Verh. orn. Ges. Bayern 23, (1978/79): 191–200

Population trends in diving ducks at Myvatn, Iceland, in relation to food

Arnthor Gardarsson

Institute of Biology, University of Iceland, Grensasveg 12, Reykjavik, Iceland

Introduction

This paper is based largely on a more detailed and extensive paper (GARDARSSON, 1979) on waterfowl populations at Lake Myvatn, north Iceland. The abundance of waterfowl, especially ducks, at Myvatn is well known. In recent years certain waterfowl populations at Myvatn have decreased noticeably and, together with the commercially important char *(Salvelinus alpinus)*, reached very low levels in 1976. Some recovery seems to be taking place in 1977. Recent population fluctuations are associated with changes in the food supply in the lake, and by inference long-term fluctuations (GUDMUNDSSON, 1979, ADALSTEINSSON, 1976) may be similarly explained.

The work described here is of an exploratory character and is being followed up by further work at a recently established field research station in the area.

Study area

Lake Myvatn (about 65°40′ N, 17°00′ W, altitude 277 m) and surrounding wetlands lie in a shallow basin in the volcanic zone of north Iceland. The lake is shallow (mostly 1-3 m) and fed by warm (up to 23°C) and cold (5-6°C) springs which are rich in nutrients (cf. Olafsson 1979). Its area is about 37 km^2; other wetlands (exclusive of bogs, but including ponds, lakes and riparian marshes) in the basin total about 16 km^2; the basin is drained by the river Laxá, about 7 km^2 in area. The Myvatn system supports the most important breeding concentration of ducks (about 8,000 pairs) in Iceland.

Char, trout *(Salmo trutta)*, stickleback *(Gasterosteus aculeatus)*, and many birds, prey on aquatic invertebrates at Myvatn (ADALSTEINSSON, 1976, BENGTSON, 1971, FJELDSÅ, 1973, GARDARSSON, 1979). Life cycles and production of benthic invertebrates in Myvatn are discussed by e. g. ADALSTEINSSON (1979) and LINDEGAARD and JÓNASSON (1975, 1979). The food base of fish and waterfowl is narrow and shows extensive overlap (Fig. 1). Most diving ducks, and the char, feed largely on similar foods, including Chironomidae (midges), Cladocera (mainly *Eurycercus lamellatus)*, Gastropoda *(Lymnaea peregra)*, Bivalvia *(Pisidium* spp.), and sticklebacks (which themselves take mainly chironomids and cladocerans) and their eggs. At times the crustaceans *Lepi-*

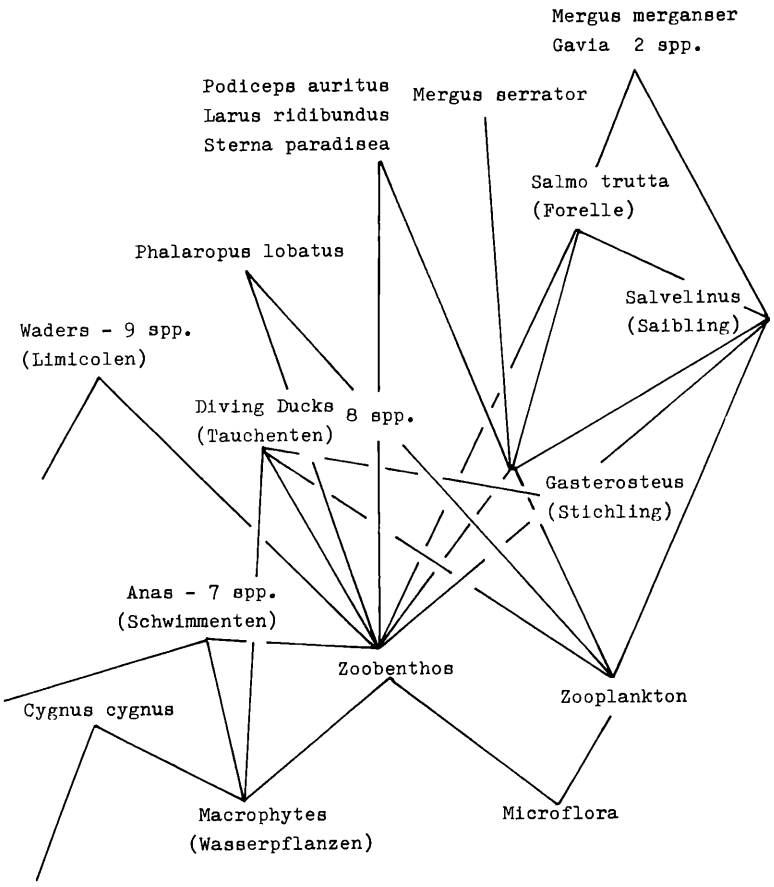

Fig. 1.
A simplified portion of the food web at Myvatn, especially as related to diving ducks. Terrestrial food chains, most top predators, and many components of the aquatic food chain, are omitted.

durus arcticus and *Daphnia longispina* are important in the diet; in the Laxá river the blackfly *Simulium vittatum* is the most important food.

Red-necked phalaropes *(Phalaropus lobatus)* appear to feed largely on emerging and adult midges. Arctic terns *(Sterna paradisaea)* and black-headed gulls *(Larus ridibundus)* take mainly midges and sticklebacks, and slavonian grebes *(Podiceps auritus)* sticklebacks and various aquatic insects. Red-breasted mergansers *(Mergus serrator)* feed almost exclusively on sticklebacks. Goosanders *(Mergus merganser)* and the divers *(Gavia immer* and *G. stellata)* feed on fish, probably mainly salmonids, though sticklebacks are taken also. Whooper swans *(Cygnus cygnus)* and surface-feeding ducks *(Anas* spp.) are wholly or largely herbivorous. The most important food plants are the green alga *Cladophora aegagrophila* and the pondweed *Potamogeton filiformis*.

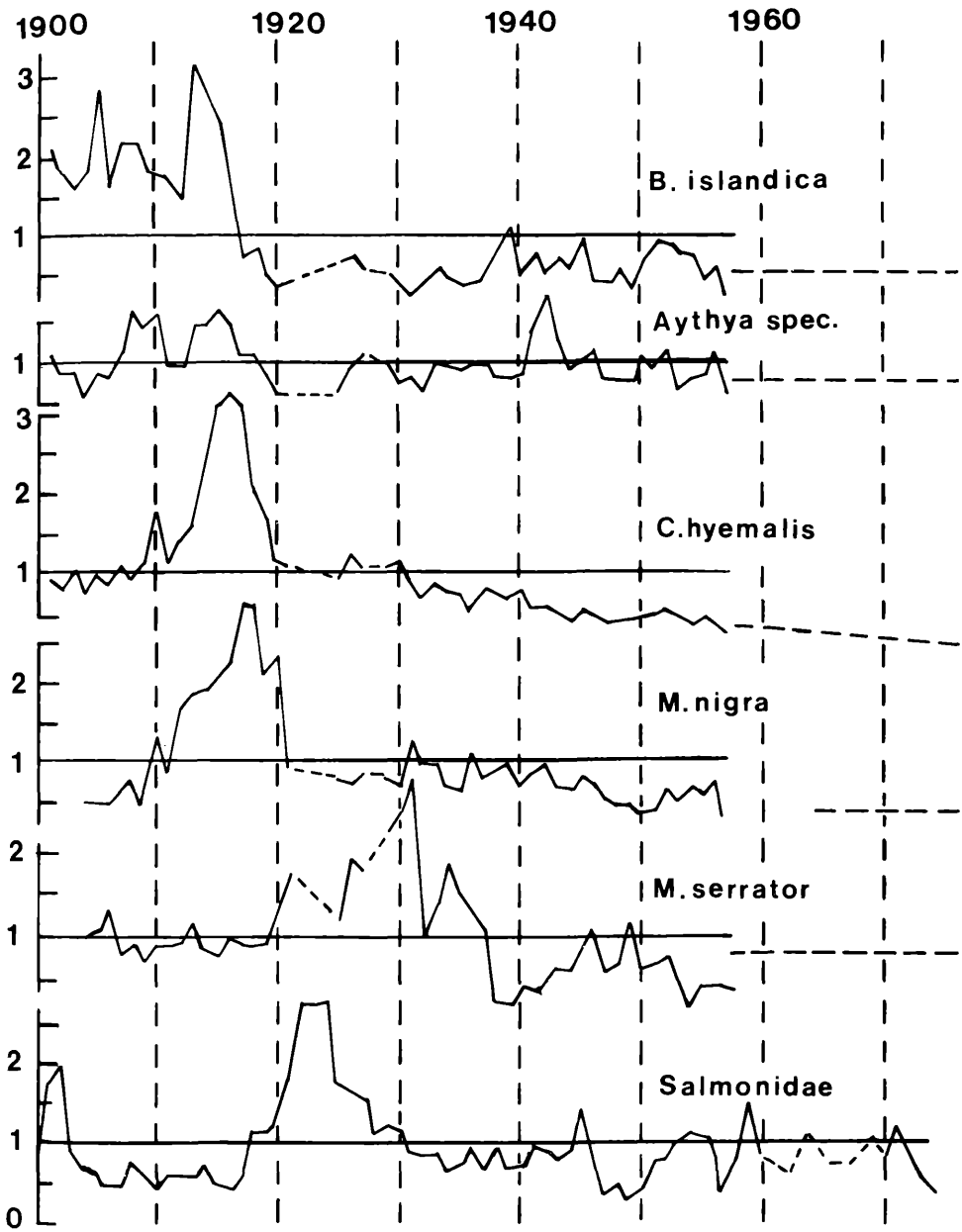

Fig. 2.
Population indices for diving ducks and fish at Myvatn. Indices are based on data for harvested eggs during 1901-1957 (GUDMUNDSSON, 1979), 1.0 = mean annual number of eggs harvested during that period; fish catch, mainly char, during 1900-1974 (ADALSTEINSSON, 1976), 1.0 = mean annual fish catch during that period. Dotted line for duck populations in recent years based on census data (GARDARSSON, 1979) and fitted approximately to the index based on egg harvest, but data overlap only in one year, 1949.

Methods

Population estimates were primarily based on censuses early in the breeding season. Censuses were generally made from high vantage points with × 20 prismatic telescopes; records were made on cassette tape or by a second observer. The numbers of moulting males were in some cases used as a check on spring population estimates, provided that the approximate area of origin of the moulting birds could be deduced. Other independent population estimates were derived from the proportional numbers of nests and broods found. Aerial surveys and low level aerial photography were used to supplement ground observations in some cases.

Stomach contents were estimated by a visual method. The contents were spread out in a shallow dish under a binocular microscope and the cover (i. e. volume) of each food group estimated. This was the only feasible method to deal with much of the material which consisted largely of a mixture of algal filaments and entomostracan crustaceans. The sample unit was the total stomach contents, i. e. oesophagus-proventriculus-gizzard. The stomach contents reported on here were taken during July-August 1941 (30 samples from shot birds), 1960 (234 samples from birds accidentally drowned in fishing nets), and 1975-76 (12 samples from netted birds). These samples belonged to five species of diving ducks common at the lake, tufted duck *(Aythya fuligula)*, scaup *(Aythya marila)*, common scoter *(Melanitta nigra)*, long-tailed duck *(Clangula hyemalis)*, and Barrow's goldeneye *(Bucephala islandica)*. Published data from 1968-70 (Bengtson, 1971) were also utilized.

The populations of diving ducks

Diving ducks are the most important waterfowl of the Myvatn area. Ten species occur regularly: tufted duck, scaup, pochard *(Aythya ferina)*, common scoter, long-tailed duck, harlequin duck *(Histrionicus histrionicus)*, Barrow's goldeneye, common goldeneye *(Bucephala clangula)*, red-breasted merganser, and goosander. Adults of these species totalled about 10,000 individuals in 1976. Long term fluctuations of waterfowl populations of Myvatn are described by Gudmundsson (1979) and Gardarsson (1979), and fluctuations in the catch of char and trout by Adalsteinsson (1976). These fluctuations are summarized in Fig. 2 and outlined for the diving ducks below.

The tufted duck is at present the most abundant duck species on the lake, with about 3,000 pairs (i. e. males). It was first recorded in 1895 and was common already in 1907. There are strong indications that the population level has remained approximately unchanged or perhaps increased slightly during the last decades. The scaup was probably the most abundant duck at Myvatn at least from 1747, when Joen Bendixsen compiled the first list of Myvatn waterfowl, and until sometime between 1970 and 1974. In 1949 there may have been about 4,000 pairs of scaup at the lake, in 1975 they were down to about 1,400. There were some signs of recovery in the scaup population in 1977 (Fig. 3). Both scaup and tufted duck moult on Lake Myvatn, and in 1975-76 about 300 males of each species migrated to the lake from up to 70 km away for moulting.

The common scoter is at present a rather scarce species at Myvatn, with about 250 pairs. There is evidence of large fluctuations in its population. It was said to be rela-

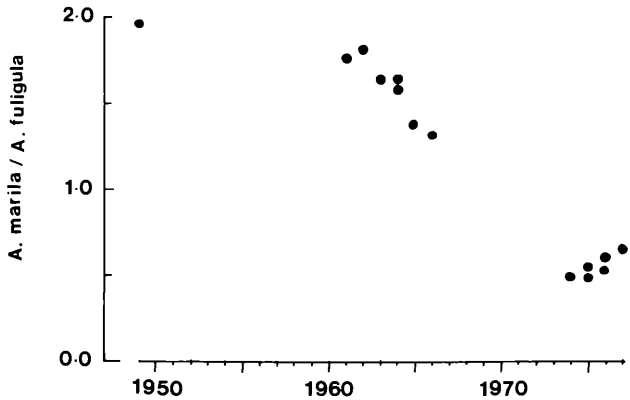

Fig. 3.
The ratio of scaup *(Aythya marila)* to tufted duck *(Aythya fuligula)* at Myvatn during 1949-1977. Based on census data from BENGTSON (1972b), BOYD (unpublished), FJELDSÅ (1975), GARDARSSON (1979 and unpublished), GUDMUNDSSON (1979).

tively scarce in the 1850s, an increase was noted early in the 20th century, and peak numbers were reached about 1917. Then followed a rapid decline. In 1949 there can hardly have been more than 1,000 pairs, and present levels were probably reached in the early 1960s. Scoter males leave the lake in early July, prior to moulting at sea, as do females during August, often before the young are fledged.

The long-tailed duck is at present one of the scarce species of the lake, with about 150 pairs. It has a history of long term fluctuations parallelling those of the scoter. Until about 1920 the long-tail appears to have been the second most abundant duck at Myvatn, and during its population peak about 1916 its numbers may have approached those of the scaup. The peak was followed by a catastrophic decline. In 1949 there may have been about 1,000 pairs, in 1964 about 400. It seems likely that from 1949 to 1976 there was a continuing steady decline in the longtail population of about 5% p. a. This trend had probably been continuous since 1920. Until recently, Myvatn was an important moulting area for longtail males. Few moulted in 1975 and none in 1976, but several males were again found moulting in 1977.

The tufted duck, scaup, scoter, and long-tailed duck, occupy similar habitats at Myvatn and feed on quite similar foods. The other common diving ducks of the area are clearly segregated ecologically.

The Barrow's goldeneye has a total population of about 1,000 adult males and 700 adult females in the entire Myvatn-Laxá watershed. The population has been stable at least since 1960 and probably much longer. High levels at Myvatn during the first one and a half decades of this century may be interpreted as indicative of either a larger population or that the breeding population was relatively concentrated at Myvatn at the time. The Barrow's goldeneye differs from other diving ducks of the area in several important respects. It is mainly a year-round resident; it is concentrated at the outlet of the river Laxá, where feeding conditions are especially good, but also makes opportunistic use of the lake and the lower Laxá; it is highly territorial and shows overt aggression towards other species.

	n	Cladocera	Chironomidae	Lymnaea	Pisidium	Other[1])
Aythya fuligula						
1960	6	13 (83)	21 (83)	42 (67)	—	24
1968—70	65	0 (3)***	24 (52)	66 (52)	tr (12)	10
Aythya marila						
1960	26	65 (100)	10 (70)	1 (35)	tr (15)	24
1968—70	159	6 (6)***	56 (61)	29 (27)	6 (21)	3
Melanitta nigra						
1960	111	92 (99)	2 (69)	tr (8)	0 (25)	6
1968—70	141	14 (34)*	85 (72)	tr (4)	0 (7) ***	1
Clangula hyemalis						
1960	15	78 (93)	5 (80)	0 (47)	tr (13)	17
1968—70	33	22 (64)	73 (55)	—	tr (9)	5
Bucephala islandica						
1960	6	94 (100)	2 (83)	—	—	4
1968—70	34	— ***	54 (82)	33 (29)	—	13

Differences in frequencies between periods tested with X^2 and Fisher exact probability test:

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$

[1]) Mostly copepods.

Table 1.
Main foods of young diving ducks at Myvatn. To facilitate comparison between years, the food composition in 1960 is calculated exclusive of *Cladophora* in 1960. Per cent volume in 1960, wet weight in 1968-70 (per cent frequency of occurrence in parentheses). O = less than 1 %, tr = traces.

The harlequin duck is restricted to rivers and streams, though it is scarce on the uppermost Laxá where it may be excluded by the aggressively territorial Barrow's goldeneye. Its total population in 1976 on the entire Laxá was about 150 pairs and there is evidence of relative stability in the past two decades (cf. Bengtson 1972a).

The two fish-eating ducks of the area differ widely in habits: The red-breasted merganser is a summer visitor at the lake and feeds largely on sticklebacks. Its present breeding population is about 200 pairs and it seems to be more or less stable in recent years. The red-breasted merganser went through a population peak in 1931 and then declined rapidly to a low in 1939. During 1975 and 1976 about 700 males moulted on Myvatn, but only about 300 in 1977 when there was a suggestion that sticklebacks had decreased. The goosander is mainly a winter visitor (up to about 250 present), and only about 30 pairs breed, mostly along the Laxá river.

Changes in diet

A comparison of the summer food (July-August) of five species of diving ducks during 1960 and 1968-70 shows that significant changes in food composition occurred. These changes are thought to reflect changes in food availability. All five species fed mainly on benthic invertebrates, the young (Table 1) tending to take more entomostracans and the adults (Table 2) more chironomids and molluscs.

In 1960, young scaup, scoters, and longtails, fed mainly on the cladoceran *Eurycercus lamellatus*, as did Barrow's goldeneye ducklings at the lake, though most of the latter fed on the upper Laxá river, mainly on blackfly larvae. Young tufted duck (only 6

	n	Cladocera	Chironomidae	Lymnaea	Pisidium	Other[1])
Aythya fuligula						
1941	5	—	1 (60)	75 (80)	tr (20)	24
1960	2	—	—	100 (100)	—	0
1968—70	51	1 (4)	29 (55)	39 (39)	tr (16)	31
Aythya marila						
1941	8	18 (37)	50 (87)	24 (12)	—	8
1960	28	40 (86)	31 (86)	6 (4)	—	23
1968—70	150	2 (19)***	57 (65)*	7 (29)	1 (21)	33
1975—76	12	tr (8)	7 (25)†	40 (58)	22 (67)††	31
Melanitta nigra						
1941	8	45 (37)	55 (75)	—	—	0
1960	11	57 (82)	12 (82)	tr (9)	23 (27)	8
1968—70	43	1 (9)**	49 (79)	9 (9)	5 (14)	36
Clangula hyemalis						
1941	4	2 (25)	47 (75)	49 (25)	—	2
1960	24	75 (96)	18 (78)	tr (4)	1 (8)	7
1968—70	85	2 (12)***	82 (80)	tr (3)	tr (3)	10
Bucephala islandica						
1960	5	18 (100)	80 (100)	—	tr (20)	2
1968—70	36	tr (5)***	47 (50)	4 (22)	—	49

Significance levels of differences in frequencies between periods (X^2 and Fisher exact probability test) shown as follows:

Between 1941—1960 and 1968—70:

* $P < 0.05$

** $P < 0.01$

*** $P < 0.001$

Between 1968—70 and 1975—76:

\+ $P < 0.05$

++ $P < 0.01$

[1]) Mostly sticklebacks and their eggs.

Table 2.

Main foods of adult diving ducks at Myvatn. Per cent volume exclusive of *Cladophora* in 1941, 1960, 1975-76; per cent wet weight in 1968-70 (per cent frequency in parentheses). O = less than 1 %, tr = traces.

samples) took less cladocerans and more *Lymnaea* than the other species, and both tufted and scaup ducklings took relatively large amounts of chironomids and copepods. In 1968-70, chironomid larvae were the main food of those species previously subsisting largely on cladocerans, the tufted alone continuing with a similar diet as in 1960, though also with less cladocerans. All species except longtail took cladocerans significantly less frequently in 1968-70 than in 1960.

Adults of all species relied less on cladocerans than the young, but showed similar changes in food, all except tufted duck taking significantly lower frequencies of cladocerans in 1968-70 than in 1941 and 1960 combined. There are indications that cladocerans were important in the diet of adult ducks in 1941 also, and the somewhat lower amounts recorded then as compared with 1960 were probably caused mainly by sampling bias (1941 stomachs were from shot birds, 1960 samples from birds caught in fishing nets). Twelve adult scaup from 1975-76 had fed mainly on molluscs and taken chironomids in significantly lower and *Pisidium* in significantly higher frequencies than in 1968-70. This was associated with extremely low chironomid populations (Lindegaard and Jónasson 1979).

Current work suggests that both diving ducks and char prefer chydorid cladocerans, in particular *Eurycercus lamellatus* which is the largest chydorid in Myvatn, to chironomids which in turn are probably preferred to molluscs. Thus the changes in food during the 1960s are best interpreted as being caused by a decline in the chydorids. Scaup, scoter and longtail switched to other foods in the lake when cladocerans became scarcer, but the latter two species showed stronger preferences for cladocerans. The Barrow's goldeneye had alternative abundant food resources in the river. The tufted duck probably did not have the marked preference for cladocerans shown by the other species.

Discussion

The long term record (Fig. 2) suggests that factors operating in the Myvatn area were determining both the resident fish and the largely migratory duck populations. Thus local breeding populations of ducks would seem to be regulated at the breeding grounds and population regulation in winter would only set an overall limit to the total, or flyway, population.

The pattern of fluctuations and the observed changes in food suggest that feeding conditions at Myvatn are perhaps the main factor determining population levels of both fish and waterfowl. Thus the three duck species which are currently declining all showed preferences for cladocerans which apparently declined in the 1960s. The three species which have been at stable levels in recent years appear to be at least comparatively independent of cladocerans as food.

By inference, the much larger fluctuations known to have occurred in these populations earlier in this century were presumably caused by changes in food availability, determined partly by the abundance and species composition of the benthic invertebrates and partly by time-lag effects set up by the fluctuations in the duck and fish populations themselves. Further analysis of this situation is dependent on long-term monitoring, a major objective of the recently established field station at Myvatn.

Summary

Changes in populations and food habits of diving ducks at Myvatn, Iceland, are reviewed. Recent population changes were associated with changes in food. Three species, *Aythya marila, Melanitta nigra,* and *Clangula hyemalis,* which preferred the chydorid cladoceran *Eurycercus lamellatus* declined during the 1960s as did their preferred food species. Three duck species, *Aythya fuligula, Bucephala islandica,* and *Mergus serrator,* which were relatively independent of cladoceran food had stable populations. Large fluctuations in duck and fish populations at Myvatn during this century were by inference caused by changes in food availability.

Acknowledgements

I express my sincere gratitude to Mr. Arni EINARSSON for his enthusiastic help at all stages of this work and to Dr. Finnur GUDMUNDSSON and Mr. Hugh BOYD for providing their unpublished data. Mrs. Freydis SIGURDARDOTTIR and her late husband Mr. Geir KRISTJANSSON did much to make field work in 1960-61 possible. Parts of this study were financed by the Nature Conservation Council of Iceland and financial assistance was received from the Menningarsjodur Islands. Facilities for field work in 1975-77 were provided by the Myvatn Field Research Station.

References

ADALSTEINSSON, H. (1976): Fiskstofnar Myvatns. Natturufraedingurinn 45: 154-177.

ADALSTEINSSON, H. (1979): Observations on seasonal variation and ecology of benthic Crustacea of Lake Myvatn in 1973. Oikos 32. (In press).

BENGTSON, S.-A. (1971): Food and feeding of diving ducks breeding at Lake Myvatn, Iceland. Ornis Fennica 48: 77–92.

BENGTSON, S.-A. (1972a): Breeding ecology of the harlequin duck *Histrionicus histrionicus* (L.) in Iceland. Ornis Scandinavica 3: 1–19.

BENGTSON, S.-A. (1972b): Reproduction and fluctuations in the size of duck populations at Lake Myvatn, Iceland. Oikos 23: 35-58.

FJELDSÅ, J. (1973): Feeding and habitat selection of the horned grebe *Podiceps auritus* (Aves) in the breeding season. Vidensk. Meddr dansk naturh. Foren. 136: 57-95.

FJELDSÅ, J. (1975): Recent changes in the waterfowl situation in the lakes Myvatn and Vikingavatn, Iceland. Dansk orn. Foren. Tidsskr. 69: 89-102.

GARDARSSON, A. (1979): Waterfowl populations of Myvatn and recent changes in their numbers and food habits. Oikos 32. (In press).

GUDMUNDSSON, F. (1979): The past status of the Myvatn waterfowl populations. Oikos 32. (In press).

LINDEGAARD, C. and P. M. JÓNASSON. (1975): Life cycles of *Chironomus hyperboreus* Staeger and *Tanitarsus gracilentus* (Holmgren) (Chironomidae, Diptera) in Lake Myvatn, northern Iceland. Verh. Int. Verein. Limnol. 19: 3155-3163.

LINDEGAARD, C. and P. M. JÓNASSON. (1979): The abundance, population dynamics and production of zoobenthos in Lake Myvatn. Oikos 32. (In press).

OLAFSSON, J. (1979): The chemistry of Lake Myvatn and River Laxá. Oikos 32. (In press).