32	74.4	1123.8	77.9
Pisces				
Anchoa mitchilli	12	27.9	210.3	14.6
Urophycis chuss	8	18.6	488.0	33.8
Merluccius bilinearis	4	9.3	80.5	5.6
Mugil cephalus	2	4.6	90.0	6.2
Unidentified remains	11	25.6	255.0	17.7
Miscellaneous debris•	14	32.6	29.5	2.0
Empty	17	28.3	xxx	xxx
Total	60	xxx	1443.2	100.0
Total				
Invertebrates	50	52.6	1156.6	33.5
Arthropoda				
Crustacea				
Amphipoda§	31	32.6	627.7	18.2
Mysidacea†	4	4.2	136.0	3.9
Decapoda				
Brachyura				
Ovalipes ocellatus	14	14.7	348.0	10.1
Unidentified	6	6.3	30.9	0.9
Macrura				
Crangon septemspinosa	1	1.1	7.0	0.2
Emerita talpoida	1	1.1	0.6	Tr.
Unidentified	1	1.1	1.0	Tr.
Isopoda‡	4	4.2	5.4	0.2
Vertebrates	63	66.3	2249.8	65.2
Pisces				
Anchoa mitchilli	14	14.7	218.8	6.3
Urophycis chuss	10	10.5	525.5	15.2
Menidia menidia	2	2.1	12.0	0.3
Stenotomus chrysops	3	3.2	313.0	9.1
Syngnathus fuscus	2	2.1	93.0	2.7
Merluccius bilinearis	4	4.2	80.5	2.3
Apeltes quadracus	1	1.1	0.2	Tr.
Mugil cephalus	2	2.1	90.0	2.6
Sphaeroides maculatus	2	2.1	102.0	3.0
Cyprinodon variegatus	1	1.1	1.5	Tr.
Tautoga onitis	1	1.1	136.5	4.0
Unidentified remains	31	32.6	676.8	19.6
Miscellaneous debris•	22	23.2	42.7	1.2
Empty	28	29.5	xxx	xxx
Total	123	xxx	3449.1	100.0

*Spring = April 27 to June 17; summer = June 23 to September 4; fall = October 14 to November 24.

§Primarily *Gammarus* sp. and *Haustorius canadensis*.

†Primarily *Neomysis americana*.

‡Primarily *Idotea metallica*.

•Mostly mollusc shell fragments, sand grains and pebbles and fragments of plant material including *Ulva* sp., *Spartina* sp. and *Zostera marina*.

Vertebrate organisms were more prevalent in medium fish than in small fish, occurring in 46 per cent and constituting 46 per cent of the food volume of their stomachs. The bay anchovy (*Anchoa mitchilli*) was the dominent vertebrate food item. This species comprised 27 per cent of all foods by volume and occurred in 32 (22 per cent) stomachs.

LARGE FISH

Although invertebrates occurred in 53 percent and constituted a third of the total food volume of stomachs from large fish, vertebrate organisms were the dominant food items. Vertebrates occurred in 66 per cent of the stomachs and constituted 66 per cent of the total food by volume.

Amphipods remained the dominant invertebrate food item (Table 3), but the lady or calico crab (*Ovalipes ocellatus*) was frequently encountered in its soft-shell stage of development. This species occurred in 15 per cent of the stomachs and constituted 10 per cent of all foods by volume. Dominant vertebrate foods were the bay anchovy (*Anchoa mitchilli*) and the squirrel hake (*Urophycis chuss*). The former species occurred more frequently (15 per cent vs. 10 per cent, respectively), while the latter comprised a greater volume (6 per cent vs. 15 per cent, respectively). The scup (*Stenotomus chrysops*) occurred in only three stomachs but constituted approximately 9 per cent of the total food by volume.

ANALYSIS OF OCCURRENCE OBSERVATIONS

Tables 1 to 3 indicate wide differences between the percentage occurrences of both invertebrate and vertebrate food items in relation to fish size and season of capture. To determine whether they were real or only apparent, these differences were treated by analysis of variance techniques. The percentage data were transformed to the arcsin $\sqrt{X}$ (Bartlett, 1947) and subjected to a weighted analysis based on the unequal subclass denominators (Yates, 1934; Cochran, 1943). Sources of variation were tested by chi-square rather than F as suggested by Steel and Torrie (1960) for binomially distributed data. The results of these tests are presented in Tables 4 and 5.

TABLE 4. ANALYSIS OF VARIANCE FOR PERCENTAGE FREQUENCIES OF OCCURRENCE OF INVERTEBRATE FOOD ITEMS

Source of variation	Degrees of freedom	Sum of squares	x^2	x^2 (.01)
Season	2	22,683.02	27.63**	9.21
Size	2	3,941.07	4.80	9.21
Interaction	4	6,155.51	7.50	13.28
Error		821.00		

**Significant at the .01 level of probability.

TABLE 5. ANALYSIS OF VARIANCE FOR PERCENTAGE FREQUENCIES OF OCCURRENCE OF VERTEBRATE FOOD ITEMS

Source of variation	Degrees of freedom	Sum of squares	x^2	x^2 (.01)
Season	2	35,093.59	42.74**	9.21
Size	2	22,436.53	27.33**	9.21
Interaction	4	7,993.65	9.74	13.28
Error		821.00		

** Significant at the .01 level of probability.

The chi-square values indicate significant differences between the relative occurrences of invertebrate food items by season (Table 4), and significant differences between the relative occurrences of vertebrate food items by season and size (Table 5). The relative occurrence of invertebrates decreased between spring and fall, while that of vertebrates simultaneously decreased slightly between spring and summer but increased sharply in the fall. The relative frequency of vertebrate occurrences also increased as fish size increased. The observed decrease in the percentage occurrence of invertebrate foods corresponding to increases in fish size was not significant. These observations are illustrated graphically in Figure 1.

DISCUSSION

The data reveal that invertebrates, especially amphipods, are important food items for striped bass of all sizes (i.e., 275 to 940 millimeters) in the south shore surf environment of Long Island. Indeed, invertebrates occurred in 50 to 80 per cent, and constituted 35 to 85 per cent of the total food volume, of all stomachs by size category. In view of previous studies, these observations seem rather unique. While it has been demonstrated by several authors that invertebrates constitute a major portion of the diet of juvenile striped bass (Scofield and Coleman, 1910; Hildebrand and Schroeder, 1928; Shapovalov, 1936; Curran and Ries, 1937; Townes, 1937; deSylva *et al.,* 1962; Heubach *et al.,* 1963; Stevens, 1966; Thomas, 1967), some of these and other researches also reveal that invertebrates generally occur much less frequently and in relatively smaller quantities in stomachs from large specimens. Stevens (1966), for example, reported that invertebrate organisms averaged only 3 per cent or less of the total volume of food consumed by striped bass 2 years of age and older from the Sacramento-San Joaquin Delta region of California. Similarly, for the same general area, Thomas (1967) observed that although *Neomysis* occurred in 42 per cent of the stomachs of striped bass 6 to 10 inches in length, this same food item occurred in only 8 per cent of the stomachs of specimens 11 to 15 inches in length and

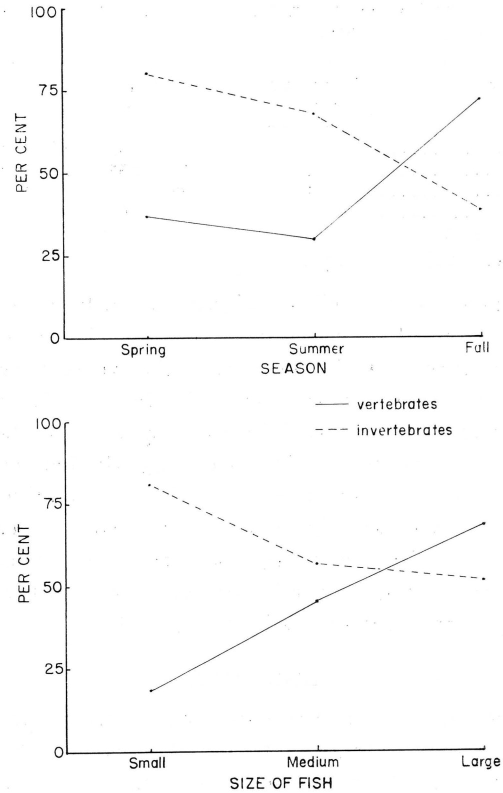

Figure 1. Percentage frequency of occurrence for vertebrate and invertebrate food items in striped bass stomachs according to season of capture and size of fish.

was entirely absent from stomachs of specimens over 16 inches in length. Even for fish collected from a single school, Shapovalov (1936) indicated that small crustaceans occurred in 63 per cent of the stomachs of striped bass ranging between 200 millimeters and 400 millimeters in length, but occurred in only 12 per cent of the stomachs from striped bass between 400 millimeters and 490 millimeters in length. Since such a wide variety and large quantity of fish are available in the Long Island surf from May through November (Schaefer, 1967), it is difficult to explain the high occurrence and large volume of invertebrates in stomachs from medium and large striped bass collected there. Perhaps it is related to the commonness and abundance of amphipods in the intertidal and subtidal zones of sandy shorelines (Colman and Segrove, 1955; Sameoto, 1969) and to the frequent turbidity of the surf environment caused by severe wave action. Striped bass, as well as other predatory fishes, may have a difficult time in pursuing and killing fast-swimming vertebrates under such conditions, and so resort to the more catchable invertebrates for food. Thomas (1967) suggested that the greater turbidity present in the Delta of the Sacramento-San Joaquin watershed was the most likely hypothesis for explaining the high incidence of mysids and low incidence of fish in stomachs of juvenile striped bass collected there.

It is further difficult to imagine striped bass as large as 600 millimeters or more in length consuming amphipods as small as 10 millimeters or less, singly. It seems more likely that these organisms are ingested in much the same way as plankton are, for the most part, by typical plankton feeders, i.e., indiscriminately and in masses. If this is true, then the amphipods commonly encountered in the present study must literally occur in "swarms" in the south shore surf of Long Island, although this has not yet been documented. For nearby Great South Bay, however, Townes (1939) reported capturing single species of amphipods in densities as high as 43,000 (*Ampelisca spinipes*) and 45,000 (*Corophium insidiosum*) specimens per square meter.

It is not particularly surprising that vertebrate foods increased in their frequency of occurrence and in volume with corresponding increases in fish size. Other authors have made similar observations. Shapovalov (1936), for example, found fish and fish remains in approximately 85 per cent of the stomachs he examined from striped bass longer than 400 millimeters at Waddell Creek Lagoon in California. Similar foods occurred in only 38 per cent of the stomachs collected from smaller individuals. For the Delta region of the Sacramento and San Joaquin Rivers, Stevens (1966) also reported that subadult and adult striped bass fed "primarily" or "almost entirely" on fish, but the young and juveniles consumed these vertebrate foods to a much lesser degree. In Chesapeake Bay, Hildebrand and Schroeder (1928) observed that "the larger fish had fed principally on fish, whereas the smaller ones had eaten mainly crustaceans", while farther north along the Atlantic coast, Bigelow and Schroeder (1953) indicated that herring, smelt, sand launce, eels and silver hake were among the chief prey of larger bass in the Gulf of Maine.

The significant decrease in the relative occurrence of invertebrate foods and the significant increase in the relative occurrence of vertebrate foods between spring and fall are most probably interrelated observations. Data are not presently available, however, to indicate whether these observations are attributable to a decrease in the abundance of invertebrates, an increase in the abundance of preferred fish or to a combination of these and other factors. Both Johnson and

Calhoun (1952) and Thomas (1967) reported that, while anchovies (*Engraulis mordax*), shrimp (*Crago*) and mysids (*Neomysis*) were important food items of striped bass throughout the year, anchovies occurred more frequently in the summer and fall diet and the invertebrates more frequently in the winter and spring diet. Stevens (1966) also noted a similar pattern for the diets of juvenile, subadult and adult striped bass in the Sacramento-San Joaquin Delta. The latter two authors suggested that these changes in diet were directly related to abundance and availability of specific food items. In view of this, the stomach contents records of the present investigation suggest that the bay anchovy, the most frequently occurring vertebrate food item, was more abundant in the surf environment during the fall than previously indicated by an earlier study (Schaefer, 1967). Nichols and Breder (1926) reported the species as being most numerous in the fall in the vicinity of New York.

The fishes ingested by striped bass in the Long Island surf are also noteworthy in view of the observations made by other investigators. The bay anchovy was also recorded by Hollis (1952) as one of the most commonly occurring foods in stomachs of striped bass from the salt waters of Chesapeake Bay. He observed that the bay anchovy was an abundant species there at the time of his collections. On the contrary, while only a few Atlantic silversides (*Menidia menidia*) were encountered as foods in the present investigation, Merriman (1941) reported the species as the most common form in the diet of striped bass from nearby Connecticut waters. Of particular interest was the almost complete absence of herrings (Clupeidae), which are known to be abundant in the Long Island surf (Schaefer, 1967), and mullets (Mugilidae) from the stomach contents. Both Hollis (1952) and Merriman (1941) found one species of the herring family, the Atlantic menhaden (*Brevoortia tyrannus*), to be a common food organism of striped bass, while local fishermen presume mullets to dominate the diet of striped bass in the surf during the fall months. The silver hake (*Merluccius bilinearis*), encountered infrequently in the present study, was listed as a chief food of striped bass in the Gulf of Maine (Bigelow and Schroeder, 1953).

Some of these feeding observations may offer a plausible explanation, in part at least, for the disproportionately low catch rates in the sport fishery for striped bass in relation to their abundance in the Long Island surf. When striped bass first appear annually in this environment, usually in late April, sport fishermen traditionally seek to catch them with a variety of invertebrate baits. For the most part, these baits include bloodworms (*Glycera*), sandworms (*Nereis*) and clam meats (*Mercenaria* or *Spisula*). In the present study, however, these items occurred very infrequently among the stomach contents of the examined specimens during the spring, as well as throughout the summer and fall. It is suggested that since these baits are not normally preyed upon by striped bass in the surf zone, they may be generally avoided by the species in preference to food organisms which occur there in natural abundance. Thomas (1967) noted that "... animals which live in the bottom, such as annelid worms and clams, seldom contribute significantly to their diet."

Although many anglers persist in fishing for striped bass with the aforementioned baits through August at certain south shore beaches, many also resort to artificial lures, generally imitative of small fish, by June (Briggs, 1965). This is an interesting transition since, as the data again reveal, striped bass continue to feed primarily on small invertebrate organisms throughout the summer period. As summertime catch rates indicate (Briggs, 1962, 1965), the transition by anglers to the use of artificial lures at this time is not particularly effective. Indeed, for the most part, catch rates for striped bass declined during this season. Briggs (1965) suggested, however, that the change in fishing methods may not have been prompted primarily by a desire to improve catches of striped bass, but rather by a desire to avoid the capture of other bothersome species such as the northern puffer (*Sphaeroides maculatus*) which occurs in abundance in the surf from late May to September (Schaefer, 1967).

The continuation and increase in the use of artificial lures into the fall seems to be a successful practice, as indicated by the general increase in the catch per effort for striped bass at that time of year (Briggs, 1962, 1965). Certainly this technique, which is designed to mimic forage fish, is in accord with the fall feeding preferences of the striped bass in the surf environment. Since fish constitute the major portion of the diet of the species between late September and late November, it seems reasonable to conclude that the traditional fishing method employed at this time of year is the most appropriate one.

Briggs (1965) concluded from his data that anglers seeking striped bass in the Long Island surf "would do better to fish during the spring or fall migrations of this fish when the degree of success is higher." Since the species is also abundant in this environment during the summer (Schaefer, 1967), an alternative suggestion is offered which might make more efficient use of the available resource. Based on the observations of the present investigation, it would seem wiser for anglers to experiment with non-traditional baits and lures which better parallel the seasonal feeding preferences of striped bass along the outer beach, especially during the summer months. It should be noted, however, that, based upon the small sizes of many of the most common food organisms encountered, the development of new fishing techniques and the use of non-traditional surf-angling gear may be required to do this.

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FEASIBILITY OF STOCKING MOOSE IN THE ADIRONDACKS

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ABSTRACT

Suggestions that moose might be reestablished in the Adirondack region of New York prompted a review of available information concerning the feasibility of such an undertaking. Moose were native to the Adirondacks, but they disappeared shortly after the mid-1800's. All the basic environmental requirements for sustaining a moose population appear still to be present. However, virtually all habitat suitable for moose is now overstocked with deer. Furthermore, the deer are heavily infested with a nematode, *Pneumostrongylus tenuis,* to which they are largely immune but which causes a generally fatal neurologic disease in moose. The evidence indicates that this moose disease would doom any stocking effort to failure.

Suggestions that moose (*Alces alces*) might be reestablished in the Adirondack region of New York prompted a review of available information concerning the feasibility of such an undertaking. Since moose were numerous there in colonial times, the region is fundamentally suitable for the species. However, over the past century, the environment has been substantially altered by man's occupation and related influences. This paper represents an effort to assess present conditions in the region in relation to the possibility that stocking might be successful.

HISTORY OF MOOSE IN THE ADIRONDACKS

When the Adirondack region was first explored, moose were plentiful (Grant, 1902). They remained so through the early 1800's. During this time deer were scarce, especially in the central part of the region. About mid-century the moose disappeared.

The last authenticated record of a native moose taken in the Adirondacks was that of a cow killed in 1861 near Raquette Lake in Hamilton County (Merriam, 1886). However, Colvin (1874) reported that "in a few of the most remote portions of the wilderness [Adirondacks] we have met with indications of the Moose, which, to some of the guides, seemed unmistakable. This gigantic deer is, however, almost extinct in the Adirondacks".

Writing in 1878, Colvin (1880) noted that moose, imported from Maine and Nova Scotia, "have been restored to the grounds of the Adirondack club, near Lake Sanford". Between 1894 and 1903, several owners of preserves in the central Adirondacks imported moose and liberated them on their lands, notably Nehasane Park in northern Hamilton and Herkimer Counties. But the numbers were few. The largest liberation (six males and six females) was made by the State at Uncas Station near Raquette Lake in 1902-03. The records that could be traced were summarized by Bump (1940). Although variously reported for several years, these animals soon disappeared. Some were known to have been poached, and others were believed to have perished in the extensive forest fires that occurred during that period.

In recent years, moose have been observed from time to time in New York, chiefly in the Adirondack region. Following is a chronological summary of the observations recorded.[1]

In 1936, Raymond Burmaster, game protector, reported that a bull moose was seen near Elizabethtown in Essex County.

In 1937, a moose was reported as having been seen near Coreys on Upper Saranac Lake in Franklin County in the late summer, and a bull moose was shot on nearby Bartlett Mountain during the hunting season. This was considered to be the same one seen the year before.

In 1950, a moose was seen on a road near Tupper Lake in Franklin County in the late summer. Ten days later, a moose was seen on two successive days at the Troy Country Club in Rensselaer County, and a few days after that one was reported to have been seen a few miles south of Rutland in Vermont. A moose, believed to have been this same animal, was subsequently sighted in several localities in Massachusetts and continued to wander southeasterly, finally disappearing after being seen in Rhode Island.

In the winter of 1951-52, three moose were seen being "dogged" into the St. Lawrence River from the Canadian side. They landed near Red Mills in St. Lawrence County. A bull and a cow were seen near Red Mills in January and stayed between Red Mills and Louisville all winter, but they had gone by April.

In 1952, a moose was seen near Tupper Lake during the late summer, and one was encountered on the highway near Coreys in September. During September and October, moose tracks were found by Greenleaf Chase, conservation biologist, along the Cold River in Hamilton County. In early October, a moose passed east of Long Lake Village in Hamilton County leaving numerous tracks identified by Chase. In late October, moose tracks were reported by a forest ranger in the vicinity of Glasby Plain on the Oswegatchie River in St. Lawrence County. In December, a moose was reported at Chase Lake in Lewis County that wintered there and disappeared. It is believed that these observations represented the same moose and that it was

[1]The authors are indebted to Greenleaf Chase, conservation biologist, and John E. Wilson, regional supervisor of fish and wildlife, N.Y.S. Conservation Department, for most of the recent records of moose in this State.

one of the three that crossed the St. Lawrence River the winter before. Connecting the seven locations in sequence with straight lines makes a total of about 217 miles bounding an area of about 1,800 square miles.

In the winter of 1958-59, Carl Prue, conservation officer, reported that a moose was seen crossing the St. Lawrence River on the ice from Canada near Louisville Landing in St. Lawrence County, and there were several reports of moose being seen in the vicinity of Louisville during the pike run in the Oswegatchie River.

In 1962, during August and September, a moose was reported as having been seen near Winthrop and Brasher Falls in St. Lawrence County, near St. Regis Falls, Duane, Mountain View and Wolf Pond

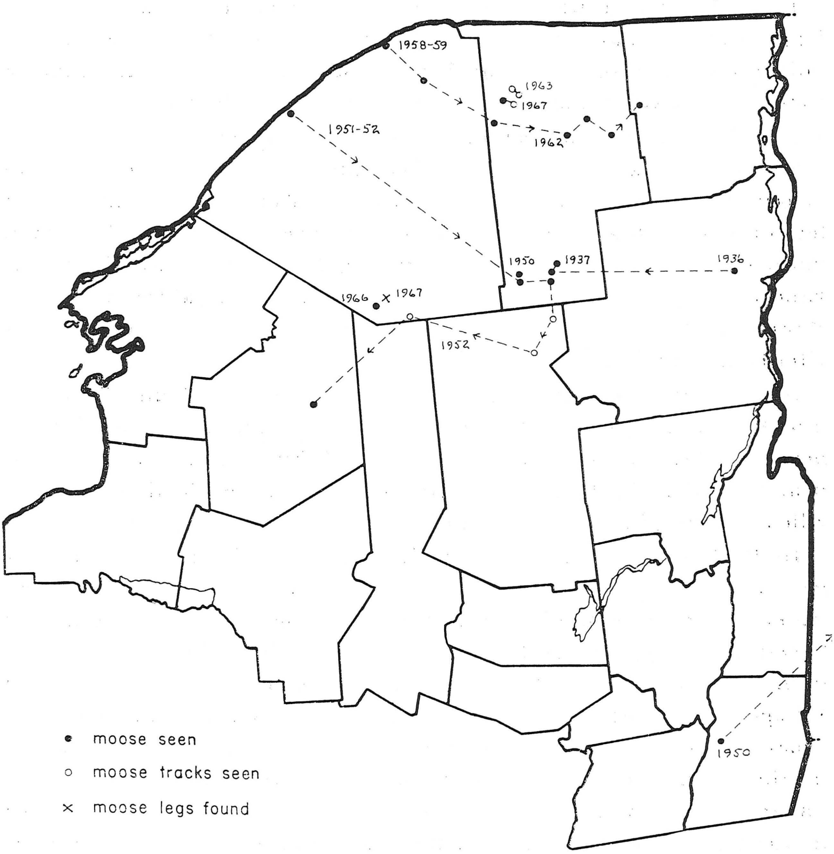

Figure 1. Locations where moose or their tracks have been seen in northeastern New York in recent years. Sequences representing same animal based on judgment of: Raymond Burmaster, conservation officer, for 1936-37; Greenleaf Chase, conservation biologist, for 1951-52; and Carl Prue, conservation officer, for 1958-1962.

in Franklin County and near the "spring" at Upper Chateaugay Lake in Clinton County. On October 25 a male moose, 2½ years old and weighing 830 pounds, was shot in the Rocky Brook section on the west side of Upper Chateaugay Lake in the Town of Bellmont in Franklin County. Two other moose were reported to have been with this male, and a female was rumored to have been shot (but not recovered) in the same area about 2 weeks later. One of these is believed to have been the moose that was seen crossing from Canada in 1958-59.

In 1963, Carl Prue reported the tracks of a small moose about March 1 along the Deer River about 3 miles north of the Everton Road in the Town of Brandon in Franklin County. Also during March, Father Mayo saw moose tracks in the same town near Skerry.

In 1966, William Benson, State wildlife trapper, saw the tracks of two moose near Streeter Lake in St. Lawrence County in late September, and it was reported to him that a full-grown cow and a small bull had been seen. The following spring, Carlos Law, caretaker at the Schuler estate at Streeter Lake, found two legs of a moose in a ditch beside a road about ¼ mile northeast of the lake and about 2 miles from where Benson had seen tracks the previous fall. This moose had apparently been killed in the early winter.

In 1967, Mr. and Mrs. Woods of Reynoldston sighted a moose from their car near the Brandon-Dickinson town line on October 12, and on November 7 Thomas Campbell of Skerry a few miles to the east saw a moose track in his potato field.

Beginning with the one seen in 1936, at least 13 different moose have wandered into New York (Figure 1). Only one is known to have left the State. The other 12 all disappeared in the Adirondacks, and only two are known to have been shot. It would seem from these records that the life expectancy of a moose that wanders into the Adirondacks is much less than 1 year. Only one is known to have survived as long as 12 to 15 months.

MOOSE HABITAT AND ECOLOGY

Available information on the environmental requirements of moose has been reviewed, and pertinent data are summarized. Habitat is considered to include soil, climate, topography, cover and food. The relationships of moose and deer where they occupy the same range are also discussed.

HABITAT REQUIREMENTS

The habitat requirements of moose and the environmental factors limiting moose distribution and abundance are rather sketchily documented.

SOIL Moose range in North America extends over many soil types, but no importance has been placed on associating the soil type with the presence of moose. However, the vast majority of the range is on strongly acid soils. Very little has been done in the way of relating soil deficiencies to the existence of moose, their population density or their physical size. Telfer (1965), referring to available information on soil types in Nova Scotia, found no serious deficiencies in any element including cobalt. Nevertheless, soils are important because they influence the vegetation which provides cover and food. Cover, in turn, affects the microclimate in which moose exist.

CLIMATE AND TOPOGRAPHY Several studies have been made in an attempt to relate climatic conditions to the distribution of moose. Telfer (1965, 1967a, 1967b, 1968b) considered the relationship between snow depth and distribution. He and Des Meules (1962) showed that snow depths in excess of 36 inches severely limited the movements of moose. Des Meules (1964) reported a minimum bedding depth of 24 inches and a maximum of 40 inches. Where topography was involved and snow depths were greater at higher elevations, moose tended to move to higher ground to find a yarding area where snow depths were optimum for bedding. Telfer (1967a) found in Nova Scotia that moose tended to stay the year around at elevations above 600 feet. However, this was probably because of the climate, food and shelter at those elevations.

Temperature has not been shown to affect the distribution of moose, but it may influence their seasonal movements. In mountainous western range, seasonal migrations take place (Hosley, 1949; Spencer and Chatelain 1953). Moose winter in the lowlands then migrate to the uplands for the summer and fall. They have been seen at timberline during the summer (Telfer, 1965-66). Moose do not frequent the tundra or sub-alpine types (Pimlott, 1953; Telfer, 1965-66). In Michigan (Hickie, 1938), Newfoundland (Pimlott, 1953) and New Brunswick (Telfer, 1968b) where differences in elevation are minor, moose still move about from place to place, but food and cover may be the more important underlying causes.

COVER The boreal zone with its associated plant communities includes the vast majority of North America's moose range. Moose are resident from Newfoundland to Alaska. Established populations are found as far south as Wyoming, northern Michigan, northern Minnesota, Maine and New Hampshire. Originally moose were found in larger areas of Wyoming, Montana, Michigan, and Minnesota and were also resident in Wisconsin, Vermont, Massachusetts, New York and Pennsylvania (Hosley, 1949). The cover over much of their original range consisted of mixed hardwoods and conifers. Such areas are a transition between southern hardwoods and boreal forest.

The present population occupies areas where the predominent climax forest is coniferous. In the Northeast this consists chiefly of white spruce (*Picea glauca*), red spruce (*P. rubens*), black spruce (*P. mariana*), balsam fir (*Abies balsamea*) and tamarac (*Larix laricina*). Hardwoods associated with these conifers are paper birch (*Betula papyrifera*), pin cherry (*Prunus pennsylvanica*), choke cherry (*P. virginina*) and quaking aspen (*Populus tremuloides*). On the southern limit of the range several maples (*Acer* sp.), ashes (*Fraxinus* sp.), yellow birch (*B. lutea*), gray birch (*B. populifolia*), beech (*Fagus grandifolia*) and black cherry (*P. serotina*) are common in the overstory. Preferred moose habitat is characterized by flat to moderately hilly terraine with coniferous lowlands and swamps interspersed with ridges of mixed hardwoods and conifers. Where present, old burns are an extensively used cover type.

FOOD Food preferences are of interest in relation to competition between moose and deer (*Odocoileus virginianus*) for the same species and for the total food supply available. Information pertinent to conditions in the Adirondacks is summarized by season.

Mech (1966) reported that on Isle Royale in Michigan the preferred summer browse was sugar maple (*A. saccharum*), mountain maple (*A. spicatum*), mountain ash (*Sorbus aucuparia*), paper birch, yellow birch, aspen (*Populus* sp.), willow (*Salix* sp.), pin cherry and red-osier dogwood (*Cornus stolonifera*). During this season moose also feed on aquatic plants. Preferences in central Ontario, as reported by de Vos (1958), were — early June: horsetail (*Equisetum* sp.); June and July: eel grass (*Vallisneria americana*), pondweed (*Potomogeton* sp.), yellow pond lily (*Nuphar advena*) and bulrush (*Scirpus* sp.); from July through September: eel grass and pondweed. He also found wild rice (*Zizania* sp.) to be heavily used where available.

With respect to winter and spring, Dyer (as reported by Hosley, 1949) found that the principle browse species eaten by moose in 12 yards in the Mt. Katahdin region of Maine were balsam fir, mountain maple, striped maple (*A. pennsylvanicum*), mountain ash, paper birch, pin cherry and aspen. However, these were also the predominant species present, and they were eaten at roughly the same rates as their availability except for paper birch which was taken to a much lesser degree. In Newfoundland, Bergerud *et al.* (1962) found paper birch to be the preferred winter food species, while balsam fir provided the staple (90 per cent) diet. Under penned conditions an adult moose consumed 67 pounds of balsam fir and 11 pounds of paper birch per day. Others (Des Meules, 1961, 1962; Hickie, 1938; Jordan, 1964) have reported similar findings elsewhere. Also in Newfoundland, Pimlott (1953) used ground hemlock (*Taxus brevifolia*), paper birch and balsam fir as indicies of browse use and found that, where there was an overpopulation of moose, browsing on white spruce was evident.

MOOSE — DEER RELATIONSHIPS

In the Northeast, moose and deer occupy similar habitat and feed on the same browse species. Where their ranges overlap, as would be the case if moose were stocked in the Adirondacks, they compete, in various degrees, for food and shelter. In such situations, any substantial increase in one species tends to be achieved at the expense of the other. This relationship, as well as their combined effect on the environment, must be considered in evaluating the desirability of introducing one species on range already occupied by the other. Therefore, data from parts of southern Canada where the ranges of moose and deer now overlap are of interest.

A study of this relationship is being carried on by Telfer (1967a, 1967b, 1968a) in Nova Scotia where deer are the introduced species. All elements essential to both moose and deer are present in the soils there, and browse supplies were considered adequate. The deer have done well where old farmland has reverted to hardwoods and where logging or fire has created large areas of sprouting hardwoods and secondgrowth. He estimated the average population densities on a five-county study area along the eastern mainland of the province to be 1.6 moose and 10 deer per square mile. However, the areas occupied by the two species were found in general to be separate. On his study area moose very largely stayed the year around on a plateau[2] that begins at about 400 feet elevation and reaches a maximum of 925 feet. They wintered chiefly above 600 feet. Although deer moved into this area during the summer and fall, they returned to lower elevations as snow accumulated, and their winter concentration areas were mostly below 600 feet.

Telfer (1968b) also studied this relationship on an area in New Brunswick where the maximum elevation was 375 feet. He observed no general movement of either moose or deer that could be related to differences in elevation. The two species tended to use the same cover types during late winter and spring. Their actual wintering grounds, however, overlapped on only 1 per cent of the area. Temperatures in comparable stands of red spruce in wintering grounds of the

[2]Part of the Cobequid Hills, a plateau area of about 1,000 square miles.

two species averaged 4°F. higher in the one used by deer. Moose "yarded" where snow depths ranged up to 34 inches, but deer never yarded in snow over 22 inches deep.

As already mentioned, moose rely heavily on balsam fir and paper birch for winter food in Newfoundland and Quebec. But, on the southern limit of their range in Ontario and Maine, the maples and other hardwoods which are staple foods of deer occur more frequently in their winter diet. Moreover, an adult moose eats 50 to 60 pounds of browse per day (Bergerud *et al.,* 1962) while an adult deer eats only 4 to 6 pounds (Maynard *et al.,* 1935). Also, moose normally browse a stratum from 3 to 8 feet from the ground, while deer browse from 0 to 5 feet. And moose damage to small trees is often severe because they are prone to ride down saplings and break them off to obtain food. Thus, moose would have a detrimental effect on the food supply of deer where the two species occupied the same wintering grounds. However, moose can move freely in deep snow where deer are restricted, and, as observed in Nova Scotia by Telfer, the two seldom winter in the same areas.

In the Adirondacks winter is the critical period for deer, and where deep snows occur they concentrate in the same lowland wintering areas year after year. Any competition with moose for food would be most important in these localities. Furthermore, in the central Adirondacks where the possibility of establishing moose would be greatest, it is unlikely, because of the topography, that moose would winter in separate areas.

SUITABILITY OF THE ADIRONDACKS FOR MOOSE

The Adirondack Forest Preserve together with the Tug Hill plateau may be considered broadly to constitute the potential moose habitat in the Adirondack region. This area comprises nearly 2½ million acres. Although elevations range from about 1,500 feet to over 5,000 feet and sections are mountainous, a large proportion of the area is only moderately hilly with many lakes, ponds and swamps. Soils are moderately coarse-textured and strongly acid and occur on glacial till emanating from granite rock (Cline, 1955). Mean temperatures range from 55° to 65° F. in June, and from 10° to 20° F. in January. Mean annual snowfall ranges from 60-80 inches along Lake Champlain to 160-180 inches on Tug Hill (Mordoff, 1924).

Cover types vary from mixed hardwoods and pine to spruce and fir. In general mixed hardwoods are found on south- and east-facing slopes, while spruce and fir predominate on north slopes and in acid bogs (Smith, 1955). All of the principal foods of moose are present in various degrees of abundance, except for ground hemlock which has been largely eliminated by deer. The shrubs usually associated with northern hardwoods are also present.

All the basic environmental requirements for sustaining a moose population appear to be present in the Adirondack region. However, virtually all habitat suitable for moose is already overstocked with deer. Since both species depend on browse for their food, they would compete for the available supply. Competition would be most significant with respect to winter range. Although major winter foods of moose in southern Canada, such as balsam fir, paper birch and ground hemlock, are less plentiful in the Adirondacks, moose would find the browse used by deer a satisfactory alternative.

The ridges in the vicinity of coniferous valley-bottom wintering grounds are essential feeding areas for deer during the early winter and in early spring. They would also constitute the habitat preferred by moose throughout the winter. Since the rate of browse consumption by moose is 5 to 10 times that by deer, any appreciable population of moose would severely reduce the common food supply. This would cause the deer to feed to a greater degree within the wintering ground itself than they usually would and increase the possibility of overbrowsing. Wintering grounds already overbrowsed, or nearly so, would deteriorate at an accelerated rate. The resultant lowered overall carrying capacity for deer would be followed by a decline in population.

It might be theorized that the presence of a few small groups of moose in the Adirondacks would be worth the loss of deer that might be involved. However, it is not realistic to expect that such a situation could be maintained. If such a group were to become established and thrive, other suitable habitat would be occupied as time went on. But there is no evidence that the liberation of any reasonable number of moose would be successful. Like other animals released in a strange environment, liberated moose would wander, often substantial distances. Thus it would be extremely difficult to establish an effective breeding nucleus at any chosen site. Also, even in localities that are "remote" for the Adirondacks, substantial mortality from illegal hunting would be likely. But, in any case, the paramount factor that would probably cause a moose-stocking project to fail is disease.

MOOSE DISEASE

For many years there have been reports from the southern part of its range of unexplained mortality among moose that was ascribed to "moose sickness". Recent findings indicate that a nematode (roundworm), *Pneumostrongylus tenuis,* is the cause of the malady. The parasite affects the cerebrospinal nervous system, and Anderson (1965b) demonstrated that it has little pathologic effect on white-tailed deer but is deadly to moose.

CHARACTERISTICS AND SIGNIFICANCE

Moose sickness or moose neurologic disease as described by Anderson (1965b) is "characterized by locomotor ataxia, general and lumbar weakness, apparent deafness and blindness or impaired vision, fearlessness, listlessness, circling (often associated with peculiar positions of the head and neck), and paraplegia. It is found in moose of all age groups at all periods of the year. . . . Death often follows paraplegia which may be considered as a frequent terminal stage of the disorder." It has been reported in moose from New Brunswick and Nova Scotia (Smith *et al.,* 1964), Maine (Behrend and Witter, 1968), Ontario (Anderson, 1965a) and Minnesota (Kurtz *et al.,* 1966).

Anderson (1965b) commented on the occurrence of the disease in moose and its relationship to deer as follows:

> "Moose neurologic disease is a common and widespread phenomenon on the southern fringe of moose distribution in continental eastern North America having been reported in Minnesota, southern Ontario, southern Quebec, Maine, New Brunswick and Nova Scotia. . . . the known distribution of the disease indicates its occurrence only in regions where white-tailed deer and moose overlap in abundance. We are then able to explain its absence in such places as Newfoundland and Isle Royale where there are no deer.
>
> "Moose are considered by many specialists as more recent arrivals to North America from Eurasia. Possibly there was not originally too much contact between moose and white-tailed deer because one was confined largely to the southern parts of the continent and the other to the northern parts. There seems to be considerable evidence that the white-tailed deer has recently extended its range northward and increased markedly in areas where moose were once predominant. Thus, moose may first have been exposed on a large scale to *P. tenuis.* a parasite to which they are apparently highly susceptible and poorly adapted (cf. the pathogenicity in deer and moose) within recent times. This would help to explain the lack of well-authenticated records of this rather spectacular disease prior to about 1912 and why it seems to occur precisely in those areas on the southern limits of moose distribution where moose and deer come into contact in greatest numbers."

Other studies have also provided evidence of the significance of the disease. Karns (1967) concluded that, in Minnesota, it was probably responsible for the major population decline of moose in the 1920's and 1930's. In Nova Scotia, Telfer (1967a) found that in the Cobequid Hills a population of moose thrived apparently because it occupied an area little frequented by deer, but he also stated that "The decline of moose in the rest of Nova Scotia has been linked to "moose disease" by Benson (1958) and Dodds (1963)."

THE CAUSATIVE ORGANISM

The nematode, *Pneumostrongylus tenuis,* occurs in the brain and spinal cord of wild cervids (deer, moose, elk, caribou) and sheep. It has been found among deer throughout eastern North America at least as far south as Virginia, and its incidence has been shown to be directly related to the density of the deer population, i.e., the greater the density of deer, the greater the incidence of the parasite. Anderson (1963) described its incidence and development in deer.

LIFE CYCLE The adult worms are found in the subdural space, especially of the cranium, and also in the cranial sinuses which are possibly more important locations especially in long-standing infections. There they deposit their eggs. Upon hatching, the larvae enter small blood vessels near the egg masses and are carried to the lungs where they break out into the alveoli (air cells). Eggs are also deposited directly into the blood stream and are carried to the lungs in great numbers where they form minute, scattered embolisms that become fibrosed. The larvae from these eggs also enter the alveoli. From the lungs, these first-stage larvae move up the respiratory tract, are swallowed, and are passed out in the feces.

The larvae then infest a snail or slug which serves as intermediate host. In Nova Scotia, Parker (1966) reported at least 20 species of snail and five species of slug to be potential intermediate hosts of *P. tenuis*. Essentially the same species of snail were reported for Algonquin Park in Ontario by Anderson (1965b). All are terrestrial and were found in all forest types. Snails of this sort are distributed generally throughout the Northeast. Whether aquatic snails harbor the parasite was not determined.

Deer become infected when they ingest infected mollusks with their food. Snails and slugs are particularly common in the spring and are found on vegetation in wet situations. Areas of high infection are where deer concentrations are greatest at this time. Presumably the same would be true for moose.

After being ingested, the larvae find their way to the cranial and spinal region and develop into adult worms. The following note by Anderson (1965b) is of interest.

> "A remarkable feature of the life cycle is the fact that the early development of *P. tenuis* in deer takes place in the parenchyma of the spinal cord — mainly in dorsal horns. The medulla oblongata is sometimes invaded but rarely other regions of the brain. By 40 days, however, worms leave the parenchyma and move into the spinal subdural space where they mature. They tend to accumulate thereafter in the cranial region and they may penetrate the cranial dura mater and enter the intercavernous sinus behind the pituitary fossa. Infected fawns start to pass larvae 82-91 days after infection."

INCIDENCE IN DEER Wherever *P. tenuis* has been found in white-tailed deer the incidence of infection has been high. In Ontario, adults were found in 41 per cent of 172 adult deer, but a much higher percentage were passing first-stage larvae in their droppings

(Anderson, 1965b). In Minnesota, Karns (1967) found adult worms in 49 per cent of 140 heads examined. He also reported that all deer over 4½ years old were infected and that the rate of infection ranged from 68 per cent at high deer population densities to 39 per cent when densities were lower. In Maine, Behrend and Witler (1968) found the parasite in 84 per cent of 196 heads of deer of all ages, the incidence in adults being 90 per cent and that in fawns 66 per cent. They concluded that *P. tenuis* occurred in all parts of Maine. In Pennsylvania, Alibasoglu *et al.* (1961) found it in 80 per cent of 80 deer heads examined. In Virginia, Dudak *et al.* (1965) found it in 68 per cent of adult males examined and in 80 per cent of females over 1½ years old.

In New York, as reported elsewhere in this issue, Behrend (1970) found that 77 per cent of 180 deer heads from the Adirondack region contained this parasite. Incidence was independent of sex and geographic location within the region, but it was directly related to the age of the deer.

EFFECT ON MOOSE The general symptoms of moose disease have been described. However, little is known of the specific effects of the parasite on an infected animal. Anderson (1965b) reported that, after 3 weeks, moose calves experimentally infected with larvae of *P. tenuis* shed from deer became lethargic and seemed unwilling to rise. Worms were found in the brain as well as within the subdural spaces, especially of the spinal cord where extensive traumatic lesions were found throughout. He commented further as follows:

> "...although development of *P. tenuis* in moose was similar to that in deer in the sense that worms, developing mainly in dorsal horns, were at the same level of development as they would have been in deer at comparable times, the amount of traumatic damage done to the parenchyma was much greater. Several factors contributed to bring this about. Firstly, worms invaded and damaged the central canal. Secondly, worms coiled upon themselves in the dorsal horns and inflicted considerable traumatic damage to surrounding tissues; indeed in some places dorsal horns were largely replaced by worms. Thirdly, worms stayed an abnormally long time in the cord and, as growth continued normally, their size alone became a factor in the amount of damage done. Fourthly, the calves seemed to lack resistance to the infection as indicated by the fact that we were able to account for 41 of the 200 worms used for infecting one of the calves; this is a recovery far in excess of that which we have come to expect in deer given even double the number of infective larvae."

DISCUSSION

At the time moose were plentiful in the Adirondacks, deer were virtually absent, and they disappeared at about the time deer began to be numerous there. Whether or not moose disease was a factor will never be known, but current evidence of the incompatibility of moose and deer makes it a possibility.

In addition to the liberations of moose in the 1890's and early 1900's that have been noted, elk were also stocked in the region. Between 1895 and 1906 about 275 elk were released, the number at any one point, in any one year, varying between four and 51. They were liberated in Litchfield Park (Hamilton County), Nehasane Park (Herkimer County), Forked Lake (Hamilton County), Whitney Preserve (Hamilton County), Racquette Lake (Hamilton County), Bay Pond Park (Franklin County), Saranac Inn (Franklin County), Paul Smith's (Franklin County), Big Moose Lake (Hamilton-Herkimer Counties), Harris Lake (Essex County), Woodruff Pond (Essex County), Lake George (Warren County) and Tongue Mountain (Warren County). In 1916, a carload (possibly 25 animals) was liberated in the Adirondacks. In 1932, six animals, all adults, were liberated at the De Bar Mountain Game Refuge (Franklin County). None of these liberations resulted in the establishment of a population. In most instances some animals survived for several years, but the exact cause of their disappearance was unknown. In all probability, poaching was a significant factor. However, recent studies (Anderson *et al.,* 1966) have indicated that *P. tenuis,* the cause of moose disease, is apparently fatal to elk also.

Neither deer nor moose were native to Newfoundland, and deer have never been introduced. Records compiled by Pimlott (1953) show that a bull and a cow were liberated in 1878 and that two bulls and two cows were liberated in 1904. The first pair apparently did not thrive. The second introduction, however, has resulted in a population of some 40,000 that is distributed over the entire island. It seems more than coincidence that this took place in the absence of deer.

Similarly, Isle Royale in Lake Superior, which has no deer, supports a moose population of about 600. Mortality is primarily due to predation by wolves (Mech, 1966).

In spite of the presence of deer, sparce populations of moose persist in the Upper Peninsula of Michigan, northern Vermont and northern New Hampshire. The range in Michigan is peripheral to Ontario range that is occupied by a substantial moose population. Pimlott and Carberry (1958) observed that "moose probably filter in from Ontario and . . . this ingress may be important in maintaining a Michigan moose population." The range in New Hampshire, and secondarily that in Vermont, is peripheral to that of Maine where moose are more abundant. Perhaps recruitment from Maine is a factor in maintaining moose in New Hampshire and Vermont. However, New York has no adjoining moose population. Those that have been recorded from within the State in recent years must be considered as wandering strays.

CONCLUSIONS

Moose were native to the Adirondacks, and the habitat there appears to still be suitable for the species. Deer now occur throughout the potential moose habitat. If moose were introduced, they would compete seriously with deer for the common food supply in any area where they became established. However, conceding the effect on deer in selected localities, and assuming that the other difficulties of establishment could be overcome, the evidence indicates strongly that moose disease would doom any stocking effort to failure. This conclusion is corroborated by the findings of Behrend (1970).

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DSTRIBUTION OF LARVAL DIGENETIC TREMATODES IN A PART OF LAKE CHAMPLAIN AND THEIR RELATIONSHIPS WITH FISH AND WILDLIFE[1]

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ABSTRACT

During the period from 1961 to 1968, a total of 6,887 snails were collected from eight different sites in Lake Champlain in the vicinity of Plattsburgh and were isolated individually in lake water according to genus and species. Each snail was examined daily for one week for shed trematode cercariae. The number and name of each type of cercaria observed were recorded for each genus of snail. Ten families of digenetic trematodes were represented. The relationships of each type of trematode with its definitive host are discussed to indicate the importance of these parasites to the health of their fish, bird and mammal hosts.

There are approximately 200 species of digenetic trematodes known. The adults parasitize a wide range of vertebrates, including amphibians, fish, birds and mammals. Larvae parasitize both invertebrates and vertebrates which are usually involved in a food chain to the definitive host (the host that harbors the sexually mature parasites). The eggs of these trematodes are passed out of the bodies of the definitive hosts in feces or urine. Continuation of the life cycle depends upon these eggs reaching the proper environment for survival and access to the first intermediate hosts.

The distribution of digenetic trematodes is dependent upon the distribution of molluscs suitable as intermediate hosts. The definitive host may disseminate the trematode eggs throughout its range of movement, but, if the proper molluscs are not present to receive the larval parasites, the trematodes will fail to complete their development. The types of mollusc living in a given area are, therefore, important to the well-being of game fish, birds and mammals in that the molluscan fauna may become a source of infection by potentially harmful trematodes. Knowledge of the trematodes harbored by vertebrates is of limited value for evaluating parasite hazard unless a study of the molluscan fauna is also made. On the other hand, a study of the molluscan fauna and the types of cercariae which it harbors in a given area can indicate the "trematode risks" to vertebrates in that area. The present study was concerned with the kinds of snails that occur in Lake Champlain in the vicinity of Plattsburgh and the identities of the

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larval digenetic trematodes harbored by these molluscs. The proportion of infections among snails was considered a good indication of the prevalence of each trematode in the study area.

The study area extended along the western shore of Lake Champlain from Plattsburgh Bay to Wickham Marsh just north of Port Kent. The following collecting sites were used (Figure 1):

(A) Scomotion Creek (Dead Creek)
(B) Moffit's Road (drainage ditches)
(C) Crab Island
(D) Valcour Island
(E) Valcour Educational Center
(F) Ausable Point State Park
(G) Ausable Point wildlife conservation area (behind towers of radio station WEAV)
(H) Wickham Marsh

MATERIALS AND METHODS

All of the collecting sites, except two, are easily reached by road; sites C and D are reached only by boat. The boat "Argo" of the State University College at Plattsburgh was used to collect at these sites. The work was carried on from 1961 to 1968.

Snails were either picked up by hand or dipped out of the water with a tea strainer attached to a broom handle. All snails were isolated individually in jars and vials of appropriate sizes with lake water and small pieces of lettuce for food. Each was labelled showing date collected, site, genus and type of snail, and they were then separated according to collecting site and genus.

Observations were made daily over a 1-week period. When possible, each trematode cercaria shed by a snail was identified and recorded for that snail. The total number of infections by each trematode was recorded for each snail species. This was done daily and continued for all collections at each site. After all these observations were made, the uninfected snails were returned to the sites where they had been collected, while the infected snails were maintained in aquaria for use in teaching and research.

RESULTS

Site F contained the most snail species, followed, in decreasing order, by sites, A, D, B, G, C, E and H (Table 1). The snail with the widest distribution was *Lymnaea palustris* which was found at six of the eight sites. The other snails identified, in decreasing order of dis-

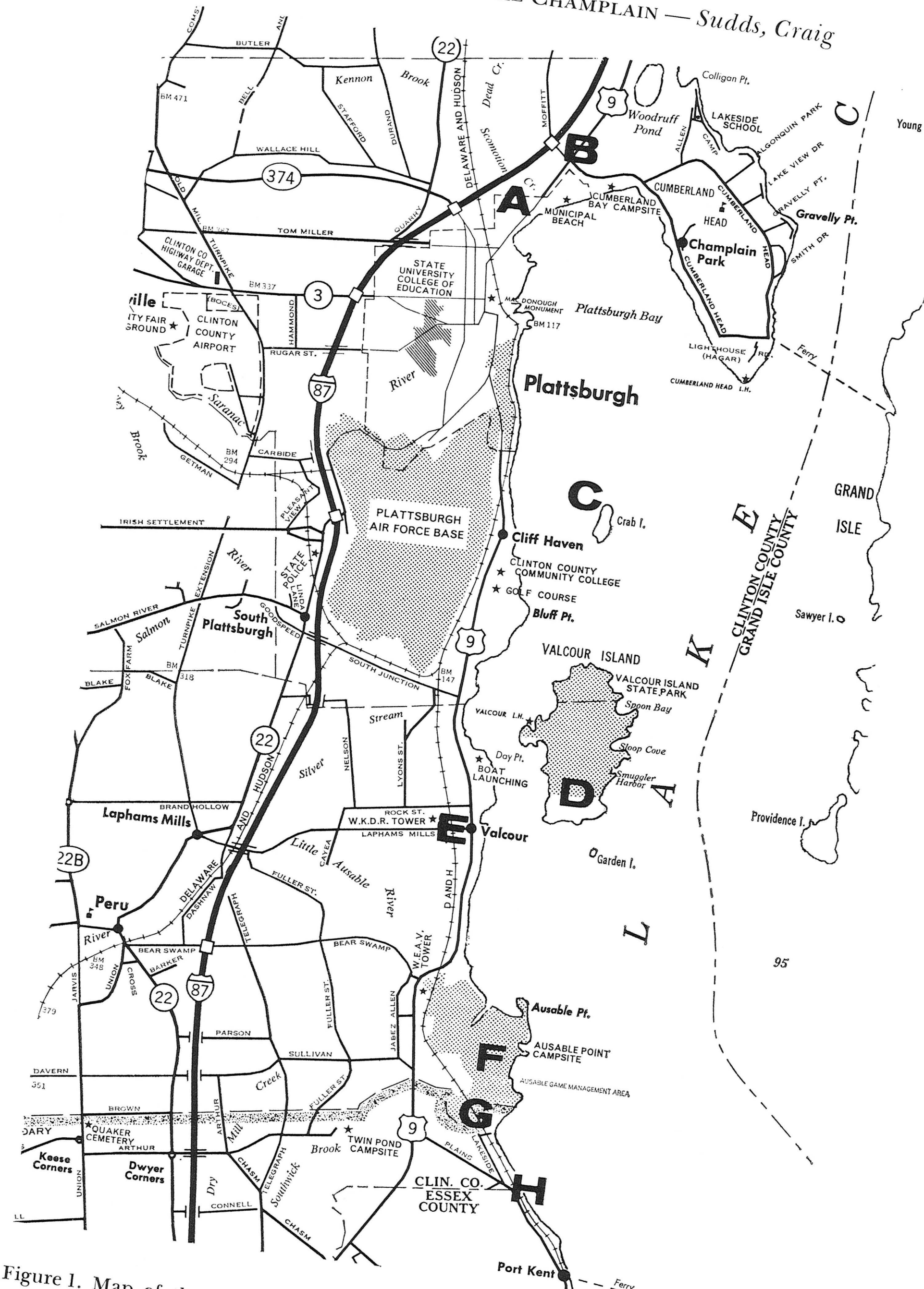


Figure 1. Map of the part of Lake Champlain studied showing location of collecting sites.

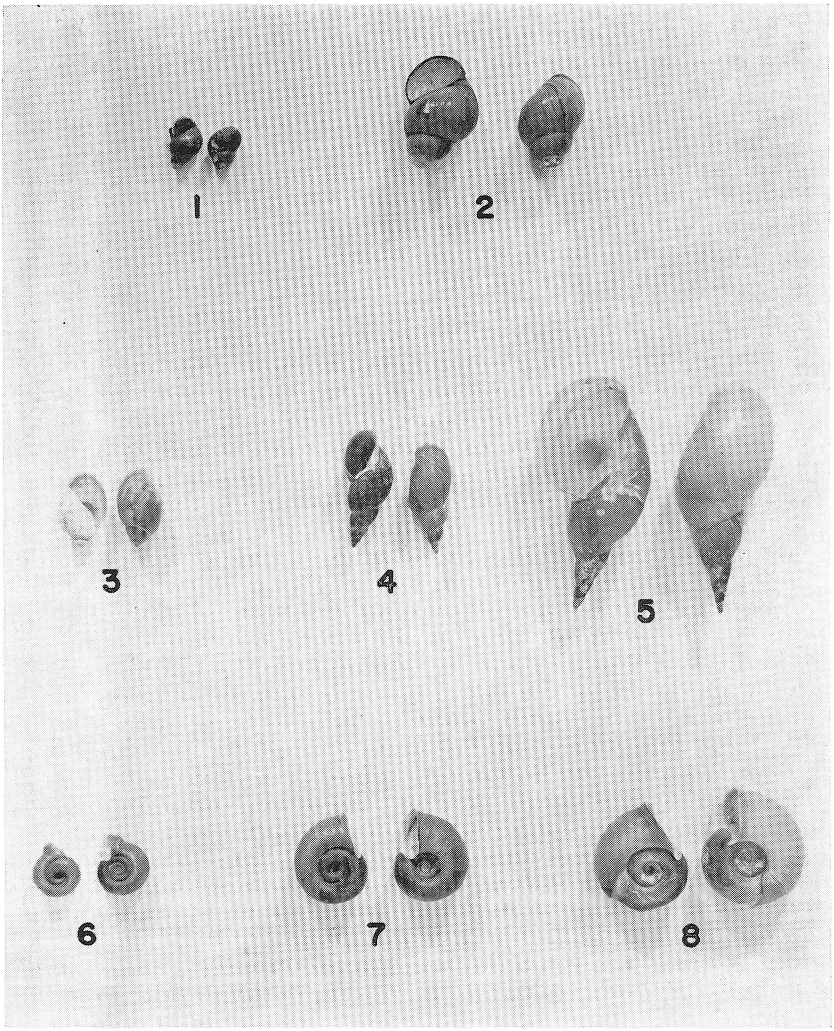
TABLE 1. NUMBER OF EACH SPECIES OF SNAIL COLLECTED AT EACH SITE

Species	Collection site								Total
	A	B	C	D	E	F	G	H	
Lymnaea stagnalis	1,042	0	0	0	0	709	486	1	2,238
L. palustris	254	1,702	0	3	0	199	231	10	2,399
Helisoma trivolvis	153	32	0	0	0	55	79	0	319
H. pseudotrivolvis	0	0	0	0	153	304	41	0	498
H. campanulatum	1	0	1	19	0	25	0	0	46
Physa sp.	434	156	6	9	0	49	0	0	654
Gyralus sp.	128	85	0	0	0	0	0	0	213
Stagnicola emarginata	0	0	45	6	362	0	0	0	413
Campeloma rufum	0	0	0	3	0	18	0	0	21
Bulimus tentaculata	39	0	0	0	0	0	0	0	39
Planorbula sp.	0	0	0	0	0	40	0	0	40
Armiger sp.	0	0	0	0	0	7	0	0	7
Total	2,051	1,975	52	40	515	1,406	837	11	6,887

TABLE 2. NUMBER OF EACH SPECIES OF TREMATODE COLLECTED AT EACH SITE

Species	Collection site								Total
	A	B	C	D	E	F	G	H	
1. *Trichobilharzia elvae*	13	0	0	0	0	15	8	0	36
2. *Cercariae bessiae*	2	0	0	0	0	0	0	0	2
3. *Haplometrana* sp.	1	0	0	0	0	0	0	0	1
4. *Lechriorchis* sp.	17	0	0	0	0	0	0	0	17
5. *Haematoloechus* sp.	15	21	0	0	0	0	0	0	36
6. *Gigantobilharzia* sp.	2	0	1	0	0	0	0	0	3
7. *Cotylurus flabelliformis*	8	0	0	0	0	10	0	0	18
8. *Diplostomum flexicaudum*	34	0	1	4	88	173	2	0	302
9. *Plagiorchis* sp.	11	0	0	0	170	13	0	0	194
10. *Spirorchus parvus*	4	5	0	0	0	0	17	0	26
11. *Megalodiscus* sp.	30	0	0	0	0	0	0	0	30
12. *Clinostomum* sp.	6	0	0	0	0	15	0	0	21
13. *Halipegus* sp.	16	3	0	0	0	0	0	0	19
14. *Notocotylus* sp.	17	13	0	0	0	0	0	0	30
15. *Trichobilharzia physellae*	0	0	0	1	0	0	0	0	1
16. *Schistosomatium douthitti*	75	192	0	0	0	72	26	0	365
17. Strigeid cercariae	0	0	7	1	0	0	10	0	18
18. Stylet cercariae	329	260	1	3	33	143	57	2	828
Total	580	494	10	9	291	441	120	2	1,947

tribution, were *Physa* sp., *Helisoma trivolvis, Helisoma campanulatum, Lymnaea stagnalis, Helisoma pseudotrivolvis, Stagnicola emarginata, Gyraulus* sp., *Campeloma rufum, Bulimus tentaculata, Planorbula* sp. and *Armiger* sp. Most of these are illustrated in Figure 2.



1. *Bulimus tentaculata*
2. *Campeloma rufum*
3. *Physa gyrina*
4. *Lymnaea palustris*
5. *Lymnaea stagnalis*
6. *Helisoma campanulatum*
7. *Helisoma pseudotrivolvis*
8. *Helisoma trivolvis*

Figure 2. Shells of some of the snails recorded.

The largest number of trematode genera was found at Site A, followed, in decreasing order, by Sites F, B, G, C, D, E and H (Table 2). Stylet cercaria infections were found in all areas. Cercariae of the following species, according to their degree of distribution among the collecting sites, were identified: *Diplostomum flexicaudum, Schisto-*

TABLE 3. NUMBER OF EACH SPECIES OF TREMATODE RECORDED FOR EACH SPECIES OF SNAIL AND DEGREE OF INFECTION IN SNAIL POPULATION*

Species of Snail	Species of Trematode §																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Lymaea stagnalis																		
Number	36	..	..	..	..	..	18	206	23	..	..	..	..	..	..	136	3	289
Per cent	1.6	..	..	..	..	..	0.8	9.2	1.0	..	..	..	..	..	..	6.1	0.1	12.9
L. palustris																		
Number	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	239	8	379
Per cent	..	..	..	..	..	..	..	0.1	..	..	..	..	..	..	..	10.0	0.3	15.8
Helisoma trivolis																		
Number	..	2	..	..	..	..	..	..	..	9	30	22	..	..	..	..	..	45
Per cent	..	0.6	..	..	..	..	..	..	..	2.8	9.4	6.9	..	..	..	..	..	14.1
H. pseudotrivolvis																		
Number	..	..	..	..	..	..	..	..	..	17	..	21	..	..	..	..	..	89
Per cent	..	..	..	..	..	..	..	..	..	3.4	..	4.2	..	..	..	..	..	17.9
H. campanulatum																		
Number	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Per cent	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.2
Physa sp.																		
Number	..	..	1	17	..	3	..	..	..	..	..	..	19	28	1	..	..	2
Per cent	..	..	0.2	2.6	..	0.5	..	..	..	..	..	..	2.9	4.3	0.2	..	..	0.3
Campeloma rufum																		
Number	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..
Per cent	..	..	..	..	..	..	..	9.5	..	..	..	..	..	..	..	..	..	..
Gyraulus sp.																		
Number	..	..	36	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Per cent	..	..	16.9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Stagnicola emarginata																		
Number	..	..	..	..	..	..	..	91	170	..	..	..	..	..	..	..	7	4
Per cent	..	..	..	..	..	..	..	22.0	41.2	..	..	..	..	..	..	..	1.7	1.0
Bulimus sp.																		
Number	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Per cent	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5.1
Planorbula sp.																		
Number	..	..	..	..	36	..	..	..	..	..	..	..	..	..	..	..	..	4
Per cent	..	..	..	..	90.0	..	..	..	..	..	..	..	..	..	..	..	..	10.0
Armiger sp.																		
Number	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Per cent	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	28.6

* Percentage of total specimens of each snail collected as given in Table 1.
§ Designated by number according to Table 2.

somatium douthitti, Plagiorchis sp., *Spirorchis parvus, Trichobilharzia elvae, Notocotylus* sp., *Halipegus* sp., *Clinostomum* sp., *Cotyluris flabelliformis, Gigantobilharzia* sp., *Haematoloechus* sp., *Trichobilharzia physellae, Megalodiscus* sp., *Lechriorchis* sp., *Haplometrana* sp. and *Cercaria bessiae.* The distribution of each species of trematode among the collected snails was determined. Frequency of occurrence with respect to each species of snail is summarized in Table 3.

CHARACTERISTICS OF SNAILS IN THE STUDY AREA

Lymnaeid snails are the most abundant aquatic snails in the Plattsburgh area of Lake Champlain (Table 1). They are found in a variety of habitats ranging from wave-swept lake beaches to streams and stagnant marshes. *Lymnaea stagnalis appressa,* the largest lymnaeid snail (average length 3.9 centimeters) is usually found in sheltered lakeshore areas and in quiet inlets of the lake, but it has been collected on sandy beaches with wave action. *Lymnaea stagnalis* may also be found in streams, rivers and stagnant ponds. *Lymnaea palustris elodes* (average length 1.8 centimeters) is found mostly in stagnant or slow-moving water habitats such as swamps, ponds and drainage ditches. This snail is seldom found on the lakeshore and then only in protected "backwater" situations. *Lymnaea palustris* has been collected from drainage ditches and in puddles of water on the center mall of the Northway (Route 87). This snail is present in large numbers in the small ponds associated with the Ausable Point State Park. *Stagnicola emarginata angulata* (average length 1.9 centimeters), another lymnaeid snail of this region, is found almost exclusively on the lakeshore where there is considerable water movement.

The genus *Helisoma* is a planorbid-type (flat-coiled) snail represented by three species in this area. *Helisoma trivolvis* (average diameter of shell 1.4 centimeters) is found in stagnant and slow-moving water and rarely on open lakeshore sites. *Helisoma pseudotrivolvis* (average diameter of shell 1.3 centimeters) inhabits sheltered rocky sections of the lake shore. *Helisoma campanulatum* (average diameter of shell 1.2 centimeters) seemed to prefer lakeshore habitat (Valcour Island and Ausable Point beaches).

Physa sp. (identical to *Physa gyrina* of Michigan) and *Gyraulus* sp. (planorbid-type snails with average shell diameters of 0.7 centimeters) inhabit streams and marshes. The physids which were collected in the vicinity of Ausable Point were located in the inlet at the public fishing area (Site F) and in the wildlife conservation area (Site G).

Campeloma rufum (average length 2.5 centimeters) is found on sandy beaches of the lake where wave action is present. This snail is a scavenger on the organic detritus in the sand and is seldom found on aquatic vegetation.

Bulimus (an operculate snail) and *Gyraulus, Planorbula* and *Armiger* (planorbid-type snails) are found associated with slow-moving streams, shallow pools and marshes. These snails are often found on submerged vegetation, both living and decaying.

LIFE CYCLES AND HOST RELATIONSHIPS

Since digenetic trematodes within a taxonomic order have similar life cycles, the trematode cercariae identified in this study are grouped in their respective orders (according to LaRue, 1938). The general life-cycle pattern is outlined for each order followed by the specific life cycles of the trematodes represented in this paper. Finally, the relationship of each trematode with its definitive host or hosts is discussed.

The order Strigeatida comprises a group of intestinal parasites of birds and mammals which consume fish, frogs and snails. The eggs of these parasites are passed from the definitive host in their feces. Development of the first larval stage (miracidium) occurs within the egg in the water. The ciliated miracidium then emerges from the egg and swims about. When a suitable snail (e.g., *Lymnaea stagnalis*) is contacted, penetration into the snail's body takes place. There, the miracidium develops into a long (5 to 15 millimeters) sac-like organism called a mother sporocyst which produces numerous smaller sacs called daughter sporocysts. These daughters migrate to the digestive gland of the host snail where they attach themselves and produce the fourth larval stage (cercaria). These cercariae escape from the snail and swim about in the water penetrating the tissues of other snails, fish, tadpoles and frogs. Within these animals, the cercariae develop into encysted, resting stages called metacercariae. Infection of the definitive host occurs when it eats the snail, fish, frog or tadpole and ingests the metacercariae along with it. The adult strigeids live attached to the lining of the digestive tract of the definitive host.

The cercariae of *Cotylurus flabelliformis* were found to be emerging from *Lymnaea stagnalis* collected in Scomotion (Dead) Creek and at Ausable Point State Park (Table 2). Ducks become infected with the adult parasites when they ingest snails containing the metacercariae, but the effect of these parasites upon ducks is unknown. Ducks examined by the senior author were parasitized by as many as 50 worms. The intestines of those birds with heavy infections contained large amounts of mucus. According to Edward Gardephe of the New York State Conservation Department (personal communication), both Scomotion Creek and Ausable Marsh have nesting populations of ducks, and the black duck, found in both areas, is an avid feeder upon snails.

Another strigeid-type trematode which was identified during this study is *Diplostomum flexicaudum*. The cercariae of this parasite penetrate fish, e.g., sticklebacks, and develop into metacercariae in the eyes and brain of the fish. Ducks and other fish-eating birds become infected with adult trematodes by ingesting infected fish. The effect of these worms upon the birds is not known. In England, following reports that fish catches in certain rivers were declining markedly, investigation revealed that fish there were being blinded in great numbers by another species of *Diplostomum* and that the population of the snail serving as first intermediate host of the parasite had also increased (Peter Bottomley, personal communication). Organic matter pollution of these rivers was considered partially responsible for the increase in the snail population, particularly snails which feed on algae and/or organic detritus.

The adults of a third strigeid (*Clinostomum*) live in the mouth of the great blue heron. Perch and certain other fish serve as second intermediate hosts. The metacercariae encyst on the body and fins of these fish and undergo extensive development and increase in size. They become prominent as yellow and black spots (sometimes referred to as "grubs") which may attain a size of from 3 to 5 millimeters in diameter. Although these "grubs" have never been known to produce infection in humans, the sight of them deters some people from eating the fish. *Helisoma pseudotrivolvis,* collected from Scomotion Creek and at Ausable Point State Park, was found to be serving as the first intermediate host of this parasite. Herons frequent the Ausable Point area, and perch there were infected with the metacercariae.

While the superfamily Schistosomatoidea is placed in the order Strigeatida by LaRue (1938), the life cycle differs significantly from those already discussed. Snails of this group serve as the first intermediate host, and the cercariae escape from the snail host to swim through the water. However, instead of there being a second intermediate host, the cercariae penetrate the skin of the definitive host. After penetration, the larval parasites (schistosomulae) migrate through the circulatory system to reach the blood vessels surrounding the digestive tract or urinary bladder. Unlike other digenetic trematodes which are hermaphroditic, the schistosomes have separate sexes. The paired adult worms reside in the blood vessels for the remainder of their lives. The fertilized females release numerous eggs into the blood stream which penetrate through the walls of the blood vessels and then move through the wall of the digestive tract eventually entering the lumen of this structure and passing out with the feces. The five larval schistosomes identified in the study area (with their definitive hosts) were: *Trichobilharzia elvae* and *T. physellae* (ducks and geese); *Schistosomatium douthitti* (muskrats); *Spirorchis parvis* (turtles); and *Gigantobilharzia* sp. (birds or mammals). Fortunately, snails naturally infected with human schistosomes are not found in the continental United States.

Observations of the senior author indicate that experimental exposure of ducks to several hundred cercariae of *T. elvae* often produces severe debilitation and death. *Lymnaea stagnalis* serves as the snail host for this parasite, and, of the 2,248 collected, only 36 (1.6 per cent) were found to be infected with this parasite (Table 3). At both areas (Scomotion Creek and Ausable Point State Park) where snails infected with *T. elvae* were found, nesting populations of ducks are present each year. Millions of cercariae may be produced by a small number of infected snails over a period of a few months. While the life span of a cercaria is only about 24 hours, the daily output of fresh cercariae per snail is in the magnitude of thousands. Water currents tend to disseminate them and reduce their concentration in a given area. Nevertheless, the density of cercariae in shallow, sheltered waters may become high even though only a dozen or so infected snails are present. In experimental infections, young ducks are very susceptible to debilitation and death (McMullen and Beaver, 1945; Najim, 1956). If humans enter water containing the cercariae of *T. elvae,* penetration of the skin will occur. These cercariae do not complete development into adult male and female worms in the human body, but frequently produce a dermatitis condition often referred to as "swimmer's itch" (Cort, 1950). "Swimmer's itch" has been reported from numerous locations throughout the United States where ducks and lymnaeid snails coinhabit ponds, lakes and marshes (Swanson *et al.,* 1960). The comments concerning *T. elvae* apply also to *T. physellae* which was found to be infecting one physid snail from Valcour Island (Table 2).

Schistosomatium douthitti is found wherever muskrats and lymnaeid snails co-exist. Both *Lymnae stagnalis* and *L. palustris* serve as intermediate hosts of this schistosome. It is not unusual to find infected snails in the drainage ditches along highways as well as in streams and marshes. It is difficult to assess the effect of *S. douthitti* on the population of muskrats of a given area. Experimental laboratory studies show that heavy infections of muskrats will produce debilitation and death (Price, 1931). In the later stages of such infection (1 to 3 months after the female worms begin to produce eggs) increasing numbers of eggs are carried to the host's liver by the hepatic-portal blood system. These eggs become lodged in the liver tissues with resulting liver pathology (necrosis, granuloma formation and hypertrophy). Cercariae of *S. douthitti* also produce dermatitis in humans, but, since muskrats and infected snails are found in marshes and ditches, this is an occupational hazard to biologists instead of a recreational hazard to swimmers.

A fourth schistosome, *Spirorchis parvis,* was isolated from *Helisoma trivolvis* collected at Scotmotion Creek and the Ausable Point wildlife conservation area. The definitive host of this parasite is the painted turtle (*Chrysemys picta*) which occurs in both of these areas. The senior author has examined snapping turtles (*Chelydra serpentina*) which were infected with *S. parvis* or a related species. Masses of fibrotic tissue, filled with parasite eggs, were observed in the lining of the stomach and intestinal tract. Wall (1941) reported that heavy infections of *Spirorchis* often cause the death of the host.

Species of *Gigantobilharzia* have been described from bird infections (Najim, 1956). The pathology associated with such infections in these vertebrate hosts is essentially the same as that described for *Trichobilharzia* and *Schistosomatium*. The cercariae of *Gigantobilharzia* will produce dermatitis in humans.

Four genera of trematodes which parasitize frogs as adult worms are *Haplometrana, Haematoloechus, Megalodiscus* and *Halipegus*. The adult worms generally locate in the following body areas of the frog and have the indicated snail host. *Haplometrana* cercariae escape from physid snails and encyst on the skin of frogs where they develop into metacercariae. When the shed skin is ingested by the frog (a common occurence) adult worms develop and locate in the host's small intestine. The life cycle of *Megalodiscus* follows a pattern similar to that of *Haplometrana*, except that *Helisoma trivolvis* serves as the snail intermediate host and the adult worms locate in the rectum of the frog. *Haemotoloechus* and *Halipegus* require a second intermediate host in which the metacercarial stage develops. *Planorbula* snails serve as the first intermediate host of *Haemotoloechus;* the second intermediate host is the larvae of aquatic insects, e.g., naiad of the dragonfly. Infection of frog lungs by adult worms occurs when the frog ingests the larvae or adult insects containing the metacercariae. In the case of *Halipegus,* physid snails are the first intermediate host. Cercariae escaping from these snails are ingested by crustaceans (*Cyclops*) in which the metacercariae develop. When infected *Cyclops* are ingested by a tadpole, the metacercariae remain in the stomach of the tadpole until it metamorphoses into an adult frog, after which they migrate to the eustachian tubes and develop into adult worms.

Lechriorchis primus, a lung parasite of the garter snake (*Thamnophis sirtalis*), employs physid snails as the first intermediate host and tadpoles as the second intermediate host. The snake becomes infected by eating tadpoles. On several occasions, garter snakes have been autopsied in which the lungs contained numerous *Lechriorchis* adults. The lung tissues of these snakes appeared to be thicker and more fibrotic than in snakes with no infection. How this condition would effect the health and longevity of the snake host is not known.

Plagiorchid trematodes have a wide range of definitive hosts. The adult worms are intestinal parasites of rodents, dogs, bats, muskrats, gulls, robins, sandpipers and nighthawks. Three plagiorchids that have been described in the literature are: *Plagiorchis muris, P. macracanthus* and *P. proximus*. The plagiorchid life cycle is varied in that the cercariae, which develop in lymnaeid snails (*Stagnicola emarginata* and *Lymnaea stagnalis* in this study), may penetrate aquatic insect larvae or tadpoles to develop into the metacercarial stage. The cercariae may also develop into metacercariae within the snail host. The definitive hosts become infected upon eating these intermediate hosts.

The pathology of plagiorchid infections in these vertebrate hosts has not been determined. It is conceivable that, at least in young animals, these intestinal parasites produce varying degrees of irritation of the mucosa.

The last cercarial type to be identified during this study is *Notocotylus*. Two species of this genus are *N. stagnicolae* and *N. urbanensis*. The first employs *Stagnicola emarginata* as the first intermediate host, while ducks and mergansers are the definitive hosts. Physid snails serve as the first intermediate host of *N. urbanensis* while muskrats and ducks are parasitized by the adult worms. The notocotylid cercariae found in this area were shed from the *Physa* snails collected in areas inhabited by muskrats (Scomotion Creek and Moffit Road-Route 87 drainage ditches — Tables 2 and 3). The cercariae encyst upon vegetation, snail shells and numerous objects in the environment. Infection of the definitive hosts occurs when these objects are ingested. The adult worms reside in the digestive tracts of the vertebrate hosts.

Identification of all the cercariae isolated from collected snails was not possible. One group which was found in all of the collecting areas was designated as "stylet cercariae". The name "stylet" refers to a prominent spine or spear-shaped structure located in the anterior end of the cercaria. Another group of unidentified cercariae resembled cercariae of strigeid trematodes, but specific identification was not possible.

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THE NEMATODE, PNEUMOSTRONGYLUS TENUIS, IN WHITE-TAILED DEER IN THE ADIRONDACKS[1]

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ABSTRACT

A study to determine the incidence of the nematode, *Pneumostrongylus tenuis,* in white-tailed deer in the Adirondack region of New York was conducted in the fall of 1968. Of 180 deer heads examined, 77 per cent were found to contain this parasite. Incidence was independent of sex and geographic location, but it was directly related to age and intensity of examination. Incidence was significantly ($P<0.01$) greater in adults and yearlings than in fawns, and in adults than in yearlings. Examination of the entire brain surface and cavity yielded an incidence of 70 per cent, while only 42 per cent was found by examination of the upper portions only (as might be practiced in some field examinations). Mean number of worms was greater in adults and yearlings than in fawns. Considering problems of collection and examination, and the occurrence and abundance of *P. tenuis,* adult female deer appear to offer the greatest potential for simple studies of regional incidence.

Anderson (1965) demonstrated clearly that the nematode, *Pneumostrongylus tenuis,* has little pathological effect on white-tailed deer (*Odocoileus virginianus*) but is deadly to moose (*Alces alces*). Citing regional and historical evidence of moose disease, and the high incidence of *P. tenuis* in white-tailed deer, he hypothesized that this nematode is the etiological agent of neurologic disease in moose. Recent studies have suggested that moose populations are lowest when and where deer populations are highest (Karns, 1967) and that they are highest where some degree of ecologic separation occurs (Telfer, 1967). Karns (1967) and Behrend and Witter (1968) found further that incidence of *P. tenuis* in deer was directly related to apparent deer population density. Thus, where both cervids coexist, deer populations could conceivably control moose populations via the transmission of this parasite.

The study reported here was made to determine the incidence of *P. tenuis* in white-tailed deer in the Adirondack region of New York in connection with proposals to restock the area with moose. The last

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native wild moose in this region was supposedly taken in 1861 (Merriam, 1886), but irregular reports of moose have continued well into the present century.

MATERIALS AND METHODS

Heads from 180 deer, taken by hunters from October 25 through December 3 in 1968, were collected at checking stations and by individual contacts with hunters. Specimens were identified by number, sex, location and date of kill prior to being placed in cold storage. Age was subsequently estimated to the nearest half year by reference to the tooth replacement and wear patterns described by Severinghaus (1949). To facilitate this, jaws were removed from all specimens except fawns.

Specimens were prepared for dissection by skinning the top and sides of the cranium, and washing the exposed bone to remove loose hair. The top of the cranium and the uppermost portion of the cerebrum were removed by sawing, and the numbers of adult worms found on these portions were recorded. Next, the remaining brain mass was removed and examined, as was the remainder of the cranial cavity. Worms found during this part of the examination were also recorded. Finally, the cavernous sinus was dissected and probed, and worms found therein were recorded.

Data for each head examined were punched on McBee Keysort cards and summarized by sex, age group, county, number of worms and incidence of *P. tenuis* according to type of examination. Incidence was compared by percentage occurrence, and 2 x 2 contingency chi-square (a priori alpha = 0.05) analyses were employed to evaluate differences between age-groups and sexes. Confidence intervals (95 per cent) of the mean number of worms were compared to evaluate the extent of infection among sex-age groups.

RESULTS

Adult *P. tenuis* were found in 139 of the 180 deer heads examined, indicating a minimum incidence of 77 per cent (Table 1); 73 per cent of the 74 males were infected and 80 per cent of the 106 females. Differences between the sexes were not significant for any age group (fawn, yearling or adult) or for all ages combined. Incidence was significantly ($P < 0.01$) greater in adults than in yearlings or fawns, and greater in yearlings than in fawns.

The recorded incidence of the parasite was definitely related to the extent of the examination performed (Table 2). Over-all, incidence rose from 42 to 77 per cent with complete examinations of the cranial

TABLE 1. INCIDENCE OF ADULT *Pneumostrongylus tenuis* IN WHITE-TAILED DEER IN THE ADIRONDACKS ACCORDING TO AGE AND SEX

Age (years)	Male			Female			Total		
		Present			Present			Present	
	Absent	Number	Per cent	Absent	Number	Per cent	Absent	Number	Per cent
½	13	10	43	12	8	40	25	18	42
1½	6	14	70	3	14	82	9	28	76
2½	0	11	100	3	14	82	3	25	89
3½	1	10	91	0	12	100	1	22	96
4½	0	4	100	2	9	82	2	13	87
5½+	0	3	100	1	27	96	1	30	97
Unknown	0	2	100	0	1	100	0	3	100
Total	20	54	73	21	85	80	41	139	77

TABLE 2. INCIDENCE OF ADULT *Pneumostrongylus tenuis* IN WHITE-TAILED DEER IN THE ADIRONDACKS ACCORDING TO AGE AND TYPE OF EXAMINATION

Age (years)	Number of specimens	Incidence (percentage) according to type of examination*		
		I	I & II	I, II & III
½	43	16	40	42
1½	37	38	65	76
2½	28	46	82	89
3½	23	61	87	96
4½	15	40	80	87
5½+	31	64	94	97
Unknown	3	33	67	100
Total	180	42	70	77

*Type I = removal and examination of the upper portions of the brain cavity and cerebrum only; Type II = removal and examination of entire brain and cavity; Type III = dissection and probing of cavernous sinus.

cavity and cavernous sinuses, as opposed to inspection of the upper portions of the cranial cavity and cerebrum only (as might be practiced in some field examinations). Most of the increase, however, was accounted for by the complete inspection of the brain and cranial cavity, which increased the incidence from 42 to 70 per cent. This relationship was consistent throughout the individual age groups.

Maximum and mean numbers of worms found for several sex-age groups are shown in Table 3. Comparisons of the 95 per cent confidence intervals of the means indicate that more nematodes were found in both adults and yearlings than in fawns. Other differences do not appear significant.

TABLE 3. NUMBERS OF ADULT *Pneumostrongylus tenuis* IN WHITE-TAILED DEER IN THE ADIRONDACKS ACCORDING TO AGE AND SEX

Age (years)	Male				Female			
	Number of heads	Number of worms per head			Number of heads	Number of worms per head		
		Maximum*	Mean	Confidence §		Maximum*	Mean	Confidence §
½	10	3	1.9	±0.4	8	2	1.5	±0.4
1½	14	18	6.6	±3.0	14	17	4.8	±2.5
2½	11	10	5.1	±2.3	14	12	4.7	±2.0
3½	10	23	8.7	±4.8	12	8	3.9	±1.6
4½+ ...	7	11	6.0	±3.3	36	11	4.4	±0.9

* Minimum number of worms for each age group was one.
§ At 95 per cent level.

Worms were found in specimens of all age groups from all counties studied, where at least five specimens were examined. Disproportionate sample sizes precluded meaningful statistical analysis, but few significant differences are likely. Where at least five heads were examined per county per age group, incidence ranged from 83 to 100 per cent for adults, and from 67 to 88 per cent for yearlings. Incidence in fawns varied more widely, ranging from 35 to 67 per cent, with the largest sample (N = 23) having the lowest incidence of *P. tenuis*.

Good estimates of deer density were available for one 5,216-acre area near the center of the Adirondacks, based on drives during October. These indicated 27 deer per square mile in 1966 (before intensive hunting began), and 17 and 13 per square mile in 1967 and 1968, respectively, (Behrend *et al.*, 1970). All seven adult and one yearling deer examined from this area in 1968 contained *P. tenuis*.

DISCUSSION

These findings indicate that *P. tenuis* is prevalent in deer throughout the Adirondacks and that incidence approaches the levels found among deer in Maine by Behrend and Witter (1968). The direct relationship between incidence and age group (fawn, yearling, adult) is also consistent with the Maine study[2]. Both studies found a relatively high incidence in fawns, leaving little doubt that large numbers of fawns are infected early in life.

The lack of significant differences in incidence between the sexes is in contrast to findings in both Minnesota (Karns, 1967) and Maine (Behrend and Witter, 1968) where higher incidence was found in

[2]See also: Erratum, Jour. Wildl. Mgt. 33 (2):454.

females. The lack of agreement may have been the result of differences in the seasonal distribution of the sexes, or they may have arisen from the nonrandom sampling employed.

The great variation in the recorded incidence of *P. tenuis* with the extent of the examination clearly documents the need for thorough and standardized techniques if results from different regions are to be compared. While it is clear that the presence of the adult worm in a sample of deer heads can be detected by simple field examination (similar to Type I in Table 2), accurate determinations of incidence require thorough laboratory examination. Problems of collection and examination, and the frequency and abundance patterns of *P. tenuis* found in this study, indicate that adult female deer are the most appropriate specimens for efficient examination. This approach would minimize problems in obtaining deer heads from hunters, who are generally reluctant to part with antlered specimens, and it would provide heads which are both readily skinned and most likely to possess adult worms in high abundance and frequency.

The abundance and widespread occurrence of *P. tenuis* among deer in the Adirondacks make the reintroduction of moose, or the introduction of other cervids, appear ill-advised (see Anderson *et al.*, 1966). Moreover, as the disappearance of the moose from the Adirondacks was correlated in time with the irruption of the white-tailed deer population, it may be that the deer was partially responsible for the decimation of the moose population via disseminating the parasite.

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GENERAL NOTES

AGGRESSION AMONG CAPTIVE MUTE SWANS[1]

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Allan D. Marsters — Technical Assistant, State University College of Forestry at Syracuse University

From June 1967 to January 1969 a study of waterfowl disease was carried out at the Burnet Park Zoo in Syracuse, N. Y. During this time numerous observations were made on the aggressive behavior of three pairs of pinioned adult mute swans (*Cygnus olor*) confined to the zoo pond of less than an acre. The pond was divided into sections by wire fencing, and only one pair was held in a section. The pond also held approximately 110 captive ducks of nine species and 20 geese of six species. In addition, black ducks and mallards flew in daily and some attempted to nest at the zoo pond. During the winter over 200 black ducks and mallards visited the pond each day. The mute swans were considered an important display species because of their popularity with the public, even though they often displayed aggressive behavior toward other waterfowl.

Willey (1968) reported that, in Rhode Island, territories of nesting feral mute swans ranged from 0.5 to 11.8 acres and averaged 4.4 acres. He found that mute swans showed an aggressive attitude toward other swans, ducks, geese or men that entered their territory although, in some cases, Canada geese and puddle ducks nested unmolested within a few yards of mute swan nests.

The entire pond at the Burnet Park Zoo was probably not large enough to provide territory for a single pair of nesting mute swans. In February and March, the swans became increasingly aggressive and attacked and drowned other waterfowl. Most of the severe attacks were carried out by the cobs. During nesting, the pens were seemingly unconcerned by other waterfowl unless they came very close to the nest (Figure 1), but the cobs were almost continuously in a threat posture and chasing other waterfowl. Their nests were unsuccessful, and, with the cessation of nesting, agression by the swans decreased. However, interspecific aggression by mute swans could be observed at the zoo in any month.

In the 20 months of study at the zoo, mute swans killed two adult Canada geese, two Bean geese, two blue geese and two mallards, all of which were pinioned. They also were known to have killed 30 mallard ducklings, six wood duck ducklings and four Canada goose goslings. In January 1969 a cob killed a mallard and a black duck from a visiting flock of unpinioned ducks. More waterfowl would have been killed if they had not been rescued by the zoo staff.

The swans attacked newly hatched ducklings and wiped out an entire brood in a few hours. One cob was particularly prone to this activity (Figure 2). In general, the procedure was to swim rapidly after the brood of ducklings and pick one up, usually by the head. Then the duckling was shaken about on the surface of the water, often for several minutes. After this it was worked on with the bill, with frequent dips beneath the water, and either partly or entirely eaten. Waterlogged pieces of duckling left after a swan attack were observed to sink immediately leaving no evidence of attack. The mallard and the black duck (Figure 3) killed in January 1969 were also partially consumed by the mute swans. Both ducks were autopsied and found to be in good flesh with no evidence of disease. However, their crops were filled with grain and they may have been taken unaware while feeding or had difficulty in getting away because of the mass of grain they were carrying.

Although the zoo environment was crowded and abnormal, the observations seem worth recording. Feral mute swans and other waterfowl nest together on small ponds, and the swans may disrupt nesting or destroy ducklings that are in

[1]The authors are grateful for the cooperation of Charles Clift, Director, of the Burnet Park Zoo, and to Michael Bitsko for the black duck photograph. The research was supported in part by a National Wildlife Federation fellowship.

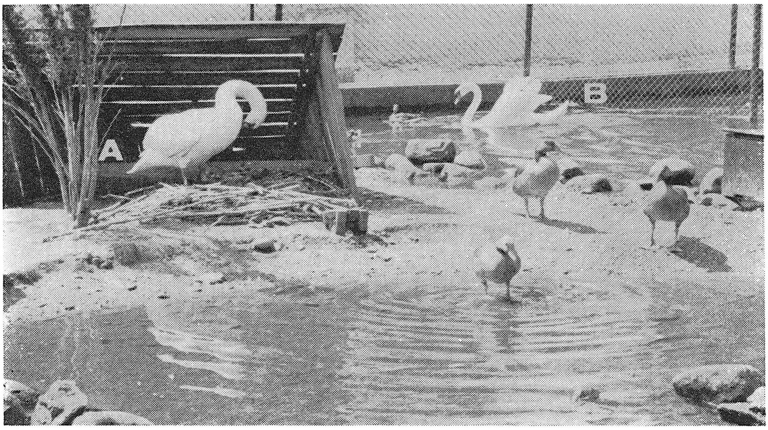

Figure 1. Mute swans: (A) the pen preening on the nest; (B) the cob in a threat attitude chasing a female mallard.

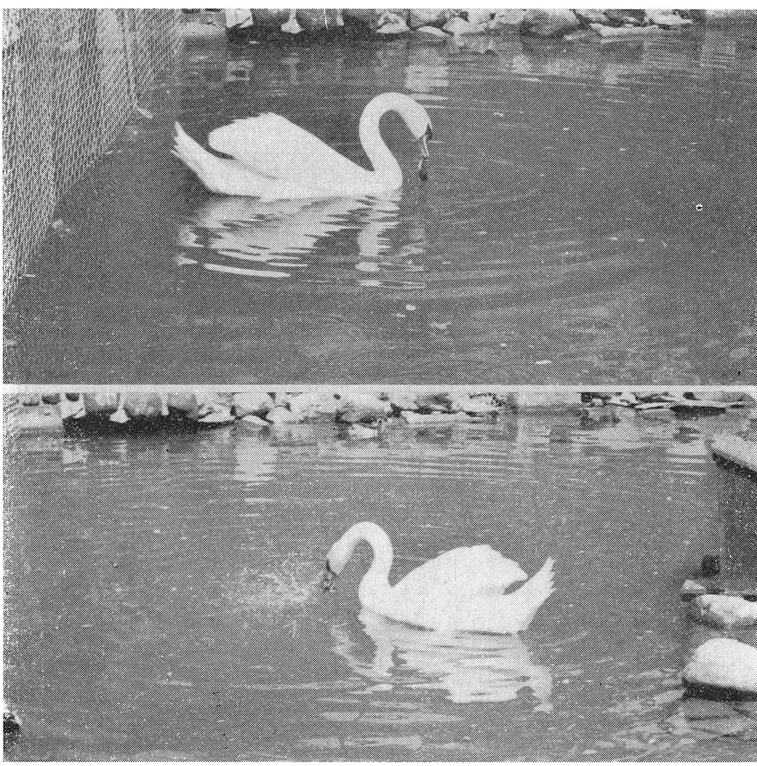

Figure 2. A cob: (above) holding a mallard duckling by the head; (below) shaking a mallard duckling.

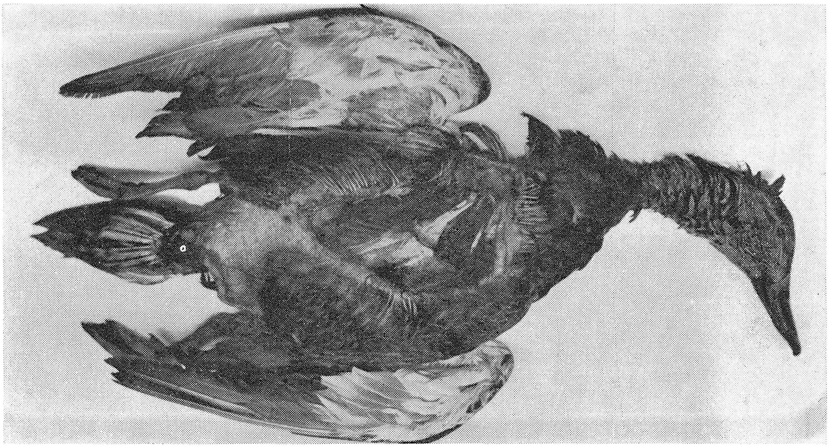

Figure 3. A black duck with its breast muscle eaten by mute swans.

their territory. Willey (1968) cited reports from Rhode Island of mute swans killing other waterfowl, but did not mention their being eaten. The zoo swans may have learned to eat their kills by chance during their extensive experience with interspecific aggression.

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RARE OR UNCOMMON FISHES SEINED IN GREAT SOUTH BAY, NEW YORK[1]

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During 1967 and 1968, several species of fish that may be considered rare or uncommon in Long Island waters were seined in Great South Bay. Specimen sizes, dates and localities of capture, and the water temperature and salinity at time of capture for gray snapper (*Lutjanus griseus*), permit (*Trachinotus falcatus*), smooth trunkfish (*Lactophrys triqueter*) and spotted hake (*Urophycis regius*) are presented in Table 1.

TABLE 1. CAPTURE DATA FOR RARE AND UNCOMMON FISHES SEINED IN GREAT SOUTH BAY IN 1967 AND 1968

Date	Locality	Length*	Water temperature °F.	Water temperature °C.	Salinity§
		Gray snapper			
September 24, 1968	Captree Island	52	70	21.1	27.0
September 27, 1968	Grass Island	60	66	18.9	27.8
		Permit			
August 4, 1967	Grass Island	37	74	23.3	24.4
August 23, 1967	Cedar Island	37	70	21.1	27.4
September 21, 1967	Cedar Island	30	68	20.0	26.0
September 28, 1967	Grass Island	36	62	16.7	27.4
October 3, 1967	Captree Island	35	60	15.6	28.2
August 6, 1968	Captree Island	35	73	22.8	26.4
August 26, 1968	Captree Island	52	74	23.3	27.0
		Smooth trunkfish			
September 13, 1968	Captree Island	12	62	16.7	30.4
		Spotted hake			
May 8, 1968	Captree Island	48	55	12.8	29.6
May 21, 1968	Captree Island	47	58	14.4	29.0
May 28, 1968	Captree Island	41	54	12.2	31.0

*In millimeters; fork length for species with forked tails, total length for others.
§In parts per thousand.

The gray snapper was found on the south shore of Long Island by Greeley (1939) in 1938, but he gave no specific localities. Most of the specimens reported by Alperin and Schaefer (1965) were from Moriches and Shinnecock Bays. They found the species in Great South Bay, but gave no specific localities. The present records apparently give the first specific sites in Great South Bay for the gray snapper.

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project F-15-R, representing Contribution No. 70-4 of the Division of Marine and Coastal Resources. The author wishes to thank Dr. C. Lavett Smith of the American Museum of Natural History for assistance in identifying the gray snappers and Dr. James C. Tyler of the Academy of Natural Sciences (Phila.) for assistance in identifying the smooth trunkfish.

Bean (1901) noted that permit might be found in Great South Bay in the summer months and mentioned individuals from Fire Island (August 5) and off the mouth of the Swan River (September) taken in 1901. Alperin and Schaefer (1965) found permit in Moriches and Shinnecock Bays, but not in Great South Bay. The October 3, 1967 record appears to be a late date for the species in Great South Bay.

Greeley (1939) found several smooth trunkfish in the Fire Island Inlet area, but Alperin and Schaefer (1965) found only a single specimen at Timber Point.

Bean (1901, 1903) encountered spotted hake in small numbers in the fall in Gravesend Bay. Although Breder (1938) did not consider the species to be rare in New York Harbor, Nichols and Breder (1926) previously reported spotted hake as uncommon at New York and Orient. Neither Greeley (1939) nor Gordon (1949) found spotted hake in their summer seining efforts. Alperin and Schaefer (1965) likewise did not report spotted hake. However, Alperin (personal communication) seined six juveniles (length measurements not taken) in Fire Island Inlet at Oak Beach on June 20, 1958 and a single individual 190 millimeters in total length at Captree Island on June 20, 1962. Alperin's specimens appear to have been the first recorded occurrences of the species in Great South Bay. But the scarcity of observations from the inshore bays makes the occurrence of the present specimens in 1968 also worthy of note.

Gray snapper, permit and smooth trunkfish essentially are strays from southern waters. Breder (1948) described the range of the gray snapper as extending from Brazil to New Jersey. He noted that while permit may be found from Brazil to Cape Cod, only the young are encountered in the northern parts of its range. Similarly, he noted that the smooth trunkfish normally reaches only to Florida. The spotted hake, on the other hand, is found from Cape Fear to Cape Cod casually in waters less than 200 fathoms (Breder, 1948). Inshore records seem to be comparatively few, however, for New York waters.

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RECORDS OF ECTOPARASITIC ISOPODS FROM GREAT SOUTH BAY, NEW YORK[1]

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Isopod parasites are frequently found on several species of fish. This note deals with two species of ectoparasitic marine isopods, *Lironeca ovalis* and *Nerocila acuminata,* found on various species of fish from Great South Bay, Long Island, New York.

Lironeca ovalis was reported by Alperin (1966) as a new parasite of striped bass (*Morone saxatilis*) in Long Island waters. He also noted that it had been observed locally to be common to abundant on juvenile bluefish (*Pomatomus saltatrix*) and that he had recorded it from Atlantic menhaden (*Brevoortia tyrannus*) and northern kingfish (*Menticirrhus saxatilis*). Miner (1950), Richardson (1905) and Sumner *et al.* (1911) included sawfish (*Pristis* sp.), bluefish, bigeye scad (*Selar crumenophthalmus*), sea trout (*Cynoscion* sp.), Atlantic croaker (*Micropogon undulatus*), pinfish (*Lagodon rhomboides*), scup (*Stenotomus chrysops*) and sunfish (*Mola* sp.) as hosts of *L. ovalis.* The parasite is generally found attached to the roof of the mouth, the inner surface of the operculum or the gills of its host (Miner, 1950; Richardson, 1905). All the present specimens were found in the opercular cavity attached to the gills of Atlantic silverside (*Menidia menidia*), mummichog (*Fundu-*

TABLE 1. OCCURENCE OF *Lironeca ovalis* ON FISH FROM GREAT SOUTH BAY, LONG ISLAND, NEW YORK IN 1968

Date	Locality	Length*	Capture gear
	Atlantic silverside		
July 26	Captree Island	108	Haul seine
July 30	Cedar Island	116	Haul seine
August 9	Grass Island	102	Haul seine
August 16	Cedar Island	111	Haul seine
August 26	Captree Island	113	Haul seine
August 27	Grass Island	100	Haul seine
	Mummichog		
August 8	Captree Island	115	Haul seine
August 15	Grass Island	100	Haul seine
	Striped killifish		
August 22	Grass Island	135	Haul seine
	Atlantic needlefish		
August 16	Cedar Island	183	Haul seine
	Crevalle jack		
September 7	Connetquot River	125	Rod and reel
September 21	Connetquot River	120	Rod and reel

*In millimeters; fork length for species with forked tails, total length for others.

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project F-15-R, representing Contribution No. 70-5 of the Division of Marine and Coastal Resources. The author wishes to thank Dr. Thomas E. Bowman, Supervisor and Curator, Division of Crustacea, Smithsonian Institution, U. S. National Museum, Washington, D.C. for his assistance in the identification of the isopods.

lus heteroclitus), striped killifish (*Fundulus majalis*), Atlantic needlefish (*Strongylura marina*) and crevalle jack (*Caranx hippos*).

Alperin (1966) noted that juvenile fish were the usual hosts of *L. ovalis* in local waters. The Atlantic needlefish and the crevalle jacks which were infested were juveniles. The other host fish are species that do not grow to large size. The sizes of the host fish and the locations, dates and methods of their capture are listed in Table 1. An example of a parasitized Atlantic silverside is shown in Figure 1.

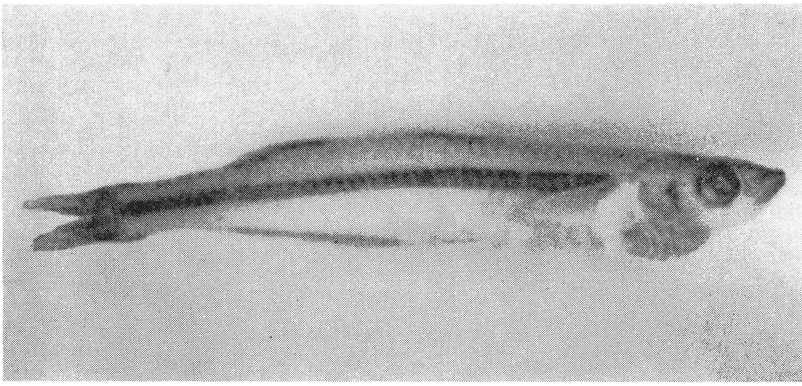

Figure 1. An Atlantic silverside parasitized by *Lironeca ovalis*.

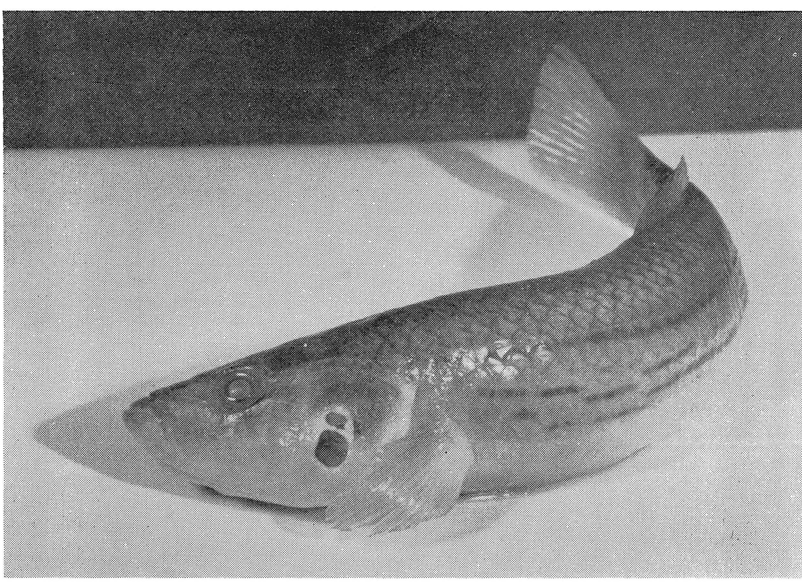

Figure 2. A striped killifish with abrasion and holes in the operculum caused by the presence of *Lironeca ovalis*.

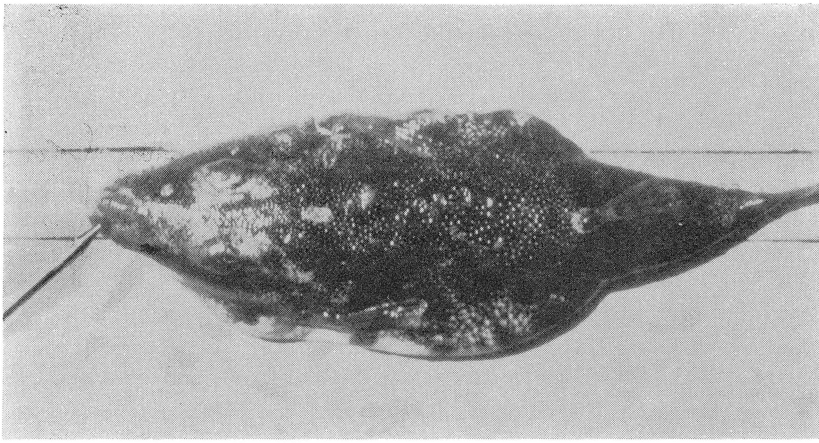

Figure 3. A northern puffer parasitized by *Nerocila acuminata*.

Alperin (1966) noted that the effects on the condition and survival of fish parasitized by *L. ovalis* are unknown. Figure 2 shows abrasion and wearing of holes in the operculum of a female striped killifish 135 millimeters in total length. A specimen of *L. ovalis* was found attached to the gills of the fish directly under the holes. Striped killifish in aquaria have been observed to burrow into sand.[2] If this behavior occurs in nature, the effect of sand abrasion on a bulging operculum caused by the presence of a parasite might very well lead to such holes.

Nerocila acuminata was found attached to the snout of a northern puffer (*Sphaeroides maculatus*). The fish (figure 3) was 237 millimeters in total length and was captured by haul seine at Cedar Island in Great South Bay on May 13, 1968. This ectoparasitic isopod has been reported from sawfish, longnose gar (*Lepisosteus osseus*), Atlantic spadefish (*Cheatodipterus faber*), hogfish (*Lachnolaimus maximus*), orange filefish (*Alutera schoepfi*) and northern puffer (Hutton, 1964; Menzies and Frankenberg, 1966; Richardson, 1905). All these previous records apparently were from Newport (Va.) and farther south in the Atlantic Ocean and into the Gulf of Mexico and westward to Bermuda.

It appears that the present records offer several new local hosts for *L. ovalis*. It also appears that the presence of *N. acuminata* on a northern puffer from Great South Bay represents a northward extension of the known range of this ectoparasitic isopod.

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[2]Donn Rosen, American Museum of Natural History, personal communication.

RESPONSE OF CHIPMUNKS AND RED SQUIRRELS TO COMMERCIAL CLEARCUT LOGGING[1]

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Commercial clearcut logging (removing all merchantable hardwood trees over 14 inches dbh and all merchantable softwood trees over 12 inches dbh) is one kind of land management that seems to have pronounced effects on some species of wildlife (Krull, 1963). Observations on the response of chipmunks (*Tamias striatus*) and red squirrels (*Tamiasciurus hudsonicus*) to this kind of forest treatment were made on the Huntington Wildlife Forest; a 15,000-acre property of the State University of New York, College of Forestry, located mostly in Essex County near the village of Newcomb.

Portions of two 1,000-acre areas were selected for study. One of these areas (hereafter referred to as the cut area) had been logged by the commercial clearcut method between 1943 and 1950, mostly after 1946. The other, used as a control, had not been logged in recent times, although some selective cutting of red spruce (*Picea rubens*) and white pine (*Pinus strobus*) probably occurred before the turn of the century. This area was almost completely covered with old-growth timber similar to that present on the cut area before logging. During the study the two areas contained approximately 70 and 140 square feet of basal area per acre[2], respectively.

The northern hardwood forest type (S.A.F. type No. 25), in which all data were collected, consisted primarily of sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), eastern hemlock (*Tsuga canadensis*) and red spruce. Red spruce made up less than 20 per cent of the entire stand. This northern hardwood type (340 acres on the cut area and 510 acres on the uncut area) occupied the most productive sites on the Huntington Wildlife Forest. Climate, geology, physiography, soils and wildlife are typical of central Adirondack conditions in general and were similar on the two study areas (Barrett *et al.*, 1961).

Data on the relative abundance of chipmunks and red squirrels on the two study areas were collected each year from 1952-1961. In mid-June, six different time-area stations were censused between 8:00 a.m. and 12:00 noon. At each station all animals either heard or seen during a 10-minute period were recorded. Depending upon the year, the six stations were censused either twice, four times or six times, on one, two or three days, respectively. Therefore, it was necessary to formulate an expression that was comparable from year to year. This was accomplished by dividing the total number of individual animals recorded each year by the aggregate number of stations censused during that particular year. The expression obtained, number of animals per station, is comparable between years. Detailed weather data were gathered, and censuses were taken only on days of very similar weather conditions. Calls and sightings accounted for 90 and 10 per cent, respectively, of the records.

Only 16 more chipmunks (126 vs. 110) were recorded on the cut area than on the uncut area during the 10-year period. Figure 1 shows that differences within years were also relatively minor. Possibly of greatest importance is that as the cut area regrew there was no significant increase or decrease (based on a regression coefficient and "*t*" test) in numbers of chipmunks. On both study areas variation in chipmunk abundance by years was consistent. For example, the highest population was observed on both areas in 1957, while the lowest population was observed a year later.

From these data, commercial clearcut logging seems to have no appreciable effect on chipmunks in northern hardwood forests. Although no quantitative data are available, indications are that yearly fluctuation in chipmunk population density

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[1]These data were summarized and evaluated while the author was a graduate student at the State University of New York, College of Forestry, Syracuse, and sincere thanks are extended to Professor Emeritus R. T. King and Drs. W. L. Webb and E. F. Patric under whose guidance he worked.

[2]Total area of the cross sections of all trees on an acre, based on diameter at breast height.

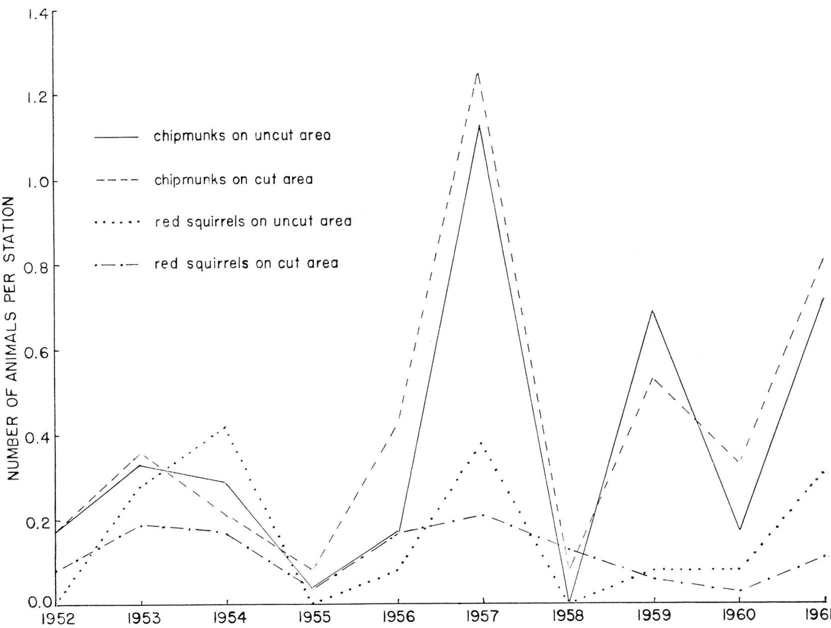

Figure 1. Trends in abundance of chipmunks and red squirrels on the two study areas from 1952 to 1961.

is primarily the result of differences in hardwood seed production. Higher population densities were observed at four-year intervals in 1953, 1957 and 1961.

Only 15 more red squirrels (48 vs. 33) were recorded on the uncut area than on the cut area. Figure 1 shows that differences within years were not large, although variation was greater for red squirrels than for chipmunks. As for chipmunks, there was no significant increase or decrease in numbers of red squirrels over the 10-year period. On both study areas variation in the red squirrel population by years was consistent.

These data indicate that in northern hardwood forests, commercial clearcut logging has no major detrimental effect on red squirrels. Of possibly greater detriment to the squirrels on the cut area was the reduction in food-producing red spruce stands. Yearly fluctuations in population density could probably be traced to periodic food source cycles, with population highs occurring every three to four years.

For the years 1952 to 1961 the chipmunk and red squirrel populations were closely correlated, i.e., generally when one was high or low, so was the other. Since the two species were similar in their censusability with the technique employed, it is also evident that chipmunks were considerably more abundant than red squirrels on both study areas.

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A FIRST RECORD OF THE SQUIRRELFISH FROM NEW YORK WATERS[1]

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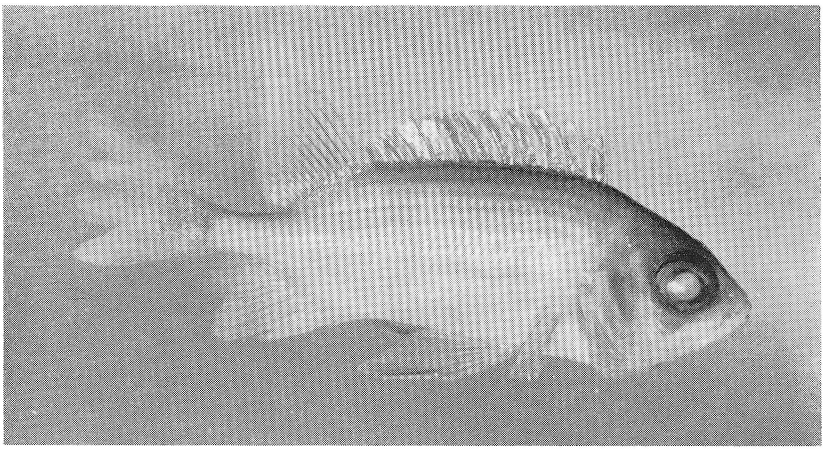
On August 14, 1969, a squirrelfish (*Holocentrus ascensionis*)[2] was collected by dip net from Reynolds Channel near the Doxsee Sea Clam Co. at Point Lookout on the south shore of Long Island. The fish was subsequently brought to the attention of the junior author for identification. Based on a search of the literature, this is a first record of the species from New York waters and extends slightly its northern range on the Atlantic coast of the United States.



First recorded squirrelfish (*Holocentrus ascensionis*) from New York waters.

Some of the more critical morphometric and meristic data are as follows: total length, 95 millimeters; fork length, 84 millimeters; standard length, 76 millimeters; depth, 26 millimeters; length of upper jaw, 11 millimeters; lower limb gill rakers of first arch, 15; pored lateral line scales, 49. At the time of collection, the water temperature was 23.4° C. and the salinity was 24.8 0/00.

The range of the squirrelfish has been given by many authors as generally extending from Brazil to Florida and Bermuda in the western Atlantic (Jordan *et al.*, 1930; Beebe and Tee-Van, 1933; Breder, 1948; Briggs, 1958; Böhlke and Chaplin, 1968). It is not surprising, therefore, to find the species absent from previous faunal lists of marine fishes reported to occur in New York waters (DeKay, 1842; Bean, 1901, 1903; Nichols and Breder, 1926; Breder, 1938; Greeley, 1939; Gordon, 1949; Latham, 1964; Alperin and Schaefer, 1965; Schaefer, 1967). Recently, however, Anderson and Gutherz (1965) reported the capture of several squirrelfish from offshore waters between Florida and New Jersey. They noted that one small specimen (< 40 millimeters in standard length), taken about 100 nautical miles southeast of Montauk Point (New York), represented an 800-mile northward range extension for the species. The current collection was made within an estuary approximately 130 nautical miles northwest of the latter location.

As noted by both McKenney (1959) and Anderson and Gutherz (1965), the genus *Holocentrus* was reported previously from Newport, Rhode Island (Goode, 1884) and Katama Bay, Massachusetts (Smith, 1899, 1901). The species identifica-

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[1]Contribution No. 70-3 from the Division of Marine and Coastal Resources.

[2]According to the nomenclature of the American Fisheries Society (1960).

tion of these records, however, is in doubt. The specimens were assigned to *H. pentacanthum* (Goode, 1884) and *H. ascensionis* (Sumner *et al.*, 1913). The only additional inshore record for the family Holocentridae in the New York vicinity appears to be a specimen of the dusky squirrelfish (*H. vexillarius*) reported by Fowler (1952) from Atlantic City, New Jersey. McKenney (1959) observed, however, that its description was more indicative of *H. coruscus* or *H. bullisi.*

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NOTES ON A FOOD PREFERENCE IN AQUARIUM CARP[1]

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Carp (*Cyprinus caprio*), taken from the Barge Canal and ranging in weight from 2 to 8 pounds, were held in a 550-gallon tank at 65° F. After a 2-week acclimatization period, they were fed commercial fish pellets and ¼-inch dry flour baits. Approximately 4 ounces per day of one or the other were eaten by 12 fish that together weighed about 50 pounds.

Feeding was hesitant at first although all of the food was consumed. Within a few days both foods were accepted with great eagerness and eaten in a few seconds. As time went on, however, the flour baits were taken with less and less eagerness until they were merely mouthed, spit out and finally ignored altogether. Refusal of flour-cornmeal baits was noted by Loeb (1960).

To examine the sensitivity of the fish to the flour content, a preference test was made. For 1 week, only commercial fish pellets were fed. These were followed by baits containing increasing percentages of white flour. Feeding reactions are shown in Table 1. As the proportion of flour was increased beyond 30 per cent,

TABLE 1. REACTIONS OF CARP IN AN AQUARIUM TO PROGRESSIVELY INCREASED AND DECREASED PERCENTAGES OF FLOUR IN BAITS

Percentage of flour	Color of bait	Days fed	Reaction of fish
0	brown	2	immediate ingestion
10	brown	2	immediate ingestion
20	brown	2	immediate ingestion
30	dark tan	2	immediate ingestion
40	dark tan	2	finicky mouthing and ingestion
50	dark tan	2	increasing mouthing and ingestion
60	dark tan	2	increased mouthing, spitting and ingestion
70	dark tan	2	mouthing and spitting
80	light tan	2	slight mouthing and spitting
90	light tan	2	baits untouched
100	white	5	baits untouched
90	light tan	2	baits untouched
80	light tan	2	baits untouched
70	dark tan	2	baits untouched
60	dark tan	2	baits untouched
50	dark tan	2	baits untouched
40	dark tan	2	baits untouched
30	dark tan	2	mouthing, spitting and ingestion
20	brown	2	mouthing and ingestion
10	brown	2	immediate ingestion
0	brown	2	immediate ingestion

the fish showed progressively less interest until they completely ignored baits containing 90 per cent or more of flour; and the reverse was true as the proportion of flour was decreased.

The original pattern of feeding involved stimulation by eye, an immediate dash for the food and ingestion. All of the fish exhibited this behavior. It would appear that the first decisions to refuse the baits were the result of taste and odor stimuli.

[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

The decision not to touch them as the percentage of flour increased was apparently made by eye, possibly controlled by one or two dominant fish. Resumption of feeding must have involved all three senses.

A limited number of subsequent tests in 1/4-acre ponds revealed no preference for either bait. Both were ingested or refused at times. The presence of natural foods in this case undoubtedly influenced the results. Stomach analyses showed that some fish had eaten baits while others favored living organisms. Rarely were both present in the same fish.

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A BIRD INGESTED BY A WHITE-TAILED DEER

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White-tailed deer (*Odocoileus virginianus*) have been observed eating fish that fishermen have thrown on the shores of streams and ponds (Severinghaus, 1967). Muntjac deer (*Muntiacus reevesi*) have been observed chewing antlers and bones (Dansie, 1968). In addition, a red deer (*Cervus elaphus*) has been observed killing and eating a Manx shearwater (*Procellaria puffinus*), and red deer were thought to have preyed upon shearwaters on a number of occasions (Wormell, 1969).

In August, 1969 a 128-pound 2½-year-old white-tailed doe from Herkimer County (N.Y.) was autopsied for suspected arsenic poisoning. While sorting the rumenal contents, several pieces of tissue resembling the breast muscle of a small bird were found along with several bits of feathers and two bird legs. Dr. Edgar M. Reilly of the New York State Museum examined a fairly intact leg and thought it might have been from a rufous-sided towhee (*Pipilo erythropthalmus*). The doe had been feeding on blackberries and blackberry vegetation. Tests for arsenic were positive.

Whether the arsenic poisoning had effected the behavior of the doe and caused her to ingest the bird is unknown. The bird may have been found dead and eaten accidentally, but the remains gave considerable evidence of mastication without rejection. Although the doe was in good flesh, she was lactating and may have had a deficiency in salts and/or proteins. Perhaps deer learn to use dead or helpless animals as a source of nutrients. This may be particularly true among deer that are living in the nutritionally poorer areas of their range.

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OCCURRENCE OF BOTFLY LARVAE IN RED FOX

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Botfly larvae of the genus *Cuterebra* are commonly parasitic on rodents and rabbits. These larvae occasionally parasitize cats, dogs and, very rarely, man (Herms and James, 1961). In New York a cuterebrid larva was found in the neck of a white-tailed deer fawn (Severinghaus, 1949). However, there seem to be no other records of their occurrence in wildlife other than rodents and lagomorphs.

During September 1969, Elmer Davies, a State trapper, caught a male red fox (*Vulpes fulva*) in St. Lawrence County that was parasitized in the neck region by two fly larvae. In October 1969, a hunter shot a female fox in Herkimer County that was infected with a single fly larva. These fully developed larvae were identified (according to Belding, 1965) at the Delmar Wildlife Research Laboratory as *Cuterebra* sp. This is believed to constitute a new host record for the genus.

Both foxes were said to have been in good flesh, and the larvae were in encapsulated pockets similar to those produced by cuterebrid larvae in their usual hosts. The hair surrounding the larval breathing holes was matted with a purulent discharge.

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The New York Fish and Game Journal is devoted to presenting the results of research and management studies in New York, and other technical papers on related subjects, that pertain to fish and wildlife problems of concern to the Conservation Department. It is published semi-annually and is distributed free to official conservation agencies and scientific institutions. It is also furnished free to selected libraries and conservation organizations in New York State. Others may subscribe at a rate of $1.50 per year or obtain individual issues for 75¢ per copy. Correspondence should be addressed to the Editor: Robert W. Darrow, New York Conservation Department, Albany, New York 12201.

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