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Authors: Kallioniemi, Heidi, Väänänen, Veli-Matti, Nummi, Petri, and Virtanen, Juha

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Bird quality, origin and predation level affect survival and reproduction of translocated common pheasants *Phasianus colchicus*

Heidi Kallioniemi, Veli-Matti Väänänen, Petri Nummi and Juha Virtanen

H. Kallioniemi (orcid.org/0000-0003-2701-5424) (heidi.kallioniemi@helsinki.fi), V.-M. Väänänen and P. Nummi, Dept of Forest sciences, PO Box 27, FI-00014 University of Helsinki, Finland. – J. Virtanen, Länsirannikon Koulutus Oy WinNova, PO Box 17, FI-28101 Pori, Finland

We investigated the survival and breeding success of common pheasants *Phasianus colchicus* of two origins and in two predator densities. We translocated hand-reared and wild pheasant hens to southern Finland (60°N, 24°E) and hand-reared ones to central Finland (63°N, 27°E). Both groups of birds were treated similarly before release and translocated to areas with no local pheasant populations. Both areas appeared similar, the only major difference being the amount of predators. The red fox *Vulpes vulpes* was the major predator of pheasants present in the southern study, where it was abundant, whereas it was almost non-existant in central Finland. In accordance with earlier studies, the wild birds survived much better than the hand-reared ones in the area with a high red fox density. The hand-reared birds located in the low red fox density area survived better than the hens in the area of high red fox density. However, no significant difference was observed in the survival of the hand-reared birds in the low fox density area and wild birds in the high fox density area. Interestingly, after the first two weeks, the survival of pheasants in different groups was equal. We additionally found no significant differences between the bird-groups in terms of hatching success when comparing hens that managed to initiate nesting. No difference was also observed between the hand-reared birds in the low fox density area and the wild in the high fox density area in brood survival to the age of six weeks. We conclude that even hand-reared pheasants can succeed in brood production in an area with low fox densities. We furthermore suggest that pheasants that survive the two first weeks after translocation have good chances of producing a brood whether they are wild or hand-reared.

The common pheasant *Phasianus colchicus* (hereafter pheasant) is the most abundant and economically important quarry species in Europe (Draycott et al. 2008): over 20 million pheasants are annually shot in Europe (Anonymous 2013). Tapper (1999) estimates that to supplement wild stocks for shooting, approximately 20 million pheasants are hand-reared and released each summer in Britain alone. The majority of hand-reared pheasants are released during summer and autumn for commercial hunting. The main aim is to enable the shooting of a large number of birds during a few-hour hunting event. Adult pheasants are also released in late spring, in hope of establishing or supporting a permanent population.

Results of pheasant introductions have not always been encouraging. Earlier studies have shown that the survival of hand-reared birds is usually poor (Hessler et al. 1970, Hill and Robertson 1988a, b, Brittas et al. 1992, Musil and Connelly 2009). Pheasant introductions often fail, as do grey partridge *Perdix perdix* introductions mainly due to predation and the quality of the birds, which may vary considerably (Krauss et al. 1987, Putaala et al. 1997, Putaala and Hissa 1998). Predator density is one of the most important factors affecting the survival of introduced pheasants (Krauss et al. 1987, Brittas et al. 1992). However, predator density and community structure vary considerably geographically. For example, red fox *Vulpes vulpes* and badger *Meles meles* densities in Great Britain or central Europe are many-fold compared to those found in Fennoscandia, e.g. in Finland (Kauhala et al. 2006). Other predators are additionally found, e.g. the raccoon dog *Nyctereutes procyonoides* has dramatically increased in Finland during the past 30 years (Kauhala et al. 2006). This means that results from Great Britain or North America are not necessarily applicable for management purposes in Fennoscandia.

Finland lies in the northernmost part of the pheasants' range. Even at these high latitudes re-stocking using hand-reared birds is a common way to improve a shoot. As forest grouse and grey partridge populations are currently declining, especially in southernmost Finland (Väisänen et al. 2011), pheasant hunting provides the possibility of continuing sport hunting, particularly with pointing dogs (Väänänen and Nummi 2000). However, the quality of pheasants is essential because pheasant hunting with pointing dogs is most challenging when birds are wild.

Hand-reared pheasants are usually released in late summer or autumn. Shoots stocked by reared birds therefore often appear artificial. Re-stocking with hens in late spring aims to create a huntable population of the released hens' offspring. Chicks born in the wild could also be important in supporting wild populations since they more closely resemble wild birds. Their behaviour also enables a more challenging hunt than the use of hand-reared stocks.

Here we compare survival, mortality factors and reproduction of translocated hand-reared and wild pheasants in two study areas. We first investigate the survival of translocated wild and hand-reared pheasants in an area in southern Finland where predator densities are high. Next we compare hand-reared birds in this area with those in an area in central Finland where predator density is low. Based on earlier studies we hypothesise that the survival of wild transferred pheasants is higher than that of hand-reared birds. However, we presume that in our study the difference is smaller than in studies where wild birds originated from the study area. We additionally presume that a high predator density (especially of red fox) negatively affects pheasant survival.

Material and methods

Study areas

The study was conducted in Finland during 1995–2000 in two locations: Suitia in southern Finland (60°N, 24°E) and Maaninka in central Finland (63°N, 27°E). We translocated hand-reared and wild pheasants to southern Finland and hand-reared pheasants to central Finland. Both areas consist of agricultural areas intervened with small forest patches, wetlands and wastelands, and were thus suitable breeding habitats for pheasants. Overall, the study areas in Suitia and Maaninka were rather similar. The distance between the two studies is approximately 300 km in the north–south direction.

The Suitia area consisted of cultivated fields. The average size of a field segment was 5.6 ha. The segments were separated by open ditches. Many of the segments were divided into smaller plots of particular crops: wheat, barley, oat, rye, rape, peas and linseed. Several pastures and grasslands were also located in the area. Wild pheasants have previously occurred in the area, but during our study only a few other individuals apart from the released birds were seen. Red fox was the most abundant mammalian predator in Suitia. Other mammalian predators included the raccoon dog, mink *Neovison vison*, pine marten *Martes martes*, stoat *Mustela erminea,* badger and the domestic cat *Felis catus*. Avian predators included corvids such as the hooded crow *Corvus corone cornix*, the eagle owl *Bubo bubo* and marsh harrier *Circus aeruginosus*, and goshawks *Accipiter gentilis* were also present from August onwards. There was practically no predator control in Suitia, and only a few raccoon dogs were killed annually.

In Maaninka, the crops included the same species as Suitia except for the pea. Maaninka also had small hemp fields that can offer good cover for pheasants after the brood phase. Similar to Suitia, there were many pastures and grasslands in Maaninka, and small forest patches (mostly under 0.5 ha) within the fields were typical. A shallow eutrophic wetland (200 ha) is located in the middle of the Maaninka study area, where densely vegetated margin areas offered good shelter for pheasants. Mammalian predators in Maaninka included the red fox, raccoon dog, mink, pine marten (very rare), stoat and domestic cat. Of avian predators the eagle owl and goshawk were present especially in autumn, and also corvids (raven *Corvus corax* very rare) and marsh harrier were common. Local hunters were very active in controlling mammalian predators, so the numbers of red fox and raccoon dog were low in Maaninka during the pheasant nesting season (Kauhala 1996).

The Suitia observations were gathered in 1995–2000 and the Maaninka observations in 1998–2000. The hand-reared hens in both Suitia and Maaninka mainly originated from the eggs of wild pheasants. Only the first seven hand-reared pheasant hens (in 1996) in Suitia originated from a commercial pheasant breeding company. All hand-reared birds in Maaninka were offspring of the transferred wild birds that we used in our study in Suitia. Hand-reared pheasants in Suitia and Maaninka were reared using the same methods. The rearing pens allowed the birds to make short flight attempts and roost aboveground. The pens had small spruce trees and hay for cover. The pens offered a height between 2.5–4 m and the surface area varied from 40 to 100 m^2. All wild pheasants were trapped in the Helsinki area (40 km from Suitia) during the period of February–March and kept in pens before being released in late May.

In Suitia we released a total of 77 (31 wild and 46 hand-reared) radio-marked pheasant hens: 10 wild birds in 1995; nine wild and seven hand-reared in 1996; seven wild and 10 hand-reared in 1997; five wild and 15 hand-reared in 1998, nine hand-reared in 1999 and five hand-reared in 2000. In 1999 one hen died because of an injury caused by the transmitter, so it is excluded from the observations. In Maaninka we only released hand-reared pheasants, a total of 37 hens. During 1998–2000 the numbers released were as follows: 1998: 11, 1999: 16, and 2000: 10. The length of the study period was determined at 13 weeks beginning the day of the bird releases.

Marking and releasing the birds

We chose only fit and healthy-looking pheasants for the study. All hens were marked with a leg ring and a necklace radio-transmitter. The radio-transmitters had a life expectancy of 6–12 months, weighed 16 g, had no mortality sensors and were detectable from 2000 m in good conditions. Weather conditions and landscape topography greatly affected the detection distance of the transmitters. After attaching the radio-transmitters, the birds had 2–3 days to become accustomed to the tag before being released into the wild.

Both wild and hand-reared hens in Suitia were kept in smaller pens with a wild cock before the release. Groups were mixed, so that one pen had both wild and hand-reared hens. The pheasants in Suitia were released by opening the pens every morning, so that the birds were free to leave at their own pace.

In Maaninka, the hand-reared hens were released with a cock directly from transport boxes that are built for pheasants. The boxes were placed in a suitable place with good vegetation cover. They were then opened and the birds were allowed to leave the boxes freely in a direction they themselves chose with as little stress as possible.

In both locations the birds were released in late May, when sheltering vegetation had grown. The releases occurred in the morning. The bird groups were always similar, one cock and three hens. Translocation densities were similar both in Suitia and Maaninka, a distance of 250 m was left between individual groups.

Tracking pheasants and determining causes of death

The pheasants were monitored regularly during the study period. In Suitia the hens were tracked daily after release and any nests were found by tracking. After brood hatching the hens were tracked twice a day. During weekends tracking was more irregular. In Maaninka the hens were tracked 3–5 times per week.

We had to pay special attention to the movements of the hens to gain accurate survival data. Whenever a transmitter was tracked to the same place for 2–3 days in a row, and we were certain it was not just a nesting hen, we located the exact site of the signal. Usually in these cases we found a pheasant carcass or just the transmitter. The cause of death was assumed by analysing bite marks on the carcass or even on the transmitter. In five cases we located the transmitters in a predator den. In studies like this it is often difficult to identify the predator that has killed the bird in the first place. There is always the risk that a mammalian predator has only found a carcass killed by an avian predator or something else, but then gets the blame because it leaves visible bite marks. To avoid such misinterpretations we investigated the carcasses very carefully. The birds were also checked at 2–3 days intervals so that dead birds were located quite quickly. Time of death was determined to a daily accuracy. If the date of death was uncertain, we defined time of death as the mid-point between the last certain alive tracking and the discovery of the remains or transmitter.

Brood size was estimated by counting the number of hatched eggs. After two weeks the size was estimated again by tracking down the brood to a visual contact. After that the size was estimated whenever possible without unnecessarily disturbing the birds for six weeks after hatching.

The abundance of mammalian predators

The abundance of mammalian predators was estimated during the wintertime. The Finnish wildlife-triangle-scheme (WTS) offers a good method for estimating and comparing wildlife abundance in different areas (Lindén 1996a). One wildlife triangle is a permanent count line in a forest area. Its total length is 12 km, where all animal tracks crossing the line are counted once a year on a specific date. Both areas had available wildlife-triangle data for the red fox, pine marten and stoat (Lindén 1996b).

The pine marten is a forest species and does not inhabit cultivated fields in our study areas. The WTS had no observations of pine marten tracks in our study areas. The marten is therefore excluded from our analyses and we will concentrate on the abundance differences of the red fox and stoat in the study areas.

Abundance is given as a mean value of the wildlife-triangles located at a 30-km distance from the study areas from year 1990 to 2003 (WTS data). This gives an overall picture of the small predator abundance in the area and its development during the study years. Track density has been counted as prints crossing the count line per 10 km per day, and is therefore a measure for the relative abundance of a species (Lindén 1996a).

Statistical methods

The areal differences in the causes of death and breeding success were tested using the χ^2, G^2-test and Fisher exact test (Ranta et al. 1994).

Survival probabilities were estimated with the staggered-entry Kaplan–Meier method (Ranta et al. 1994). The survival probabilities between different bird groups were tested using the log-rank-test, which has been applied by Pollock et al. (1989) to suit telemetry studies. Both methods have been commonly used in pheasant, partridge and forest grouse studies (Brittas et al. 1992, Wilson et al. 1992, Putaala and Hissa 1998, Virtanen et al. 1998, Musil and Connelly 2009, Åhlen et al. 2013).

Predation by red fox was compared to total predation between the study areas using the G^2-test.

Red fox abundance between the study areas was tested by the Wilcoxons matched-pairs signed-rank test (Ranta et al. 1994). The time period during which mortality was analysed had to be extended until the end of October because the sample size would otherwise have been too small for testing.

Results

Hen mortality

Mortality of the hand-reared hens in Suitia was very high during the first two weeks (Fig. 1A). Out of 23 (51% of the total released) dead hens, 16 (70% of the dead) were killed by red foxes. Wild birds in Suitia suffered two losses during the first two weeks (Fig. 1B). During the same time period three hand-reared hens died (8%) in the study area of Maaninka (Fig. 1C).

In Maaninka 76% of the hand-reared hens survived for the entire study period (Fig. 1C). Contact was lost with three hens, so they were excluded from the study. In Suitia only 21% of the hand-reared hens survived (Fig. 1A). There was a significant difference between Maaninka and Suitia regarding the mortality of hand-reared pheasant hens (log-rank-test $\chi^2 = 31.33$, DF = 1, $p < 0.001$). Wild birds in Suitia also suffered from quite heavy mortality: only 42% of hens were alive at the end of the study period (Fig. 1B). However, wild birds survived much better than hand-reared hens in Suitia (log-rank-test, $\chi^2 = 14.43$, DF = 1, $p < 0.001$). No significant difference in survival was observed between the hand-reared birds in Maaninka and the wild individuals in Suitia (log-rank-test, $\chi^2 = 3.53$, DF = 1, $p < 0.1$). All in all, differences in mortality occured at the beginning of the study period after which mortality among the groups evened out. We tested survival among groups excluding the first two weeks, which seemed to contain most of the differences

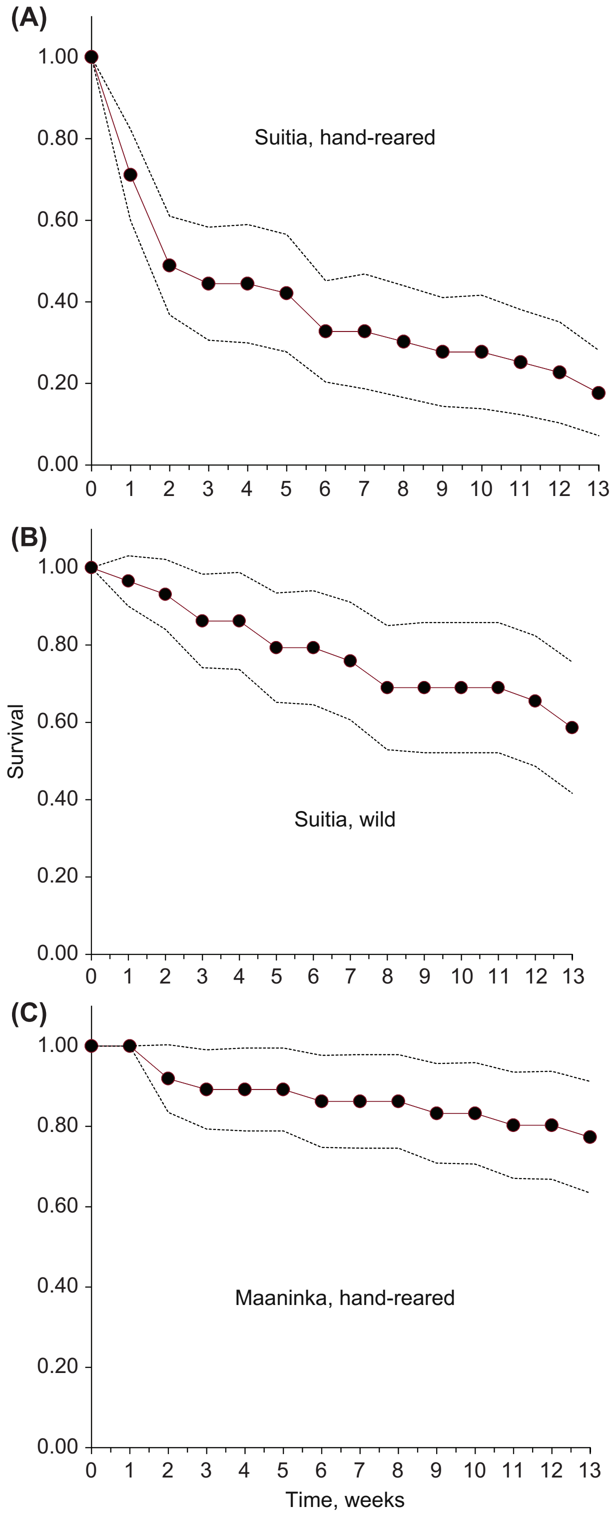

Figure 1. Survival of pheasant hens during a 13-week period after release based on the Kaplan–Meyer method. Dotted lines represent the 95% confidence interval for survival. (A) represents the hand-reared hens in Suitia, (B) the wild hens in Suitia and (C) the hand-reared hens in Maaninka.

between the study groups. During this later period, we could detect no significant difference between the groups (Suitia wild and hand-reared log-rank test: $\chi^2 = 0.143$, DF = 1, p = 0.705; Suitia hand-reared and Maaninka hand-reared $\chi^2 = 0.117$, DF = 1, p = 0.732; Maaninka hand-reared and Suitia wild $\chi^2 = 0.552$, DF = 1, p = 0.458).

Predators caused 97% of the hand-reared bird mortalities in Suitia, and 69% of these hens were killed by the red fox. Nearly half of the birds were killed during the first two weeks after release (Fig. 1A). Predators caused 74% of the deaths in Maaninka, but only 14% of the deaths were caused by red foxes. By the end of October, 18 of the wild birds in Suitia had been killed; six by red foxes (33%), two by birds of prey and two by an unknown predator.

Regarding the hand-reared birds, a difference in predation was observed between the areas; fox predation was clearly lower in Maaninka than Suitia (G-test, $G^2 = 8.688$, DF = 1, $p < 0.01$). No significant difference was observed in fox predation between the wild and hand-reared birds in Suitia ($\chi^2 = 0.059$, DF = 1, $p > 0.1$).

The hand-reared pheasants in Maaninka only suffered light fox predation compared to the birds in Suitia (Table 1). The wild birds of Suitia suffered many accidents, including three individuals drowning in a slurry basin. Birds preying on pheasants were mostly goshawks, but two were eagle owls (Table 1).

Table 1. Causes of death for released hand-reared and wild female pheasants in two different areas. The number of deaths in each group as well as the percentage of each death type of all the death cases in the group (in parentheses) are shown.

Death causes	Maaninka, hand-reared	Suitia, wild	Suitia, hand-reared
Red fox	2 (10.5)	6 (33.3)	24 (66.7)
American mink	1 (3.7)	–	–
Badger	–	–	3 (8.3)
Mammalian predator	–	–	4 (11.1)
Domestic cat	4 (21.1)	–	1 (2.8)
Domestic dog	2 (10.5)	–	–
Bird of prey	5 (26.3)	2 (11.1)	3 (8.3)
Unidentified predator	–	2 (11.1)	–
Accidents (e.g. car, drowning)	3 (15.8)	8 (44.4)	–
Other causes	2 (10.5)	–	1 (2.8)
Total	19	18	36

Nesting

Hens at both locations tried to begin nesting within one week of their release. The last brood hatched in September. In Maaninka 84% of the hens (31 birds) managed to begin incubating. In Suitia only 38% (17 birds) of the hand-reared and 74% of the wild (23 birds) birds succeeded to begin incubating. No statistically significant difference in hatching success (one-day-old brood) was observed between Maaninka hand-reared and Suitia wild birds (G-test, $G^2 = 1.425$, DF = 1, $p > 0.1$). Hatching success between the hand-reared birds in Maaninka and Suitia was significantly different both during the shared study years 1998–2000 ($G^2 = 13.392$, DF = 1, $p < 0.001$) and when all the years are combined ($G^2 = 20.683$, DF = 1, $p < 0.001$). Our results change if we do not take into account the first two weeks when the mortality of the hand-reared birds in Suitia was very high (Fig. 1 A). In this case we found no statistical differences between our study pheasant groups (Fisher exact test $p > 0.136$ in all cases).

Brood production

In Suitia eight (47%) of the hand-reared birds that began nesting managed to produce a brood, (1-day-old chicks), while nine birds failed, mainly due to nest predation. In Maaninka 23 (74%) birds managed to produce a brood, while seven failed. Of the wild birds that began nesting in Suitia, 16 (70%) managed to produce a brood, while seven failed, two of which died while incubating. No significant differences were observed in brood production successes between the groups of birds that managed to begin nesting (G-test, $G^2 = 2.228$, DF = 1, $p > 0.1$). In 1998 the summer in Maaninka was cold and rainy and the brood production success of pheasants was very poor (only five broods out of nine nests initiated, and none of them reached an age of six weeks). Brood production in Maaninka was better during the other years (17 broods/22 nests). The brood production of hand-reared pheasants in Maaninka was better than in Suitia when excluding 1998 (Fisher exact test, $p < 0.001$).

In Suitia three (38%) of the hand-reared birds managed to raise their broods to the age of six weeks, while five hens failed in their attempts. In Maaninka 13 birds (57%) managed to raise a brood and 10 failed. However, no significant difference was observed between the two groups ($\chi^2 = 0.267$, DF = 1, $p > 0.1$). In Suitia 13 (81%) of the wild birds managed to raise a brood to the age of six weeks, whereas three birds lost their broods. A nearly significant difference was observed between brood survival to the age of six weeks in Suitia (hand-reared versus wild) ($\chi^2 = 2.777$, DF = 1, $p < 0.1$). No difference was observed between the hand-reared birds in Maaninka and the wild birds in Suitia ($\chi^2 = 1.652$, DF = 1, $p > 0.1$). Results did not change when we excluded the data of the poor brood production year in Maaninka (1998) from the analysis.

Population densities of small mammal predators

A significant difference was observed in the WTS counts for the red fox snow track counts between Maaninka and Suitia (Wilcoxon, $Z = -3.296$, $p = 0.001$). The highest yearly track count in Maaninka (5.19) is lower than the lowest count in Suitia (6.8). The mean value of all the study years in Suitia is almost five times higher compared to Maaninka, and this difference is even higher in the shared study years (1998–2000). No mammal predator is very abundant in Maaninka and there are considerably less foxes than in Suitia.

Discussion

As predicted, both bird quality and predator density affected the survival of pheasants, as has been found in earlier studies (Hessler et al. 1970, Hill and Robertson 1988a, b, Krauss et al. 1987, Brittas et al. 1992, Wilson et al. 1992, Leif 1994, Musil and Connelly 2009). However, some of the differences found between our study groups were not as pronounced as they have been in many of the earlier studies. Some of this may be related to methodological differences.

In many cases the study setup has not been ideal for studying the general quality differences in hand-reared and wild birds (Krauss et al. 1987, Brittas et al. 1992, Leif 1994), as wild birds are represented by a local bird population. A comparison between wild and introduced hand-reared pheasants is hence ambiguous, because the wild birds are already adapted to the conditions in the study area. Mortality caused by predation can be density dependent, so that when increasing the number of pheasants in an area, the level of predation also rises. This might be expected to more strongly affect the naive hand-reared birds, whereas local wild birds would suffer only a slightly higher mortality than earlier. Density-dependent population regulation caused by predation has been shown in grey partridges, as well as in many other game birds, at least during some stage of the life cycle (McGowan 1975, Potts 1986, Bro et al. 2003), and the same may also be predicted to be true in pheasants (Draycott et al. 2008).

In our study all pheasants were released into a new environment, as were the ones in the study by Musil and Connelly (2009) in Idaho, USA. As a methodological improvement to their study, our study areas had no local wild pheasant populations, and both study groups were similarly reared and fed for two months. We additionally kept both bird groups in similar conditions and in mixed groups in pens, so we can assume that they share the same parasites, which has not been the case in earlier studies.

This accentuates that in our experiment both pheasant groups had the same opportunities to survive and reproduce.

Predator density is much lower in Finland than in Great Britain or central Europe (Kauhala et al. 2006). Our Suitia study area in southwestern Finland is the most dense red fox area in the country, whereas our Maaninka study area is situated in central Finland where red fox abundance has been low for a long time (Kauhala 1996). The red fox density index in Suitia was an average five times higher than that in Maaninka.

Besides the fox, the occurrence of other predators and birds of prey in our study areas were probably very similar, although there is no data available on the occurrence of the cat and raccoon dog in the study areas. There are probably many more raccoon dogs in Suitia than Maaninka, since raccoon dogs are hunted very efficiently in Maaninka (V.-M. Väänänen unpubl.).

The WTS snow-track indexes for stouts are slightly higher in Maaninka than in Suitia, because the stoat population abundance grows from south to north in Finland (Lindén 1996b). The stout can predate game birds when the abundance of voles is low (Lindén 1996a), but especially in Suitia area there were very few stouts. The stout probably had no significant effect on pheasant survival in Maaninka either, because according to field observations at least average amounts of voles were present (Klemola et al. 2002), meaning that stoats have probably not had any need to try and hunt pheasants, which are much more difficult to catch.

The red fox seems to be one of the most important summertime predators of game birds in both Finland and elsewhere (Potts 1986, Hill and Robertson 1988a, Putaala and Hissa 1998, Storch et al. 2005). The role of the raccoon dog is not clear. The raccoon dog is very abundant in Finland, and recent estimates of the raccoon dog hunting bag have varied between 134 000 and 172 000 in the period of 2007–2012 (Kauhala et al. 2006, Metsästys 2012). These numbers indicate that raccoon dogs are very common in southern and central Finland, where over 90% of the Finnish raccoon dog bag comes from (Metsästys 2012). We therefore assume that the raccoon dog may affect the nesting success of birds, such as pheasants and ducks, through their high numbers (Väänänen et al. 2007). However, we acknowledge that we found only a few depredated pheasant eggs with tooth marks in the eggshells, and it was not possible to say whether the predator was a red fox or raccoon dog. A recent study (Viranta and Kauhala 2011) suggests that red fox females have adapted to a more carnivorous diet after the arrival of a new competitor, the raccoon dog. So the impact of the raccoon dog on the whole small game community may be more complicated than previously assumed.

Survival of hens

Because our hand-reared birds were of the same origin they offer a nice pair for comparison between our two study areas with very different predator abundances, in this case the red fox. On the other hand, the wild translocated birds in Suitia give a very good comparison on the effect of bird quality versus predator abundance, as well as on bird quality versus the effect of translocation on birds. Both study areas appeared suitable for pheasants.

In Maaninka the introduced hand-reared birds survived well through the study period, whereas the hand-reared birds in Suitia suffered high predation during the first two weeks. The difference between the study areas is over three fold. The wild birds in Suitia survived similarly to the birds in Maaninka, both had a very steady death rate over the study period. The death rate of the hand-reared birds in Suitia evened out after a few weeks, indicating that the best-adapted birds were able to survive even under high predator pressure. When excluding the first two weeks of our study, we could not find any statistically significant difference between the survival of any of the bird groups. A high death rate of hand-reared birds during the first weeks has been reported in many game bird studies (Potts 1980, Musil and Connelly 2009). It is to be noted that survival is not necessarily just about behavioural differences between hand-reared and wild pheasants. Putaala (1997) studied differences between hand-reared and wild grey partridges and stated that it could be that the released birds lacking both behavioural and physiological preconditions to use natural food are thus initially forced to focus on maintaining a positive energy and nutrient balance at the cost of an increased predation risk. Hoodless et al. (1997) found that released pheasants that were given supplementary wheat spent proportionally less time actively foraging for food and more time being alert, compared to pheasants without supplementary food.

The dominance of the fox as a predator was no surprise in Suitia, since the fox population remained high during the whole study period. Other predators had only little effect on pheasant hen mortality. On the other hand, the fact that badgers killed three hens in Suitia soon after their release, illustrates the inability of hand-reared birds to adapt to conditions in nature.

In Maaninka four hens with broods were killed by cats. In Suitia only one hand-reared bird was killed by a cat. Wild birds had no fatalities caused by cats. This shows that cats can locally have a big role in pheasant survival.

The impact of avian predators on pheasant survival during the breeding season was smaller than expected. Birds of prey were the largest single cause of mortality in Maaninka, but most of the fatalities did not occur until September and October. This is easily understood because as the harvesting and ploughing starts, the pheasants loose many of their sheltered feeding habitats in arable fields (Virtanen et al. 1998). This provides better hunting possibilities for example for goshawks. Goshawks nest in forests during midsummer and are therefore primarily not hunting in fielded areas.

Breeding success

When comparing breeding success between the two study areas, it should be noted that Maaninka is situated 300 km north of Suitia, which lies on the southern coast of Finland. The geographic difference is undoubtedly a disadvantage to the pheasants in Maaninka when considering the weather conditions. This should be visible in the poorer breeding success of the Maaninka pheasants.

Despite this clear disadvantage, breeding success of the hand-reared birds in Maaninka is higher than of those in Suitia. Breeding success of the hand-reared birds in our study cannot be properly compared because of the high mortality of the Suitia birds before the chicks even hatched. Poor breeding success of hand-reared birds compared to wild birds has been reported earlier by several authors (Leif 1994, Musil and Connelly 2009). Still, if a hen of a hand-reared origin manages to hatch a clutch, it has almost as good a chance to raise the brood as wild birds do (Leif 1994, Virtanen et al. 1998).

The proportion of hens with chicks was rather high in Maaninka, especially if 1998 is left out. Summer 1998 was very rainy and cold, so the pheasants in Maaninka completely failed in their attempts to produce over six-week-old broods. In the two following study years, weather conditions were closer to average and the Maaninka birds managed to produce broods surprisingly well. Half of the hand-reared hens raised their young to the age of six weeks in the period of 1999–2000. These results show that even hand-reared pheasants can breed successfully, especially if the number of foxes is kept low.

Management implications

Our results do not differ much from those in earlier studies: hand-reared pheasants survive badly in an area with high populations of common opportunistic predators, such as the red fox (Krauss et al. 1987, Brittas et al. 1992, Leif 1994, Sage et al. 2003, Musil and Connelly 2009). However, the survival of hand-reared and translocated wild pheasants did not differ as much in our study as in earlier studies. For example, the survival of translocated wild pheasants was seven times higher in the study by Musil and Connelly (2009) than that of the hand-reared pheasants. In our study wild hens survived only two times better. And when we excluded the mortality of the first two weeks from our experiment we found no significant difference in survival between wild and hand-reared birds. We conclude that when releasing hand-reared and wild hens before egg laying in spring, the hand-reared are much more exposed to predation for the first two weeks. Later no differences in survival can be found between the two groups.

Extensive long-term predator control in areas with high predator density has increased the breeding success of ground-nesting birds, indicating that high predation rate is a problem (Tapper et al. 1996, Bolton et al. 2007, Väänänen et al. 2007). The role of predation is emphasised when habitat quality decreases (Whittingham and Evans 2004). Musil and Connelly (2009) pointed out that short-term and small-scale predator removal did not increase the overall survival of wild or hand-reared pheasants. Frey et al. (2003) demonstrated that very large-scale predator removal can improve pheasant survival even in the first year. All these studies point out that predator control is one of the key elements when augmenting wild stocks or when trying to establish pheasant populations to new areas. Another discussion, though, is in which cases it is feasible to strongly manipulate native predator communities to mitigate the breeding success of an alien species such as the pheasant.

The information gained during our study is useful in planning the introductions of hand-reared birds, whether they are reintroductions of endangered species or introductions for game management purposes. Decreasing bird mortality at the very beginning is crucially important. Besides predator control other methods that improve the survival of female pheasants could be useful. One interesting method was tried out successfully by Krauss et al. (1987): game managers improved the field survival of hand-reared pheasants by employing propagation practices aimed at increasing their excitability, fear of humans and use of cover. We additionally suggest that it is important to develop rearing methods that teach naive hand-reared birds how to avoid different types of predation (Griffin et al. 2000).

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