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Metazoan parasites of pike, *Esox lucius* Linnaeus, from Southern Indian Lake, Manitoba, Canada

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Metazoan parasites of pike *Esox lucius* from Southern Indian Lake, Manitoba were studied to reveal species composition, differences with host age, sex, and location and season of capture. Pike hosted 18 species of metazoan parasites, two of which, *Tetraonchus monenteron* and *Proteocephalus pinguis*, made up over 84% of metazoan parasite numbers. Some parasite species exhibited definite patterns of abundance with host age and season which resulted from changes in host diet and behaviour. No differences in parasite abundance existed between the host sexes. Ranking of parasite abundances was significantly different between two sampling sites only 2 km apart as a result of intermediate host distribution. Impoundment could greatly change pike parasite levels. An initial decrease in parasite numbers could be followed by a rapid increase.

I. INTRODUCTION

Impoundment plans for hydroelectric purposes exist for many lakes of northern Canada. Although some of these basins support viable commercial fisheries, the effects on the parasitofauna is seldom investigated. Some parasitological studies of impounded reservoirs have been made by Smirnova (1955) and other Soviet authors. Hoffman & Bauer (1971) emphasized the need for more detailed pre-impoundment and post-impoundment studies of fish parasites in reservoirs. More recently Becker *et al.* (1978) discussed ichthyoparasite succession in a new Arkansas reservoir.

The parasitofauna of several fish species including *Esox lucius* L. were studied to determine pre-impoundment conditions prior to assessing the effects of lake impoundment and current diversion on a northern reservoir. Background data was collected from a range of host ages, seasons and sampling sites at Southern Indian Lake. The expected consequences of impoundment and diversion on the metazoan parasites of pike are predicted.

II. MATERIALS AND METHODS

A description of Southern Indian Lake and sampling sites are outlined by Watson & Dick (1979). Pike were collected from June 1975 to September 1976 using gillnets (10–133 mm mesh). Fish were collected from each of four sites (see Watson & Dick, 1979: fig. 1) once weekly from late May to mid-September 1976. Methods for collection of data from fish and parasites, testing sampling site differences and determination of prevalence, intensity and abundance are described by Watson & Dick (1979). Age distribution of samples appears in Table I. Seasonal distribution of samples appears in Table II. Seasons were defined as: winter (January–April), spring (May–June), summer (July–September) and autumn (October–December). Indices of similarity of parasite fauna between hosts were

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TABLE I. Age distribution of pike (*Esox lucius*) sampled

	Scale age							
	0	1	2	3	4	5	6	7
No. of pike	2	10	21	55	74	78	46	68

TABLE II. Seasonal distribution of pike (*Esox lucius*) sampled

	Winter	Spring	Summer	Autumn
No. of pike	16	191	237	—

calculated by summing the lesser of two abundances for parasites occurring in both host species and expressing this as a percentage of abundance of all parasites in these two species.

III. RESULTS

PARASITE FAUNA

A total of 444 pike were autopsied to reveal all metazoan parasites. These hosted 18 species of parasites which are listed in order of prevalence in Table III.

Based on abundance, the parasite fauna of pike had a 5% index of similarity with that of cisco, *Coregonus artedii*, and only 2·7% with whitefish, *Coregonus clupeaformis* (Watson & Dick, 1979). Generally, intensities of infection in pike (Table III) were higher than reported for Southern Indian Lake cisco or whitefish. Only eight species of parasites were present in greater than 10% of pike.

HOST AGE

Study of parasite abundance in pike of different ages revealed four basic patterns (Table IV). Abundance of some parasites remained constant with host age once the parasite was established, whereas some increased, decreased or remained independent of host age.

SEASON

Pike parasites were grouped by their season of maximum abundance (Table V). *Diphyllobothrium* sp., *Raphidascaris* sp. and *Triaenophorus crassus* failed to exhibit significant seasonal abundance maxima.

SEX

No differences were observed in the abundance of any parasite in pike of different sexes.

SAMPLING SITES

The ranking of the abundance of major pike parasites was significantly different between sites C and D (see Watson & Dick, 1979: fig. 1). Of cisco and whitefish

TABLE III. Pike (*Esox lucius*) parasites

	Prevalence	Intensity	Abundance	Dominance
Proteocephalus pinguis LaRue, 1911	96·2	70·38	67·71	30·03
Tetraonchus monenteron (Wagener, 1957) Diesing, 1858	94·8	129·17	122·45	54·34
Triaenophorus crassus Forel, 1768	72·5	14·55	10·55	4·68
Contracaecum brachyurum (Ward and Magath, 1917)	65·5	15·96	10·45	4·64
Diphyllobothrium sp.*	54·8	3·42	1·87	0·83
Raphidascaris sp.	46·6	10·89	5·07	2·25
Triaenophorus nodulosus Pallas, 1781	33·1	15·52	5·14	2·28
Centrovarium lobotes (MacCallum, 1895)	16·4	12·90	2·12	0·94
Crepidostomum farionis (O. F. Muller, 1784)	0·67	1·86	0·02	—
Piscicola milneri (Verrill, 1874)	0·2	1·00	0·00	—
Cyathocephalus truncatus (Pallas, 1781)	0·2	5·00	0·01	—
Metechinorhynchus salmonis O. F. Muller, 1780	0·2	1·00	0·00	—
*Spinitectus gracilis** Ward and Magath, 1916	0·2	1·00	0·00	—
Ergasilus luciopercarum Henderson, 1926	0·2	1·00	0·00	—
Glochidia (*Pelecypoda*)*	0·2	25·00	0·06	—
Glaridacris catostomi Cooper, 1920	0·2	5·00	0·01	—
Salmincola extensus (Kessler, 1868)	0·2	1·00	0·00	—
Argulus canadensis Wilson, 1916	0·2	1·00	0·00	—
			225·45	

*Larval forms.

parasites studied concurrently, only the former revealed significant intersite ranking differences (Watson & Dick, 1979).

IV. DISCUSSION

PARASITE FAUNA

High prevalence values for *P. pinguis* may have been related to the large percentage of pike which consumed fish (50% of those with recognizable food). Fish in the pike diet may have acted as paratenic hosts. *Tetraonchus monenteron* was prevalent and infection intensities were high. These monogeneans formed over 50% of all Southern Indian Lake pike parasite numbers but were found only on the gills of pike. Pike were abundant in the relatively shallow waters of the

TABLE IV. Patterns of major parasite abundance with pike age using the Cox and Stuart Test for trend

Pattern	Parasite
Independent	*Proteocephalus pinguis*
Independent once established	*Centrovarium lobotes*
Increase	*Diphyllobothrium* sp.*
	Triaenophorus crassus
	Tetraonchus monenteron
	Rhaphidascaris sp.
Decrease	*Triaenophorus nodulosus*

*Larval forms.

TABLE V. Patterns of major parasite abundance in pike with season* using the Cox and Stuart Test for trend

Pattern	Parasite
Independent	Diphyllobothrium sp.†
	Raphidascaris sp.
	Triaenophorus crassus
Highest in winter	*Proteocephalus pinguis*
Highest in spring	*Centrovarium lobotes*
	Triaenophorus nodulosus
Highest in summer	*Tetraonchus monenteron*

*Autumn not sampled.
†Larval forms.

sampling sites (< 3 m) thus allowing for an efficient interfish transfer of these monogeneans. Since *T. crassus* plerocercoids are prevalent in Southern Indian Lake whitefish and cisco (Watson & Dick, 1979) it was expected that mature cestodes would be a major pike parasite. *Triaenophorus crassus* and *Raphidascaris* sp. made up most of the overlap in parasite fauna between whitefish and cisco and those of pike. The relationship is a trophic one, with pike being the predator.

Several authors have reported *P. pinguis* as a major parasite of pike (Bangham & Adams, 1939, and others) but only Threlfall & Hanek (1970) and Arthur *et al.* (1976) have reported *T. monenteron* with intensity levels comparable to the present study. The latter two studies were of pike parasites in northern locations (Labrador and the Yukon, respectively). Similarities to the parasite fauna of pike in Southern Indian Lake may be attributable to latitude and/or climatic influences.

HOST AGE

Of the major Southern Indian Lake pike parasites, only the abundance of *P. pinguis* appeared to be independent of host age. This resulted from a relatively constant ingestion of infected hosts. Hunter (1929) suggested that young pike became infected by eating infected plankton, while older pike ate infected yellow perch and cyprinids. Constant intake of *P. pinguis* during the transition of diet from copepods to small fish allowed abundance values to remain independent of host age. Seasonal loss of *P. pinguis* from pike requires a constant annual intake of the parasite to maintain constant infection levels.

Centrovarium lobotes was not found in pike 0–2 years old but pike two years of age and older were infected with *C. lobotes* since these fish were large enough to consume numerous infected fish species, including cyprinids. Seasonal abundance of *C. lobotes* fluctuated widely and only an irregular diet of infected fish could have maintained abundance levels independent of pike age once infections were established.

Several pike parasites increased in abundance with host age. *T. monenteron* increased in abundance as pike reached spawning age and intraspecies contact was increased. Accumulation of *T. monenteron* may have been due to increased gill surface. *Raphidascaris* sp. from the intestines of pike is believed to be the mature form of larval *Raphidascaris* sp. found by Watson & Dick (1979) encysted in the intestinal mesenteries and visceral organs of Southern Indian Lake whitefish and cisco. Cisco and whitefish were not infected with larvae of *Raphidascaris* until one and three years of age, respectively. The diet of older pike had fewer cyprinids and more coregonids. As ingestion of infected coregonids increased with age, an increased abundance of *Raphidascaris* was expected. *T. crassus* abundance also increased with host age as a result of increased consumption of infected coregonids.

Only *T. nodulosus* decreased in abundance with host age and is probably related to an increase in the number of coregonids eaten and a decrease in consumption of infected perch, *Perca flavescens*, and young burbot, *Lota lota*. The latter two species have been shown by Miller (1945) and others to be intermediate hosts of *T. nodulosus*. Lawler (1969) found evidence that *T. nodulosus* and *T. crassus* interacted negatively such that an increase in numbers of one parasite adversely affected the numbers of the other parasite. This interaction would intensify as more coregonids infected with *T. crassus* were eaten by pike. Work by Lawler (1969) showing that pike under 3 pounds (6·6 kg) had more *T. nodulosus* than *T. crassus* is corroborated by our findings in pike of similar weight.

SEASON

Abundance values of three pike parasites, *Diphyllobothrium* sp., *Raphidascaris* sp., and *T. crassus* were independent of season (Table IV). *Diphyllobothrium* sp. is maintained as a plerocercoid in pike musculature and is probably long-lived. A long-lived parasite may not have its abundance correlated with season as a gradual accumulation could mask seasonal changes. *Raphidascaris* sp. may also be long-lived but more likely a constant diet of infected coregonids throughout the season maintained abundance levels. Moravec (1970) observed a distinct seasonal cycle of abundance for *Raphidascaris acus* in brown trout (*Salmo trutta* *m. fario*) and related it, in part, to seasonal changes in trout diet. A distinct seasonal abundance pattern could not be demonstrated for *T. crassus* although minimum abundance occurred in May during the pike spawning period. In contrast, Miller (1952) and others have found a period during which pike are nearly free from *T. crassus* during May to the end of July.

Triaenophorus nodulosus, *C. lobotes*, *T. monenteron* and *P. pinguis* had patterns of abundance that peaked at some time during the year (Table V). *Triaenophorus nodulosus* abundance reached a maximum during early May, just prior to an almost complete loss of this cestode by late spring. Lawler (1969) observed losses of *T. nodulosus* from pike during late spring to early summer. A spring maximum in the abundance of *C. lobotes* probably resulted from a change in feeding patterns to different fish. During spring, pike were frequently caught in shallow areas of the lake where consumption of cyprinids and trout perch (*Percopsis omiscomaycus*) was common. The summer maximum of *T. monenteron* is believed to be related to the life cycle of the parasite and was possibly the period of reinfection by the monogenean. Abundance of *P. pinguis* reached a maximum in late winter prior to the loss of mature gravid worms during spring pike spawning.

SAMPLING SITES

Sites C and D were about 2 km apart but differed in several respects. Site C was an extremely shallow, stagnant, weedy bay while site D was an exposed deeper site. Significant differences in parasite ranking between these sites resulted from the higher abundance of *T. nodulosus* and the lower abundance of *C. lobotes* at site C. Cyprinid species and other fish which vector metacercariae of *C. lobotes* (*Percopsis omiscomaycus*, *Notropis hudsonius* etc.) were present in greater numbers at site C thus explaining the greater abundance of the trematode. Plerocercoids of *T. nodulosus* have been shown to be vectored by yellow perch (*Perca flavescens*) and young burbot (*Lota lota*) (Miller, 1945). Burbot were most abundant at site D while yellow perch were almost absent from both sites. It appears that differences in the availability of intermediate fish hosts created significant intersite differences in parasite abundances.

FUTURE CHANGES

Our present knowledge of the consequences of diversion and impoundment on fish parasites has been largely based on work of Smirnova (1955) and other Soviet workers. A pre-impoundment study in northern Canada predicted trans-faunation of fish parasites (Arthur *et al.*, 1976). Lubinsky (1973) reported that Smirnova (1955) and others found an initial decrease in number of parasites followed by a period of rapid increase during which numbers exceeded original levels, often resulting in pathogenic effects. They found numbers were often slow to return to the original levels suggesting that the effects were long-lasting.

Any prediction that can be made on changes in fish parasite levels, especially of a predating fish like pike, should take into account a possible change in feeding patterns. At Southern Indian Lake, impoundment will cause dilution of fish and intermediate hosts resulting in an immediate though possibly temporary reduction in parasite numbers. Thereafter, the lasting effects on parasite numbers will depend on habitat changes, as they affect intermediate host numbers, and the timing and degree of contact between infected and noninfected hosts. If pike do not concentrate in the newly-created, shallow flooded areas, numbers of *T. monenteron* will decrease. Changes in the parasite composition of prey species such as whitefish, cisco, cyprinids and burbot will eventually be reflected in pike. If as predicted by Watson & Dick (1979), intensity of *T. crassus* plerocercoids in whitefish and cisco increases, then mature cestodes of this species are expected to increase in intensity in pike.

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