ORNIS SVECICA 5:133–142, 1995 https://doi.org/10.34080/os.v5.23015

Feeding ecology of the Long-tailed Duck *Clangula hyemalis* wintering in the Gulf of Gdańsk (southern Baltic Sea)

LECH STEMPNIEWICZ

Abstract

The feeding ecology of the Long-tailed Duck *Clangula hyemalis* was studied in the Gulf of Gdańsk during eight wintering seasons (November–April) 1972–1976 and 1986–1990 (423 food samples). The number of food taxa consumed was at least 28 (23 animal and 5 plant). Long-tailed Ducks fed mainly on bivalves of which *Macoma baltica* and *Mya arenaria* were the most important, then *Mytilus edulis* and *Cardium glaucum*. Fish, mostly Ammodytidae, and fish eggs were present in ca. every fourth sample. Crustaceans, polychaetes and gastropods constituted the remaining significant prey. Plant food was incidental. Birds selected main food items (3 bivalves) of shell length ca. 11.0–11.6 mm regardless of their different average size found in zoobenthos. Seasonal and some age and sex related differences in Long-tailed Duck diet were found. They consumed proportionally more *Mytilus* and *Cardium* in December and January and less later in the season. Crustaceans, polychaetes and especially fish (fish eggs) increased their percent share in the diet in the spring. Adult birds tended to eat more *Mytilus* and *Cardium* while immatures ingested more crustaceans. Birds caught in nets set deep (> 20 m) fed largely on *Mesidothea entomon*. Long-tailed Ducks function as first to fourth-order carnivores in the food web of the Gulf of Gdańsk. Due to their high numbers and long period of staying they consume considerable biomass of main food prey. Estimated yearly consumption of bivalves amounts to 6 350 tonnes (*Macoma baltica* – 2 100, *Mya arenaria* – 1 700, *Mytilus edulis* – 1 600, *Cardium glaucum* – 950), fish – 1 120, crustaceans – 400, polychaetes – 200, and gastropods – 125 tonnes. At least locally, they prey significantly on certain age classes of the most important food taxa.

Lech Stempniewicz, Department of Vertebrate Ecology and Zoology, University of Gdańsk, Legionów 9, 80-441 Gdańsk, Poland

Recieved 6 July 1995, Accepted 1 October 1995, Editor: S. Svensson

Introduction

The Long-tailed Duck *Clangula hyemalis* is one of the most abundant sea ducks inhabiting arctic and subarctic coasts, and wintering in the boreal zone of the Atlantic and Pacific oceans. The Baltic Sea is the most important wintering area in western Palearctic (Cramp & Simmons 1977, Laursen 1989). During winter, these small diving ducks occupy shallow (3–15 m deep) inshore waters with abundant food, making bottom feeding efficient. They can reach depths of 60 m and spend as long as one minute under water (Mathiasson 1970, Nilsson 1972, Cramp & Simmons 1977). Their diets differ regionally and seasonally and consist mainly of bivalves and crustaceans as well as of polychaetes, gastropods and fish (fish eggs) (Madsen 1954, Nilsson 1972, Petersson & Ellarson 1977, Ainley & Sanger 1979, Sanger & Jones 1984, Goudie & Ankney 1986). There are scarce data on Long-tailed Duck feeding ecology from the Baltic Sea. Madsen (1954) collected some material in the Kattegat region and Nilsson's (1972) studies were carried out in Swedish coastal waters. No published information is available from southern Baltic, including the Polish coast, except two MSc theses (Mikulak 1989, Maciejkowicz 1991).

The Gulf of Gdańsk has high biological productivity, and important commercial fisheries. Surveys of marine birds show high concentrations of diving ducks in the area. The Long-tailed Duck is the most numerous species wintering in the gulf. Between October and May thousands of birds stay here achieving peak numbers (30–40 000) in December and March (Górski & Strawiński 1986, Meissner & Maracewicz 1993). Each season 7 000 – 8 000 Long-tailed Ducks drown in fishing nets set in the gulf (Stempniewicz 1994).

Investigations of the feeding ecology of marine

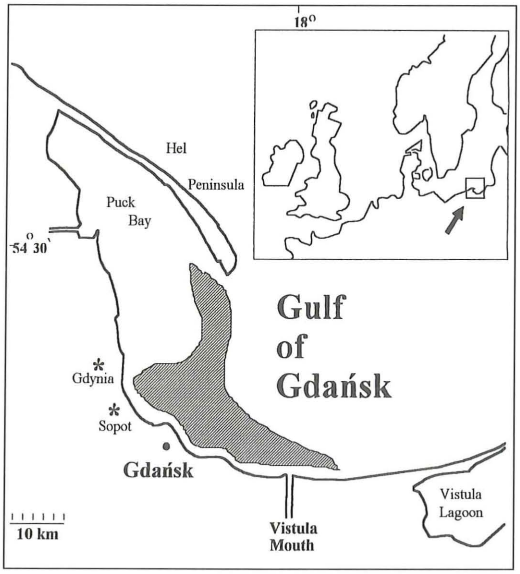

Fig. 1. Area of the Gulf of Gdańsk, Southern Baltic (asterisks indicate the fishing ports, Orłowo and Sopot, where net catches were collected; shading indicates fishing grounds).

Gdanskbukten. Asterisker anger fiskehamnarna Orlowo och Sopot där nätfångsterna insamlades. Skuggning anger fiskeområdena.

birds provide a key link in the interpretation of the relationship between biological productivity and abundance of birds (Ashmole 1971, Furness & Monaghan 1987, Stempniewicz 1986, 1991). This study of the Long-tailed Ducks was a part of a larger interdisciplinary programme entailing all numerous marine birds wintering in the Gulf.

The objectives of this study were to determine food composition, seasonal changes in diet and prey size selection. On that basis the annual consumption of the main food types was estimated.

Material and methods

The study area (i.e. fishing grounds) covers shallow (2–10 m) coastal waters of the Gulf of Gdańsk from Gdynia to the west of Vistula Mouth, and deeper waters (up to 80 m) in the central part of the Gulf (Fig. 1). This area is very rich in benthic fauna (bivalves, gastropods, polychaetes, crustaceans) and fishes. Nets are set all year around but the main fishing season (November–April) coincides with the wintering season of the Long-tailed Duck in the Gulf of Gdańsk.

Birds entangled and drowned in nets were collected with the co-operation of fishermen from two fishing ports Orłowo and Sopot. The birds were collected 1–3 times a week over 8 seasons (November-May) from 1972 to 1976 and 1986 to 1990. In total, 607 Long-tailed Ducks were collected and 423 food samples (193 adult males, 77 adult females, 61 immature males and 79 immature females) were analysed in detail. Birds were thoroughly examined and dissected in the laboratory, and the age (two categories: immature and adult) and sex of each individual was determined.

Total contents of the oesophagus, proventriculus and gizzard were preserved in a 4% formaldehyde solution and analysed later in the laboratory. Each sample was washed on a 0.5 mm mesh size screen and analysed under stereo microscope. The material was sorted and then identified to the lowest possible taxonomic level. The number, length and weight of all identifiable food items were noted. The number of fish and polychaetes ingested was estimated as half the number of otholits and jaws found in the samples.

The following coefficients were used to present the results of the analyses of the food samples. Frequency of occurrence (%FO) was determined as the percentage of samples containing a given prey type. Also weight of the food samples and percentage by volume (%V) of particular prey taxa were calculated.

Result and discussion

Food composition

The list of preys of the Long-tailed Duck wintering in the Gulf of Gdańsk contains at least 28 food taxa, including 23 animal and 5 plant taxa. The most important food component were bivalves, found in almost every sample (%FO = 97.1%) and constituting 77% of the food content volume. Among them *Macoma baltica* and *Mya arenaria* were taken most often, then *Mytilus edulis* and *Cardium glaucum*. Fish, and especially sandlances Ammodytidae and stickleback *Gasterosteus aculeatus* as well as fish eggs were found in every fourth stomach. Crustaceans and gastropods were ingested with similar frequency but found in smaller amounts. Polychaetes and plants occurred in ca. 10% of samples (Table 1). However, proportions of particular food taxa found in the Long-tailed Duck diet are certainly biased. Different digestion rates of hard-shelled (e.g. bivalves) and soft-bodied prey (e.g. fine crusta-

Table 1. List of prey taxa, their percent volume and frequency of occurrence in the Long-tailed Duck diet.

Lista över födoslag, deras volymsprocent och förekomstfrekvens i alfågelns diet.

Prey taxa	%V	%FO
Plantae	**0.5**	**9.5**
Algae	*	2.4
Spermatophyta (seeds)	0.5	8.7
Potamogeton sp.	0.2	4.3
Polygonum sp.	0.1	1.8
Carpinus betulus	0.1	2.1
Cerasus vulgaris	0.1	2.3
Polychaeta	**2.5**	**9.9**
Nereis diversicolor	2.5	9.9
Terebellides stroemi	*	0.2
Priapulida	*	**1.1**
Halicryptus spinulosus	*	1.1
Bivalvia	**77.0**	**97.1**
Mya arenaria	20.7	41.8
Macoma baltica	25.5	52.6
Cardium glaucum	11.3	30.7
Mytilus edulis	19.5	33.9
Gastropoda	**1.5**	**24.8**
Hydrobia ventrosa	1.5	24.1
Theodoxus fluviatilis	*	0.2
Valvata piscinalis	*	4.1
Lamellidoris muricata	*	0.2
Gastropoda *n.d.*	*	3.3
Crustacea	**4.8**	**21.3**
Balanus improvisus	0.1	3.8
Gammarus salinus	*	0.2
Gammarus sp.	0.3	6.8
Amphipoda *n.d.*	*	1.4
Mysis mixta	*	0.2
Mysis sp.	1.2	12.2
Palaemon adspersus	0.9	1.8
Crangon crangon	0.2	2.8
Decapoda *n.d.*	*	2.5
Mesidothea entomon	2.1	3.4
Crustacea *n.d.*	*	2.1
Pisces	**13.6**	**24.9**
Ammodytes tobianus	0.7	2.3
Hyperoplus lanceolatus	0.1	0.7
Ammodytidae *n.d.*	2.5	16.1
Zoarces viviparus	0.7	1.4
Gasterosteus aculeatus	4.4	11.6
Platichthys flesus	*	0.7
Pleuronectidae *n.d.*	*	0.7
Gobidae *n.d.*	*	0.7
Pisces *n.d.*	0.2	8.3
fish eggs *fiskägg*	5.0	9.2
Pebbles, gravel, sand *Grus, sand*		**90.6**
Anthropogenic elements *Antropogena objekt*		**0.7**

* traces *spår*

ceans, polychaetes, gastropods) may distort their original relative volumes. Bivalves were most probably overrepresented in those samples where gizzard contents predominated. On the other hand, abundant small prey is usually overestimated by frequency of occurrence coefficient (Sanger & Jones 1984). For these reasons the results should be interpreted with caution.

The results show that Long-tailed Ducks feed almost exclusively on benthic animals or those living close to the bottom. In general, food composition reflects roughly the food resources in the Gulf of Gdańsk. Similar relationships were found in earlier studies carried out in different areas (Madsen 1954, Nilsson 1972, Petersson & Ellarson 1977, Sanger & Jones 1984, Goudie & Ankney 1986).

In spite of this general opportunism the Long-tailed Ducks show some feeding preferences. Bivalves indeed predominate both in zoobenthos and in the duck diets. However, the Blue Mussel being an absolute dominant in the Gulf was taken by ducks in moderate quantities. On the other hand, the Sand Gaper, constituting one of the most important food prey, belongs to the least numerous bivalves in the Gulf (Beil 1977, Gostkowska & Turas 1988). Also the proportions of gastropods and crustaceans were higher in the duck food than in zoobenthos.

However, such comparisons are risky because data for zoobenthos are large scale and average for the whole gulf. Long-tailed Ducks feed in preferred areas which may differ very much from the general picture of numbers, distribution and proportions of benthic animals. The relationship between the place and depth of feeding and the food composition is well illustrated by those birds drowned in nets set at depth exceeding 20 m. In all stomachs examined (n=37) the predominating prey was *Mesidothea entomon*.

Prey size

Mean size of the three most important Long-tailed Duck food items, i.e. *Macoma baltica*, *Mya arenaria* and *Mytilus edulis*, was almost the same (11.0–11.6 mm) in spite of the fact that these bivalves differ much in size (Frączkowska 1974, Beil 1977, Cuena & Wołowicz 1981, Wołowicz 1984). It seems that birds selected mainly one size class from a much wider spectrum of prey size classes. According to optimal foraging theory (Krebs & Davies 1981, Draulans 1982, Ydenberg 1988) birds should select as large available items (contributing much energy) as they are able to catch and swallow.

Table 2. Food content of the Long-tailed Ducks *Clangula hyemalis* wintering in the Gulf of Gdańsk
Födoinnehåll hos alfåglar övervintrande i Gdanskbukten

		Food content (g)		Organic content (g)		Inorganic content (g)		Organic content (cm³)		N	*Mya*	
In total	Mean (SD)	8.7	6.5	7.2	6.5	1.7	2.2	4.4	4.6	423	20.7	36.
(n=470)	%FO										41.8	
Adults	Mean (SD)	9.3	7.2	7.7	6.8	1.6	2.0	4.7	4.8	270	16.2	32.
(n=299)	%FO										39.6	
Immatures	Mean(SD)	7.6	5.0	6.1	5.9	2.0	2.7	3.9	4.4	140	25.6	40.
(n=157)	%FO										40.7	
Females	Mean(SD)	7.3	5.6	5.7	5.4	1.7	2.0	3.4	3.8	158	24.0	39.
(n=178)	%FO										44.3	
Males	Mean (SD)	9.6	6.9	8.0	7.0	1.7	2.3	4.9	5.0	259	18.0	34.
(n=286)	%FO										39.0	
Adult females	Mean (SD)	8.1	6.9	6.7	5.9	1.2	1.5	3.9	4.1	77	22.7	39.
(n=87)	%FO										45.5	
Immature females	Mean (SD)	6.4	3.9	4.8	4.9	2.1	2.3	2.9	3.5	79	24.3	39.
(n=88)	%FO										41.8	
Adult males	Mean (SD)	9.8	7.2	8.0	7.1	1.7	2.1	4.9	5.0	193	13.6	29.
(n=212)	%FO										37.3	
Immature males	Mean(SD)	9.2	5.8	8.1	6.7	1.9	3.1	5.3	5.2	61	27.2	41.
(n=68)	%FO										39.3	

The size of prey is limited by size of the bird's bill and throat. Bivalves of ca. 11 mm length appear to be optimal food for the rather small Long-tailed Duck. Specimens from this size-class are common in all bivalve species occurring in the Gulf (Frączkowska 1974, Beil 1977, Cuena & Wołowicz 1981, 1984). Feeding on smaller bivalves is less efficient despite their higher numbers. Larger specimens, however, contributing more energy because of size and higher body to shell ratio, occur in much lower density, making feeding on them (time spent for searching) less profitable. The largest bivalve found in the food samples was a 35 mm blue mussel (Table 3).

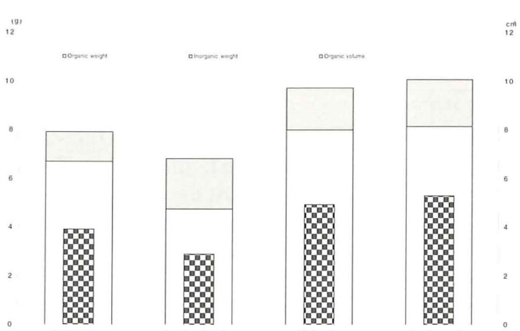

Fig. 2. Mean food content weight (g) and volume (cm³) of the Long-tailed Duck age-sex groups.
Födoinnehållets medelvikt (g) och volym (cm³) för alfåglar av olika ålder och kön.

Age and sex related differences in the diet

Mean weight and volume of organic food content was significantly higher in males (t-test, P<0.001). This may be a result of differences in body size between the sexes. Immature birds, especially females, had higher proportions of inorganic fractions (sand, gravel, pebbles) in the food content (t-test, P<0.001; Table 2, Fig. 2).

The proportions of bivalves in food of particular age-sex groups were similar. However, blue mussel and cockle were taken more often and in greater amounts by adult birds. Immatures, and particularly females, preferred crustaceans (Table 2). Other taxa were ingested by all age-sex groups in similar proportions.

Adult males constituted over 90 % of the birds drowned in nets set deeper than 20 m. They fed almost exclusively on the isopod *Mesidothea entomon*. This suggests that only bigger and heavier adult males are able to dive and feed efficiently at greater depths. Patterns of winter distribution of the

Percent volume Volymsprocent (% V)															
Macoma		*Mylilus*		*Cardium*		Pisces		Crustacea		Polychaeta		Gastropoda		Plants	
25.5	38.5	19.5	36.6	11.3	27.6	13.6	31.6	4.8	17.5	2.5	12.4	1.5	7.3	0.5	5.4
52.6		33.9		30.7		24.9		21.3		9.9		24.8		9.5	
23.8	37.2	23.6	39.2	14.6	31.1	15.0	33.0	2.7	12.5	2.4	11.5	1.6	8.1	0.3	3.1
53.3		36.8		33.7		25.3		17.4		10.4		26.7		7.0	
28.9	41.0	13.6	31.5	4.9	18.3	9.4	24.3	12.1	29.8	3.0	14.6	1.2	5.7	0.9	8.5
49.6		31.4		23.6		26.4		29.5		9.3		22.1		14.3	
21.9	36.5	17.7	35.4	11.1	28.5	12.3	30.9	7.6	22.6	3.6	16.4	1.3	5.8	0.1	0.5
45.9		31.6		25.3		21.0		24.1		9.5		24.1		9.5	
27.4	39.6	21.1	37.6	11.4	27.2	14.6	32.3	3.3	13.5	2.0	9.4	1.6	8.2	0.7	6.9
56.0		36.0		33.2		27.8		20.2		10.4		25.5		9.6	
16.2	31.5	20.6	38.5	15.1	33.6	20.0	38.3	1.7	11.4	2.9	13.7	0.8	3.2	0.0	0.1
42.9		29.9		26.0		24.7		14.3		11.7		24.7		1.3	
28.0	40.4	15.3	32.5	6.7	21.7	5.1	19.2	13.5	28.8	4.3	19	1.8	7.5	0.2	0.7
48.7		34.2		24.1		17.9		34.2		7.6		24.1		17.7	
26.8	39.0	24.8	39.5	14.4	30.1	13.0	30.6	3.1	12.9	2.2	10.5	2.0	9.4	0.4	3.6
57.5		39.6		36.8		25.4		18.8		9.8		27.5		9.3	
30.0	42.0	11.4	30.3	2.5	12.5	21.1	37.8	4.2	15.6	1.4	5.2	0.3	0.9	1.7	12.8
50.8		27.9		23.0		37.7		23.0		13.1		19.7		9.8	

Long-tailed Ducks seem to support this suggestion. Adult males tend to choose more open and deeper areas than females and immature birds (Mathiasson 1970, Górski & Strawiński 1986, Meissner & Maracewicz 1993).

Mean size of the most common prey species was more even in adult birds than in immatures. The latter, and especially the young males, took significantly larger *Mya arenaria* and *Macoma baltica*, and smaller *Cardium glaucum* and *Mytilus edulis* (Table 3, Fig. 3).

However, differences found in food composition and mean prey size taken by particular age-sex groups may reflect (at least partly) differences in their winter distribution, feeding grounds (area and depth) and feeding efficiency.

Seasonal changes in the diet

Mean weight and volume of the organic fraction was higher in December and January than in later months. The proportion of the inorganic fraction increased during the spring months (Fig. 4). It seems, however, that these differences are partly a result of changing proportions of the age-sex groups in the material collected during particular months. High proportion of adult males at the beginning and immature females at the end of the wintering season certainly influenced the differences observed in weight and volume of the food content as well as in food composition.

Proportion of bivalves in the diet tends to decrease along with the progress of the wintering season in the Gulf of Gdańsk. This is a result of a sharp decrease in the share of blue mussel and also cockle in the food samples towards the spring. The remaining two bivalve species (*Mya arenaria* and *Macoma baltica*) showed a slight constant increase in the diets in the consecutive months (Fig. 5 and 6). A decreasing

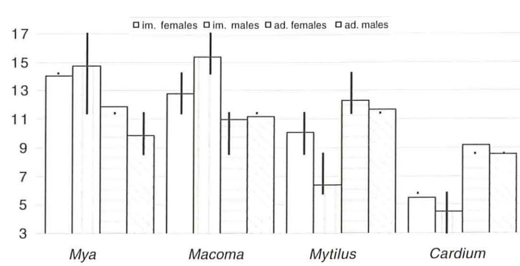

Fig. 3. Mean size (± SE) of four bivalve species taken by Long-tailed Ducks in the Gulf of Gdańsk.

Medelstorleken för fyra musselarter som tagits av alfåglar i Gdanskbukten.

Table 3. Prey size ingested by Long-tailed Ducks in the Gulf of Gdańsk.
Intagen bytesstorlek hos alfåglar i Gdanskbukten.

	In total	Adults	Imm-atures	Males	Females	Ad. males	Ad. females	Im. males	Im. females
Mya arenaria									
mean	11.6	10.6	14.3	10.7	12.7	9.9	11.9	14.8	14.1
S E	0.47	0.52	0.93	0.66	0.63	0.67	0.78	2.24	1.01
max.	34	35	34	35	34	35	23	33	34
n	185	131	38	107	78	84	47	10	28
Macoma baltica									
mean	11.5	11.2	13.5	11.0	11.9	11.2	11.0	15.4	12.8
S E	0.44	0.51	0.9	0.60	0.64	0.61	0.97	1.43	1.12
max.	21	21	21	21	21	21	16	20	21
n	175	146	27	133	42	124	22	7	20
Cardium glaucum									
mean	8.3	8.9	5.3	8.5	7.5	8.6	9.2	4.5	5.5
S E	0.32	0.40	0.59	0.51	0.49	0.54	0.94	1.21	1.11
max.	18	18	16	18	18	18	18	6	16
n	231	185	39	160	71	147	38	8	31
Mytilus edulis									
mean	11.0	11.8	7.5	10.8	11.5	11.7	12.3	6.4	10.1
S E	0.23	0.29	0.37	0.31	0.52	0.38	0.76	0.88	1.09
max.	35	35	29	35	34	35	34	29	28
n	750	608	120	566	184	475	133	87	33
Hydrobia ventrosa									
mean	3.2								
S E	0.22								
max.	5								
n	188								

Note: Differences in mean prey size ingested by adult and immature birds are significant; t- test, assuming unequal variances [t=3.1–3.5; P (2 tails)=0.001–0.002].

tendency was observed in case of gastropods, but crustaceans, polychaetes and fish (particularly fish eggs) generally increased their share during the spring months (Fig. 5).

Estimated yearly consumption of main food taxa

Daily energy expenditure in birds is related to such factors as body size, ambient temperature, type of flight, activity, etc. (Whittow & Rahn 1984, Birt-Friesen et al. 1989). Field measurements of metabolic rate using double labelled water of many seabird species allows the elaboration of regression equations relating metabolic rate and body weight. For diving seabirds with active type of flight, staying in a cold water zone, the regression has the form: log y = 3.24 + 0.727 log x; where y is field metabolic rate (FMR) in kJ/24h, and x is body weight in kg (Birt-Friesen et al. 1989). By substituting the mean body

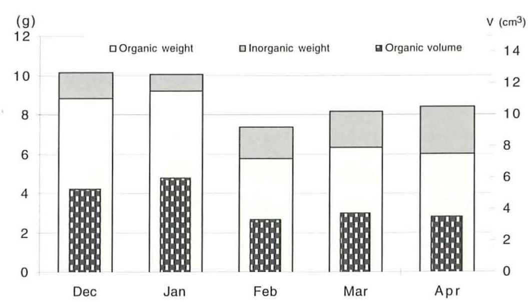

Fig. 4. Seasonal changes in the Long-tailed Duck food content weight (g) and volume (cm³).
Säsongsförändringen i vikt (g) och volym (cm³) för alfåglarnas födoinnehåll.

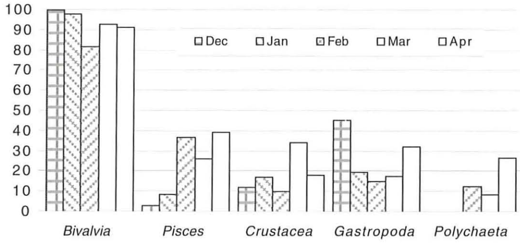

Fig. 5. Seasonal changes in frequency of occurrence (%) of most important food preys in the Long-tailed Duck diet.

Säsongsförändring i frekvensen (%) för de viktigaste födoslagen i alfåglarnas diet.

weight of the Long-tailed Ducks the value of their FMR amounts to ca.1 500 kJ/24h.

The caloric value of a bivalve is very different depending on species, body size, body to shell ratio, water content in tissues, season, region, etc. For bivalve species from the Gulf of Gdańsk, the average values of water content (57.8%), proportion of shell in body weight (85.9%) and thus energetic value (21 kJ/g dry weight) were accepted (Szaniawska et al. 1986, Pazikowska & Szaniawska 1988).

Based on the assumptions above an average value of energy contents of wet mass of four bivalve species (1.2 kJ/g) was calculated. Taking into account the 70% assimilation rate of water bird food (Wiens & Scott 1975, Furness 1978, Whittow & Rahn 1984), it was calculated that Long-tailed Ducks wintering in the Gulf of Gdańsk assimilate ca. 0.84 kJ from 1 g of wet mass of bivalves (with shell) or 6.12 kJ from 1 g of wet body mass (without shell). Assuming 1 500 kJ to be the daily energy demand, this equals a consumption of 1 786 g and 245 g, respectively, of wet bivalve mass. Using these figures I estimated the equivalent amount of food that

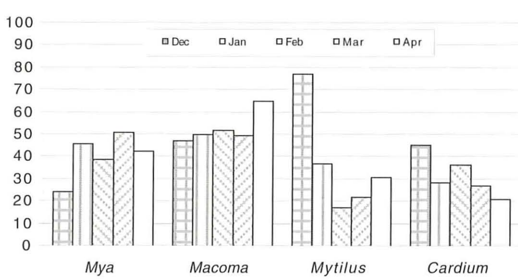

Fig. 6. Seasonal changes in frequency (%) of occurrence of four bivalve species in the Long-tailed Duck diet.

Säsongsförändring i förekomstfrekvens (%) för fyra musselarter i alfåglarnas diet.

Table 4. Estimated energy demand and biomass of the main food taxa consumed by Long-tailed Ducks during one wintering season (September–May).

Uppskattning av energibehovet och biomassekonsumtionen för de viktigaste bytesslagen hos alfågeln under vintersäsongen (september–maj).

Sum of mean montly numbers of birds*	154 000
Summan av månatliga medeltal fåglar	
No. of birds × days (N), thousands*	4 620
Antal fåglar × dagar, tusental	
Energy demand (N × 1500 kJ/24h)	6.9 x 10^9
Energibehov	
Biomass (tonnes) consumed per season (70% assimilation)	
Konsumerad biomassa per säsong	
Bivalvia	6 350
Macoma baltica	2 100
Mya arenaria	1 700
Mytilus edulis	1 600
Cardium glaucum	950
Pisces	1 120
Crustacea	400
Polychaeta	200
Gastropoda	125

Data from: Meissner & Maracewicz (1993), Meissner (unpubl.), Stempniewicz (unpubl.)

the birds consumed. The same procedure was used when estimating fish, gastropods, polychaetes and crustacean consumption. Their average energetic contents were taken from the literature (Brown & Nettleship 1984, Jorde & Owen 1988).

Mean number of birds staying in the study area, period of staying (birds × days) and food consumption were taken into account when estimating the yearly, total consumption of the main prey species taken by the Long-tailed Duck in the Gulf of Gdańsk during the wintering season.

During one season in the Gulf the Long-tailed Ducks consume ca. 6 350 tonnes of bivalves, 1 120 tonnes of fish, 400 tonnes of crustaceans, 200 tonnes of polychaetes and 125 tonnes of gastropods. Consumption of prey taxa constituting less than 1% of diet was not estimated (Table 4).

Losses caused by feeding birds may be higher than estimated in the case of the *Mya arenaria* and *Mytilus edulis* populations. Long-tailed Ducks often cut and eat only siphons of large *Mya arenaria* specimens sticking out from the bottom sand, not being able to swallow whole animals. Of course, these damaged bivalves die and form non-utilised material (NU). In case of blue mussel, occurring in large and dense shoals composed of high numbers of specimens stuck together, foraging ducks cause side-losses by tearing off single bivalves and damaging neighbouring specimens. So, the material removed (MR) by feeding birds is considerably larger than consumed.

Also crustaceans and polychaetes are certainly consumed in larger amounts than estimated. It is well known that proportions of fine and soft animals (crustaceans, polychaetes, oligochaetes, insect larvae, etc.) are usually underestimated in water birds diets (Nilsson 1972, Sanger & Jones 1984, Goudie & Ankney 1986). The reason is that soft-bodied animals are crumbled, digested and assimilated much easier and faster than those covered with shell or hard carapace. Bivalves, for instance, stay in the alimentary tract for 30–40 min (Grandy 1972).

The feeding of the Long-tailed Ducks has most probably a negligible impact on the enormous, superabundant bivalve resources in the Gulf of Gdańsk. However, their predatory pressure is temporary and spatially unequal. During the winter months of highest Long-tailed Duck occurrence (December–April) in the shallow zone (5–20 m deep) and particularly in areas of great aggregations of feeding ducks (e.g. regions of Vistula Mouth, outer coast of Hel Peninsula and Vistula Spit) the Long-tailed Ducks may exert a significant pressure on bivalves of preferred age and size classes.

Acknowledgements

The present paper has gained much from the substantial help afforded by my colleagues from Gdańsk University Department of the Ecology and Zoology of Vertebrates. I would like to offer my cordial thanks to Michał Goc, Lech Iliszko and Czesław Nitecki, for their help in collecting the material and laboratory work. I am grateful to Włodzimierz Meissner for affording his as yet unpublished data on the numbers and distribution of marine birds in the Gulf of Gdańsk, and the discussion. Iwona Pawlina, Elżbieta Mikulak and Izabela Maciejkowicz elaborated part of the food sample collection while preparing their MSc theses.

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Sammanfattning

Alfågelns Clangula hyemalis *födoekologi under övervintringen i Gdanskbukten i södra Östersjön*

I Västpalearktis är Östersjön alfågelns viktigaste övervintringsområde och där uppehåller den sig främst i områden där vattendjupet är 3–15 m. Födovalet vintertid har inte tidigare studerats i södra Östersjön. Denna studie utfördes i Gdanskbukten, där alfågeln är den vanligaste dykanden, upp till 40.000 individer. Mellan 7.000 och 8.000 av dem drunknar i fisknät varje säsong. Det var sådana fåglar som utnyttjades i denna studie. Jag fick döda alfåglar av fiskare som landade sina fångster i hamnarna i Orlowo och Sopot. Insamlingen skedde under åtta säsonger (november–maj) åren 1972–76 och 1986–90. Totalt analyserade jag födoinnehållet i 423 fåglar (193 adulta hanar, 77 adulta honor, 61 unga hanar och 79 unga honor).

Jag bestämde fåglarnas kön och ålder och dissekerade sedan fåglarna. Innehållet i strupen och magarna konserverades i 4 % formalinlösning. Senare i laboratoriet tvättades provet genom ett 0,5 mm nät och studerades under ett stereomikroskop. Materialet sorterades och bestämdes till lägsta möjliga taxonomiska nivå. Antal, längd och vikt registrerades för alla identifierbara födoobjekt. Antalet fiskar och havsborstmaskar uppskattades som halva antalet påträffade otoliter och käkar.

Födan kom från minst 28 olika grupper, 23 slags djur och 5 slags växter. Det viktigaste födoslaget var musslor, som fanns i 97 % av stickproven och utgjorde 77 % av volymen. Samtliga födoslagsandelar visas i Tabell 1. Alfåglarna levde nästan uteslutande av organismer som finns på botten eller nära botten.

Förekomsten av födoslag i födan stämde ungefär med dessas abundans på bottnarna. Alfågeln är alltså en opportunist som tar det som finns. Trots detta finns vissa preferenser. Blåmusslan som är den absolut dominerande arten tas exempelvis i proportionsvis mindre omfattning.

Av musslor föredrog alfåglarna storlekar inom ett snävt intervall trots att det finns ett mycket vidare storleksintervall att välja inom (Fig. 3, Tabell 3). Detta beror säkerligen på att vissa storlekar bäst passar alfågelns näbbstorlek och ger det bästa energiutbytet. Just storlekar runt 11 mm förekommer i mycket stor omfattning i bukten. Större individer är fåtaligare och mindre individer ger mindre energi.

Hanarnas födoinnehåll vägde mer och hade större halt av organiskt material än honornas, vilket kanske kan förklaras av deras större kroppsvikt. Ungfåglarna hade större halt av oorgansiska fraktioner (Tabell 2, Fig. 2). Andelen musslor var likartad i de olika fågelkategorierna. Det fanns också en tendens att blåmusslor konsumerades oftare av adulta fåglar medan ungfåglar, särskilt unga honor, föredrog kräftdjur.

Adulta hanar utgjorde mer än 90 % av de fåglar som drunknade i nät på mer än 20 m djup. De levde nästan uteslutande på isopoden *Mesidothea entomon*. Detta antyder att det bara är de tyngre adulta hanarna som kan söka föda effektivt på större djur, något som också stöds av att de vintertid uppehåller sig på djupare vatten än honor och ungfåglar. Vikten och volymen av den organiska fraktionen var högst i december och januari (Fig. 4). Skillnaderna kan dock delvis bero på förändringar i ålders- och könssammansättningen med hög andel av adulta hanar i början och av unga honor i slutet av vintern. Andelen musslor i dieten tenderade att minska under vintern, främst gäller detta blåmussla (Fig. 5 och 6). För att bestämma hur mycket föda som alfåglarna totalt konsumerar i undersökningsområdet har jag med hjälp av en formel för ämnesomsättningen beräknat det dagliga energibehovet. Vidare har jag utnyttjat befintliga värden för energiinnehållet i de olika födoslagen. Med kännedom om antalet fåglar i undersökningsområdet kan sedan det totala uttaget av föda beräknas. Dessa beräkningar redovisas i Tabell 4.

Resultatet blir att alfåglarna årligen konsumerar 6350 ton musslor, 1120 ton fisk, 400 ton kräftdjur, 200 ton havsborstmaskar och 125 ton snäckor. Det verkliga födouttaget är dock större eftersom det uppstår en hel del förluster. Exempelvis biter alfåglarna av många sifoner som sticker upp ur bottenslammet från musslorna, som sedan dör. Kräftdjur och havsborstmaskar konsumeras troligen i större mängd än vad siffrorna visar eftersom resterna av dessa mjuka organismer försvinner snabbt genom matsmältningskanalen.

Totalt sett har alfåglarnas uttag en helt marginell effekt på de enorma mängder föda som finns på bottnarna i Gdanskbukten. Alfåglarnas predation är dock koncentrerad till en kort del av året och till vissa grunda delar av bukten. Det är därför möjligt att man inom de smärre områden där de största koncentrationerna av alfågel finns kan få en påvisbar effekt på den storlekskategori av musslor som fåglarna föredrar.