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ORIGINAL PAPER

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Diet composition and food consumption of the grey heron (*Ardea cinerea*) from breeding colonies in northern Poland

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Abstract The diet of the grey heron (*Ardea cinerea*) was investigated in three colonies in northern Poland (Mosty, Kiersity and Kąty Rybackie) varying in size, habitat type and composition of feeding areas used by birds. The diet was assessed during the breeding season on the base of pellets and regurgitated food. Pellets from all studied colonies consisted mainly of mammal hair (almost 100% of samples), bone remains (20–24%) and invertebrate remains (26–51%, mainly water beetle, *Dytiscus marginalis*). Bones and hair of water vole (*Arvicola terrestris*) and *Microtus* voles were the most common remains of mammals recorded in pellets. Remains of other animal taxa were found sporadically. In the colonies at Mosty and Kiersity, fish composed more than 95% of collected regurgitated prey items. Food consumption of herons from the biggest colony at Kąty Rybackie was estimated to exceed 100 t per season. Herons from Mosty consumed ca 46–52 t, from Kiersity 30–38 t of food per season. The impact of herons on fish communities was much lower than other losses due to predation (herons from Kąty Rybackie caught only 6% of fishermen bycatch, birds from Mosty took 10–14% of round gobies eaten by cormorants).

Keywords Pellets · Regurgitated food · Heronries

Introduction

The grey heron (*Ardea cinerea*), a large, abundant and gregarious piscivorous bird species, is able to capture large quantities of prey and is accused of causing damage at fish farms. Therefore this species is frequently incriminated as a pest in Europe, especially in countries where it is the only colonial piscivorous species. However, contrary to public belief, it was found that fish losses caused by herons are relatively low compared to other sources of mortality, especially diseases, accidents, and low water quality (Kushlan and Hafner 2000).

Food composition of the grey heron is well documented in Western Europe (Owen 1955, 1960; Milstein et al. 1970; Utschick 1981; Draulans et al. 1987; Marquiss and Leitch 1990; Gregory 1990). Scarcity of data about the herons' diet from Eastern and Central Europe (Dementev and Gladkov 1951; Ilitchev and Miheev 1986) impedes estimation of potential influence of herons on fish communities in natural water bodies as well as in aquacultures.

Herons have an extremely efficient digestive system (Vinokurov 1960), and only remains of insect chitinous exoskeletons, bird feathers, mammalian hair, skulls and some bones are not completely digested and, therefore, regurgitated as pellets. The majority of bones, scales and otoliths are digested completely (Draulans et al. 1987; Gregory 1990). Heron nestlings respond to approaching predators by regurgitating their last meal (Moser 1986). Analyses of pellets and regurgitated food allow a qualitative estimate of grey heron diet.

The aim of this study is to compare the diet composition and biomass of the food ingested by herons from three breeding colonies differing in size, habitat type and composition of feeding areas used by the birds.

Study area

All three studied heronries are situated in northern Poland

The colony at Kąty Rybackie is situated at the „Kąty Rybackie" reserve on the Vistula Spit (54°21'N, 19°14'E), 100 m from the Gulf of Gdańsk (the Baltic Sea) and 2 km from the Vistula Lagoon. The nests are situated on Scot's pine (*Pinus sylvestris*) in the coastal pine forest. Because of its coastal location, the colony is periodically exposed to strong winds. This breeding

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colony is mixed with cormorant (*Phalacrocorax carbo*). The heronry is the biggest of the three studied (716–879 nests in 1999–2002). Feeding areas are situated close to the colony – in the food-abundant Vistula Lagoon (Jakubas 2005). An additional important food source are fish regurgitated by cormorants from the same colony (Wojczulanis et al. 2005).

The colony at Mosty (54°37'N, 18°29'E) is situated in the Reda River Valley, 0.7 km from the Gulf of Puck coast (the Baltic Sea). Here, the herons nest on common alder (*Alnus glutinosa*) in a small wood. During the study period, a distinct increase in the number of occupied nests was observed (from 238 nests in 1999 to 412 nests in 2002). This heronry is periodically exposed to strong winds, too. The colony adjoins buildings of Mosty village and is at risk of human disturbance. Abundant feeding areas are situated 0–8 km away from the heronry (sandy coast of the Gulf of Puck, meadows and reedbeds; Jakubas 2004).

The colony at Kiersity (53°57'N, 19°28'E) is situated in Iawa Lake District. This is an inland colony, situated away from the Baltic coast. There are 215–277 occupied nests on 140 years old pedunculate oak (*Quercus robur*) in a small wood on the Korsuń lake shore (22.5 ha). The main feeding area („Drużno Lake" reserve) is situated at a distance of 20 km from the colony (Jakubas 2005).

Materials and methods

Pellets were collected in all studied colonies during the breeding seasons 1999–2001. The colony area was searched every week from March to July and all visible pellets were collected. In the biggest colony (Kąty Rybackie), pellets were collected in a sample plot with 289, 289 (1999–2000) and 170 occupied nests (2001). At Mosty and Kiersity, pellets were searched in the whole area of the colony. In total, 1,194 pellets were collected and analysed (121 at Mosty, 434 at Kiersity and 639 at Kąty Rybackie). The pellets were stored in a bag and dried for 3–4 days at room temperature before analysis. All mammal bones, invertebrate remains, feathers and other solid parts were removed from a pellet and collected. Mammal skulls and invertebrate remains were identified using literature (Pucek 1984; Stańczykowska 1986; Zahradnik 1996; Engelhardt 1998).

From each sample of pellets collected during one visit in the colony, six pellets were selected for hair analyses. From each pellet, ten hairs were sampled for microscopic analysis. Scale pattern of the hair cuticula, medullary patterns and pattern of sectioned hair were used for species identification, using the keys of Dziurdziuk (1973) and Aeschlimann (1982). Additionally, hairs taken from the collected pellets were compared with hairs from the collection of identified, stuffed mammals. Hairs were prepared for identification by the methods proposed by Dziurdziuk (1973).

All percentages given in the paper refer to the number of pellets in which a given prey item was in relation to the total number of analysed pellets. Percentages do not sum up to 100 because more than one type of remain/species was recorded per pellet.

Data were analysed with *G* tests and Chi-square tests with Yates' correction (in case of 2×2 tests)(Zar 1996). Heterogeneity of insects and mammals found in pellets and regurgitated food were estimated with Shannon–Wiener diversity index (H') and Pielou evenness index (J') (Krebs 1996). The *t* test of Hutcheson (1970) was used to compare diversity indexes among colonies.

When approached by predators, including man, heron nestlings respond by spontaneous regurgitation of their last meal (Moser 1986). Regurgitated food was collected beneath trees with nests during regular visits throughout the chick rearing period in 2000–2002 and was found mainly from May to July. Analyses of diet from regurgitated prey items are potentially biased because of differential rates of digestion of prey items (Owen 1955). The prey items were grouped into partly digested (mostly fish with digested heads) and non-digested. All prey items were identified and measured with 0.5 cm accuracy. Fish were measured from the tip of head to the fork of tail. In total, 221 prey items were collected in 2000–2002 at Mosty and Kiersity (124 in 2000, 71 in 2001 and 26 in 2002). At Kąty Rybackie, only a few regurgitated fish were collected because usually it was impossible to separate items regurgitated by cormorants and herons.

Due to the mentioned limitations in the analyses of pellets and regurgitated food (different stage of digestion of prey, lack of some taxa in pellets and regurgitated food), quantitative estimation of grey heron food consumption during the whole breeding season was based on the data of breeding ecology and population size. The following data were considered: number of nests in the colony (Jakubas 2004), mean number of chicks per nest [weighted mean calculated from the number of medium-aged chicks (21–27 days old), large chicks (28–38 days old) and fledglings (39–51 days)], and mean number of feedings per chick (Jakubas 2003). Mean daily food demand of adult bird was estimated at 270 g (Kushlan and Hafner 2000). Values of 300–800 g cited in literature (Creutz 1964, 1981) were not taken into consideration because they were obtained in captivity. Such conditions lead to over-consumption (Marion 1990). Mean weight of food delivered to the nest during one feeding - 230 g (Ilitchev and Miheev 1986). Food consumption in the breeding seasons for the years not included in the study (1997, 1999, in Discussion) was calculated assuming the same food composition in accordance with breeding success and colony size (data from Jakubas 2003).

Results

Pellets

Pellets collected in all colonies studied contained mainly hair (almost 100% of samples, Fig. 1). Bird feathers were the main structural component in only 11 (0.9%) of the analysed pellets. Most pellets that contained feathers were found at Mosty ($G_2 = 8.17$, $P < 0.05$). Bone remains (skulls, bones) were recorded in 21–24% of pellets ($G_2 = 1.26$, n.s.). The frequency of occurrence of invertebrate remains (mainly the insect elythra) varied among colonies from 26% to 51% ($G_3 = 10.8$, $P < 0.05$). At Mosty, the lowest number of pellets contained insect remains (comparison with Kiersity: $\chi^2{}_1 = 5.5$, $P < 0.05$, comparison with Kąty Rybackie: $\chi^2{}_1 = 9.3$, $P < 0.005$). Fish otoliths and scales were rarely found in samples from Kiersity and Kąty Rybackie (1–5%). Other types of remains (snail shells, forceps of crayfish, ilium of frogs) were noted occasionally (<1% of pellets) in two colonies only (Fig. 1). Two pellets found at Kąty Rybackie contained ichthyological labels from digested fish.

The following prey taxa were found in the collected pellets:

Crustaceans

At Kąty Rybackie, remains of common crayfish (*Astacus astacus*) were found in two pellets (0.2% of all pellets) in 1999 and 2000.

Insects

Remains of species from the families Dytiscidae (19–48% in different heronries) and Carabidae (1–5%) were the most frequently found in the pellets. The frequency of their occurrence was similar in all studied colonies ($G_2 = 0.27$, n.s.). Remains of Hydrophilidae and Elatheridae were an important component of pellets from Kąty Rybackie and Kiersity, but were not found at Mosty. Water beetle (*Dytiscus marginalis*) was the most common insect species found in samples from Kąty Rybackie, Kiersity (in more than 40% of pellets) and Mosty (Table 1). Insects from five other families were recorded less frequently (Table 1). Similar species composition of insects in pellets was noted only at Kiersity and Kąty Rybackie ($G_{10} = 5.97$, n.s.). The highest heterogeneity index was noted in samples from Kiersity, the lowest at Mosty (Table 2). However, intercolonial differences were *not significant* (Hutcheson *t* test, n.s.).

Snails

A shell of the pond snail (*Planorbarius corneus*) was found in one pellet from Mosty, and the shell of a ramshorn snail (*Planorbis planorbis*) in one pellet from Kąty Rybackie.

Fish

Fish remains were rarely recorded in pellets. At Kąty Rybackie scales and otholits of ruffe (*Gymnocephalus cernuus*) were recorded in 37 pellets (6% of all collected) in 1999–2001 combined. Additionally, in two pellets ichthyological labels were found. One label from the first pellet and four labels from the second pellet originated from individually marked second-year-old trouts (*Salmo trutta*) (length - 175–220 mm, weight - 120–150 g). At Kiersity, unidentified elastic, cycloid scales were found in two pellets. In one pellet, scales of ruffe were found.

Amphibia

Amphibian remains were found in 0.2–0.3% of all pellets from Kiersity and Kąty Rybackie. At Kiersity, two ilium bones of common frog (*Rana temporaria*) were found, and in one pellet remains of an unidentified frog were recorded.

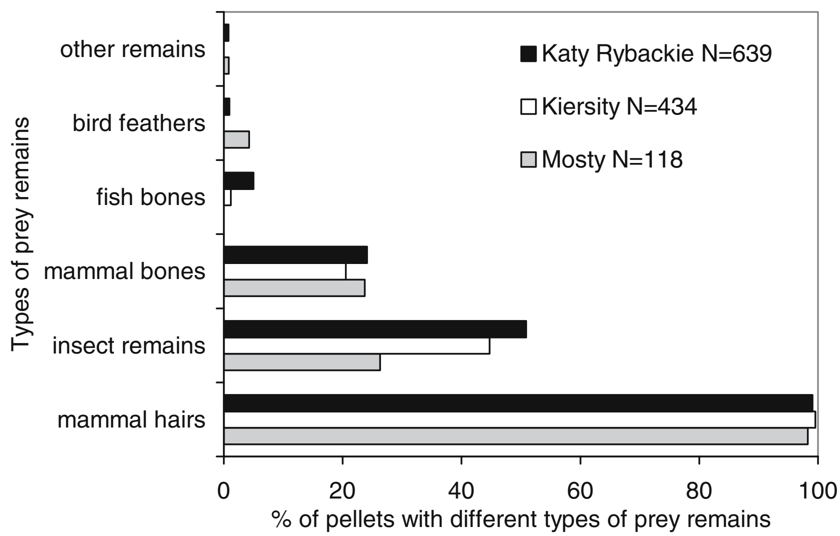

Fig. 1 Frequency of occurrence of different types of prey remains in pellets of grey herons collected in colonies studied in Poland during 1999–2001 period

Table 1 Frequency of insect taxa in pellets of grey herons in the colonies studied in Poland during 1999–2001 period

Prey taxa	Mosty		Kiersity		Kąty Rybackie	
	No	%	No	%	No	%
Dytiscidae	25	19	204	45	298	48
Dytiscus marginalis	23	17	200	44	296	47
Cybister lateralimarginalis	1	1	4	1	1	< 1
Gyrinius minutus	–	–	–	–	2	< 1
Hyphydrus ovatus	1	1	–	–	1	< 1
Carabidae	2	1	17	4	29	5
Elatheridae	4	3	13	3	27	4
Hydrophilidae	–	–	20	4	29	5
Cerambicidae	–	–	10	2	12	2
Odonata	1		8	2	11	2
Coccinelidae	–	–	2	< 1	10	2
Coccinella sp.	–	–	2	< 1	8	1
Chrysomelidae	–	–	2	< 1	5	< 1
Leptinotarsa decemlineata	–	–	2	< 1	3	< 1
Scarabidae	1	1	1	< 1	4	< 1
Geotrupes sp.	1	1	1	< 1	3	< 1
Curculionidae	–	–	1	< 1	2	< 1
Cantharidae	–	–	1	< 1	1	< 1
Silphidae	–	–	–	–	1	< 1
Number of pellets	121	–	434	–	639	–
H' – diversity index	1.22	–	1.56	–	1.76	–
J' – evenness index	0.53	–	0.45	–	0.49	–

Birds

Bird feathers (unidentified) were recorded in 4% of pellets from Mosty. In the other colonies, feathers were rarely recorded (in 0.5–0.9% of pellets).

Mammals

The analysis of bone remains showed that water vole (*Arvicola terrestris*) was the most common mammal species found in samples from all colonies studied (Table 2). Proportions of occurrence of this species, the mole (*Talpa europaea*) and *Microtus* voles in the samples were similar in all heronries ($G_4 = 2.80$, n.s.). The high percentage of unidentified bone remains was caused by the high degree of digestion.

Hair of the water vole

Microtus voles, the mole and shrews *Sorex*/*Neomys* were found in pellets from all colonies studied (Table 2). Hair of the first three species dominated in samples from all colonies. Frequencies of occurrence of those species differed among the heronries studied ($G_6 = 14.1$, $P < 0.05$). The highest heterogeneity of mammal species found in pellets was recorded in samples from Kiersity. Only five mammal species were found in pellets from Mosty. However, heterogeneity index values were similar in all colonies (Hutcheson *t* test, n.s.).

Identification of mammals by bones and hair showed different frequencies of occurrence of taxa in all studied colonies (Mosty, $G_2 = 11.7$, $P < 0.05$, Kiersity, $G_3 = 19.48$, $P < 0.05$, Kąty Rybackie, $G_3 = 33.02$, $P < 0.05$).

Table 2 Percentage of pellets of grey herons containing different mammalian taxa (identified by bone remains/hair) in breeding colonies in Poland during 1999–2001 period (H' – diversity index, J'- evenness index)

Prey species	Mosty		Kiersity		Kąty Ryb	
	No	%	No	%	No	%
Arvicola terrestris	15/45	11/42	41/123	9/60	90/115	14/58
Microtus sp.	6/83	4/77	10/122	2/60	37/103	6/52
Cleithrionomys glareolus	-/3	-/3	3/15	3/7	11/12	2/6
Sorex/Neomys	-/8	-/7	-/22	-/11	-/25	-/13
Talpa europaea	4/51	3/47	12/99	3/48	20/103	3/52
Glis glis	-/-	-/-	-/-	-/-	-/4	- /2
Unidentified remains	49/-	37/-	39/-	9/-	51/-	8/-
Number of pellets	121/108	–	434/204	–	639/198	–
H' – only for hair	1.81	–	1.98	–	2.06	–
J' – only for hair	0.78	–	0.85	–	0.80	–

Regurgitated food

In colonies, where considerable samples of regurgitated food were collected, fish constituted over 95% of collected prey items. At Mosty, round goby (*Neogobius melanostomus*) was the most important prey species, occurring in 94% of the examined samples. Other fish, amphibians and mammals were found occasionally (Tables 3, 4, Fig. 2). Diversity and evenness indexes were low (H'=0.34, J'=0.10). At Kiersity, roach (*Rutilus rutilus*) (30% of occurrence), crucian carp (*Carassius carassius*) (18%) and rudd (*Scardinius erythrophthalmus*) (14%) were the most common prey. Other prey items were recorded less frequently (Tables 3, 4, Fig. 2). The diversity index of regurgitated fish was higher at Kiersity than at Mosty (Hutcheson *t* test, $t_{2,53}=3.08$, $P<0.005$). At Kąty Rybackie, in the part of the colony occupied exclusively by herons, bream (*Abramis brama*), crucian carp, tench (*Tinca tinca*), roach and three-spined stickleback (*Gasterosteus aculeatus*) were found.

Mean length of regurgitated fish in all colonies was 10–20 cm (Table 3). Fish collected at Mosty were smaller than at Kiersity (all fish species combined, *U* Mann–Whitney test, $Z=-3.70$, $P<0.005$, $N=131$).

Biomass of food ingested by the grey heron

Food consumed by herons during the whole breeding season was estimated for each of the colonies studied based on the number of nests (Table 5). The estimation of contribution of particular taxa to biomass in the heron diet was not possible by this method. However, according to data on regurgitated food, the fish component forms at least 90% of the herons' diet. Other components (insects, frogs, small mammals) were usually smaller and had lower biomass than fish. Thus, the presented estimation refers mainly to fish prey.

The highest food consumption (more than 100 tons per season) was recorded in the biggest colony (Kąty Rybackie), mainly in May (>30 t). Herons from Mosty consumed 46–52 t of food each season, from Kiersity 30–38 t per breeding season, mainly in May and June (Table 5).

Discussion

The most important component of grey heron diet in the colonies studied was fish, as was shown by the analysis of regurgitated food. Results of stomach analysis and regurgitated food analyses performed in other colonies in Europe were similar (Owen 1955, 1960; Andone et al. 1969; Milstein et al. 1970; Moser 1986; Draulans et al. 1987; Gregory 1990; Peris et al. 1994; Cramp 1998 after Schlegel 1935; Lekuona 2001, 2002). Due to the extremely efficient digestive system, fish remains in pellets were found occasionally during the present study, as well as in 1993–1994 at Kąty Rybackie (Makrycki 1994) and in Belgian heronries (Draulans et al. 1987). Species composition of insects found in the colonies studied was similar to values reported from Belgium and Hungary (Draulans et al. 1987; Cramp 1998 after Vasvari 1954). The frequency of occurrence of insects remains in pellets varied among the colonies studied (26–51%) and between Hungary and Italy (25–68% stomachs contained insects remains; Moltoni 1936; Cramp 1998 after Vasvari 1954). In Belgium, insects were found in pellets from coastal heronries more rarely than from inland colonies (Draulans et al. 1987). A similar situation was observed in the coastal heronry at Mosty (Fig. 1), where the majority of birds hunted for prey in shallow coastal water (Jakubas 2004). It seems that insects, because of their small size (except for the relatively big water beetle), are not important in the energy budget of herons. However, there may be other causes for heron predation on invertebrates (Draulans et al. 1987), such as nutritional reasons. Similarly to the majority of studied heronries in Europe (Milstein et al. 1970; Cramp 1998; Lekuona 2001, 2002), other invertebrates (crustaceans, molluscs) were of marginal importance in the studied colonies. However, locally, this type of prey is more important in the diet of grey herons [e.g. on Caspian

Table 3 Mean body length (cm) ± SD (*N*) of fish found in studied heronries in Poland during 2000–2002 period

Species	Mosty		Kiersity	
	Undigested	Partly digested	Undigested	Partly digested
Round Goby *Neogobius melanostomus*	11.3 ± 2.29 (82)	10.2 ± 2.11 (70)	–	–
Three-spined stickleback *Gasterosteus aculeatus*	6.0 ± 0.50 (3)	5.6 ± 0.25 (4)	3.5 (1)	–
Plaice/Flounder *Platessa platessa*	–	36.0 (1)	–	–
Crucian carp *Carassius carassius*	–	–	11.7 ± 4.00 (8)	17.0 (1)
Bream *Abramis brama*	–	–	15.0 ± 9.53 (3)	–
Tench *Tinca tinca*	–	–	22.3 ± 5.69 (3)	16.5 ± 3.54 (2)
Perch *Perca fluviatilis*	7.0 (1)	–	11.9 ± 3.57 (4)	–
Roach *Rutilus rutilus*	–		14.1 ± 2.93 (14)	13.0 (1)
Pike *Esox lucius*	–	–	16.0 ± 4.24 (2)	–
Bleak *Alburnus alburnus*	–	–	10.8 ± 1.04 (3)	–
Rudd *Scardinius erythrophthalmus*	–	–	12.3 ± 2.86 (7)	–
All fish species	11.0 ± 2.48 (86)	10.3 ± 3.78 (75)	13.4 ± 4.78 (45)	15.8 ± 2.75 (4)

Table 4 Amphibians and mammals found in regurgitated food of grey herons found in studied heronries in Poland during 2000–2002 period—mean body length (cm) ± SD (N), + - partly digested

Prey species	Mosty	Kiersity	Kąty Rybackie
Pelobates fuscus	–	–	5.5 (1)
Rana lessonae	–	5.5 (1)	–
Rana terrestris	–	–	13.0 ± 1.41 (2)
Rana sp.	–	–	+ (1)
Microtus arvalis	–	–	14.0 (1)
Neomys fodiens	+ (1)	–	–
Rattus sp.	–	8.5 (1)	10.0 (1)

shores (Dementiev and Gladkov 1951) and Spain (Peris et al. 1994)]. Amphibians were found in pellets occasionally, and in many studies amphibians were not reported (e.g. Draulans et al. 1987; Makrycki 1994). The observation of ten common spadefoots (*Pelobates fuscus*) in the oesophagus and stomach of freshly dead adult female grey herons found in 1999 at Kiersity indicated that the contribution of amphibians in the heron diet could be higher than estimated by other methods. Studies in Hungary and Italy showed that frogs were present in > 20% of Grey Heron stomachs (Moltoni 1936; Cramp 1998 after Vasvari 1954). In contrast to other European colonies (Dementiev and Gladkov 1951; Milstein et al. 1970; Marquiss and Leitch 1990; Cramp 1998), reptile and bird remains were absent from or scarce in the examined samples. The species composition of mammals regurgitated and found in pellets was similar to reported from Belgium and Hungary (Draulans et al. 1987; data from stomachs: Cramp 1998 after Vasvari 1954). In contrast to pellets, the frequency of mammals in regurgitated samples was very low. Locally, mammals [e.g. susliks (*Citellus* sp.) and mice in Bessarabia] can be a main component of a diet (Dementiev and Gladkov 1951).

Diet varies considerably with habitat and season (Cramp 1998) and is strongly influenced by the availability of prey in the foraging area. Diet of herons from the colony at Mosty was almost monopolised by round goby, which was a very abundant, high quality and easy to catch prey. In spite of the occurrence of a few feeding areas, the majority of herons from Mosty chose feeding areas abundant in round goby (Jakubas 2004). Similarly in Scotland, despite availability of native fish species, grey herons hunted for more abundant and more easily caught newly introduced prey-ruffe (*Gymnocephalus cernuus*) (Adams and Mitchell 1995).

Herons from Kąty Rybackie consumed > 100 t of food per season. In 1997, cormorants consumed 505 t of fish —34% of the total biomass of fish taken by fishermen in the Vistula Lagoon (the main feeding area of herons) as bycatch (i.e. fish below the legal size limit) (Stempniewicz 1997). Herons caught only 95 t—6% of fishermen bycatch and 19% of food taken by Cormorants (assuming that heron foraged only in the lagoon). In the studied seasons, consumption by cormorants was much higher because of the much higher number of breeding pairs. In spite of strong pressure exerted by cormorants, fishermen and herons on small fish in the Vistula Lagoon, their influence on the fish community remained stable (Stempniewicz et al. 2003). Indeed, herons took less fish from the Vistula Lagoon, because during the chick-rearing period up to 18% (in 2002) of the herons able to fly (adults and fledglings) foraged on fish regurgitated by cormorants in the colony (Wojczulanis et al. 2005).

Herons from the colony at Mosty consumed 46–52 t of food per nesting season. The composition of regurgitated food (round goby —95% of prey items) and low numbers of pellets found indicated high food selectivity of herons from Mosty. Round goby, newly introduced in the Gulf of Gdańsk, is a very abundant fish and may become a serious competitor for food with other fish species from the coastal zone of the Baltic Sea (feeding mainly on crustaceans and molluscs; Skóra 1997). Round goby in the Gulf of Gdańsk has no natural fish enemies and its population is being limited only by cormorants (non-breeding birds ate ca 375–635 t of Round Goby in 1999; Bzoma 1998, 2004), grey herons (took in 1999 ca 55–65 t assuming feeding till October; it was 10–14% of Cormorants' consumption) and to a small degree by anglers (Skóra and Rzeźnik 2001) and

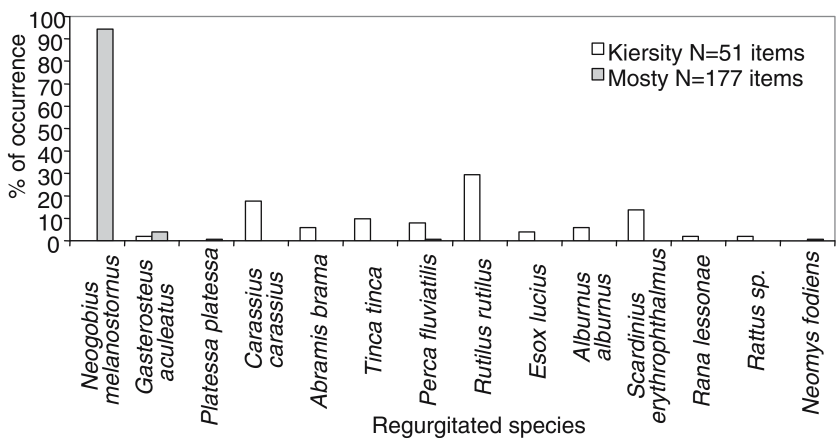

Fig. 2 Frequency of occurrence of prey items in regurgitated samples from Mosty and Kiersity colonies during 2000–2002 period

Table 5 Estimation of grey heron food consumption (t) in the colonies at Mosty, Kiersity and Kąty Rybackie in the consecutive months of the breeding season during 2000–2002 period

Colony	Season	February	March	April	May	June	July	Total
Mosty	2000	4.5	5.6	8.6	11.6	9.8	6.2	46.3
	2001	–	5.6	10.5	13.9	10.3	6.9	47.1
	2002	–	6.7	11.3	15.7	10.3	8.4	52.4
Kiersity	2000	–	4.5	7.9	11.2	9.1	5.8	38.4
	2001	–	3.5	5.8	8.3	7.2	4.7	29.5
	2002	–	3.7	6.4	8.3	6.7	5.0	30.1
Kąty Rybackie	2000	–	14.2	29.2	38.7	26.9	17.4	126.5
	2001	–	13.1	25.2	34.2	25.0	16.1	113.6
	2002	–	11.6	24.4	30.9	20.5	20.5	107.9

other piscivorous birds (Bzoma 2004). The rapid increase of round goby population was probably the reason of the size increase of the heronry at Mosty (Jakubas 2004).

At Kiersity, herons consumed 30–39 t of food per breeding season. The majority of herons foraged in Druzno Lake [70–80% of the herons flew in that direction (Jakubas 2003); so they took ca 21–31 t of food from that lake]. Mean total harvest by fishermen from Druzno Lake in 1990–2000 was estimated at 37.2 t per year, but this value was underestimated (Martyniak et al. 2002). Fish species composition was similar in samples from Kiersity and in commercial catches (in 1990–2000) and ichthyological catches (in 2001) in Druzno Lake (Martyniak et al. 2002). Thus herons were not selective in their prey choice. The length of regurgitated prey indicated that herons hunted for fish smaller than the size considered of economic value.

In natural feeding areas (flooded wetland in France and trout rivers in Switzerland), grey herons took only about 6% of the available prey (Geiger 1983, 1984a, 1984b; Fischbacher 1984; Anonymous 1984; Feunteun and Marion 1994). Only under special conditions (high densities of fish) heron predation caused a 76% decrease in fish biomass [in Everglades (USA); Kushlan 1976]. In artificial habitats, in contrast to the impression of fishermen, heron predation was relatively low (0–13%, reviewed in Kushlan and Hafner 2000). Reports on bird predation suggest that herons, because of their anatomy (which restricts their foraging to shallow water) and their feeding behavior are less efficient than other fish-eaters (pelicans, cormorants, mammals). Thus, herons cause far less losses compared to predation of most other species (Kushlan and Hafner 2000). Other sources of fish mortality, especially diseases, accidents and water quality often are more important than bird predation (Kushlan and Hafner 2000).

The lack of data on fish community biomass in the areas studied did not allow estimating the percentage of killed fish in relation to fish stock biomass. The presented estimates of food consumption showed that the impact of herons on fish communities was much lower than other predation losses. Only at Kiersity, the estimated values of consumption were higher but the data of the fishermen harvest were not reliable. Due to the small size and the species composition of fish taken by herons, they can be considered to be of negligible economic value. Moreover, herons can have a positive influence on the fish community because they preferentially take fish in poorest condition (parasitized, with cataracts; Ashkenazi and Yom-Tov 1993; Carss 1993). So, in many cases fish mortality caused by herons represents compensatory mortality.

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