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The impact of the White-tailed Eagle *Haliaeetus albicilla* and the Osprey *Pandion haliaetus* on Estonian Common Carp *Cyprinus carpio* production: How large is the economic loss?

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Abstract. Protected bird species have been suspected to be a cause of a significant economic loss at Estonian fish farms, but its extent has remained unexplored. We counted the number of White-tailed Eagles and Ospreys, and the quantity of fish they take, and analysed the economic loss in five carp farms in 2001–2004. Each of Estonian four larger carp farms was used by a pair of breeding White-tailed Eagles, and by up to three immature birds, whereas Ospreys were recorded at all five studied farms. The average daily number of foraging White-tailed Eagles per farm was 1.3–3.3; the number of birds was constant during the breeding period but differed between years. The average number of Ospreys (0.5–2.8) fluctuated both within and between years. White-tailed Eagles foraged upon 300–1050 g third-year fish, and caught on average 0.4 fish per day per eagle. Ospreys took third-year fish at the beginning of the breeding season but second-year fish later; they always selected fish weighing 200–400 g, and caught 0.3–3.7 fish per day. The total amount of fish taken by the two species differed significantly between years and regions. The extent of loss caused to a fish farm depended on the methodology used for estimation. Calculations based on potential final weight of fish were on average 44% higher than those based on current weight, and constituted up to 4% of the total price of fish sold, and 2% of the total weight of fish reared by the company.

Key words: freshwater aquaculture, fish pond, foraging ecology, piscivore, birds of prey, economic loss, damage estimation.

INTRODUCTION

Fish farming is a widespread activity that shows growing tendencies, and its importance seems to increase even more in the future along with human population

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increase and decline of wild fish stocks (Meske, 1985; Egna & Boyd, 1997). In Estonia, some 220 enterprises are involved currently in fish breeding, whereas commercial farms comprise about 10% of them (Tohvert & Paaver, 1999; Paaver, 2000). Freshwater fish aquacultures may be subdivided into warmwater and coldwater types (Avault, 1996). The most popular fish species stocked in Estonian warmwater aquacultures is the Common Carp *Cyprinus carpio* whereas the Rainbow Trout *Oncorhynchus mykiss* is usually reared in coldwater types (Enneveer, 1985; Tohvert & Paaver, 1999). Overwhelmingly, the carp species are giving the highest production in aquacultures worldwide (Naylor et al., 2000), and also in Estonia the Common Carp was cultured up to 1990 in the same amount as was the Rainbow Trout (up to 900 t); however, the production of the latter is now some five times higher than that of the Common Carp, and currently the total number of large carp farms in Estonia is less than ten (Tohvert & Paaver, 1999; Paaver, 2000; Statistical Office of Estonia, 2005).

Aquacultures, where the population density of fish is much higher than in natural waters, are a suitable foraging biotope for many fish-eating birds (e.g. the Grey Heron *Ardea cinerea*, gulls *Larus* spp., storks *Ciconia* spp.) and mammals (the Mink *Mustela vison*, the Otter *Lutra lutra*), predators that may decrease the profit of fish farms (McLarney, 1984; Avault, 1996; Hallikainen, 2001). During winter, fish are kept in deep and narrow overwintering ponds covered by ice. At this time, the impact of piscivorous birds is almost absent, and the loss caused by mustelids may be significantly decreased using special protection fences (Hallikainen, 2001). In spring, carps are relocated to large and shallow grow-out ponds where they spend their growth period. Here they are easy prey to piscivores, and therefore the economic loss during summer is relatively high. Unfortunately, all methods purposing to keep predators away are difficult to implement on large water areas (McLarney, 1984). The elimination of pests has been suggested as a possible solution, but usually this method is not effective (Feare, 1991; Bechard & Márquez, 2001; Hallikainen, 2001; Yodzis, 2001); moreover, it cannot be used against protected animals.

In the current paper, we analyse the impact of two protected bird species – the White-tailed Eagle *Haliaeetus albicilla* and the Osprey *Pandion haliaetus* – at Estonian carp-rearing aquacultures. These birds of prey are under strict conservation both in Estonia (Category I protected species) and elsewhere (e.g. Appendix I species in the EU Birds Directive). The diet of the White-tailed Eagle contains mainly fish and waterfowl, with the proportion of fish ranging from one third to four fifths depending on the region, year, and method of analysis (Cramp & Simmons, 1980; Helander, 1983; Randla & Tammur, 1996; Sulkava et al., 1997). The Osprey forages almost exclusively on fish, but the species composition of the prey varies both spatially and temporally (Cramp & Simmons, 1980; Saurola & Koivu, 1987; Edwards, 1998). Both raptors hunt also at fish ponds (Saurola & Koivu, 1987; Jetmar, 2000; Helander & Stjernberg, 2002) and may affect the fish production. In several countries, compensation is paid for the loss caused by pest animals, and large amounts of financial resources have been used for this purpose (Hallikainen, 2001). Obviously, the presence of piscivorous birds does not mean that stock is being significantly depleted (McLarney, 1984), and the real loss caused by predators has to be estimated. Unfortunately, studies grounding the compensation are scarce, and published papers describing methods of estimation are almost absent. Unlike the agricultural damage caused by migrating geese and cranes, as well as the shred of fishing gear by seals, no method has been proposed to estimate the compensation for economic loss caused by protected piscivorous bird species in Estonia. In the current paper, we estimate the impact of the White-tailed Eagle and the Osprey on carp production at Estonian aquacultures, and give some suggestions for further estimation of the loss, as well as for compensation mechanisms.

MATERIAL AND METHODS

Study areas

All Estonian freshwater fish farms involved in large-scale carp production are established in the eastern part of the country (Tohvert & Paaver, 1999). The current study was performed mainly at four larger farms: Vagula (57°50′ N; 26°51′ E) and Ilmatsalu (58°23′ N; 26°32′ E), where the total area of fish ponds amounts to 163.5 and 125 ha, respectively, and Haaslava (58°20′ N; 26°48′ E) and Härjanurme (58°40′ N; 26°22′ E), which are significantly smaller covering 56.5 and 41 ha, respectively. Additionally, a smaller farm at Käruveski (58°57′ N; 26°28′ E), where the water area does not exceed a few hectares, was included into the study for one year. In all the fish farms studied, the Common Carp is the main fish produced, and other species form only a minor proportion of the cultured fish; the only exception is the small Käruveski farm, where the Rainbow Trout is the main species reared. All the aquacultures studied are connected to natural water bodies, which may serve as an additional foraging ground to piscivores: Ilmatsalu and Haaslava adjoin the Suur-Emajõgi River; Käruveski is situated at the headwaters and Härjanurme at the middle part of the Pedja River; and Vagula is located between Lake Vagula and the Pühajõgi River. At all farms the foraging White-tailed Eagles and Ospreys as well as the number of fish taken were counted. At Ilmatsalu J.T. gathered additional information about foraging efficiency, prey size, age-related behaviour, and cleptoparasitism.

Fieldwork

The length of the fish rearing period (excl. overwintering time) differs between years and depends on the time of ice melting, water level, weather, and organizational matters. Usually, the relocation of fish to grow-out ponds is finished before 1 May, and the final autumnal harvest at the second half of October (Enneveer, 1985). For the current work, the length of the fish rearing time was taken as 180 days (average length in the study years), and it was divided into four sections according to the breeding biology and phenology of the studied birds. The first period began on 22 April and ended on 15 June (altogether 55 days), the second was between 16 June and 15 July (31 days), and the third from 16 July to 15 August (31 days). The fourth period was from 16 August to 18 October (63 days) for White-tailed Eagles, but only between 16 August and 18 September (33 days) for Ospreys, whose migration is accomplished earlier.

To obtain a fair overview of all periods, an equal number of observation days was defined to each period. The observations of the first period were carried out in May when White-tailed Eagle nestlings are about one month old, whereas Ospreys are incubating eggs, or their young are just hatching. Observations of the second period were performed in late June or in early July, when young White-tailed Eagles are about fledging and nestlings of the Osprey are about one month old. Observations of the third period were in late July or early August, when White-tailed Eagle fledglings are still in the vicinity of the nest but Osprey nestlings are just going to fledge. Observations of the fourth period were mostly in the first half of September, when both Ospreys and White-tailed Eagles are migrating (Häkkinen, 1978; Cramp & Simmons, 1980; Pettay et al., 2004; unpublished data of the Eagle Club for the study area).

The fieldwork was performed in 2001–2004. In the first two years we investigated only Haaslava and Ilmatsalu farms. In 2003, also Härjanurme and Vagula were included. In 2004, we observed again at four fish farms, but instead of Härjanurme we studied Käruveski ponds. In 2001, a total of 16 days were spent at Ilmatsalu and 4 days at Haaslava, followed by the opposite ratio in 2002. In the last two years, four observation days per season were spent in all farms except at Ilmatsalu in 2003, when additional financing by the farm owners enabled to perform altogether 20 observation days. During four years, the total number of observation time extended up to 1405 hours.

Two persons (partly as relays) recorded the presence and activity of piscivorous raptors at fish ponds from sunrise till sunset, i.e. during the whole potential foraging period of birds. Buildings and other elevations providing a good overview of the ponds were selected as observation points, and binoculars and fieldscopes were always used to specify details of objects. In addition to the number of birds and their foraging success, we recorded the particular pond from which the fish was caught (size of the fish inhabiting each pond was known), the time when birds arrived and left, flying direction to distinguish eagles between breeding territories, and other aspects of birds' behaviour.

Estimation of economic loss

To estimate the economic loss we used various approaches. The direct method is based on counting the fish taken by birds, whereas the indirect method is based on the average requirement of food per eagle family. In the estimation by current weight the weight of fish at the moment it is taken from the pond is used, whereas the estimation of missed profit is based on average weight of fish at the final harvest (potential weight). In the current study we used the direct method and calculated the economic loss using both the current and potential weight.

Carps bred at the aquaculture are subdivided into three age groups. For the current study, only two larger groups were of importance: (i) second-year fish, which are used again for culturing in the next year, and (ii) third-year fish (or fourth-year inferior individuals) sold in the same year. The average weights of these two groups in each period were used in the calculations based on current weight. The average final weight of the groups (275 g and 1050 g) was used in the calculations of potential final weight (Fig. 1).

To calculate the total loss during a culture period we multiplied (i) the average number of fish taken per day during the period with (ii) the length of the period, (iii) the average current weight or the average final weight of the fish, and (iv) price of the fish per live weight kilogram (35 Estonian kroons (EEK; equals EUR 2.2) for second-year and EEK 30 (EUR 1.9) for third-year carp at the time of the study). Since the Osprey switched from one fish age-group to another in the middle of the breeding season (see Results), we subdivided the culture period for this species' calculations into two sections and considered herewith also the prey proportion in the respective period (first section was formed as a summary of the first period and one third of the second period; Fig. 2). The number of fish caught in the first culture period section was the average number of fish per day in the first and second observation periods, and that in the second section, the average of the third and fourth observation periods.

Profits-and-loss data of the Ilmatsalu farm (OÜ Ilmatsalu Kala) were obtained from the Estonian Central Commercial Register.

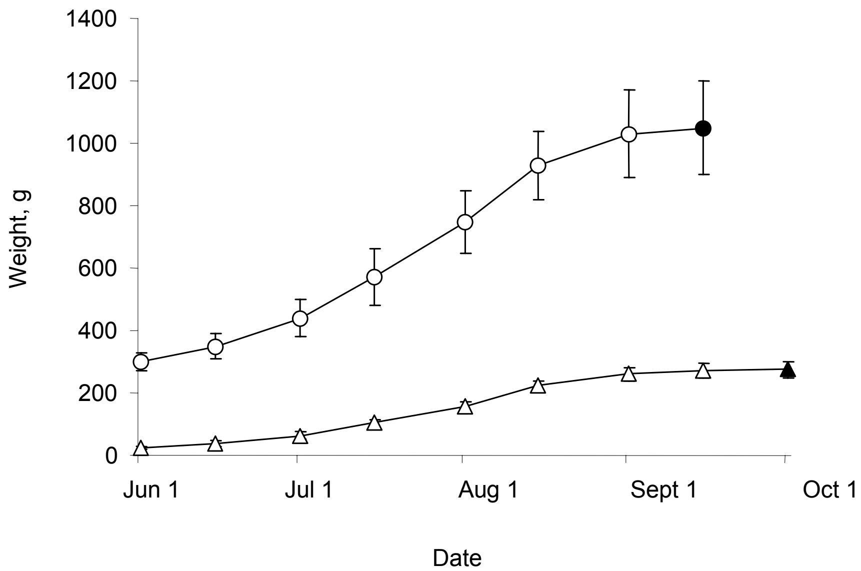

Fig. 1. Growth curves of the Common Carp in the second (Δ) and third year (o), based on long-term data from Ilmatsalu. Whiskers indicate the annual minimum and maximum values. The final potential weights used in the current study are presented by filled symbols (after Puhk & Tohvert, 1978).

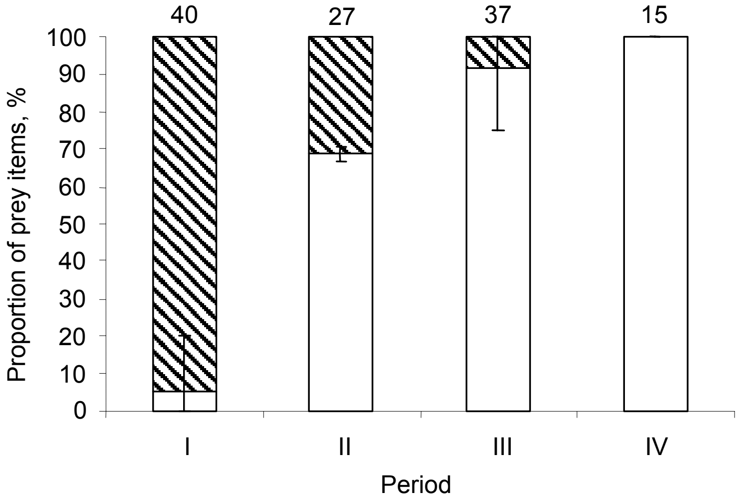

Fig. 2. Average proportions of the second- (white bars) and third-year carps (bars filled with diagonals) taken by Ospreys at Ilmatsalu during four observation periods in 2001–2004. The recorded annual minimum and maximum proportions for each period are shown within the bars by whiskers. The figures above the bars show sample sizes.

RESULTS

The White-tailed Eagle

Each of the larger studied fish farms (Haaslava, Härjanurme, Ilmatsalu, and Vagula) was hosting a pair of White-tailed Eagles breeding nearby, and the eagles used regularly fish ponds as a foraging ground. Seldom one or two additional adult birds were recorded at Ilmatsalu. Additionally, Haaslava, Härjanurme, and Vagula were used regularly by one, and Ilmatsalu, depending on the year, up to three immature eagles per day. In total, the highest number of White-tailed Eagles was recorded at Ilmatsalu (average number of birds per day 3.3 ± 1.0 SD). Other farms hosted a smaller number of eagles – Haaslava 1.9±0.4, Vagula 1.6±0.4, and Härjanurme 1.3 eagles per day. We did not find any difference in the number of eagles between observation periods within a year (ANOVA: $F_{3,84} = 0.51$; $p = 0.68$). Instead, there was a significant between-years difference: 4.0 eagles per day were recoded at Ilmatsalu in 2001, but only 2.4 in 2003 ($t = 4.59$; $df = 34$; $p < 0.001$).

Obviously, foraging White-tailed Eagles preferred third-year fish, 97.8% of fish caught in 2001–2003 at Ilmatsalu belonged to this group ($n = 45$). We did not find any difference in prey preference between adult and immature birds. There was a significant positive correlation between the number of eagles recorded in the farm and the number of fish taken (Fig. 3a). White-tailed Eagles caught at Haaslava and Ilmatsalu on average 0.4±0.2 and at Vagula 0.4±0.1 fish per eagle per day; at Härjanurme we did not record a successful hunting of eagles. Also, no

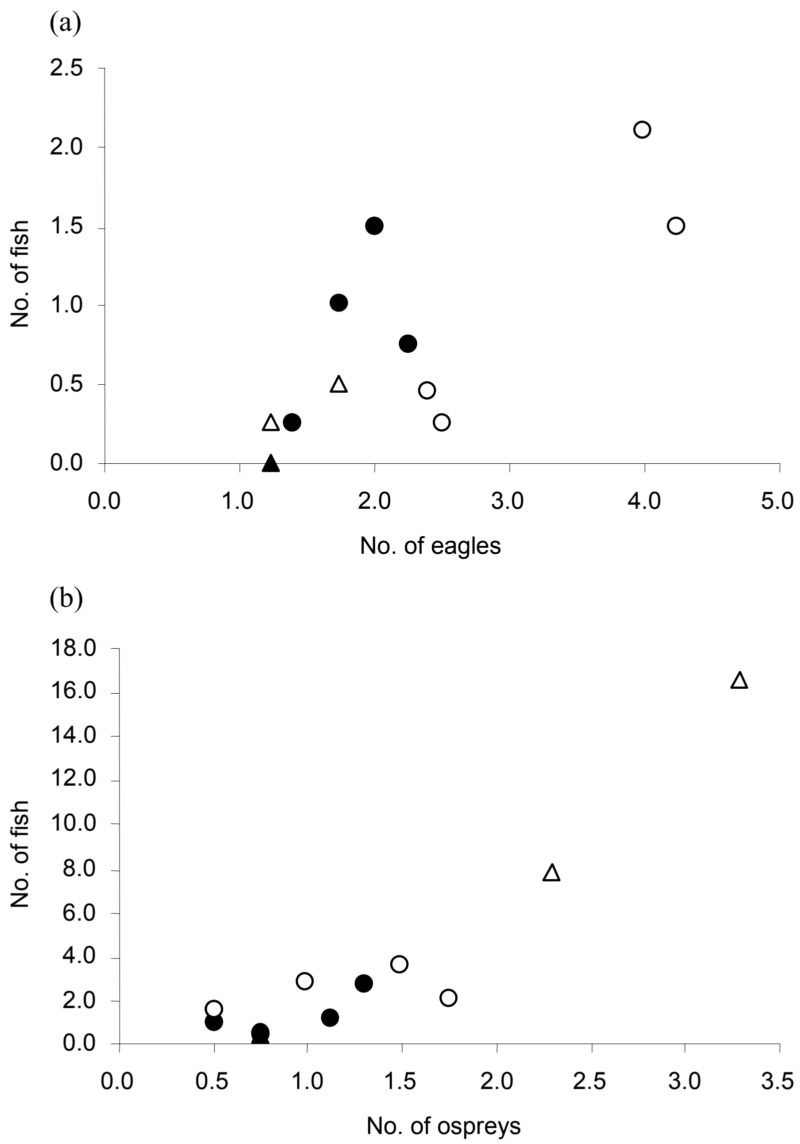

Fig. 3. Average daily numbers of fish taken by birds in relation to the numbers of White-tailed Eagles (a; $r = 0.76$; $p < 0.01$; $n = 11$) and Ospreys (b; $r = 0.91$; $p < 0.001$; $n = 12$) foraging at carp cultures in 2001–2004. Every point indicates the data collected in a year at a fish farm; filled circles show data from Haaslava, empty circles from Ilmatsalu, the filled triangle from Härjanurme, and empty triangles from Vagula.

between-period difference in the number of fish caught per eagle per day was detected (ANOVA: $F_{3,71} = 1.09$; $p = 0.36$), but such a difference exists between years: 2.1 fish per day per eagle was caught at Ilmatsalu in 2001, but only 0.4 in 2003 ($t = 3.97$; $df = 34$; $p < 0.001$). Unfortunately, our data are too limited to find a clear relation between productivity and fishing frequency of eagles. The difference between years is caused by the fluctuating number of immature birds: the proportion of fish taken at Ilmatsalu by immatures was 57.1% ($n = 35$) in 2001 and 55.6% ($n = 9$) in 2003, whereas in 2002, when the local pair bred successfully, two immatures present succeeded in catching only one out of six taken fish recorded (16.7%). The total foraging efficiency of eagles (proportion of successful attacks from all attacks) was 40.3% (60.0% in the first, 24.1% in the second, 29.2% in the third, and 47.8% in the fourth observation period; $n = 116$). Some fish consumed by White-tailed Eagles were initially caught by Ospreys and overtaken by cleptoparasitism: the proportion was 6% in 2001 ($n = 35$) and 44% in 2003 ($n = 9$). For the Osprey, it meant a loss of 8.3% (in 2001; $n = 24$) and 6.5% of fish (in 2003; $n = 77$).

The Osprey

We recorded Ospreys at every studied fish farm. The highest number of individuals was recorded at Vagula, where the average number of birds per day was 2.8 ± 0.7 (SD). At Ilmatsalu, there were 1.2 ± 0.6, at Haaslava 0.9 ± 0.4, at Härjanurme 0.8, and at Käruveski 0.5 visiting Ospreys per day. At Vagula fish ponds we recorded up to four simultaneously hunting birds, at Ilmatsalu and Haaslava up to three, and at Härjanurme and Käruveski only one Osprey at a time.

The number of Ospreys differed notably during a rearing period and between years. For example, we recorded up to two Ospreys per day at Ilmatsalu during the first observation period in 2001, but during the other periods birds were rarely seen. However, in 2002–2004 the ponds were used evenly throughout the rearing period. Ospreys foraging at Haaslava came from three and at Vagula from four different directions, but at Haaslava we did not record Ospreys in 2001, 2002, and 2004 from the beginning of June till mid-July, after which the number of records increased significantly. At Käruveski farm we first saw an Osprey in the middle of the second observation period, at the time when small carps were settled. Hence, the daily numbers of feeding Ospreys differed significantly between observation periods (ANOVA: $F_{3,84} = 3.58$; $p = 0.017$) – there was a significant increase in the fourth period compared to the third. Similarly, we found significant between-years variation at the intensively studied Ilmatsalu aquaculture: on average 0.5 Ospreys per day were recorded there in 2001, and 1.75 in 2003 ($t = 5.48$; $df = 34$; $p < 0.001$).

We noted a clear preference of the Osprey towards a certain size of fish. The average weight of carp taken by Ospreys at Ilmatsalu was 290 g (200–400 g). When third-year fish exceeded the optimum size, Ospreys started to take second-year fish (Fig. 2).

The average number of fish per day taken by Osprey was 3.7 ± 1.5 at Vagula, 1.8 ± 0.8 at Ilmatsalu, 1.5 at Käruveski, 0.6 ± 0.3 at Haaslava, and 0.3 at Härjanurme. Similarly to the number of Ospreys, there was a significant difference between the number of fish taken in Ilmatsalu in 2001 and in 2003, on average 1.5 and 3.6 fish per day respectively ($t = 2.37$; $df = 34$; $p < 0.05$). However, there was no difference between observation periods in the number of fish taken per bird (ANOVA: $F_{3,57} = 0.84$; $p = 0.48$). A significant and strong positive correlation between the number of birds recorded at the farm and the number of fish taken existed also in Ospreys (Fig. 3b).

The average time Ospreys spent to catch a fish was 18 min when all foraging events were considered, but 10 min when only successful hunts were taken into account (i.e. length of the successful hunting event; $n = 119$). Hunting time was the longest in the fourth period, on average 26 min ($n = 16$). The proportion of successful attacks from all attacks recorded was 53.2% ($n = 226$): 45.6% in the first, 57.1% in the second, 58.3% in the third, and 51.9% in the fourth period.

Economic loss caused by the White-tailed Eagle and the Osprey

We found strong and significant positive correlations between the number of birds and the fish taken by them. The number of fish caught by White-tailed Eagles equals 0.5 × number of eagles – 0.34 ($R^2 = 0.58$), whereas the number of fish taken by Ospreys is 4.9 × number of Ospreys – 2.8 ($R^2 = 0.83$) (Fig. 3).

At Vagula, the fish hunted by Ospreys comprised 93% of the total number of fish taken by the two raptor species, whereas the same proportion was 50% at Ilmatsalu and 30% at Haaslava. At Käruveski and Härjanurme we recorded only hunting by Ospreys (although the White-tailed Eagle was previously known to forage on Härjanurme fish ponds as well). The total quantity of fish taken by raptors differed between years and locations, and the estimated loss depended on the method used in calculation (Table 1). The financial loss caused by the studied species was 44% larger when potential final weight of fish was used in the calculations compared to the estimate by current weight. The higher the proportion of third-year fish among the prey, the larger was the difference between the two estimation methods (Fig. 4, Table 1).

Table 1. Average (and min–max) quantity of fish taken by the White-tailed Eagle and the Osprey and its price in five Estonian carp farms according to the current and potential final weight of fish. One Estonian kroon (EEK) equals 15.6 euros

Fish farm (No. of observation years)	Current weight		Final weight	
	Weight, kg	Price, EEK	Weight, kg	Price, EEK
Haaslava (4)	162 (97–205)	5670 (3395–7175)	242 (122–330)	7548 (3911–10170)
Härjanurme (1)	16	560	68	2048
Ilmatsalu (4)	235 (161–359)	8225 (5635–12565)	456 (276–582)	13883 (8659–17517)
Käruveski (1)	49	1715	70	2454
Vagula (2)	435 (262–609)	15225 (9170–21315)	1103 (621–1584)	34709 (19914–49503)

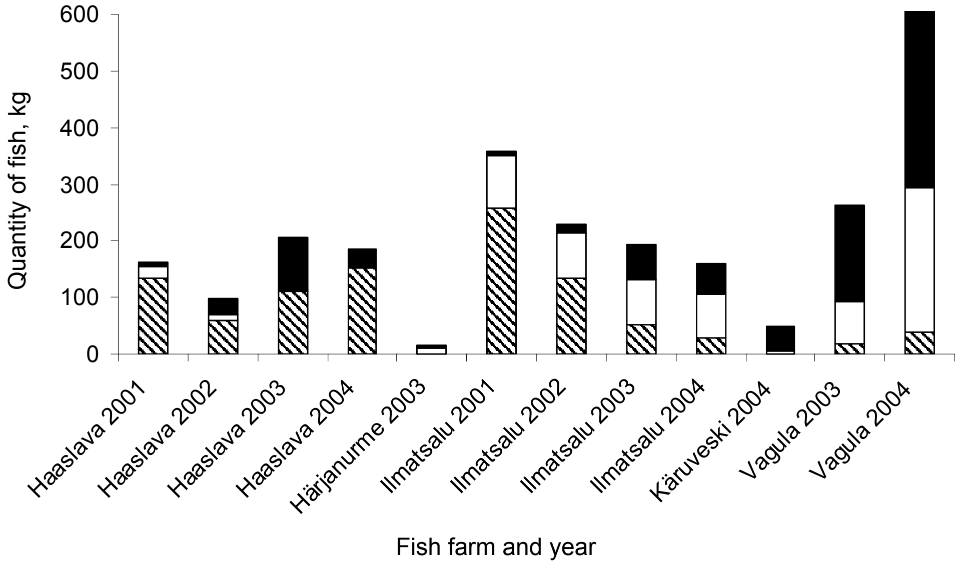

Fig. 4. Quantity of the second- and third-year carps taken by the White-tailed Eagle and the Osprey at five Estonian fish farms in 2001–2004. Black bars indicate the second-year, and white bars the third-year fish taken by the Osprey. The bars filled with diagonals show the third-year fish taken by the White-tailed Eagle.

DISCUSSION

In the current study, we counted the number of White-tailed Eagles and Ospreys foraging at Estonian largest carp fish farms, measured the quantity of fish taken by the two raptor species, and estimated the total loss caused to the farming companies.

The five studied fish farms were used by Ospreys originating from 7–8 and White-tailed Eagles from 4–5 breeding territories. We studied all larger Estonian carp cultures, and only smaller ones, where the number of foraging birds cannot be very high, remained unexplored. Therefore we can conclude that the total number of birds that regularly use freshwater aquacultures as foraging grounds does probably not exceed our count much. The Estonian Osprey population consists of 45–50 breeding pairs, and that of the White-tailed Eagle of 110–120 pairs (Elts et al., 2003). Hence, some 14–18% of the Osprey and 4–5% of the White-tailed Eagle breeding population depend on carp farms. Therefore, the role of these aquacultures for the Estonian Osprey population can be stated as considerable, but the impact on the White-tailed Eagle population is negligible. However, one cannot ignore the potential conflict between piscivorous raptors and fish breeders even when a small proportion of individuals is involved, since according to the Estonian Nature Conservation Law, effective protection must be guaranteed to all individuals of Category I protected species, the owner of every farm has the right to obtain a fair income, and unresolved conflicts potentially harm all the conservation efforts. Preclusion of conflicts demands the knowledge about the quantity of the loss and consideration of the compensation alternatives.

We found that the number of eagles differs significantly both between years and between regions. Although we did not register any change between observation periods in the White-tailed Eagle, such differences existed in the Osprey. However, an expected increase of hunting activity in the second observation period, when the growth of nestlings is fastest and the energy requirement highest (Nilsson & Nilsson, 1976; Häkkinen, 1978), was found only at Vagula in 2004. Otherwise, the number of Osprey observations decreased at the end of the first period and rose again at the beginning of the third period. We suspect that for the Ospreys fish ponds need not have been the only foraging area but they fed small nestlings with prey caught elsewhere. One reason may be the long distance between nests and fish ponds (in Estonia the average distance between an Osprey nest and its hunting area is 5.1 km, and maximum 21.5 km; Lõhmus, 2001) and at the end of the first period also the male is involved in the incubation of eggs at the nest (Cramp & Simmons, 1980). This assumption is verified by the finding of an Osprey nest only close to Vagula fish ponds, while elsewhere Ospreys arrive from farther locations. Despite the long flying distance, aquacultures harbouring a rich food supply must still be an attractor for Ospreys, because the successful fishing here takes six times less time than on natural waters (Lõhmus, 2001). This earlier estimation, based on a small sample size, was now verified by the study at Ilmatsalu. The capture of prey took more time in the migration period, probably because of the arrival of new birds unaware about the local conditions. Secondly, the breeding success of White-tailed Eagles breeding near commercial fish ponds is higher than the average. During the study years, the number of fledged young per pair breeding near fish farms was 1.25 ($n = 25$), but only 0.94 for the rest of the East Estonian population ($n = 70$; unpublished data of Eagle Club).

The total quantity of fish taken by birds of prey seems high at first glance (Table 1), but, in fact, it does not constitute a significant proportion of the total weight of fish cultured. Although the growth conditions for fish and the quantity of fish taken by raptors differ between years, the data from Ilmatsalu show that the total loss does not exceed here 3–4% of the total profit obtained by selling fish and 2% of total weight of fish raised, even when the higher estimation based on potential final weight is used in calculations (Table 2). However, when the fish production is inhibited by other factors, the loss caused by birds may be relatively high. For example, the extraordinarily dry summer in 2002 led to a decrease of the net profit to a level that was comparable to the loss caused by raptors. In August, the water level declined by 50%, feeding of fish had to be stopped, and one third of the planned yield was not received (M. Puhk, pers. comm.).

Our estimations of loss do not include the raptor-caused injuries, which may lead to a decline of growth, damaged exterior, sore complications and diseases, or death of fish. However, it is well known that predators, including piscivorous raptors, select injured prey, and sometimes take even dead fish (Moll, 1962; Dunstan, 1974; Cramp & Simmons, 1980). Therefore, one can suppose that

Table 2. Quantity and price of the fish taken by the White-tailed Eagle and the Osprey at Ilmatsalu, and its proportion in the net profit, income obtained at marketing, and total yield of fish raised in 2001–2003. Calculations are based on potential final weight of fish. One Estonian kroon (EEK) equals 15.6 euros

Year	Fish taken by birds		Proportion (%) of		
	Weight, kg	Price, EEK	Net profit	Sale profit	Total yield
2001	582	17 517	19.5	3.3	1.6
2002	535	16 080	80.1	3.8	1.4
2003	430	13 274	13.7	2.1	1.2

damaged fish is among the first ones selected by predators. Nevertheless, we must admit that, because of damaged fish, the real loss may be somewhat higher than our estimation.

On the other hand, the Common Carp cultured at fish ponds is not the only prey for eagles breeding nearby. In 2002, prey remains were collected from White-tailed Eagle nests located in the vicinity of fish ponds at Ilmatsalu and Härjanurme. The identified prey items included three Mallards *Anas platyrhynchos*, two Ravens *Corvus corax*, one goose *Anser* sp., three Pikes *Esox lucius*, two cyprinids, and one unidentified fish (authors' unpublished data). Although such prey analyses often underestimate the proportion of fish (Sulkava et al., 1997), the data show the diversity of the eagle's diet. Moreover, direct observations performed at the White-tailed Eagle nest near Härjanurme on 17 June 2002 reported a pike, a cyprinid, and a nestling of unidentified bird species as prey items brought to the nest during the day (data by U. Sellis). In Lithuania, White-tailed Eagles breeding near fish ponds may even avoid fish cultures and prefer to hunt on natural water bodies (Mečionis & Jusys, 1994).

There are several possibilities of estimating economic loss caused by piscivorous pests. One way is to use the estimation based on the amount of food needed by a predator. In Finland, the daily requirement of an Osprey family was estimated as 1.5 kg in compensation calculation (Hallikainen, 2001). Similar methodology was used for Finnish White-tailed Eagles (Hallikainen, 2001) and Polish Ospreys (Mizera, 1995). Despite some roughness, the advantage of this method is the low cost of estimation. A more accurate, but also a more expensive alternative is the estimation by direct observations performed by impartial experts. This option has now been used in Estonia for several years, and results are presented in the current article. In principle, after obtaining the necessary information about the general pattern of raptor-caused loss, it is now possible to continue with using extrapolation of the discovered relationship between the number of raptors and the fish taken by them, presented here. Then, the number of breeding pairs of White-tailed Eagles and Ospreys and their breeding success in a particular year might be the only information needed, and the probable loss may be estimated for every farm. Unfortunately, this estimation may be biased when a precise loss at a particular farm is of interest. For example, both in Haaslava and Ilmatsalu, the slope of the relationship estimated using only four-year data from the particular farm (Fig. 3) is higher for the White-tailed Eagle ($y = 0.8 \times x - 0.6$ at Haaslava, and $y = 0.8 \times x - 1.6$ at Ilmatsalu), but lower for the Osprey ($y = 2.0 \times x - 0.5$ at Haaslava, and $y = 0.8 \times x + 1.6$ at Ilmatsalu) than the average slope calculated using pooled data from all farms (see Results). Another alternative for Estonia is to apply the method used in Finland, which calculates the loss using the required amount of food: 500–600 g for the White-tailed Eagle and 250–350 g for the Osprey per day per individual (Moll, 1962; Cramp & Simmons, 1980).

Compensation of economic loss includes several hidden threats. Disbursal of compensations has been now stopped in Germany and in Poland since it appeared to be ineffective and gave rise to fictive loss reports (B. Struwe-Juhl & T. Mizera, pers. comm.). In Estonia, the owner of the fish pond has to undertake measures to prevent loss, and, according to the Nature Conservation Law, people having not performed these measures do not have the right to apply for compensation. Unlike small-sized trout cultures, large carp ponds are complicated to protect by covering, but suggested options include, for example, attraction of raptors to forage upon low-value fish raised at a special pond (Hallikainen, 2001). Obviously, the establishment and maintaining of such extra ponds requires additional resources, and before suggesting the method to the wide audience, its effectiveness must be tested. To some extent, simply presence of people near fish ponds keeps eagles away: at Haaslava, where people were often moving between ponds, we recorded White-tailed Eagles hunting mainly in early morning, whereas the large Ilmatsalu pond system with low human activity was used by eagles during the whole day. One should still keep in mind that birds may get used to human attendance (e.g. Ospreys at Haaslava, Käruveski, and Vagula; see also Bechard & Márquez, 2001). On the other hand, this opportunity may be used in self-compensation of the economic loss by other potential sources of income, such as hosting of birders, for instance.

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Meri- ja kalakotkas Eesti karpkalakasvandustes: kui suur on majanduslik kahju?

Joosep Tuvi ja Ülo Väli

Kaitsealused linnuliigid võivad Eesti karpkalakasvandustes tekitada olulist majanduslikku kahju, kuid selle suurust pole seni analüüsitud. Artiklis on vaadeldud merikotka *Haliaeetus albicilla* ning kalakotka *Pandion haliaetus* poolt püütavate kalade hulka ja hinnatud majandusliku kahju suurust viies Eesti karpkalakasvanduses aastail 2001–2004. Igas neljast Eesti suuremast kalakasvandusest käis toitumas üks paar läheduses pesitsevaid merikotkaid ja kuni kolm mittesuguküpset lindu. Keskmiselt kohati kasvandustes toitumas 1,3–3,3 merikotkast päevas, lindude arv oli pesitsusperioodi vältel stabiilne, kuid erines aastati. Kalakotkaid käis tiikidel keskmiselt 0,5–2,8 isendit päevas, nende arv vaheldus nii pesitsusperioodi vältel kui ka aastati. Merikotkad eelistasid kolmanda (või neljanda) aasta kaubakalu raskusega 300–1050 g ja püüdsid keskmiselt 0,4 kala päevas kotka kohta. Kalakotkad püüdsid pesitsusperioodi algul kolmanda, hiljem teise aasta kalu, kuid kokkuvõttes eelistasid alati 200–400 g raskusi karpe; päevas püüti keskmiselt 0,3–3,7 kala. Kotkaste poolt kalakasvandustes püütavad summaarsed kalakogused erinesid aastati ja piirkonniti oluliselt. Kalakasvandusele põhjustatava majandusliku kahju suuruse hinnang sõltus hindamise metoodikast: potentsiaalse lõppkaalu järgi arvutades oli kotkaste poolt kalamajanditele tekitatud rahaline kahju keskmiselt 44% võrra suurem kui hetkekaalul põhinev hinnang. Ilmatsalu kalakasvanduse andmetel ei ületa potentsiaalse lõppkaalu alusel hinnatud kahju tavaliselt 2% kasvatatud kalade kogukaalust ja 4% kalade müügitulust. Puhaskasumist võib kotkaste põhjustatud kahju suurus moodustada 14–20%, kuid eriti ebasoodsate ilmastikutingimuste poolt põhjustatud väikese kalatoodangu korral isegi kuni 80%.