The rôle of fish in the selection of lakes by nonpiscivorous ducks: Mallard, Teal and Goldeneye

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During recent decades the importance of fish for the chemical, physical and biological conditions in fresh waters has received increasing attention in limnological research. The predation pressure from fish is one of the main factors determining the species composition in the plankton communities (e.g. Stenson 1972) and in the fauna of aquatic insects present in a lake (e.g. Macan 1977, Stenson *et al.* 1978, Eriksson 1979). High predation pressure from fish makes the plankton communities develop towards a composition of species with high turn-over rates of nutrients, while the reverse occurs when the predation pressure from fish is low. Thus, decreased predation pressure on plankton results in a lake developing towards a more oligotrophic state with declining availability of nutrients (e.g. Henrikson *et al.* 1980). By contrast, increased predation pressure may initiate a eutrophication process (Andersson *et al.* 1978).

Thus, biotic as well as abiotic conditions in a lake are strongly dependent on the fish fauna, and so it is reasonable to expect that fish also influence the conditions that are important for waterfowl species which do not eat fish. Competition between fish and waterfowl for common prey organisms may occur (e.g. Pehrsson 1974, 1979, Eriksson 1979, Eadie & Keast 1982). In lakes with high densities of cyprinid fish, submerged vegetation may be grazed to such an extent that the feeding conditions for waterfowl are impaired (e.g. Karlsson *et al.* 1976). Eutrophication processes may also result in impaired feeding conditions for ducks (Andersson 1981).

The aim of the present study is to relate the occurrence of two dabbling duck species, Mallard *Anas platyrhynchos* and Teal *A. crecca*, and one diving duck, Goldeneye *Bucephala clangula*, to the abundance of fish and to other lake characteristics such as spatial heterogeneity and presence of emergent vegetation and mire habitats along the shores. These factors may influence the conditions for the prey organisms, such as aquatic insects, and the availability of sites protected from predators (e.g. Pattersson 1976, Joyner 1980, Kaminski & Prince 1981, Godin & Joyner 1981, Talent *et al.* 1982).

The three duck species are the most common anatids in oligotrophic lakes in southwest Sweden. Mallard and Teal have both plant and animal diets, but recent research has shown the extreme importance of animal foods for egg-laying and incubating females and for newly hatched young of different dabbling duck species (e.g. Krapu 1981, Pehrsson 1979, Danell & Sjoberg 1980). Goldeneye feed, almost exclusively, on animal foods during the breeding period, as do the ducklings (Eriksson 1976).

Aquatic insects occurring in the study lakes include ephemerid larvae, Odonata larvae, water bugs (Corixidae and *Notonecta* spp.), dytiscids, Trichoptera larvae, *Chaoborus* larvae and chironomid larvae. These insects are prey organisms of both fish (e.g. perch *Perca fluviatilis* and roach *Leuciscus rutilis,* Andersson 1972, Craig 1974), and the three duck species. In this kind of freshwater habitat, Pehrsson (1979) found a reduced feeding efficiency by Mallard ducklings in lakes with fish populations present. Eriksson (1979) presents evidence, based on field experiments, of competition between fish and Goldeneye for common prey (see also Eadie & Keast 1982).

The predictions are: firstly, a negative relationship between the abundance of fish and the presence of ducks; secondly, positive relationships between spatial heterogeneity, emergent vegetation, or mire shores, and the abundance of ducks.

Study area

The study includes 58 lakes in the provinces of Dalsland, Bohuslän, Väster-

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gotland and Halland (approximately 56°40'-59°N, 11°40'-13°20'E) in southwest Sweden. The lakes are of an oligotrophic character. Rock, morain and mires are the main shore types. In most lakes, emergent vegetation is sparse, and it occurs mainly in clumps along the shores. Primary data used for calculations in the present study are summarised in the Appendix, but for further information about the lakes, see, e.g., Almer & Hanson (1980) and Göteborgsregionen (1980).

Perch, roach, pike *Esox lucius* and eel *Anquilla anquilla* are the commonest fish species present. In thirteen lakes salmonids are present, including brown trout *Salmo trutta,* char *Salvelinus alpinus,* white-fish *Coregonus* spp., cisco *Coregonus albula* and smelt *Osmerus eperlanus.*

Methods

Lake utilisation by waterfowl

Each lake was visited once during the period 4-14 May 1981. This is when most species shift between egg-laying and incubation. The lakes were surveyed from the shore. Thirteen were surveyed again by canoe during the period 18-31 July to search for young birds. At this time the majority of these were in age-classes IIb-IIIa, between half-grown and fledged.

Abundance of fish

Fish samples were obtained using gill nets in May 1979 (10 lakes) and June-July 1981 (48 lakes, see Appendix). Fish abundance is expressed as the mean number of fish per catch effort, the catch in one gill net during one night of approximately 12 hours. The method gives a very rough and relative estimate of the fish density. Pelagically living species, such as white-fish and cisco, are probably underestimated, and selectivity for certain size classes may occur. Because of possible biases, the fish data are used only to rank order the lakes. See Filipsson (1972) for details of gill net methods.

Lake characteristics

The ratio between shorelength and surface area was used as an index of the spatial heterogeneity of each lake. The proportion of shorelength with mire shores was estimated by a field visit and with studies from maps. The extent of clumps or bands of emergent vegetation (mainly *Phragmites communis* and *Carex* spp.) was expressed as a proportion of shoreline so occupied in early May. In the lakes investigated the more central parts are generally too deep to allow growth of emergent plants. The survey was carried out too early to include the occurrence of *Scirpus lacustris,* which is unfortunate as this plant produces seeds important as food for dabbling ducks.

Results

Spearman rank correlation coefficients, r_s, with correction for ties, are given in Table 1. Similar interpretations are obtained whether the number of ducks is related to surface area or to shorelength of the lakes. The number of Goldeneye and the density of the fish populations were negatively correlated, but this trend was not evident for either Mallard or Teal. With increasing spatial heterogeneity of a lake, there were greater numbers of Mallard and Goldeneye, but no apparent relationship with the number of Teal. The latter was, however, correlated with the extent of emergent vegetation along the shoreline. A higher proportion of mire vegetation on the shore gave more Mallards.

As with adult Goldeneye, the young Goldeneye tended to be found on lakes with low fish densities (Table 2). This was not the case for young Mallard or Teal.

Discussion

Lake selection by adult ducks during the breeding period

The results suggest that competition with fishes for food is unimportant for the selection of lakes by Mallard and Teal but important for the Goldeneye. One possible reason is simply that fish did not effectively reduce the availability of food items that are important for Mallard and

Table 1. Spearman rank correlation coefficients, r , corrected for ties, relating the presence of ducks to fish density and other characteristics of 58 lakes in south-west Sweden. (1) = number of ducks related to lake surface area, (2) = number of ducks related to shorelength. Primary data is given in Appendix.

		Number of fish per catch effort		Ratio: shorelength / surface area		% shorelength with emergent vegetation		% shorelength with mire shores	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Number	Mallard	−0.07	−0.02	0.36**	0.25*	0.16	0.18	0.24*	0.25*
of	Teal	0.01	0.04	0.05	0.05	0.26*	0.26*	0.17	0.14
ducks	Goldeneye	−0.25*	−0.22*	0.40**	0.31**	−0.08	−0.04	−0.08	−0.06

* $p<0.05$
** $p<0.01$

Table 2. Mean numbers of fish per catch effort in lakes where young duck were surveyed. n= the number of lakes.

	Yearlings seen				Yearlings not seen			
	$\bar{X}$	±	S.E.	n	$\bar{X}$	±	S.E.	n
Mallard	44	±	17	3	23	±	6	10
Teal	20			1	29	±	7	12
Goldeneye	4	±	3	2	32	±	6	11

Teal. Another explanation is concerned with the different ducks' feeding techniques. Adult dabbling ducks feed only in the most shallow parts of a lake. These areas are generally closest to the shore or among emergent vegetation. In lakes with low density of fish, aquatic insects may occur abundantly in the pelagic parts (Henrikson & Oscarson 1981), where they are available to Goldeneye but not to Mallard and Teal. In lakes with high density of fish, the pelagic populations of aquatic insects are reduced, and restricted to emergent vegetation or the littoral parts of the lake, where they are safer from fish predation. These are the only habitats which can be exploited by dabbling ducks. This may also explain the preference by Mallard for mire shores, as well as the preference by Teal for emergent vegetation (Table 1). When fish are present, Goldeneye may also show a preference for lakes with a high ratio between shorelength and surface area.

The need for protective cover against predators may be an additional aspect of the habitat preferences observed. Dabbling ducks may be more susceptible to predation (e.g. from raptors) than diving ducks out in open water, since the latter can dive more easily. However, Pehrsson (1979) presents evidence that although the areas closest to the shore are the best feeding places for Mallard, ducks are more susceptible there to mammalian predators, such as fox *Vulpes vulpes.*

Lake selection by young ducks

The survey of young ducks was carried out when they were between half-grown and fledged, following the period when the highest duckling mortality would be expected to have occurred (e.g. Bengston 1972). Among the thirteen lakes surveyed, Goldeneye young, as with adults, showed a preference for those with low densities of fish (Table 2: Mann-Whitney U test $p = 0.05$). In Mallard, higher feeding rates have been recorded for small ducklings when feeding on aquatic insects in lakes devoid of fish (Pehrsson 1979), but as the ducklings grow older, they to an increasing extent feed on vegetative food. This shift in diet often includes a habitat shift from a 'hatching lake' to a 'rearing lake' (Pehrsson 1980). In the latter presence of fish is of no disadvantage and, indeed, no preference by young Mallard or Teal for lakes with low fish density was found.

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Summary

The occurrence of Mallard *Anas platyrhynchos*, Teal *A. crecca* and Goldeneye *Bucephala clangula* during the first half of May 1981 was related to the abundance of fish, the spatial heterogeneity of the lakes, the extent of emergent vegetation, and the presence of mire shores in 58 oligotrophic lakes in southwest Sweden. Thirteen of the lakes were surveyed again for young birds during late July. Goldeneye (a diving duck) tend to avoid lakes where the availability of suitable food organisms (aquatic insects) is reduced because of high predation pressure from fish. In adult Mallard and Teal (dabbling ducks) such competition with fish for common prey does not seem to be of importance. With a low fish density, the prey organisms expand into the pelagic parts of the lake, where they are available for diving ducks but unavailable for dabbling ducks. With a high fish density, aquatic insects concentrate in littoral habitats or emergent vegetation, where they are safer from predation by fish, but where they are available to dabbling ducks.

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Appendix. Basic data for calculation of the Spearman r_s values in Table 1.

Reference No.	Fish/ Catch	Month	Area ha	Shore km	% Shore with emergents	% Shore with mires	Ducks Recorded Mallard	Teal	Goldeneye
P.44	78	7	80	7.5	15	5	3	0	1
N.74	67	7	20	2.3	80	90	5	2	0
O.107	59	7	90	12.2	10	10	1	1	7
330	57	5+	100	5.9	10	5	6	0	2
O.21	55	7	20	2.3	30	30	0	0	0
O.51	52	6	15	1.8	40	10	2	0	0
O.49	51	6	20	3.5	35	25	4	2	2
O.69	50	7	25	2.9	30	10	5	0	4
143	47	5+	3	0.7	25	25	1	0	0
O.85	45	7	65	4.7	30	10	12	0	0
O.57	44	7	80	4.8	45	10	0	0	0
N.4	43	7	70	5.3	30	10	0	0	0
N.79	40	7	20	1.9	30	10	0	3	1
O.93	39	7	25	3.1	30	20	1	0	4
N.30	35	7	45	5.2	15	10	0	0	7
O.7	35	6	210	18.0	10	5	3	0	8
P.87	34	7	210	16.8	15	40	5	1	9
N.88	34	7	50	4.9	20	5	0	0	0
N.10	32	7	25	3.4	35	5	0	0	4
P.40	32	6	50	3.7	30	20	4	0	0
O.4	32	6	30	2.9	15	5	2	0	0
O.67	31	7	55	8.8	10	10	0	0	2
N.76	30	7	40	3.3	15	25	3	0	0
O.79	27	7	25	3.3	30	10	4	4	7
Rg.8	27	6	37	3.9	10	10	0	0	3
N.84	27	7	30	4.5	20	30	0	0	0
P.59	27	7	55	6.5	5	5	0	0	0
N.17	26	7	8	1.8	10	10	3	0	2
P.3	26	6	135	10.5	35	40	1	1	6
N.78	25	7	40	3.6	25	40	0	0	0
P.55	25	6	40	5.0	5	5	1	0	0
Rg.10	24	7	268	13.4	15	20	1	0	9
P.68	23	7	85	5.5	10	5	0	0	0
Rg.11	21	7	755	20.1	10	5	0	0	4
N.7	21	7	30	2.7	10	0	0	0	0
O.110	20	7	240	16.4	10	5	5	0	8
N.77	20	7	35	2.8	15	40	3	6	0
P.61	20	7	140	16.5	5	5	2	2	8
360	20	5+	25	3.8	5	5	1	0	3
N.71	19	7	25	2.0	10	100	5	0	0
O.77	19	7	40	4.7	40	10	0	0	0
O.96	19	7	20	5.3	15	10	3	0	6
534	17	5+	13	1.7	35	5	4	0	2
O.54	17	7	15	3.6	40	10	2	1	0

Appendix. Basic data for calculation of the Spearman r_s values in Table 1 (cont.).

Reference No.	Fish/ Catch	Month	Area ha	Shore km	% Shore with emergents	% Shore with mires	Ducks Recorded Mallard	Teal	Goldeneye
Tolsjön	17	7	2	0.5	10	70	2	0	2
O.47	15	6	20	1.8	50	5	1	7	4
O.14	13	6	13	2.7	15	30	0	1	0
N.8	9	7	250	15.8	10	5	3	0	5
Rg.12	7	7	120	11.1	10	5	1	0	0
341	6	5+	42	6.1	35	20	4	0	5
335	6	5+	42	5.1	5	5	1	0	8
O.19	5	6	12	1.9	20	40	0	0	0
N.100	5	7	22	3.3	5	10	1	0	4
614	5	5+	67	9.7	10	5	8	0	8
P.64	4	7	90	5.8	5	5	0	0	0
219	2	5+	10	2.3	30	40	7	0	2
336	1	5+	77	6.5	10	5	2	1	14
211	1	5+	10	1.9	20	30	5	0	6

Reference No. according to Almer & Hanson (1980) and Göteborgsregionen (1980)

+ Catches in 1979, otherwise 1981