Prey supply of otters (*Lutra lutra*) in small rivers in north-eastern Belarus: census method used and preliminary data obtained

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Abstract: A census method used for estimating species diversity, density and biomass of water-dwelling prey of otters (*Lutra lutra*) in small rivers is described in this paper. The method is based on net equipment mostly consisting of walls, fykes and fastenings. We created two nets that were adapted for size, flow rate and other parameters of small rivers. The preliminary results on species diversity and biomass of water-dwelling prey (fish, crayfish, frogs and rather big aquatic beetles) of otters in small rivers of north-eastern Belarus in the warm season obtained by the method described are presented. In summer (June-August) the total biomass of aquatic prey recorded in censuses on 100 m stretches of the Lovat river (northeast Belarus) varied from 0.1 kg to 4 kg and was on average 1.7 kg. Fish made up the main part (67-89%) of the aquatic prey biomass. In total we caught twenty fish species, but in the sample stretches surveyed in the census only 4 to 11 fish species were recorded. The fish species richness gradually increased with river size and as the flowing rate decreased. The same trend was found in fish biomass. Crayfish was most abundant in the moderately flowing parts of the Lovat river. In the river parts with a slow flowing rate they were slightly less abundant, while in fast flowing waters the least biomass of crayfish was registered. With an increase in the size of the river and a decreasing flowing rate the biomass of rather big aquatic beetles and edible frogs increased, as was also the trend for the fish community.

Keywords: otter, fish, crayfish, aquatic prey, census method, Belarus.

Introduction

Prey abundance is a crucial factor for predator abundances. A study of prey species diversity, as density and biomass, quite often can explain and predict the distribution of predators as well as reveal a cause of their population trend (Begon et al. 1986, Krebs 1994, Jedrzejewska & Jedrzejewski 1998). However, there is still an evident lack of relevant equipment and methodologies on how to do a census of prey, especially small prey species with secretive lifestyles in a sheltered environment (Jedrzejewska & Jedrzejewski 1998). In particular, it is difficult to obtain exact data, which is necessary to understand predator feeding strategy and population dynamics (Begon et al. 1986, Krebs 1994).

Concerning the European otter (*Lutra lutra*), which feeds on fish and other water-dwelling prey, there is also a shortage of precise data on its food supply. In inland habitats mainly consisting of rivers, this predator mostly feeds on fish, crayfish and frogs (Mason & Macdonald 1986, Jedrzejewska et al. 2001). Among riverine habitats small rivers predominate markedly. Therefore, when doing a study on otter population ecology and elaborating an action plan to protect otters and their habitats, it is very important to obtain good data on species diversity, density and biomass of the prey dwelling in small rivers.

There are many publications at least in part appertaining to fish community structure (species diversity, density and biomass) in small rivers in Europe (Le Cren 1962, Egglishaw 1970, Le Cren

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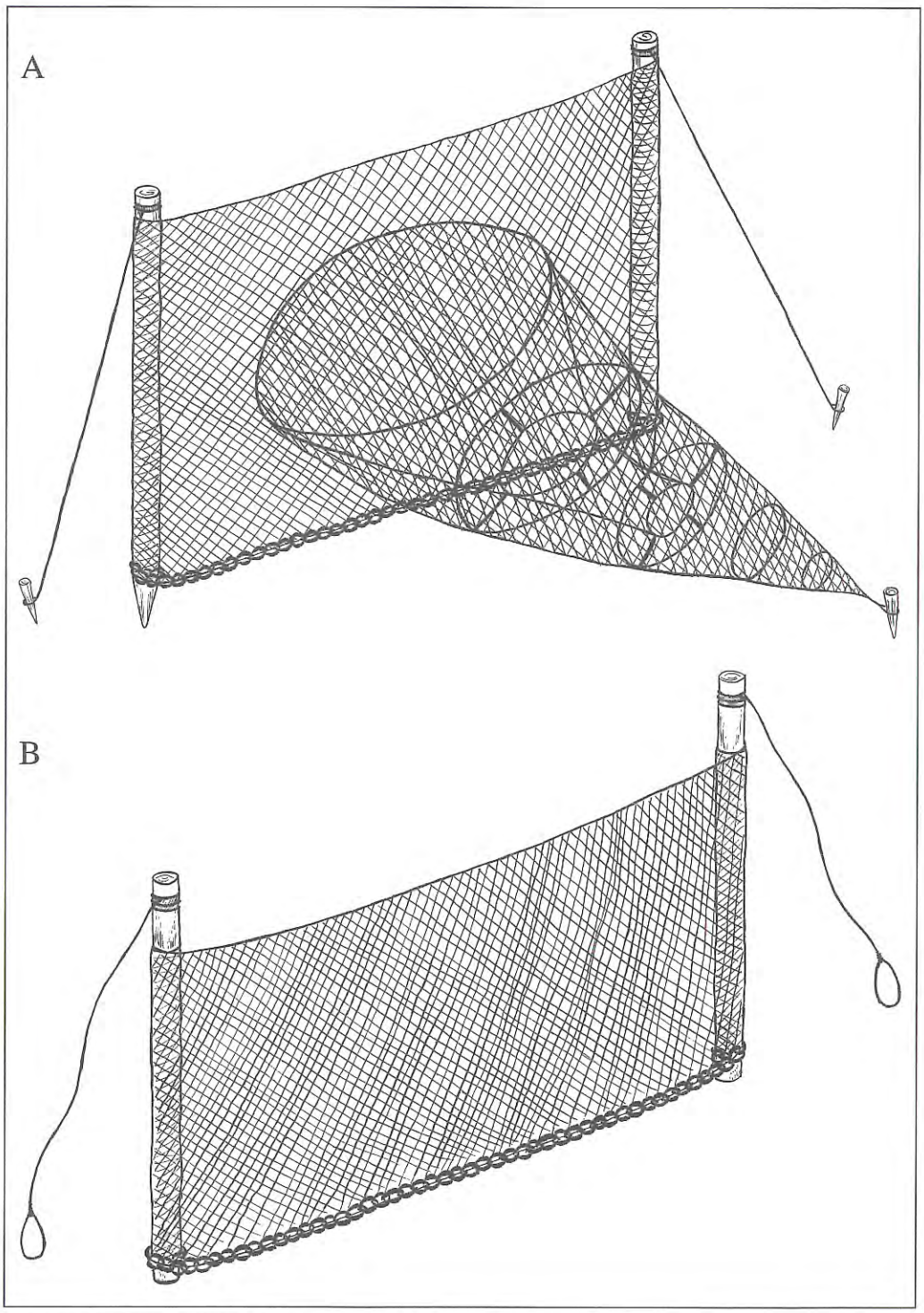

Figure 1. Catching net (A) and chasing net (B) of the big net equipment.

Photo 1. The catching net of the big net equipment has a large catching cavity like a long fyke with a funnel-shaped entrance. *Photograph: Vadim Sidorovich.*

1972, Mortensen 1977, Penczak 1981, Penczak et al. 1986, Mann & Penczak 1986, Kruuk et al. 1993, Birzaks et al. 1998, Virbickas 1998). Nevertheless in Belarus the subject has never been studied. Information concerning crayfish in small rivers and frogs, which live on small riverbanks and hibernate in streams, is even more scattered and limited (Koskela & Pasanen 1974, Tsukerzis 1989, Pasanen & Sorjonen 1994, Alehnovich et al. 1995, Sidorovich 1997, Pikulik et al. 2001, Sidorovich et al. 2001a).

In this paper we present preliminary results of a census on species diversity and biomass of water-dwelling prey (fish, crayfish, frogs and rather big aquatic beetles) of otters in small rivers of north-eastern Belarus and describe the census method used.

Materials and methods

The study took place on the upper reaches of the Lovat river, Gorodok district, Vitebsk region, north-eastern Belarus (56°E 32°N). Taking into account well-known fish habitat requirements and habitat-related features of fish community structure in Belarus (Zhukov 1965, Zhukov 1988), three types of small rivers (fast-, moderately- and slowly-flowing ones) were investigated in the upper reaches of the Lovat river. The main parameter used to separate small rivers into different habitat types of water-dwelling prey of otters was a flowing rate which, at least in the forested terrain of northern Belarus, correlates well with the majority of river parameters affecting habitat quality of fish and other aquatic prey (Zhukov 1965, Pikulik 1985, Zhukov 1988, Alehnovich et al. 1995, Sidorovich et al. 2001b).

The first type (hereafter type A) is fast-flowing (faster than 0.6 m/s) small rivers between 5 m and 8 m wide and 0.5-1.5 m deep. They have high, steep, wooded bank sides and small floodplains; the bottom is mostly rocky and sandy with some dead tree materials and aquatic plants; the riverbed is either straight or with some meanders. The second type (hereafter type B) of small

Photo 2. The chasing net of the big net equipment should be situated across the river in the upstream part of the section. *Photograph: Vadim Sidorovich.*

river presented in the Lovat river head is slow flowing (slower than 0.3 m/s), between 7 m and 25 m in width and 1-2.5 m in depth. They have marshy bank sides and wide floodplains (200-1000 m) consisting of black alder (*Alnus glutinosa*) swamps and various open marshes (reeds and sedges, often with a high diversity of grass vegetation); the bottom is muddy with a lot of dead tree materials and aquatic plants; the riverbed is either straight or with some meanders. The third type (hereafter type C) is an intermediate category between the types A and B. It includes moderately flowing (0.3-0.6 m/s) small rivers between 5 m and 16 m in width and 0.7-2 m in depth. They have high, steep, wooded bank sides and moderately wide floodplains (100-600 m) consisting of both marshes and dry lands. The bottom structure includes a whole variety of possible elements such as sandy or eutrophic substratum, scattered or pooled dead tree materials. Some bottom parts are densely overgrown by aquatic plants and the riverbed meanders tightly.

Censuses of water-dwelling prey of otters were carried out in river sections of 90-320 m length (mean length of about 210 m): in type A and B three sections were investigated, while in type C eight sections were investigated. The section length was chosen on the basis of being able to carry out the census correctly. This depended on stream complexity and the limitations of the method: necessary time and labour, obstacles that might get in the way of the net, etc. The method of estimating species diversity, density and biomass depended on the net equipment. We constructed several nets, which were adapted for size, flowing rate and other parameters of small rivers, but mainly used two kinds.

The net equipment used in type B rivers is 10-18 m wide and 1-3 m deep (hereafter *big net equipment*). It consists of two net walls (length 15-25 m, height 3-4.5 m, approximately). The net walls are fixed by wooden stakes and ropes as well as provided with a heavy chain fixed by rope at the lower side. One of the net walls has a large catching cavity (hereafter *catching net*, see figure 1a) like a 7-10 m fyke with a funnel-

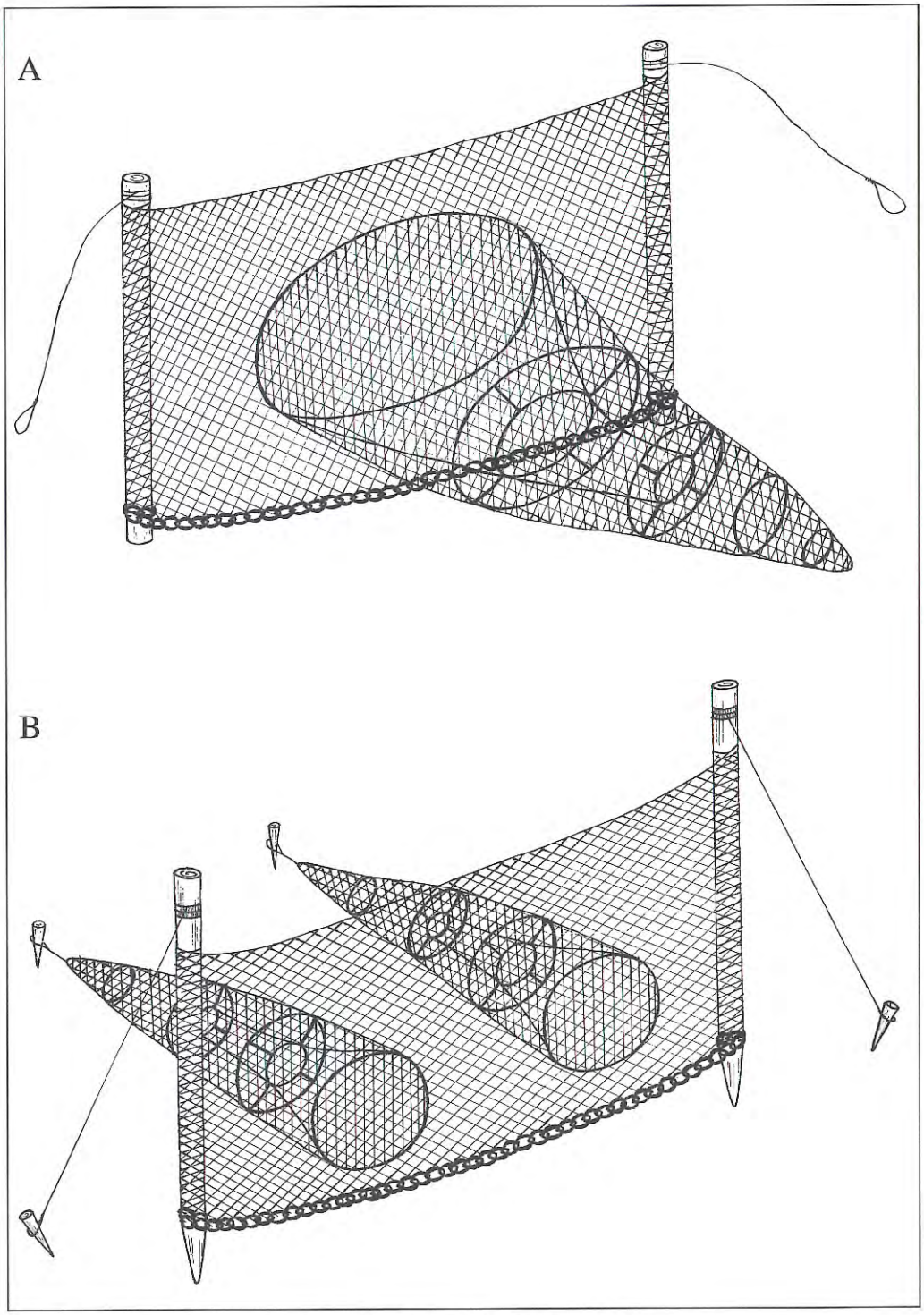

Figure 2. Moving catching net (A) and fixed catching net (B) of the small net equipment.

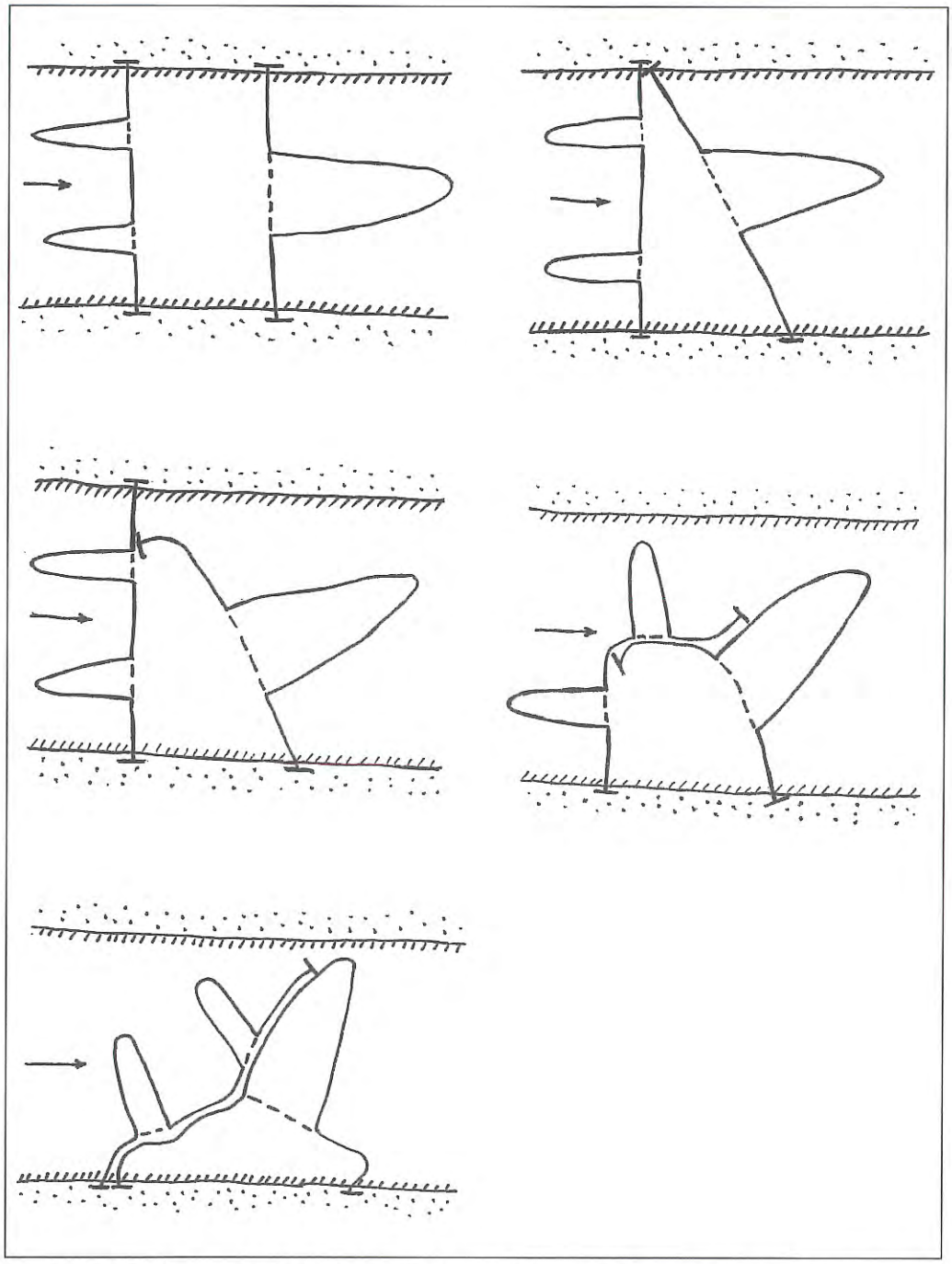

Figure 3. Outline of taking out of the net equipment to finish the catching of aquatic prey in a small river section. The arrows shown indicate the direction of water flow.

shaped entrance (photo 1). Its mouth is located about 50 cm above the lower net side and has an oval shape of 4-7 m at its widest point and 1-1.5 m at the narrowest point. When using big net equipment to do a census of water-dwelling prey in a given river section, the catching net is situated across the river in the downstream part of the section (photo 2). An auxiliary net and other objects are used to shut all holes through which aquatic prey may escape out of the section, e.g. stones and wood material found at the bottom of river. A kayak can be used to fix the net on the opposite side of the river, if it is too deep to walk across. Pulling with a rope is useful to get the net equipment onto the opposite side of the river. The other net wall of the big net equipment (hereafter *chasing net*, see figure 1b) is also situated across the river, upstream from the location of the catching net. Then the chasing net is gradually moved by at least two, preferably three or four people, from the upstream to the downstream part of the section (photo 3). People pull the net using the wooden stakes and ropes, scraping along the riverbanks. More people in wet suits clear wood material from the river bottom in the section. This action scares aquatic prey, directing many of them to the fyke in the catching net. It is also important to catch aquatic prey with landing nets in the section. This causes more prey to move towards to the fyke, some of which are captured. This is especially important when the two net walls are close to each other. The total time necessary to accomplish this kind of census of water-dwelling prey in a 150-300 m section of type B rivers varied between 3 and 7 hours depending on the number of people involved (4-7 men), the length of stretch chosen (150-300 m) and the complexity of stream structure, i.e. bank type and abundance of dead tree material and aquatic plants.

Censuses of water-dwelling prey in small rivers of types A and C are similar, but details vary in the procedures and equipment. The net equipment (figure 2, photo 4) is smaller, and also consists of two similar constructed net walls (length 8-13 m, height 1.5-2.5 m). One of the net

Photo 3. The chasing net should be gradually moved by at least two, preferably three or four, people from the upstream to the downstream part of the section. *Photograph: Vadim Sidorovich.*

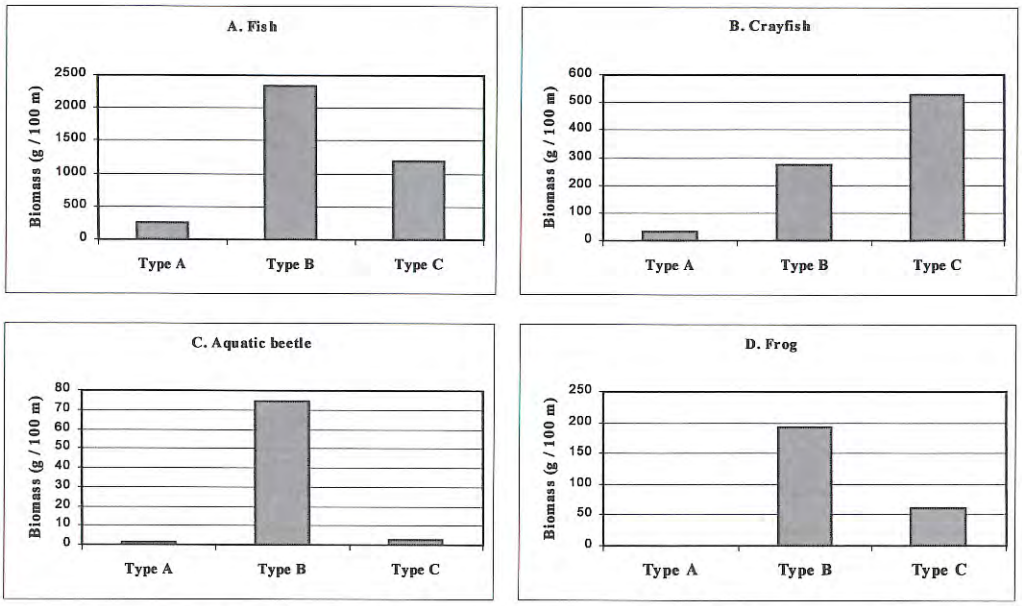

Figure 4. Biomass (g per 100 m river stretch) of water-dwelling prey of otters in the Lovat river head, the Gorodok district, Vitebsk region, northeast Belarus, June-September 2001.

walls has a relatively big fyke with a length of 2-5 m and an oval mouth size of 1.5-2 m by 0.6-1 m (referred to as *moving catching net*, see figure 2a). The fyke mouth is located at the lower net side. When using small net equipment to do a census of water-dwelling prey in a given river section, the moving catching net is situated across the river in the downstream part of the section. The other net wall of the small net equipment has no fyke when the stream is too small, or one or two fykes (hereafter *fixed catching net*, see figure 2b). It is fixed across the river in the upstream part of the location of the moving catching net. All small holes through which aquatic prey may escape from the section are shut. Then two, preferably three, people gradually move the moving catching net from downstream to upstream in the section (photo 4). The catching is finished as shown in figure 3. The total labour time required to complete a census of water-dwelling prey in a 100-150 m section of river of the types A and C varied between 3 and 6 hours, depending on the number of people involved (3-5 men), the length of the stretch chosen and the complexity of stream structure. Generally, we recommend spending at least 3 hours for a census of aquatic prey in a 100 m stretch of a small river.

The mesh of both net types was 0.6 cm. Only very small aquatic animals, that are usually not important for otters as possible prey, can get through the net.

Rate of underestimation of recorded prey was assessed by repeating the census method on the same river stretch: two extra guarding net walls were fixed across the river at the section borders and the catching was repeated several times. Our experiences showed that two repetitions are sufficient, because either no aquatic prey or only a few very small ones were captured in the second repetition. Usually, the labour time for each subsequent catching was 2-3 times less than that of the census itself. The prey underestimation was calculated as a percentage of the total additional weights of prey captured during the control catching.

Statistical analysis of the data obtained was done using the Spearman correlation (r_s) and t-test (Sokal & Rohlf 1995).

Results

Aquatic prey species diversity and biomass

In table 1 and figures 4-6 we present a summary of the census of water-dwelling prey (fish, crayfish, edible frogs and big aquatic beetles) in June-September 2001. The total biomass of aquatic prey recorded on 100 m stretches of the Lovat river varied widely from 114 g to 4046 g, and with an average of 1699 g. Fish made up the main part (67-89%) of the aquatic prey biomass.

In the small river we caught twenty fish species, but in the individual stretches surveyed only 4 to 11 fish species (on average, 5.7 in river type A, 9.8 in type B, 7.4 in type C) were recorded. The fish species richness gradually increased with river size (average width multiplied by average depth) (r_s=0.84, P<0.01), and decreased with flowing rate (r_s=-0.76, P<0.01). The same trend was found in the fish biomass (respectively r_s=0.72, P<0.01 and r_s=-0.76, P<0.01; see figure 4a). The differences in fish species diversity and total biomass revealed between the three types of the Lovat river are statistically significant (t=1.9-4.7, P_0.05). In the moderately and slowly flowing parts of the river (types C and B respectively) the pike (*Esox lucius*), the roach (*Rutilus rutilus*) and the perch (*Perca fluviatilis*) mainly contributed 78 to 80% to the fish biomass estimated, whereas in the type A sections with fast flowing rate, the stone loach (*Nemacheilus barbatulus*) and spiny loach (*Gobitis taenia*), the roach, the gudgeon (*Gobio gobio*), the pike and the burbot (*Lota lota*) were the main fish biomass components (76%) (see table 1). Concerning the weights of fish captured, the bigger the river, the higher the average weight of the fish was (figure 5). It is especially evident for the most common species such as the pike (r_s=0.92, P<0.01), the perch (r_s=0.76, P<0.01), and the roach (r_s=0.95, P<0.01).

Table 1. Species diversity and biomass of fish community in the Lovat river head, Gorodok district, Vitebsk region, northeast Belarus, June-September 2001. Type A = fast flowing, fairly shallow stream; Type B = slowly flowing, relatively deep stream; Type C = moderately flowing, medium stream depth. The biomass is given in g per 100 m stretch of river; mean ± standard deviation; n = number of the river stretches in which a census of water-dwelling prey was done.

Prey species or category		Type A n=3	Type B n=3	Type C n=8
Pike	*Esox lucius*	41.7 ±22.7	1310.8 ±730.7	449.7 ±585.8
Perch	*Perca fluviatilis*	19.0 ±32.9	383.3 ±166.4	363.8 ±388.3
Ruff	*Gymnocephalus cernuus*	0	5.9 ±10.1	1.3 ±3.8
Burbot	*Lota lota*	29.3 ±50.8	22.5 ±39.3	56.6 ±89.0
Roach	*Rutilus rutilus*	42.3 ±37.7	184.9 ±100.8	111.3 ±102.0
White bream	*Blicca bjoerkna*	0	45.0 ±77.9	5.3 ±10.4
Common bream	*Abramis brama*	0	53.2 ±49.3	84.7 ±239.5
Rudd	*Scardinius erythrophthalmus*	0	31.1 ±29.7	4.8 ±13.6
Tench	*Tinca tinca*	0	8.2 ±14.3	0
Ide	*Leuciscus idus*	0	52.0 ±47.2	22.8 ±33.1
Dace	*Leuciscus leuciscus*	0	49.6 ±85.9	18.2 ±17.5
Gudgeon	*Gobio gobio*	24.0 ±41.5	13.3 ±23.1	19.0 ±8.4
Verkhovka	*Leucaspius delineatus*	0	22.7 ±4.7	0.9 ±2.3
Riffle minnow	*Alburnoides bipunctatus*	9.0 ±18.0	0	0
Bleak	*Alburnus alburnus*	15.1 ±26.2	85.7 ±21.0	17.7 ±45.6
Crucian carp	*Carassius carassius*	0	8.5 ±14.8	0
Mud loach	*Misgurnus fossilis*	0	57.3 ±49.6	10.0 ±28.3
Spiny loach	*Gobitis taenia*	42.7 ±25.1	4.4 ±7.6	7.6 ±5.7
Stone loach	*Nemacheilus barbatulus*	20.2 ±1	0	0
Three-spined stickleback	*Gasterosteus aculeatus*	17.1 ±16.4	0	2.9 ±5.4

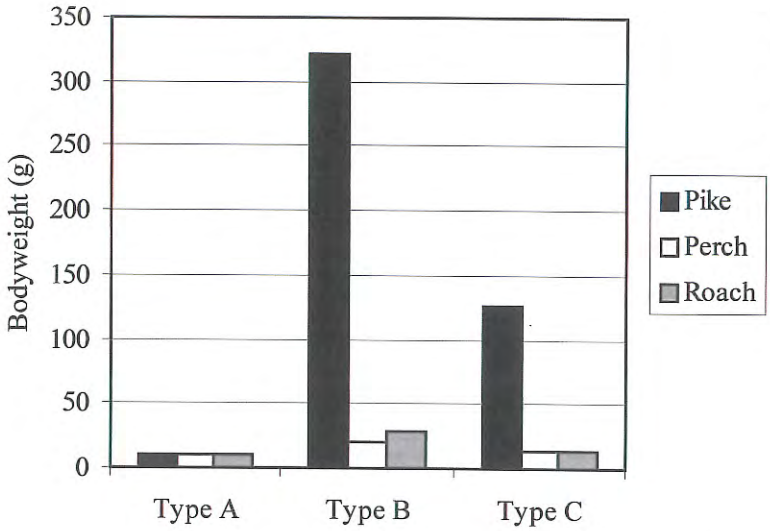

Figure 5. Average weight (g) of fish in the Lovat river head, the Gorodok district, Vitebsk region, northeast Belarus, June-September 2001.

Crayfish were most abundant in the moderately flowing parts (type C) of the Lovat river (figure 4b), while in the river part with a slow flowing rate (type B) they were slightly less abundant, and the least biomass of crayfish was registered in fast flowing waters (type A). Only the difference between types A and C is statistically significant (t=1.89, P=0.05). The crayfish recorded in the slowly flowing part of the Lovat river (the type B) were heavier than those caught in the types A and C (t=3.38, P=0.03; figure 6). Of the rather big aquatic beetles which could be relevant prey for otters, mainly *Dytiscus marginalis*, *Dytiscus latissimus*, *Dytiscus dimidiatus*, *Dytiscus circumcinctus*, *Dytiscus circumflecsus* and *Hydrophilus piceus* occurred. The biomass of rather big aquat-

Photo 4. The small net equipment consists of two constructed net walls. One of the net walls has a relatively big fyke with an oval mouth. *Photograph: Vadim Sidorovich.*

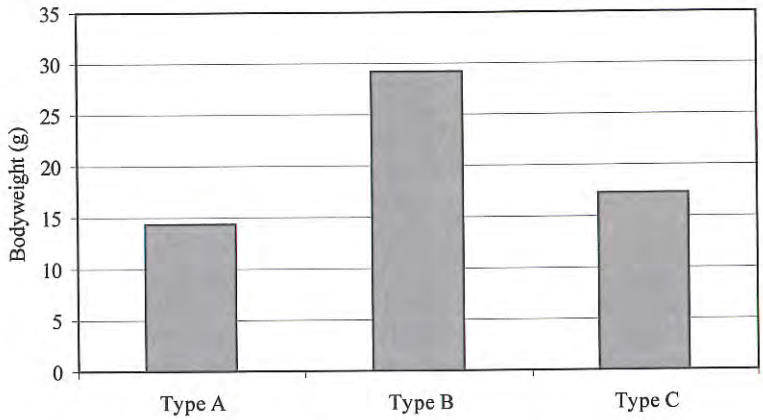

Figure 6. Average weight (g) of crayfish in the Lovat river head, the Gorodok district, Vitebsk region, northeast Belarus, June-September 2001.

ic beetles increased with an increase in the size of the river and a slower flowing rate (figure 4c). The same trend in edible frog (*Rana kl. esculenta*) biomass was registered (figure 4d).

Verification of the census method

According to the data obtained, the underestimation for fish biomass was up to 7%, with an average of 3%; crayfish up to 19%, an average of 6%; frogs up to 12%, an average of 6%; all aquatic prey together up to 10%, with an average of 5%. The prey biomass underestimation was negatively correlated with the time spent doing the census (r_s=-0.72, P<0.01) and it was independent of the section length chosen.

Discussion

The method used to assess species diversity and biomass of fish and other water-dwelling prey of otters in small rivers seems to work well enough: by doing single catching in a given small river stretch, the aquatic prey underestimation, assessed as 3% for fish on average and 6% for crayfish on average, is acceptable. This method has four evident advantages compared to other census methods for aquatic prey in small rivers. First, the method gives quite precise values of the numbers of all aquatic prey categories, while electro fishing merely produces absolute data relating to the total fish community, and using crayfish traps we only obtain a relative abundance index of this prey category (Tsukerzis 1989). Secondly, as our electro fishing experience suggests (Sidorovich et al. 2001b), in the conditions of eutrophic rivers with a lot of dead tree materials and aquatic plants, electro fishing seems to underestimate the fish community. Between 17% and 49% of fish individuals were not caught during electro fishing in a net enclosure set in the eutrophic beaver ponds with lots of dead tree material and overgrown by macrophytes, but were captured by landing nets and other net equipment. However, we agree that electro fishing is a good method for studying the fish community in rivers with stony beds as in Scotland (Egglishaw 1970, Kruuk et al. 1993). Thirdly, the equipment of the method based on nets is fairly easy to build and it is also cheap (in Belarus, the materials to build the big net cost about 150 euros) compared to the expensive equipment for electro fishing. Fourthly, using the net equipment, it is easy to keep the captured prey alive, while it is hard to be sure when performing electro fishing, that all fish affected by the electric shock would survive. On the other hand, the net method needs a large work force and the work is fairly heavy and muddy.

The second important issue to be discussed is the habitat carrying capacity of small rivers for otters in Belarus and Eastern-Europe as a whole. In Belarus, 70-80% of the river network is composed of small rivers up to 25 km in length (Kuprijanov 1966). Usually there are one to four

otters occupying a 10 km stretch of such small rivers, whereas the otter population density in bigger rivers is only 2-3 times higher (Sidorovich 1992, Sidorovich 1997). So, it appears, that in Belarus the main part of the otter population is sustained by small rivers. A very similar situation was recorded in the other countries of Eastern-Europe, namely Russia (Danilov & Tumanov 1976, Vaisfeld 1996), Latvia (Ozolins & Rantins 1992, Birzaks et al. 1998), Lithuania (Balciauskas & Ulevicius 1996, Ulevicius & Balciauskas 1996), Estonia (Kiili 1991), and Poland (Brzezinski & Romanowski 1996, Sidorovich et al. 1996, Romanowski et al. 1997). All these studies reveal the great importance of small rivers as the main otter habitat.

One of the essential components of carrying capacity of otter habitats is the biomass of water-dwelling prey. In this study we found that in the warm season the total biomass of aquatic prey dwelling in 100 m stretches of the Lovat river varied from 114 g to 4046 g, and on average was 1699 g. Taking into account that otters living in the wild need about 1 kg of food per day (Tumanov & Smelov 1980), this is not a lot. Even a rather rough approach makes this evident: for instance, if we suppose that otters consume all the prey available in the small river, each one needs to occupy about 21 km of river a year to catch enough food. Of course, this rough estimate does not take into account possible fish migration to spawn in the river in spring. That would obviously add to the prey biomass, but probably not much, because this period of greater fish abundance in the river does not last longer than two months (Zhukov 1965, Zhukov 1988). So, as usually about four otters inhabit each 10 km of small river stretch in the Lovat riverhead (Sidorovich & Macdonald 2001), a substantial part of the prey used by otters is not taken into account in the above calculations. We postulate that the common frog (*Rana temporaria*) is an important prey item in sustaining the high density of otters. Indeed, it is numerous in the riverbanks in the warm season and concentrates in small rivers for hibernation (Pikulik 1985, Sidorovich 1997, Sidorovich et al. 2001b). In December 1995, when doing a very detailed census of common frogs hibernating in 200 m of the Lovat river (flowing rate about 0.6 m/s, mean depth 0.6 m, and mean width 5 m) using similar net equipment, we caught 79 kg of common frogs, i.e. about 395 kg per 1 km of the river stretch (Sidorovich 1997). In late October and November 2000 we did a census of water-dwelling prey in three brooks flowing into the Lovat river (Sidorovich et al. 2001b). The brooks were fairly intensively dammed by beavers (*Castor fiber*). We captured about 60 kg of common frogs per 1 km of the brook stretch. A 5 to 379 fold difference was found in the common frog biomass between the beaver ponds and adjoining non-flooded parts of the small streams. In Eastern-Europe, a large part of the otter diet consists of common frogs (Jedrzejewska et al. 2001), and in the Lovat riverhead the proportion of frogs (mostly common frogs) in the otter diet varied seasonally from 30 to 42% of prey individuals, according to material recovered from scats analysed (Sidorovich 2000).

From the above-mentioned data on the total biomass of aquatic prey in the warm season and hibernating concentrations of common frogs in the small river, and from a dietary study done there before (Sidorovich 2000) it is certain that common frogs, together with fish and crayfish, sustain about four otters usually registered on a 10 km stretch of a small river in the Lovat riverhead.

Nevertheless, there is still a lack of data available on otter prey stock in riverine habitats on a seasonal basis. This gap is especially evident in relation to the cold season, when it is markedly harder for otters to survive. The described method based on net equipment may be helpful in further studies.

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Samenvatting

Prooi-aanbod voor otters (*Lutra lutra*) in kleine rivieren in noordoost Belarus: inventarisatiemethode en voorlopige resultaten

Dit artikel bespreekt een inventarisatiemethode voor het schatten van de soortenrijkdom, dichtheid en biomassa van aquatische prooidieren voor otters (*Lutra lutra*) in kleine rivieren. De methode is gebaseerd op een uitrusting van staande netten en fuiken. We vervaardigden twee netten die aangepast zijn aan de grootte, stroomsnelheid en andere parameters van kleine rivieren. De voorlopige resultaten omtrent de soortenrijkdom en biomassa van aquatische prooidieren (vis, rivierkreeft, kikkers en relatief grote waterkevers) van otters in kleine rivieren in het noordoosten van Belarus, verkregen met de beschreven inventarisatietechniek in de zomer, worden gepresenteerd. In de zomer (juni-augustus) varieërde de totale biomassa van aquatische prooidieren, gevangen in 100 m lange monstertrajecten in de Lovat rivier (noordoost Belarus), van 0,1 kg tot 4,0 kg en was gemiddeld 1,7 kg. Vissen vormde het grootste deel (67-89%) van de biomassa van de aquatische prooidieren. In totaal zijn 20 vissoorten gevangen. In de afzonderlijke monstertrajecten bedroeg dit aantal slechts 4 tot 11 vissoorten. De soortenrijkdom van vissen nam geleidelijk toe met de riviergrootte en een afname in stroomsnelheid. Dezelfde trend is gevonden in de biomassa van vissen. Rivierkreeften kenden de hoogste dichtheden in de delen van de Lovat rivier met een gematigde stroomsnelheid. Op plaatsen met een lage stroomsnelheid waren rivierkreeften iets minder overvloedig aanwezig. In snelstromende delen van de rivier is de laagste biomassa aan rivierkreeften vastgesteld. Met een toename in grootte van de rivier, en een afname in stroomsnelheid nam de biomassa aan waterkevers en kikkers toe, zoals ook het geval was bij vissen.

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