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Food availability and utilization by ducks of a shallow brackish-water bay in the northern Bothnian Bay

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In 1977, the types of activity and food-seeking behaviour of mainly surface feeding ducks was studied in relation to the abundance of potential food resources in Kalalahti, a sheltered, shallow, brackish-water bay in the northernmost part of the Bothnian Bay.

Because of the exposure to waves, emergent hydrophytes are generally poorly developed along the shores of this type of habitat, and, together with the low productivity of invertebrates in the depth zone 0—0.5 m due to the action of waves and ice, water-level fluctuations etc., long stretches of the northern coast of the Bothnian Bay are largely unsuitable as nesting and brood-rearing habitats for dabbling ducks. Moreover, large areas of the foraging grounds are accessible to dabbling ducks at rather irregular intervals, namely when the water-level is low, due to changes in atmospheric pressure and wind direction. Coastal habitats of the type represented by the Kalalahti bay, therefore, contribute only to a minor extent to the production of broods of dabbling ducks. However, these habitats are utilized whenever possible by adult ducks and fledged juveniles, especially at the end of the breeding season. They are also utilized by migrant ducks while they are building up an energy reserve prior to, and during, the autumn migration southwards.

The irregular utilization of the Kalalahti bay by ducks indicates a high degree of flexibility and opportunism in their habitat selection.

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1. Introduction

The northern part of the Bothnian Bay is a shallow, brackish-water area, where, although tidal influence is slight (Magaard 1974), relatively wide fluctuations in water-level occur due to changes in wind direction and atmoshperic pressure (Lisitzin 1974). Because of the rapid rate of land uplift, about 9 mm per year (Mörner 1977), the vegetational succession of many of the shallow bays along the coastline is continually renewed. The coastal habitats are roughly divisible into four types: 1) bays nowadays isolated from the sea, 2) shallow bays which will soon become isolated, 3) sheltered, shallow bays, and 4) the open coastline.

Many of the coastal bays are good breeding areas for ducks. This is especially so in the case of bays which have recently been isolated from the sea, or which will soon be isolated (cf. Vikberg 1978), since such bays often have well-developed belts of luxuriant vegetation, mainly of *Scirpus lacustris*, *Equisetum fluviatile*, *Eleocharis palustris* and *Carex* spp., which provide optimal habitats for wetland birds. However, large areas of coastline do not offer such optimal breeding conditions for ducks due to the action of waves and ice. In this study, interest is concentrated on the third group of habitats, the sheltered shallow bays. The function of such bays as duck habitats, their potential food resources and their importance to the duck populations living in the coastal habitats has been little studied, although a great part of the coastal area consists of this habitat type. Today, there is an increasing interest in large-scale inventory of different habitats for planning purposes. To be able to fully evaluate such inventories, detailed knowledge of the different habitat types is necessary. In this study, we have tried to evaluate a brackish-water, coastal bay habitat with regard to its suitability for ducks.

Some investigations of the bird fauna in coastal habitats have been made along the Finnish side of the Bothnian Bay (e.g. Hildén 1964, Grenquist 1965, Väisänen & Järvinen 1977, Vikberg 1978), although none of these investigations deal with the relationships between populations of dabbling ducks and their food resources.

2. Study area

Kalalahti (65°47′N, 23°50′E) is a sheltered, shallow bay of the northernmost part of the Bothnian Bay, close to the island of Seskarö in the province of Norrbotten, northern Sweden. Within the region as a whole, the mean annual temperature is +1 to +2 °C (Ångström 1974), and the mean temperature of the warmest month, July, is 16 °C. The mean annual precipitation is 500—550 mm (Wallén 1953).

In the northern part of the Bothnian Bay, there are considerable fluctuations in water-level. Low water occurs during northerly storms, which push the water southwards into the Bothnian Sea. Extreme water level amplitudes of up to 3 metres have been recorded (Lisitzin 1974). Although changes in water-level occur at irregular intervals, the general trend is that low water prevails during the spring months, until May. Later on during the summer the water-level usually increases somewhat (Lisitzin 1974).

Water depth in the study area was measured in August 16 1977. The maximum depth was 70 cm. The salinity of the water is generally low in the northern part of the Bothnian Bay: from about 0.25 ‰, or less, up to 3 ‰ (Julin & Pekkari 1956, Pekkari 1965).

A willow belt (*Salix* spp.) extends along the shores of the bay, with scattered stands of grey alder *(Alnus incana)* nearest the water's edge, and further back mainly birch woodland (*Betula* spp.) (Ericson & Wallentinus 1979). No emergent hydrophytes are present in the open water area, but the shore is fringed by a belt of mainly *Eleocharis palustris*. The dominant species of submerged plants are: *Sagittaria* sp., *Potamogeton perfoliatus, Eleocharis acicularis, Subularia aquatica, Ranunculus confervoides, Elodea canadensis* and *Callitriche autumnalis*.

3. Methods

All ducks within the 50 ha study area were counted on 33 separate occasions during the period 1976, 1977 and 1981, and by noting all those utilizing the innermost part of the bay (15 ha) at half-hourly intervals throughout three 24-hour observation periods on June 6—7, June 29—30 and August 10—11, 1977. The position of all ducks were estimated in relation to fixed points spread over the area and subsequently mapped. The observations were made through a telescope (20×) from a caravan parked on the roadside bordering a part of the study area. The usual types of activity noted were food-seeking, swimming, preening and resting. Food-seeking behaviour was divided into five subtypes (for details see Pehrsson 1979): end of bill-level straining, combined nostril and eye-level straining, combined head and neck-level straining, upending and diving. On seven occasions the number of birds was also counted in one other brackish-water and five fresh-water localities during early spring, 1976, for comparison.

For a few hours both before and during the 24-hour observation periods, 10 emergence traps (for trap type see Danell & Sjöberg 1977) were randomly distributed over the study area to collect emerging invertebrates.

Samples of invertebrates and of submerged hydrophytes were collected at 30 stations randomly distributed over the study area, on June 8 and 26 and August 17 in 1977. Invertebrates present on the water surface or just below were sampled using a sweep net (mesh size 1 mm; mouth area 346 cm^2; water volume swept, about 75 l per sample). Invertebrates living on the bottom, and those on rooted hydrophytes, were collected with a Rzóska core sampler (Rzóska 1931), with an aperture of 99 cm^2. The samples were sieved (mesh size 0.6 mm) and kept in 70 % ethanol before being weighed (wet weight) to the nearest 0.1 mg. Molluscs were weighed complete with shells.

The numbers of shoots and seeds of submerged hydrophytes from the Rzóska core samples were also counted. Excess moisture was removed with blotting paper and the shoots finally dried at 40 °C for 24 hours and weighed to the nearest 0.1 mg.

The water-levels of the Kalalahti bay were checked using a water-gauge. Figures for the water level fluctuation in the Bothnian Bay during the entire seasons of 1976, 1977 and 1981 were collected from the Ratan sea gauge (64°00′N, 20°54′E) (Swedish Meteorological and Hydrological Institute). The statistical method used was the non-parametric Mann-Whitney *U*-test (Elliott 1977). Nomenclature of plant species follows Lid (1974).

4. Results

4.1. Hydrophytes

The dominant submerged hydrophytes were: *Subularia aquatica, Potamogeton perfoliatus, Sagittaria* sp. and *Ranunculus confervoides* (Fig. 1). The most abundant seeds found were those of *Subularia aquatica* and *Potamogeton perfoliatus*. The increases in total dry weight of vegetative parts found in the Rzóska core samples from one sampling date to the next were all statistically significant ($P < 0.001$) (Fig. 1). The differences in seed weight were not significant ($P > 0.05$) (Fig. 1).

4.2. Invertebrates

The total wet weight of the invertebrates collected with the Rzóska core sampler, i.e. those living on the surface of the bottom and on the rooted, submerged hydrophytes, increased from the second to the third sampling dates ($P < 0.05$)

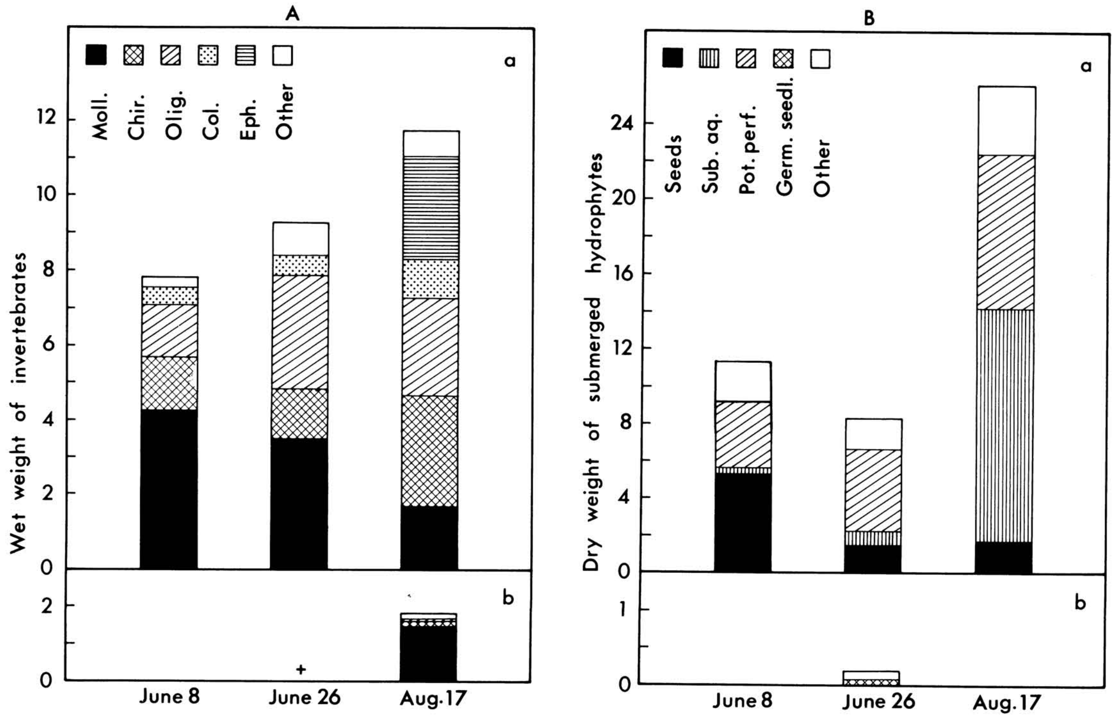


Fig. 1. A. Wet weight of invertebrates caught in a) Rzóska core sampler (g/m²) and b) sweep net (g/m³) from 30 sampling station in the Kalalahti bay, northern Bothnian Bay, in 1977. + = < 0.1 g/m³.

B. Dry weight of submerged hydrophytes from a) Rzóska core sampler (g/m²) and b) sweep net (g/m³) from the same sampling stations as in A.

(Fig. 1). The dominant taxa were Gastropoda, Oligochaeta, Chironomidae and Ephemeridae (Fig. 1).

The mean sample weights of invertebrates caught with the sweep net, just below the water surface, increased significantly from the second to the third sampling dates ($P < 0.001$) (Fig. 1). The dominant taxa were Gastropoda, Corixidae, and Chironomidae (Fig. 1). This sample, however, is merely a measurement of the quantity of invertebrates available in the upper zone of the water. Because of the low water-level during the third sampling date, the sweep net reached the vegetation on the bottom, and thus also the invertebrates living there.

4.3. Ducks

During early spring 1976, the break-up of the ice cover occurred almost simultaneously in both brackish and fresh-water localities. Already from the beginning of the season any open water was utilized by ducks (Tab. 1, Fig. 2). Those birds which appeared on the Kalalahti bay in quite large numbers during this period (mainly pairs) were migrating and utilized the bay for only a short time. Wigeon were dominant among the dabbling ducks. Their numbers were quite high in August too (Fig. 2), as were those of teal, pintail and mallard (Fig. 3).

Between the second and third observation periods, a pronounced difference was noted in the dietary patterns of the different duck species. During the second period the birds, predominantly males, were present mainly during night-time (Fig. 3). They had apparently flown in from the neighbouring areas in search of food. In the third period, with the exception of the teals and tufted ducks, all species were sighted at all times throughout the 24-hour period (Fig. 3). During the second and third periods, feeding was the main type of activity noted (Fig. 3). With regard to food-seeking behaviour in particular, this was more concentrated to the surface and just below during the second period, while during the third period mallard and wigeon, at least, sought their food more towards the bottom (Fig. 3). Since so

Table 1. Numbers of dabbling ducks in brackish-water habitats (I = Kalalahti, II = Vuononviken), river habitats (I = Selkäsaari, II = Seittu, III = Vuopio, all in Torne River) and lake habitats (I = Källträsket, II = Veittijärvi) in 1976. Ice cover in per cent in parenthesis. * = water on the ice surface. ** = ice floe.

		Brackish-water habitats		River habitats			Lake habitats	
		I	II	I	II	III	I	II
April	5	6 (>95)	0 (100)	2 (90)	0 (100)	0 (100)	13 (>95)	8 (75)*
	9	2 (50)	3 (100)*	228 (0)	0 (100)	1 (*)	—	24 (20)*
	15	59 (10)**	17 (*)	6 (**)	10 (0)**	—	—	19 (0)*
	17	25 (0)	8 (0)	—	4 (0)	2 (0)	—	24
	19	23	2	1 (0)	3	0	—	9
	23	13	2	—	0	2	—	14
June	1	34	—	—	0	0	—	—

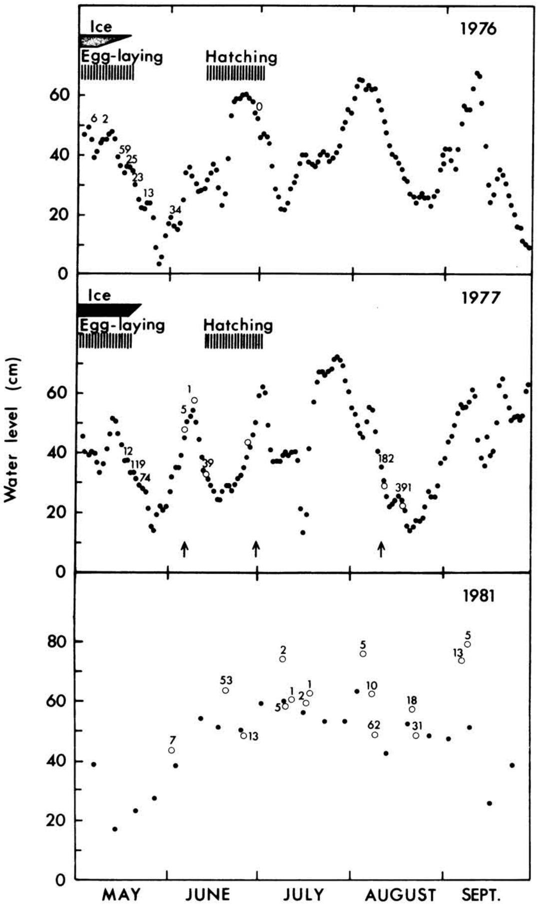


Fig. 2. Water level fluctuations in the Bothnian Bay, measured at Ratan (64°00'N, 20°54'E), province of Västerbotten, Sweden in 1976, 1977 and 1981. Open symbols indicate the local water-level fluctuations in the Kalalahti bay to the same relative scale and during the same years. Numbers of dabbling ducks observed in the Kalalahti bay at different water-levels are given. Egg-laying and hatching time of dabbling ducks are estimated mainly from Lake Veittijärvi, situated 28 km from the bay. Arrows indicate the dates of the 24-hour observation periods.

few observations were made during the first study period, no conclusions can be drawn about the general activity pattern at that time.

5. Discussion

5.1. The Kalalahti bay as a breeding site

The inshore parts of the Kalalahti bay are relatively exposed to wave action and are rather stony. Consequently emergent hydrophytes are not found to any great extent. Only a narrow shoreline belt, mainly of stands of *Eleocharis palustris,* exists. Thus, few suitable breeding sites are available for ducks, either for nesting, or where their broods might seek shelter from predators or during bad weather. The situation in the Kalalahti bay is far from a 50/50 ratio of vegetation to open water, which seems to be the ideal combination preferred by many wetland birds (Weller & Fredrickson 1974, Kaminski 1979).

Invertebrates have been shown to represent an important item of food for dabbling ducks, especially for the females during the egg-laying period and for ducklings during their initial stages of life (e.g. Sugden 1973, Krapu 1974, Krapu & Swanson 1977). The biomass values for benthic invertebrates recorded at the Kalalahti bay were not particularly high, viz. 7.8, 9.6 and 11.8 g/m^2 (wet weight) on June 8 and 26 and August 17, 1977, respectively (Fig. 1). For the hydrophytes (seeds excluded) the figures were 6.0, 7.4, and 24.1 g/m^2 (dry weight), respectively. In the softbottom areas of the Luleå district, which are also found in the northern Bothnian Bay, Kautsky (1977) obtained a mean biomass of 1.3 g/m^2 (dry weight) for invertebrates and 11.5 g/m^2 for hydrophytes, and Hällfors (1976) obtained 4.8—11.0 g/m^2 (dry weight) in June and 29—118 g/m^2 in August of plant biomass in a soft bottom in the Krunnit archipelago at a depth of 0.1—0.5 m.

Unfortunately, no comparable figures exist for really productive shallow bays in northern Sweden. For Lake Sladan, however, (now a freshwater habitat, but originating as a bay which later became isolated from the sea) invertebrate biomass values of 5.7 g/m^2 (wet weight) were recorded in an open-water area at the end of June in 1970 and 1972, and around 30 g/m^2 in an *Equisetum* belt (Danell 1973). For another freshwater habitat, Lake Veittijärvi, an invertebrate biomass value of 17 g/m^2 (wet weight) in an area of open water was recorded on June 3, 8 g/m^2 on July 2 and 23 g/m^2 on August 13, 1977 (Danell & Sjöberg 1982 and unpublished observations). For still another freshwater habitat, a slow flowing section of the lower part of the Torne River, the invertebrate biomass was as average 9.6 g/m^2 (wet weight) on September 4, 1981 (Sjöberg, unpublished data). Thus, with regard to the quantities of invertebrates present, conditions were never optimal for the female ducks in the Kalalahti bay during the early part of the breeding season. Even the availability of those benthic invertebrates and hydrophytes which were present was restricted during parts of the breeding season in all three study years because of high water-levels (Fig. 2).

The invertebrates are also of great importance to the newly-hatched ducklings of *Anas* species (e.g. Chura 1961, Perret 1962, Bartonek 1972). During the initial stages of their life, the ducklings mainly take those invertebrates present above, on, or just below the water surface (e.g. Pehrsson 1979). As they grow older, they feed at successively greater depths, and finally on the bottoms too. In a good duckling habitat, therefore, the invertebrates must be abundant at or close to the water surface. This, however, was not the case in the Kalalahti bay. The sweep net hauls yielded very few invertebrates (Fig. 1) and, during the sampling period prior to and during the egg-hatching period of the ducks (Fig. 1), no emerging Chironomids were caught in the emergence traps although larvae of this invertebrate group were quite abundant in the bottom samples (Fig. 1).

The prevailing water-level of a habitat is also of importance to the ducklings and to a great extent determines the availability of the potential food resources. Throughout 1976 and 1981 the water-level of the bay remained high, whereas during 1977 it was so low for a time during the hatching period that parts of the bottom actually dried out. Thus, for ducklings, the Kalalahti bay is not an optimal habitat, both because of its lack of vegetation for shelter and because of the relatively low numbers of suitable food items which, furthermore, are not regularly available.

5.2. The Kalalahti bay as a resting and foraging site

In 1976, Patterson presented a model of duck population regulation based on studies in Ontario, Canada, on beaver ponds with different physical and nutritional characteristics. He found that the number of breeding pairs of ducks present was dependent on the amount of surface water available, indicating that the major mechanism regulating population size was territorial behaviour. Fledged ducks, however, selected fertile wetlands, indicating that that particular part of the total population was regulated by the availability of energy resources. The habitat requirements of the duck broods were intermediate to the above respects, which implies that, over the entire breeding season, the aspects of food availability and magnitude of the food resource became increasingly important. When applied to the situation prevailing in the Kalalahti bay, a habitat in which emergent hydrophytes are almost totally absent, this means that its importance to ducks ought to increase towards the end of the breeding season. Under circumstances in which the importance of behavioural spacing as a mechanism regulating population size is less important, the bond to the breeding habitat is thereby loosened, and the birds can begin to utilize those habitats and localities which at any particular moment in time best fulfil their demands for food and shelter. They can, for example, forage in one locality and rest in another. This is apparently why, during the second observation period, most of the birds were present mainly during the night hours, when they used the locality mainly as a foraging site (Fig. 3). In this way they were able to utilize such temporary food resources as the germinated seedlings of *Subularia aquatica* (Fig. 1).

During July and August, prior to the autumn migration, the nutritional aspect is at the highest, as a criterion of habitat selection, while the physical aspect is at its lowest. During this period, during which the biomasses of both hydrophytes and invertebrates were at their highest in the Kalalahti bay (Fig. 1), the ducks used the bay throughout the day and night hours and in quite large numbers (Fig. 3).

The potential of the Kalalahti bay as a foraging area, however, was still dependent on the suitability of the water-level, which in fact fluctuated considerably during the study period (Fig. 2). During the second observation period, June 29—30, the mean water-level at the 30 sampling stations for invertebrates (spread at

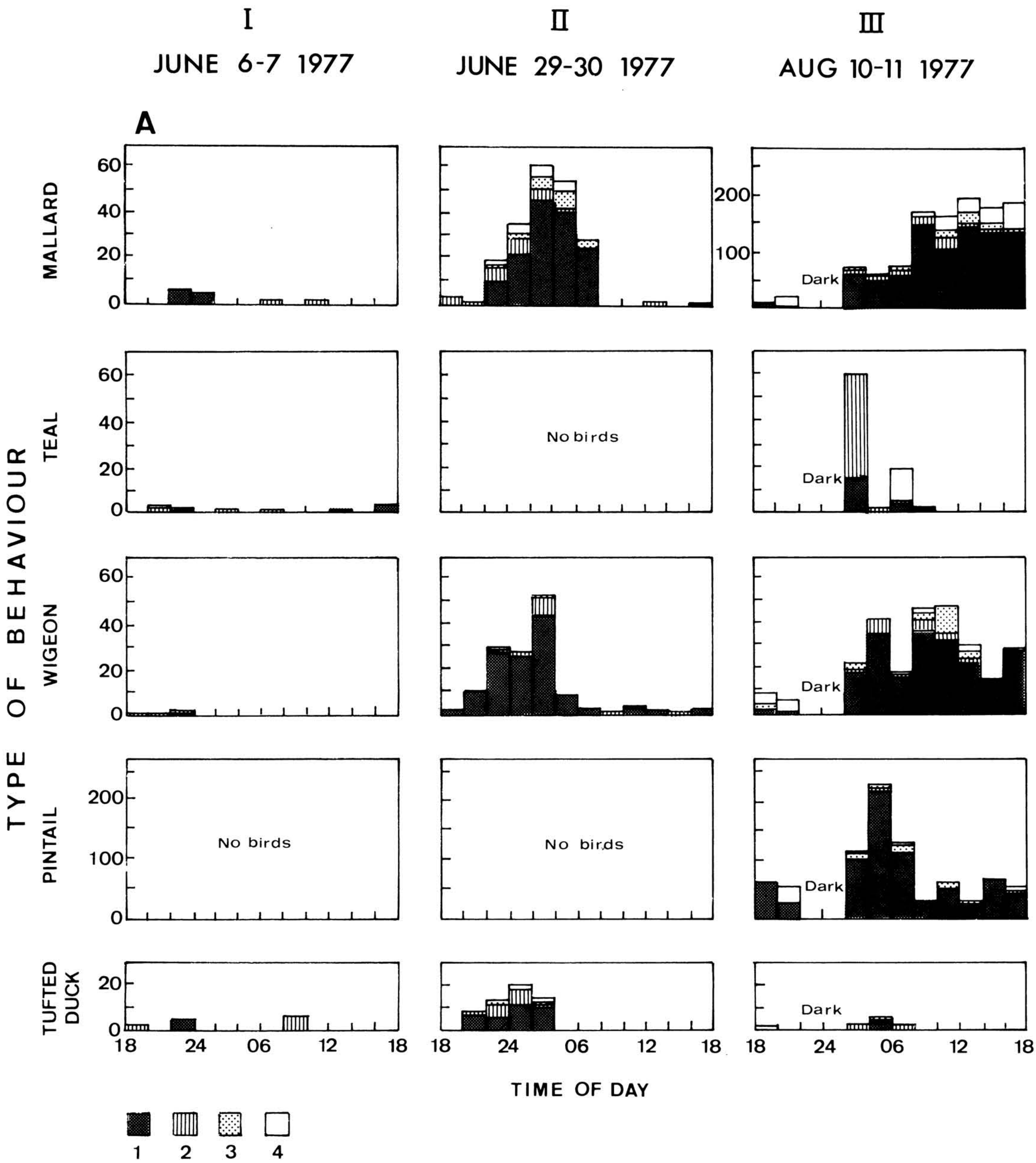
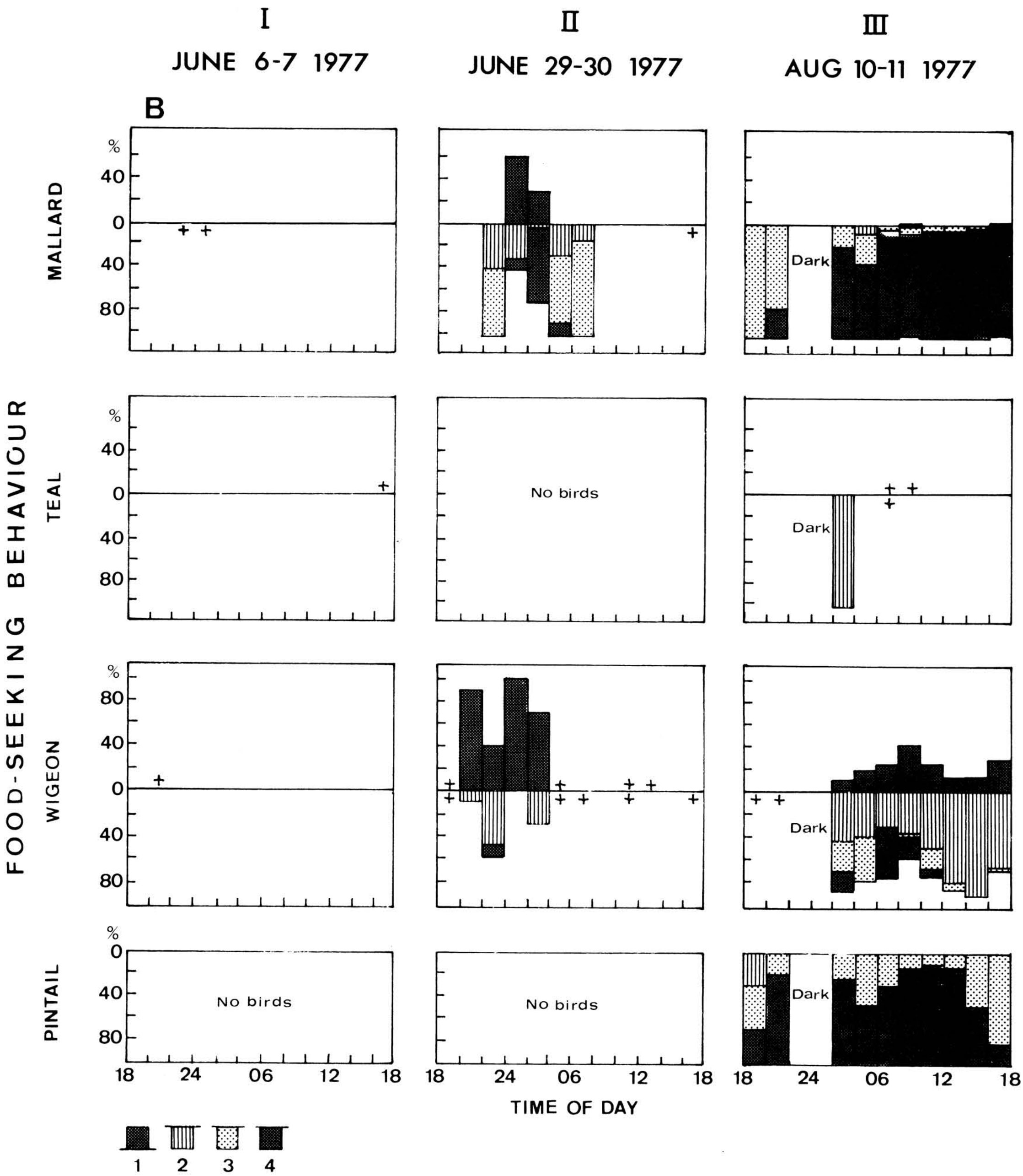


Fig. 3. A. Recordings of behavioural activity of different duck species at 30 minute intervals summarized for 2-hour periods during three 24-hour periods in Kalalahti bay. 1 = food-seeking, 2 = swimming, 3 = preening, 4 = resting.

random over the inner part of the study area) was 50 cm, while during the third period (August 10—11) the water depth was only 31 cm.

Thus, during the second period, the water depth was such that many bottom-living invertebrates were almost out of reach for both mallard and pintail, and quite definitely so for the teal. However, during the second period, the wigeon, which is more of a vegetarian feeder than the above-mentioned ducks (Olney 1964), was present on the open-water area at the same time as germinated seedlings of *Subularia aquatica* were



B. Type of food-seeking behaviour by different ducks. 1 = bill-tip-level straining, 2 = combined nostril and eye-level straining, 3 = combined head and neck-level straining, 4 = up-ending. + = < 10 birds.

floating in the water (Fig. 1), forming a suitable potential food resource for the wigeon. This duck species, therefore, was affected to a lesser extent by the prevailing high water-level at that time.

During the third observation period (August 10—11) the mean water depth at the sampling stations was barely 31 cm, which enabled all species of ducks to reach the bottom over the whole study area. During this period, most of the mallards fed on the bottom by up-ending, while during the second period (June 29—30) very little up-ending behaviour had been observed (Fig. 3).

The Kalalahti type of habitat probably represents a relatively ephemeral feature to the ducks, because its food resources are frequently only temporarily available due to the fluctuations in water-level. No stable feeding habits can be developed here as they can, for example, on a lake in which the water-level either remains the same over the entire season or at least changes in a regular manner, as in coastal areas subject to tidal changes. The latter habitats can be utilized, for example, by the shelduck (Bryant & Leng 1975) and by the eider (Cambell 1978). The Kalalahti type of habitat, however, does appear to be utilized quite efficiently when the opportunity arises, i.e. at times of low water-level (Fig. 2), and thus such a type of bay provides a valuable supplementary source of food during the period of the year when the ducks are feeding hard in preparation for their autumn migration to the south.

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