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HEMATOZOA OF THE ANATIDAE OF THE ATLANTIC FLYWAY. II. THE MARITIME PROVINCES OF CANADA

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Abstract: The prevalence of hematozoa (diagnosed from blood films) in a sample of 4200 anatids representing 14 species collected in New Brunswick, Nova Scotia and Prince Edward Island during the period 1969-1973 is given. Thirty percent of the birds harboured hematozoa; the commonest blood parasite was *Haemoproteus* (*Parahaemoproteus*) *nettionis* (in 18% of the sample), followed by *Leucocytozoon simondi* (in 14% of the sample). Four species of *Plasmodium* occurred in 5% of the sample—*Plasmodium circumflexum* was the most frequently encountered of the four. Prevalence of infection varied markedly from year to year and locality to locality. Ducks from Northwestern New Brunswick-Bathurst area were the most heavily infected while those from Prince Edward Island had a low hematozoan prevalence. Black ducks (*Anas rubripes*) were the most heavily infected of the 14 species of waterfowl sampled and possibly hematozoa may act as a limiting factor on populations of this duck. Bluewing teal (*Anas discors*) showed the lowest prevalence (7.1%) of the 14 species studied and the prevalence was in marked contrast to that of the greenwing teal (*Anas carolinensis*) (39.5%).

INTRODUCTION

Modern approaches to waterfowl management are predicated, in part, on the establishment of 'improved wetland' areas as an adjunct to the enhancement of waterfowl reproduction.[17] Such management programmes have been widely introduced into various areas of North America—programmes which, by their very nature, extensively modify localized areas of the environment. Little effort has been made, however, to assess the impact of such 'improved wetlands' on populations of helminth, protozoan, arthropod or other pathogenic agents of waterfowl (or other fauna utilizing the improved wetlands). It is entirely conceivable that the success of these management schemes, resulting in increased host population densities, will greatly enhance the opportunity for transmission of parasites, leading to a building-up of a deleterious level of parasitism which may well reduce the host population to a level defeating the initial objective of the management procedures.[8] It is essential, therefore, to monitor parasite prevalence before, during and after the implementation of 'improved wetland' schemes to determine whether an increase in parasite prevalence occurs and thus, possibly, to introduce appropriate control measures.

'Improved wetland' schemes for waterfowl management were introduced into the Tantramar area of New Brunswick and Nova Scotia by Ducks Unlimited and the Canadian Wildlife Service in 1967. The programme is still in a state of expansion. Some 5200 hectares are under government control within which several impoundments of varying size

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have been constructed. Additional impoundments are being constructed annually in an attempt to improve waterfowl production. This report summarizes the distribution and prevalence of the hematozoan parasites of the anatids of the Tantramar and surrounding regions of the Maritime Provinces of Canada for the period 1969-1973. This period, although 2 years after the establishment of the first 'improved wetland' area, effectively spans the initial period of host population increase in most of the 'improved wetland' areas. The survey also includes samples of waterfowl from Prince Edward Island and Nova Scotia, areas in which such management schemes are not yet in operation. These data represent the first analysis of the hematozoan parasites of anatids in the Maritime Provinces of Canada and are presented to provide the base-line information necessary for the monitoring of change in parasite levels that may arise as a result of waterfowl management procedures.

MATERIALS AND METHODS

Blood films were obtained from either the brachial or femoral artery of a variety of ducks and geese (the 14 species are listed in Table 4). The majority of the smears were made during the period August 1 - 25 each year of the period 1969 - 1973 by personnel of the Canadian Wildlife Service involved in duck banding programmes. The ducks involved were all local and hatching year birds (i.e.—birds reared in the areas) and were variously obtained by airboat night-lighting and bait trapping techniques. The thin films were air-dried, fixed in 100% methanol and stained with Giemsa's buffered to pH 7.2. A small number of smears were obtained from birds captured in June and July in 1972. Particular efforts were made to obtain birds of the year (HY birds) and approximately 75% of the total sample were composed of such birds in each year. Thus, although the data is presented as prevalence, they can be broadly interpreted as indicating rate of transmission for the year, region or host species.

The ducks were sampled from localities throughout the Maritime Provinces, and for convenience, such localities were grouped into six regions (Fig. 1). Although the regions appear large and to cover an extensive area, the bulk of the collecting sites (with the exception of region 2) in any region were close together. Collections were made from all regions (but *not all localities*) in 1969-71, but only in region 3 (Tantramar marshes) in all 5 years; the majority of the sample (65%) was obtained from region 3.

Region 1. Cape Breton Island, Nova Scotia. Seven localities. These localities are similar ecologically, representing marshes at the base of the mountain plateau running through the centre of the island.

Region 2. Nova Scotia, except Cape Breton Island and the Nova Scotia-New Brunswick border region. The eight collecting localities in this region are widely scattered and represent a variety of ecological types, ranging from tidal marshes to inland freshwater ponds. The sample from this region is the smallest of the six and the localities were not sampled consistently. The sample from any one locality in any one year is too small to be statistically comparable with samples from the other regions.

Region 3. Tantramar marshes and Nova Scotia-New Brunswick border region. All 11 collecting localities lie within a circle of 16 km radius; many of the areas are contiguous and all represent areas within the managed wetland programme and are essentially similar ecologically. Local birds readily move from one area to another. Eight of the localities were sampled each of the 5 years and the data from all localities are treated as a single unit.

Region 4. St. John river, southern New Brunswick. Nine localities representing different areas on or connected with, a stretch of the St. John river above and below Fredericton. The localities represent a single ecological system, subdivided for convenience in administering banding operations.

Region 5. Northeastern New Brunswick-Bathurst area. Five localities representing estuarine marshes which are ecologically similar and treated as a single unit.

Region 6. Prince Edward Island. The 20 localities in this region are similar ecologically. Sample size from any locality in a single year was too small for valid statistical comparison with samples from other regions. The data from this region, which is remarkably uniform in topography, physiography, etc., are treated as if from a single unit.

The management of the improved wetlands, the assessment of increase in anatid population and the collection of the blood films in the field were the responsibility of Whitman and Smith. Screening of the smears and analysis of the data were carried out by Bennett and Cameron.

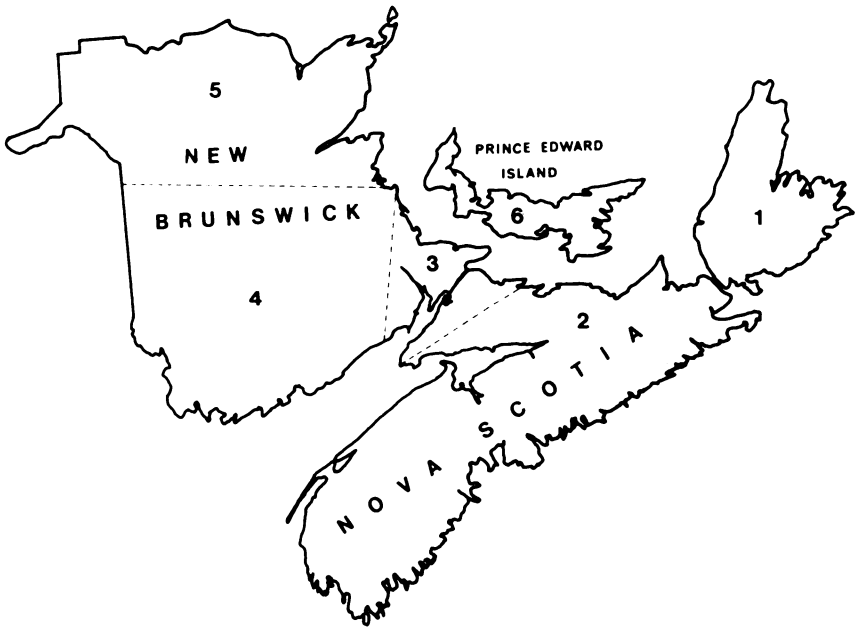

FIGURE 1. Map of the Maritime Provinces of Canada showing the six sampling regions.

RESULTS AND DISCUSSION

The prevalence of blood parasites in a sample of 4200 anatids from the Maritime Provinces of Canada, the majority from the Tantramar marsh area of the New Brunswick-Nova Scotia border, was found to average 30.3% over the period 1969-1973. *Haemoproteus* (*Parahaemoproteus*) *nettionis* was the commonest hematozoan, occurring in 18% of the population (Table 1). *Leucocytozoon simondi* was found in 14% of the birds. *Plasmodium* species, primarily *Plasmodium circumflexum,* occurred in 5% of the population. Microfiliaria, presumably *Ornithofilaria fallisensis* Anderson, were seen in only 52 birds (1.2%), a surprisingly low prevalence in view of the figures reported by Anderson.[1] *Trypanosoma avium* was virtually absent in the duck population, being noted in only two birds. This latter parasite is not readily detected by thin film technique and in ducks, provides only a transient, patent

infection;[4] hence the prevalence indicated here is undoubtedly far lower than the true prevalence of this parasite.

In other regions of North America, such as the Seney Refuge in Michigan,[13] Algonquin Park,[11] Ungava Bay,[15] Labrador,[5] and Massachusetts,[9] the overall prevalence of hematozoa in the anatid populations is nearly 100% and thus almost 3 times higher than that recorded for anatids in the Maritime provinces of Canada. Yet the Maritime provinces are topographically similar to these other regions of North America and the biting fly vectors are essentially the same species throughout. The reason for this low prevalence is unexplained, although it may be the result, in part, of the time of sampling the duck population. Blood films taken in August are made at a time when the peak transmission of blood parasites is finished for the season and the infection in the hosts is approaching a chronic level. Thus, low infection may be overlooked while screening the slides, resulting in a lower than actual prevalence. However, even allowing for this error, the overall prevalence is lower than would be anticipated on the basis of reports from elsewhere in North America. Only 8% of the ducks had infections involving two or more hematozoa. This surprisingly low level of mixed infections is undoubtedly related to the low overall prevalence noted for the Maritime provinces region.

Prevalence over the 5-year period

The prevalence of the three commonest species of hematozoa varied widely from year to year, the overall prevalence ranging from 19% in 1971 to 50.1% in 1969 (Table 1). There was no indication of a 4-year cyclical variation as reported for *L. simondi* in anatids of Seney Refuge, Michigan.[13] It should be noted, however, that while the data for 1969-71 include all regions of the Maritimes, the data for 1972-73 is exclusively for the Tantramar region.

The different species of haemosporozoans showed somewhat different patterns of fluctuations (Table 1). *Haemoproteus nettionis* occurred in 41.3% of the birds in 1969, but the prevalence dropped sharply over the next 4 years, the prevalence fluctuating in the narrow range of 7.3-13.1%. This drop is difficult to explain, but suggests a marked drop in the *Culicoides* vector population during 1970-73. Such a drop might be associated with the flooding (by creation of impoundments) of wet, boggy land and the resultant destruction of some of the breeding areas of *Culicoides*, particularly in the Tantramar region. If this did occur, then it is possible that the creation of improved wetlands might (at least in the short-term) be a means of local control of *H. nettionis*. *Plasmodium* spp. (approximately 85% *P. circumflexum*, 15% of *P. polare*, *P. relictum*

TABLE 1. Prevalence of haemosporozoa in anatids of the Maritime provinces of Canada during the period 1969-1973.

Year	Total anatids examined	infected	% infected	anatids infected with *Leucocytozoon* No.	%	*Haemoproteus* No.	%	*Plasmodium* No.	%
1969	970	486	50.1	146	15.1	402	41.4	93	9.6
1970	745	192	25.8	97	13.0	101	13.6	39	5.3
1971	907	175	19.3	61	6.7	116	12.8	32	3.5
1972	680	217	31.9	174	25.6	50	7.4	9	1.3
1973	898	202	22.5	115	12.8	90	10.0	31	3.5
Total:	4200	1272	30.3	593	14.0	759	18.0	204	5.0

and *P. vaughani*) also varied, but not as markedly, fluctuating within a narrow range over the 5-year period. In contrast to *Haemoproteus,* the *Plasmodium* prevalence was almost stable. *Leucocytozoon simondi,* while not fluctuating over as broad range as *H. nettionis,* had a larger annual fluctuation than the other two haemosporozoans and hence, was the least stable of the three groups of blood parasites.

The majority of the sample (65%) was collected from the Tantramar region. The overall infection (Table 2) was lower than that for the Maritime provinces (Table 1). In the Tantramar area, *L. simondi* was the most common parasite, but its prevalence was similar to that experienced elsewhere in the Maritimes. Similarly, *Plasmodium* spp. occurred with the same frequency in the Tantramar areas as in other regions. The prevalence of *H. nettionis* in the Tantramar region was sharply lower than in other regions, thus reducing the overall prevalence for this region to the lowest of the six under study. The annual fluctuation in prevalence of hematozoa in the Tantramar region was similar to that recorded for the other five regions. During this same 5-year period, the number of ducks breeding on the 'managed wetlands' has increased by at least 5-fold. This increase in host population has resulted in an increased density and thus, the potential for increased host-vector interactions. However, it would appear, that up to this time, the creation of managed wetlands and the concurrent increase in host population has not resulted in a demonstrable increase in the prevalence of hematozoa. It would be anticipated that there would be a time lag between the increase in host population, increase in vector population density and finally, increase in hematozoa prevalence. Possibly, the 7 years of existence of the managed wetland programme in the Tantramar area is not of sufficient length to encompass the time period indicated above. Therefore, continuation of the annual survey is required to confirm this point.

Prevalence in different regions

The overall prevalence (Table 3) of the three species of haemosporozoa varied markedly from region to region (Fig. 1). Birds of Region 3 (Tantramar marshes) showed the lowest prevalence whereas those of Region 5 (northwestern New Brunswick) showed the highest, a 3-fold difference in prevalence rates. The prevalence of the different genera also varied from area to area. Species of *Plasmodium* were the most prevalent in both northwestern and southwestern New Brunswick (Regions 4 and 5) and least common in Regions 3 and 6. The low prevalence in the Tantramar area is surprising as the physical geography of

TABLE 2. Prevalence of three genera of haemosporozoans in anatids of the Tantramar marsh area during the period 1969-1973.

Year	Total anatids examined	infected	% infected	anatids infected with *Leucocytozoon* No.	%	*Haemoproteus* No.	%	*Plasmodium* No.	%
1969	332	136	40.9	47	14.0	106	32.0	31	9.0
1970	308	55	17.8	38	12.3	17	5.6	5	1.6
1971	555	64	11.5	26	4.9	42	7.6	8	1.4
1972	633	209	32.0	174	25.5	50	7.9	9	1.4
1973	898	202	22.0	115	12.5	90	10.0	31	3.5
Total:	2726	666	22.2	400	14.4	305	11.0	84	3.0

the area is theoretically ideally suited for the breeding of the mosquito vectors of *Plasmodium*,[7] identified as *Culiseta morsitans*,[16] a culicine of permanent marshes. This mosquito should respond to the 'managed wetland' programmes by increasing its population density and it is yet possible that *Plasmodium* will become a problem in the duck population as host-vector interactions increase with the addition of increased acreages of improved wetlands and hence, increased breeding potential for the vector.

Haemoproteus nettionis was particularly prevalent in Region 5 and least prevalent in Region 3. Presumably the low prevalence is due to the absence of a high vector density in the area. Certainly, in concurrent studies on the biting fly vectors of the Tantramar region, no *Culicoides* were trapped coming to duck-baited traps in 1972-74. None of some 300 sentinel domestic ducks placed on the managed wetlands from the end of May through the end of August in 1973 contracted *H. nettionis*. These ancillary data clearly indicate that the low prevalence recorded for Region 3 is real and not an artifact of the sampling technique.

Leucocytozoon simondi was most common in Region 5, but virtually absent in Regions 1 and 6. The low prevalence in Prince Edward Island might be anticipated, as the physical geography of the province is not highly suited for the breeding sites of the simuliid vectors of this parasite. It is unlikely that *L. simondi* is a significant factor in limiting duck populations in Region 6. The low prevalence of this parasite in Cape Breton Island (Region 1) is, however, surprising. This region is mountainous and should abound in the breeding sites of simuliids.

The level of *L. simondi* in the duck population of the Tantramar marshes was unexpectedly high, especially in view of the low prevalence in Region 1. The topography of the Tantramar region is similar to that of Prince Edward Island, and a low prevalence of *L. simondi* was expected. Few simuliids have been found breeding in this region.[7] However, the introduction of water level control systems to maintain a constant water level in the managed wetlands has created streams where streams did not exist before. These streams are being colonized by some species of simuliids (mainly the mammalophilic species *Prosimulum fuscum/mixtum, Simulium venustum, S. tuberosum, S. vittatum*) which are not known to be ornithophilic but it is possible that some ornithophilic species[2] are utilizing these man-made streams and thus contributing to an unexpectedly high prevalence of *L. simondi*. If such is the case, then further annual surveys of hematozoa of this anatid population should show a continuing increase in the prevalence of *L. simondi*.

TABLE 3. Prevalence of haemosporozoa in anatids from six regions of the Maritime Provinces as in Fig. 1.

Region	Total anatids examined	infected	% infected	anatids infected with *Leucocytozoon* No.	%	*Haemoproteus* No.	%	*Plasmodium* No.	%
1	307	113	37	24	7.8	90	29.3	16	5.2
2	242	107	44	42	17.4	89	36.8	15	6.2
3	2726	666	22	383	14.0	309	11.3	87	3.2
4	254	101	40	52	20.5	45	17.8	29	11.4
5	280	187	67	76	27.1	157	56.1	41	14.6
6	377	92	24	16	4.2	69	18.3	16	4.2

Prevalence in different species of Anatidae

The prevalence of haemoprotozoa in the 14 species of anatids (Table 4) examined varied markedly. Domestic ducks seemed to be particularly susceptible as all 12 harboured *L. simondi;* this high degree of susceptibility has been commented on frequently.[11,15] Among the wild ducks, black ducks harboured blood parasites more frequently than others, nearly half the sample showing one or more species of hematozoa. The same high prevalence in this species was also recorded in Labrador,[5] and Massachusetts[9] and one speculates as to whether the so-called decline in black duck numbers in eastern North America is due completely to loss of habitat, hunting pressure and increasing competition with mallards or is in part due to the lethal hematozoa such as *L. simondi*. Certainly, the prevalence of hematozoa in black ducks in this region is sufficiently high to act as a limiting factor of the population. In contrast, although the sample is small, the prevalence in mallards is only 34.8% (Table 4). Possibly this species is not as susceptible to hematozoa as the black duck, and this may give it a competitive advantage.

None of the 22 eider ducks examined (Table 4) harboured hematozoa although this species can harbour blood parasites.[6] Eiders are normally a marine duck and their behaviour and normal habitats frequented present an ecological barrier to the vectors. Therefore, lack of parasites is not surprising. Rather surprisingly, only 30% of the wood ducks in the Maritime provinces were infected with blood parasites. This is in sharp contrast with the prevalence of hematozoa in this species noted in Massachusetts[9] where nearly 80% of the population harboured one or more hematozoa.

An interesting comparison is noted between the prevalence of blood parasites in two duck species—the American greenwing teal and the bluewing teal. The greenwing teal has an overall prevalence of blood parasites of 39.5% (the second most highly infected wild species) while only 7.1% of the bluewing teal harboured blood parasites. These figures, which are highly significantly different, are based on quite substantial samples. Similar differences have been noted between these two species at Ungava,[15] in Labrador[5] and in Massachusetts.[9] It is difficult to believe that such closely related species of ducks have differing susceptibilities to blood parasites. It would be more plausible to assume either (a) a difference in vector preference and/or (b) behavioral characteristics of one of the two teals imposing a partial ecological barrier to vector attack. There is no data to either support or negate the first hypothesis. It is known,[10,12,14] however, that American greenwing teal migrate to their breeding grounds as much as a month before the bluewing teal. This behaviour may well place them in their breeding areas at the peak of vector abundance, thus maximizing vector contact. In addition, greenwing teal prefer small ponds, edge conditions of marshes, lakes and small rivers as the nesting and/or feeding habitats, areas in which anserophilic vectors are abundant.[2,8] Bluewing teal, as a species, prefers the centres of larger lakes and marshes and nest by choice in drier, open areas, thus minimizing vector contact. In the Tantramar area, bluewings tend to occupy the same habitat as the greenwing teal, due to the lack of the larger open stretches of marshes and lakes in the area. Nevertheless, they tend to utilize the central portion of the existing marshes rather than the marsh edge habitat. These behaviour differences, particularly the later arrival on the breeding area of the bluewing teal, may explain the markedly different prevalence of hematozoa in the two teal species. American wigeon and ring-neck ducks also utilize the more central portions of a marsh for both nesting and feeding and this behaviour may also minimize vector contact and explain the low prevalence noted in these two species (Table 4).

The data certainly indicate that the prevalence of hematozoa in different species of anatids sharing the same habitat and locality differs widely. Thus, while blood parasites may act as a population limiting factor for one species in one area, they are not necessarily limiting

TABLE 4. Prevalence of hematozoa in 14 species of anatids and geese from the Maritime Provinces of Canada, 1969-1973. Percent of birds infected in parentheses.

Species	exam.	inf.	% inf.	*Leuc.*	*Haemo.*	*Plasm.*	*Tryp.*	Microf.
Domestic duck—*Anas boschas*	12	12	100	12(100)	—	—	—	—
black duck—*Anas rubripes rubripes* Brewster	1750	831	47.8	406(23.2)	541(30.9)	111(6.3)	1	40
mallard—*Anas platyrynchos platyrhynchos* L.	23	8	34.8	3(13.0)	3(13.0)	3(13.0)		1
mallard x black hybrid	6	1		1				
greenwing teal—*Anas crecca carolinensis* Gmelin	387	153	39.5	65(16.8)	86(22.2)	27(7.0)		5
bluewing teal—*Anas discors* L.	1286	91	7.1	43(3.6)	30(2.3)	20(1.5)	1	
pintail—*Anas acuta*	228	78	34.2	40(17.5)	27(11.8)	16(7.0)		3
wood duck—*Aix sponsa*	51	15	29.4	7(13.8)	10(19.6)	3(5.9)		1
shoveller—*Spatula clypeata*	6	0						
ring-necked duck—*Aythya collaris* (Donovan)	178	31	17.4	8(4.5)	19(10.6)	7(3.9)		
golden-eye—*Glaucionetta clangula*	5	5		1	4	2		
common eider—*Somateria mollissima*	22	0						
baldpate—*Mareca americana*	180	41	22.8	3(1.7)	35(19.4)	14(17.8)		2
Canada goose—*Branta canadensis* L.	66	6	9.1	1	4	1		

Leuc. = *Leucocytozoon simondi*; *Haemo.* = *Haemoproteus nettionis*; *Plasm.* = *Plasmodium* spp.; *Tryp.* = *Trypanosoma avium*; Microf. = microfilaria.

factors for other ducks in the same area. It is also clear that the epizootiology of hematozoa in anatids (and undoubtedly of all avian groups) is a complex interaction of host behaviour and habitat preferences, vector behaviour and host and habitat preferences and vector density, the latter governed by physical parameters of the environment. Thus, as previously mentioned,[7,8,9] no sweeping generalizations can be made concerning avian hematozoa—each area must be studied in detail with respect to the conditions governing that specific area.

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