Seasonal emergence of chironomids in relation to egglaying and hatching of ducks in a restored lake (northern Sweden)

KJELL DANELL and KJELL SJÖBERG

Introduction

The total area of wetlands in Sweden has been considerably reduced mainly as a result of silviculture and agriculture. In northern Sweden man earlier used almost all available areas, e.g. mires and shores of lakes and rivers, for haymaking. He also drained shallow lakes and thereby exposed the bottoms for colonization of sedges (*Carex* spp.) and water horsetail *Equisetum fluviatile*. A dam was often built at the outlet and the former lake was flooded during spring and early summer in order to fertilize and stimulate growth of emergent plants. Later the water level was lowered to facilitate haymaking. These regulated and productive shallow lakes were a suitable habitat for waterfowl.

This common practice was totally abandoned during the 1950s. The dams fell into decay and subsequent drying up resulted in an invasion of shrubs (*Salix* spp.). As a consequence large areas of wetlands were lost. Today, with an increasing interest for hunting and other outdoor activities, the decreasing populations of waterfowl, e.g. Mallard *Anas platyrhynchos*, have aroused a demand for wetland management.

In northern Sweden one possible way to increase the populations of waterfowl is to flood those abandoned lake bottoms, which today in most cases are regarded as impediments to silviculture and agriculture. Such experiments started in the early 1970s, and one of these restored lakes, Lake Veittijärvi, showed a high utilization by swimming ducks, mainly Teal *A. crecca*, Pintail *A. acuta* and Mallard. It further showed a high production of chironomids, which were a highly preferred duck food (Danell & Sjöberg, unpublished).

The aims of this investigation were to quantify the emergence of chironomids and to establish the time of emergence in relation to egglaying and hatching of ducklings.

Study area

The Lake Veittijärvi (66°3′N, 23°46′E) (Figure 1) is situated in the north-eastern corner of Sweden (province of Norrbotten) close to the Finnish border. The area belongs to the main boreal (central taiga) biotic zone (Sjörs 1963) with coniferous forests of Norway spruce *Picea abies* and Scots pine *Pinus silvestris*. The lake lies in a flat country where large expanses of mires are interrupted by thin coniferous forests.

On a mean annual basis, the temperature is 0–1°C (Ångström 1953b) and the precipitation is 500–550 mm (Wallén 1953). The temperature for the warmest month (July) is 15–16°C (Ångström 1953a). In general, ice covers lakes in this part of Sweden from about the 10th October to about the 20th May, or 200–220 days (Ångström 1958).

The lake (35 metres above sea level) has an area of about 45 hectares and is surrounded by an outer belt of birch *Betula pubescens* and an inner belt of willows *Salix lapponum* and *S. phylicifolia*. The lake was drained about 1930 and then used for hay production (*Carex* spp.) to the beginning of the 1950s. It was restored in 1971 (Figure 1) and the permanent flooding resulted in the sedges dying off, which during our studies in 1975 and 1976 were lying more or less decomposed on the bottom.

Figure 1. Lake Veittijärvi in northern Sweden.

Wildfowl 28 (1977): 129–135

During late spring and early summer most parts of the lake have a water depth of 0·3–0·5 m. The water has a brown colour, a pH range of 5·5–6·9 and a specific conductivity (μS/cm, 20°C) range of 20–110. The water temperature during 1975 and 1976 and the ice cover are shown in Figure 2.

The emergent vegetation is, at the present succession stage, very scanty, and consists of some stands of water horsetail and some scattered clones of sedge *Carex aquatilis*. Floating plants were absent. Submerged plants such as pondweeds *Potamogeton pusillus* and *P. obtusifolius* have colonized the lake during the last years.

The most abundant breeding dabbling ducks are Teal, Pintail and Mallard. Further there are a few pairs of Wigeon *Anas penelope*, Shoveler *A. clypeata* and Garganey *A. querquedula*. Of the diving ducks, Tufted Duck *Aythya fuligula* is the most common.

Methods

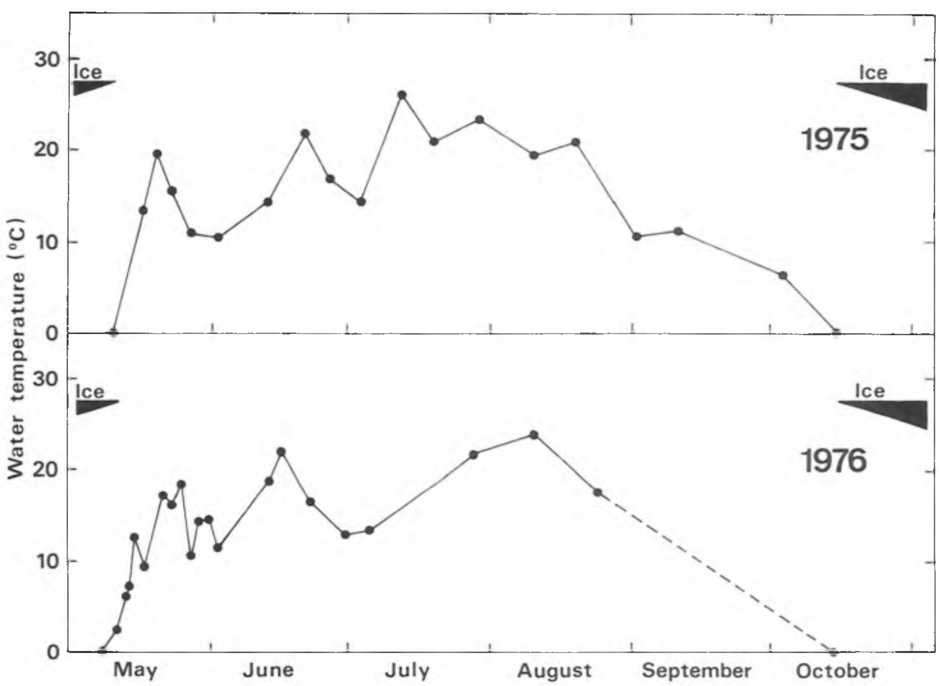
Different types of emergence traps and their pros and cons have been reviewed by Morgan (1971) and Mundie (1971). As a large number of traps, able to operate in a water depth of 0·25 m as a minimum, were desirable, a cheap and easily manufactured model (Figure 3) was designed for this study.

The main parts of the trap, a bucket and a funnel, were made of polyethylene. Two holes were cut into the bucket, which had a volume of about 5 litres, and were covered by a nylon gauze of 280 μm mesh. The container was closed by pressing the funnel into the bucket. The funnel covers an area of 0·036 m^2.

Two pieces of stainless steel were attached to the trap as holders. For holding the trap in the same position over the bottom, two metal rods were driven into the sediment. Two floats were attached so that they always kept 0·04 m of the trap above the water surface, even during periods of fluctuating water levels (Figure 3b). The material cost for one trap was approximately £4.00, and about one hour was needed to make one trap.

The emergence traps were placed in open water at ten positions chosen at random. The positions of the traps were the same in 1975 and 1976. Two sets of traps were used and were usually changed every 5–7 days; however, more often at emergence peaks and with longer intervals during the lows. When taking the trap out of water, it was first slightly pressed down to push animals floating at the apex of the funnel into the

Figure 2. Water temperature and ice cover in Lake Veittijärvi, northern Sweden. The temperatures were taken at a fixed time of the day (0·1 m below the water surface at a fixed point).



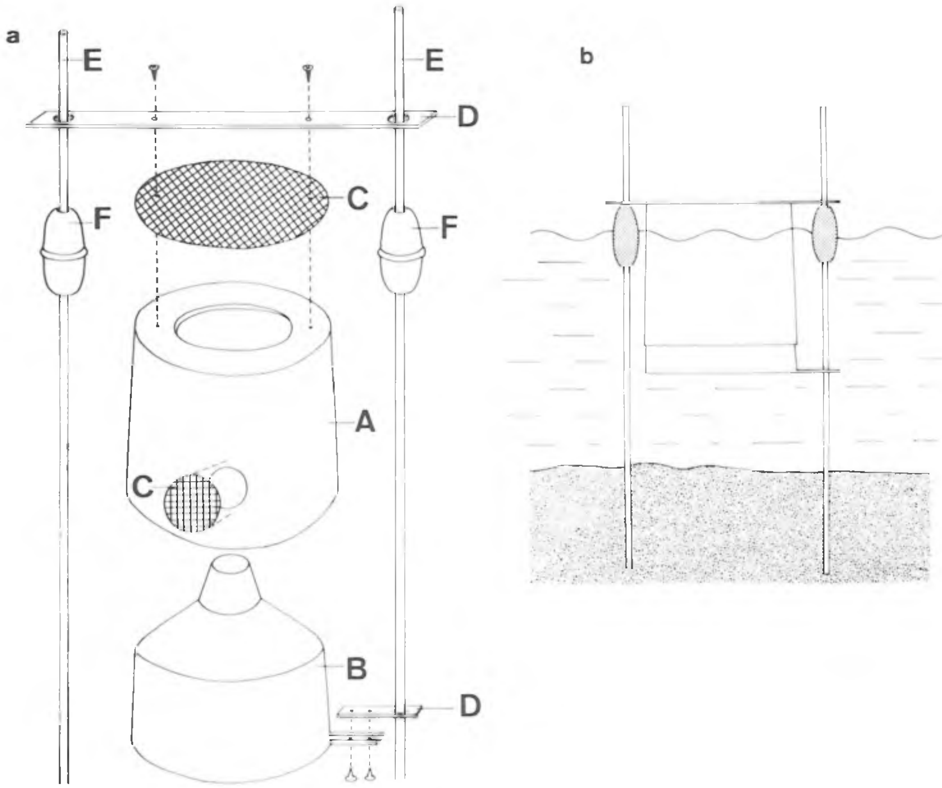


Figure 3. Emergence trap for chironomids. Bucket (A) and funnel (B) made of polyethylene. Holes were covered by a nylon gauze (C). For holding the trap in the same position over the bottom, metal rods (D and E) and floats (F) were used (for details, see text).

container. During the transport the traps were closed by inserting a lid into the hole at the apex of the funnel, and this allowed us to empty and clean the traps indoors. The chironomids were immobilized by spraying ethanol through the net or by shaking the trap containing some water.

The calculation of the confidence limit (95%) of the mean value is according to Elliott (1971, p. 81–93), which means logarithmic transformation (log x) for small samples ($n \leqslant 30$) from a contiguous distribution.

Results

The emergence of chironomids started about ten days after the ice thawed (Figure 4). At that time the water temperature had reached 15–20°C (Figure 2). About 50% of the chironomid population had emerged 1st June 1975 and 9th June 1976 (Figure 5).

The amount of emerging chironomids per m^2 was estimated to 840 ± 157 ($\bar{x} \pm$ S.E.; $n = 10$) for 1975 and $3{,}121 \pm 568$ for 1976. The 95% confidence limits were 496–1,083 and 1,953–3,941, respectively.

The chironomid species were *Anatopynia plumipes*, *Procladius* sp., *Psectrotanypus varius*, *Cricotopus sylvestris*, *Psectrocladius edwardsi*, *Chironomus tentans*, *C. polaris*, *Chironomus* sp. I and II, *Einfeldia dissidens*, *E. pagana* and *Glyptotendipes paripes*. *Chironomus polaris* was the most abundant during 1975 and *E. dissidens* during 1976. Beside chironomids single specimens of water beetles and some water bugs were trapped.

Egg-laying of Mallard, Pintail and Teal started in early May and hatching occurred in middle and late June (Figure 4).

Discussion

The chironomid fauna in the lake, as reflected by catches in the emergence traps, consists of relatively few species. The habitat is rather extreme because the shallow lake

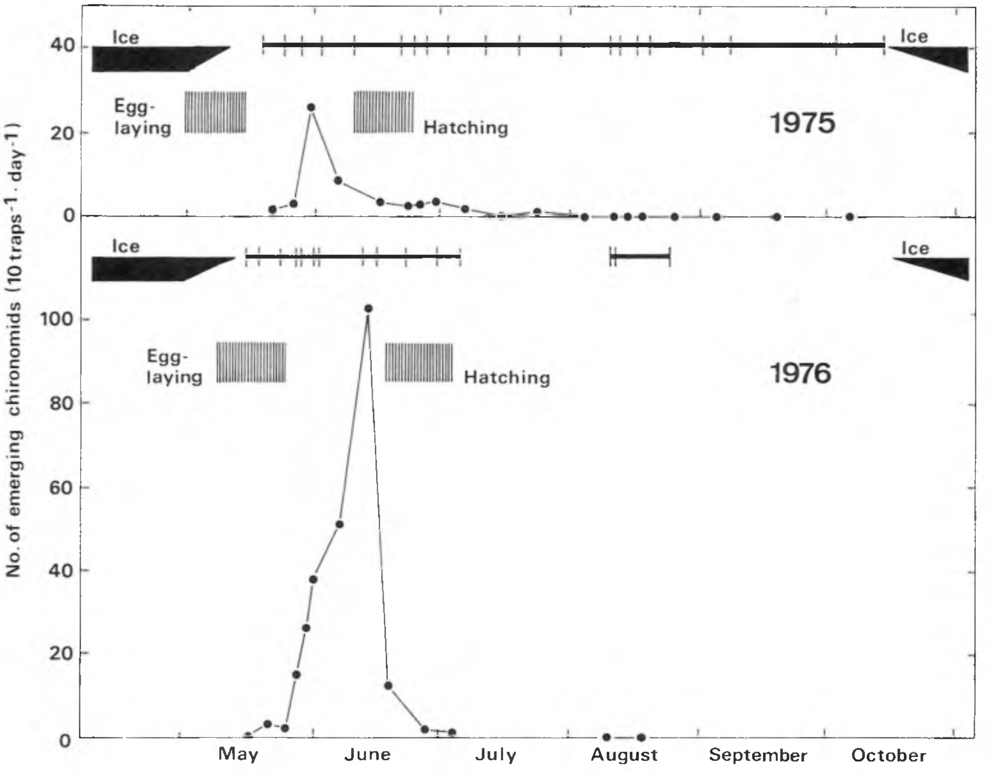


Figure 4. Numbers of emerging chironomids per day and times of egg-laying and hatching of ducks (Mallard, Pintail and Teal) at Lake Veittijärvi, northern Sweden. Ten funnel traps were used during periods indicated by horizontal bars with times of collection marked. The periods of hatching of ducklings, based on surveys in the lake, are approximate. The periods of egg-laying of ducks are based on back-calculations from hatching data.

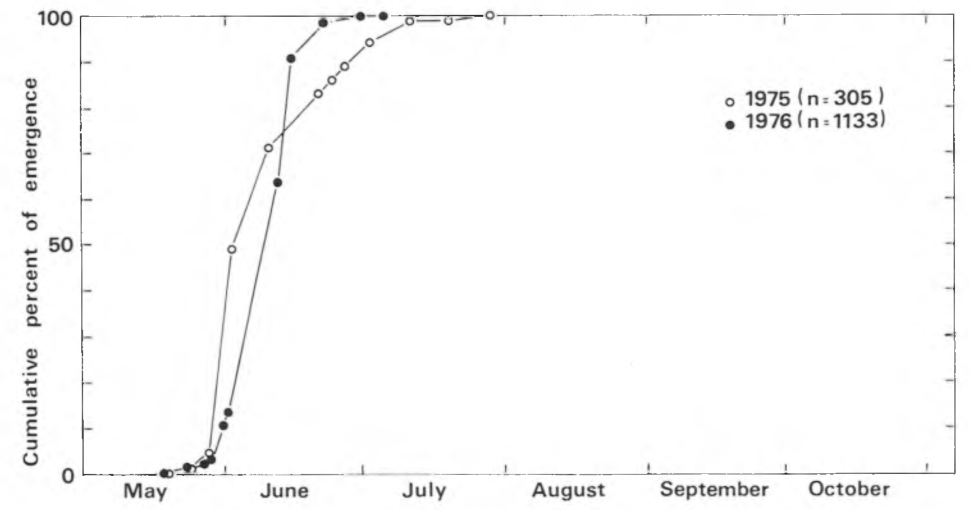


Figure 5. Cumulative percent of emerging chironomids at Lake Veittijärvi, northern Sweden.

freezes to the bottom during winter. In addition, large quantities of decomposing organic matter (*Carex* spp.) and a small water flow through the lake, ought to result in very poor oxygen conditions. Many of the chironomid species found have larvae with hemoglobin in their body fluids to stand low oxygen pressures.

The emergence was concentrated to a short period rather close to the thawing of the ice. The water warmed up very rapidly due to the small water depth and dark-coloured bottom and water. Danks & Oliver (1972) found in studies of arctic chironomids, emergence early in the season. They found that all species were synchronized and the water temperature was the proximate factor controlling emergence rather than photo-period. Narrow time limits for emergence are not confined only to arctic populations. Chironomid species in the temperate zone, which overwinter in later instars and emerge early in the spring, usually have a narrow emergence period (review by Welch 1973).

To check the efficiency of the traps to catch emerging chironomids, the larvae population was sampled with a Rzoska core sampler just before the start of emergence (18th May 1976). The density of chironomids per m^2 in the open water was estimated as 2,088 $\pm$ 655 ($\bar{x} \pm$ S.E.; n = 7). The estimated number of emerging chironomids based on the emergence traps, was 3,121 $\pm$ 568 ($\bar{x} \pm$ S.E.; n= 10). There is no significant difference (Mann-Whitney U-test, $P > 0{\cdot}05$, $U = 17$) between the two estimates.

All emergence traps involve some sampling errors (for review see Morgan (1971) and Mundie (1971)). The traps offers a relatively sheltered site and may therefore be expected to attract emerging chironomids from areas outside the trapping area and thus result in an overestimate. On the other hand, the shading effect of the traps can cause nymphs and pupae to take avoiding reactions resulting in reduced catches. McCauley (1976) has shown that significant losses from traps occur even under constant and probably favourable conditions. Under field conditions, the actual number of specimens found in the trap could be substantially less, this being dependent on factors such as wind and wave action, predation, decomposition, etc.

The density of chironomids found in Lake Veittijärvi is high even when compared with some more southern lakes, e.g. Lake Erken in the middle of Sweden (Sandberg 1969).

Figure 6. Chironomids on the water surface at a peak of emergence (30th May 1976, Lake Veittijärvi, northern Sweden).

The bulk of the diet of breeding dabbling duck females is composed of aquatic invertebrates (Perret 1962; Dirschl 1969; Swanson & Nelson 1970; Swanson *et al.* 1974; Krapu 1974; Serie & Swanson 1976) and the highest invertebrate consumption is reported to occur during the egglaying period in Pintail (Krapu 1974) and Gadwall *Anas strepera* (Serie & Swanson 1976). In northern Sweden the ducks arrive at the time the ice breaks up and egglaying starts almost

Figure 7. Chironomids accumulated at the shoreline after a period of windy weather (30th May 1976, Lake Veittijärvi, northern Sweden).

immediately. It therefore takes place before the chironomid emergence. The egg-laying hens, with a demand for a readily accessible, high quality food, can utilize the chironomids in their last larval stage.

The diet of ducklings of dabbling ducks during the first time after hatching has a high proportion of invertebrates (Chura 1961; Perret 1962; Bartonek 1972; Sugden 1973; Lees & Street 1974; Bengtson 1975). Chironomids seem universally important in the early diet of young flightless dabbling ducks. In Lake Veittijärvi the hatching of ducklings takes place just after the peak emergence of chironomids (Figure 4) and therefore the ducklings can utilize this abundant food (Figure 6). Dead or dying chironomids are often, especially after windy days, found accumulated in belts at the shoreline (Figure 7), which further increases availability.

Acknowledgements

We wish to thank Mr R. Almqvist, who promoted the restoration of Lake Veittijärvi, for permission to work in the area administered by the Norrbotten County Section of the Swedish Sportsmen's Association. We are grateful to Mr E. Andersson for valuable ideas during the construction of the emergence traps, and to Dr T. Wiederholm who kindly determined the chironomid species.

Valuable comments on the manuscript were given by Drs Å. Andersson, O. Pehrsson and T. Wiederholm.

This investigation was supported by the Research Committee of the National Swedish Environment Protection Board (contract 6–34/74–76) and the Swedish Sportsmen's Association.

Summary

The emergence of chironomids was studied using ten emergence traps in Lake Veittijärvi, northern Sweden. The lake (45 hectares) was drained about 1930 and the exposed dry bottom soon became covered by sedges, but they were killed after flooding in 1971.

At least 12 chironomid species have colonized the lake and are abundant (about 2,000 larvae per m^2) at the present stage. Their emergence started about ten days after thawing and was concentrated to a relatively short period in late May and early June. Most of the breeding dabbling duck females had completed egg-laying (a period during which they usually consume large quantities of invertebrates) before the time when adult chironomids became abundant. The hatching of ducklings (Teal *Anas crecca*, Pintail *A. acuta* and Mallard *A. platyrhynchos*) was, however, preceded by the peak of emergence of chironomids, so that the ducklings at Lake Veittijärvi were favoured by the presence of an abundant and accessible high quality food.

References

Ångström, A. 1953a. Temperature. Sheet 25–26 in *National Atlas of Sweden*. Ed. M. Lundqvist. Stockholm: Generalstabens litografiska anstalts förlag.

Ångström, A. 1953b. Annual temperature. Sheet 31–32 in *National Atlas of Sweden*. Ed. M. Lundqvist. Stockholm: Generalstabens litografiska anstalts förlag.

Ångström, A. 1958. *Sveriges Klimat*. Stockholm: Generalstabens litografiska anstalts förlag.

Bartonek, J. C. 1972. Summer foods of american widgeon, mallards, and a greenwinged teal near Great Slave Lake, N.W.T. *Can. Fld. Nat.* 86: 373–6.

Bengtson, S.-A. 1975. Food of ducklings of surface feeding ducks at Lake Mývatn, Iceland. *Ornis Fennica* 52: 1–4.

Chura, N. J. 1961. Food availability and preferences of juvenile mallards. *Trans. 26th N. Amer. Wildl. Conf.*: 121–34.

Danks, H. V. & Oliver, D. R. 1972. Seasonal emergence of some high arctic Chironomidae (Diptera). *Canadian Entomologist* 104: 661–86.

Dirschl, H. J. 1969. Foods of lesser scaup and blue-winged teal in the Saskatchewan River Delta. *J. Wildl. Mgmt.* 33: 77–87.

Elliott, J. M. 1971. Some methods for the statistical analysis of samples of benthic invertebrates. *Freshwater Biological Association, Scientific Publication* No. 25.

Krapu, G. L. 1974. Foods of breeding pintails in North Dakota. *J. Wildl. Mgmt.* 38: 408–17.

Lees, P. R. & Street, M. 1974. The feeding ecology of young mallard (*Anas platyrhynchos platyrhynchos*) and tufted duck (*Aythya fuligula*) in wet gravel quarries. *Trans. Int. Cong. Game Biol.* 11: 249–53.

McCauley, V. J. E. 1976. Efficiency of a trap for catching and retaining insects emerging from standing water. *Oikos* 27: 339–45.

Morgan, N. C. 1971. Factors in the design and selection of insect emergence traps. Pp. 93–108 in *A manual on methods for the assessment of secondary productivity in fresh waters*. IBP Handbook No. 17. Eds. W. T. Edmondson & G. G. Winberg. Oxford: Blackwell Scientific Publications.

Mundie, J. H. 1971. Techniques for sampling emerging aquatic insects. Pp. 80–93 in *A manual on methods for the assessment of secondary productivity in fresh waters*. IBP Handbook No. 17. Eds. W. T. Edmondson & G. G. Winberg. Oxford: Blackwell Scientific Publications.

Perret, N. G. 1962. The spring and summer foods of the common mallard (*Anas p. platyrhynchos* L.) in south central Manitoba. Unpublished M.Sc. Thesis, Univ. of British Columbia, Vancouver.

Sandberg, G. 1969. A quantitative study of chironomid distribution and emergence in Lake Erken. *Arch. Hydrobiol. Suppl.* 35: 119–201.

Serie, J. R. & Swanson, G. A. 1976. Feeding ecology of breeding gadwalls on saline wetlands. *J. Wildl. Mgmt.* 40: 69–81.

Sjörs, H. 1963. Amphi-Atlantic zonation, Nemoral to Arctic. Pp. 109–125 in *North Atlantic biota and their history*. Eds. A. Löve & D. Löve. Oxford: Pergamon Press.

Sugden, L. G. 1973. Feeding ecology of pintail, gadwall, american widgeon and lesser scaup ducklings in southern Alberta. *Canadian Wildlife Service, Report Series*. No. 24.

Swanson, G. A. & Nelson, H. K. 1970. Potential influence of fish rearing programmes on waterfowl breeding habitat. Pp. 65–71 in *A symposium on the management of midwestern winterkill lakes*. Ed. E. Schneberger. American Fisheries Society, Special Publication No. 1.

Swanson, G. A., Meyer, M. I. & Serie, J. R. 1974. Feeding ecology of breeding blue-winged teals. *J. Wildl. Mgmt.* 38: 396–407.

Wallén, C. C. 1953. Annual precipitation. Sheet 31–32 in *National Atlas of Sweden*. Ed. M. Lundqvist. Stockholm: Generalstabens litografiska anstalts förlag.

Welch, H. E. Jr. 1973. Emergence of Chironomidae (Diptera) from Char Lake, Resolute, Northwest Territories. *Can. J. Zool.* 51: 1113–1123.

K. Danell & K. Sjöberg, Section of Ecological Zoology, Dept. of Biology, University of Umeå, S-901 87 Umeå, Sweden.

A family of Mute Swans *Cygnus olor*. (*Philippa Scott*).