Roe deer Capreolus capreolus fawns and mowing - mortality rates and countermeasures

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Roe deer *Capreolus capreolus* fawns and mowing - mortality rates and countermeasures

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Besides red fox *Vulpes vulpes* predation, mowing is probably the most important mortality factor for roe deer *Capreolus capreolus* neonates in areas of intensive agriculture. Using radio-transmitters on roe deer neonates in south-central Sweden, I estimated mortality caused by mowing and tested and evaluated a traditional method to decrease this kind of mortality. During 1997-1999 fawn mortality caused by mowing was estimated at 25-44% of the yearly recruitment. Fawns were at risk for at least up to one month of age. The method tested uses scaring devices made of plastic sacks that are set out before mowing. The idea is that this will prevent female roe deer from placing their fawns in the field and make them remove the ones already hiding there. Black plastic sacks were attached to approximately 2-m long poles and placed in hay fields where marked fawns were bedded. During 1998-1999, 14 separate experiments were performed. Out of 22 fawns bedded in the vicinity of sacks, 18 were removed the day after the sacks were set out and three were removed on the second day. The fawns were always removed to another field or habitat patch. Fawns in the experiments were removed to a higher degree than fawns used as a control, and they were moved longer distances than both control fawns and the distances moved during the days before the experiment. The results imply that the use of this method is effective in reducing the mortality of roe deer fawns.

Key words: Capreolus capreolus, frightening method, hay cutting, mortality, mowing, roe deer fawns, scaring device

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Although a well-known phenomenon, roe deer *Capreolus capreolus* fawn mortality caused by mowing machines has been poorly examined (Linnell, Wahlström & Gaillard 1998), and there also seems to be a lack of evaluations of the methods used by farmers and hunters to reduce this kind of mortality. Being a 'hider' species (Lent 1974), roe deer neonates lie hidden in seclusion for most of the time during their first two months of life. Unfortunately, hay fields are a popular bedding habitat for roe deer neonates, and in Sweden a large, but unknown, number of roe deer fawns get killed during mechanised hay cutting every year. In West Germany, the annual loss of roe deer fawns due to mowing was estimated at 84,000, corresponding to 14.5% of the annual hunting bag (Kittler 1979).

Apart from being undesirable from an animal welfare point of view, another problem is that the carcasses of killed fawns, if undetected, might give rise to unwanted bacterial growth in the silage causing a health hazard for cattle. Finally, if mortality due to mowing is additive, it might decrease the annual hunting bag.

Using various methods, farmers and hunters in Sweden have for a long time tried to avoid killing roe deer fawns during mowing. Various visual repellents, searching with dogs and stage-wise mowing in a certain pattern are the methods that seem to be most widely used. Although believed to save some roe deer fawns, the efficiency of these methods has never been examined. In Denmark, infrared sensor equipment mounted on the tractor is used (Steinar 1998), and this kind of detection instrument has also been tested in Germany (Tank, Haschberger & Dietl 1992). In the USA, tractor-mounted flushing bars have been found to reduce mortality of ground-nesting grassland birds and this method is also believed to reduce mortality of deer *Odocoileus* spp. fawns (Green 1998).

The aim of my study was to estimate neonatal mortality in roe deer caused by mowing and to test and evaluate a simple traditional method to decrease this mortality. The method chosen for study involves plastic sacks that are put up in the field before mowing. This method is based on a simple idea: when the scaring devices (plastic sacks) are put up in the field the does will choose another area for fawn bed site, and they will remove the fawns already hiding in the field.

Study area

My study was performed at Ekenäs (58°58'N, 16°35'E), located in an agricultural landscape approximately 100 km south of the boreal zone in south-central Sweden. The core study area was 300 ha, comprising 53% forest and 47% farmland. The forest mainly consists of intensively managed stands of Scots pine *Pinus sylvestris* and Norway spruce *Picea abies*. Common broad-leaved trees are aspen *Populus tremulus*, oak *Quercus robur*, birch *Betula* spp. and alder *Alnus glutinosa*. The major part of the agricultural land is concentrated in the southern and eastern parts of the study area and is divided into two larger complexes. A third and smaller complex is found in the northwest. The complexes consist of smaller lots ranging in size within approximately 1-9 ha. Ekenäs is a dairy farm, and a large part of the agricultural area is used for production of clover hay. Other crops are rye *Secale cereale*, oats *Avena sativa*, wheat *Triticum vulgare* and rape *Brassica napus*. Approximately one third of the agricultural land is pasture. Based on a Petersen-Lincoln estimate (Caughley 1977) I estimated the density of roe deer at 23 animals/km^2 (SD = 2.1; 17 marked animals available, all resighted). Roe deer hunting is prohibited at Ekenäs.

Methods

Roe deer fawns were captured by hand soon after birth. Most fawns were detected by keeping their mothers under surveillance. Both radio-collared does of known age (in 1997 two does, in 1998 three does, and in 1999 four does) and unmarked does (11, nine and five does, respectively) were used. Females displaying signs of having fawns were localised and observed until they visited their fawns. After the visit, when the fawn had bedded again and the mother had left the area, the bed site was approached and the fawn was caught. If there was a risk of losing sight of the female and the fawn, they were approached while still being together. In that situation the fawn normally adopts a prone position when the mother runs away. Some fawns were caught after searching the immediate surroundings of already marked siblings, and some fawns were also found by systematically searching suitable bed site habitats. Body mass at capture was determined and age was estimated based on a mean body mass at birth of 1,500 g and a mean daily growth rate of 150 g (Linnell & Andersen 1998). The fawns were equipped with a radio-transmitter attached to an expandable collar. The type of transmitter used weighs 65-70 g, has a range of up to one and a half km, and a battery life of approximately one and a half years. The collar was fitted with a drop-off function.

The study of mortality caused by mowing was carried out during 1997-1999. In general, the farm personnel announced in advance when a hay field was going to be cut. Immediately before the planned mowing, the positions of radio-marked fawns were checked and those that were bedded in the field to be cut were removed by hand. Fawns were removed to the nearest forest stand or, as in some cases, the fawns themselves ran to the forest just when they were to be touched and picked up. As these 'mowing fawns' were judged to have been killed if not saved by this procedure, their proportion of all radio-marked fawns during the entire reproductive season were used as a measure of mowing mortality.

Experiments with scaring devices were performed in June-July 1998 and in May-June 1999. An experiment was defined as to the instance when an individual female and her fawn or fawns were exposed to scaring devices, regardless of whether the female had one, two or three fawns bedded in the vicinity of the sacks at the start of the experiment. Siblings exposed to sacks in the same experiment were treated individually in analysis.

The devices were black plastic sacks measuring 75 x 115 cm that were attached to 2-m long wooden poles. When marked fawns were bedded in a field, three sacks were set out approximately 100 m apart in late afternoon. The sacks were set out in the part of the field where the fawns were bedded. Although sacks were not put up all over the field, the idea was to mimic a distribution of one sack per hectare in a squared spacing. At this sack density, bedded fawns should not be further away from the nearest sack than 71 m. The average distance between the starting positions of the fawns exposed to sacks (referred to as experimental fawns) and the nearest sack was 45 m (SD = 15; range: 20-80 m). The sacks were left in the field for three days and then removed. Marked fawns not exposed to sacks during the same period were used as controls (referred to as control fawns). Siblings in the control set were treated individually in the analysis. The positions of the experimental fawns and the control fawns were checked daily in the same manner by visiting the bed sites and observing the fawns. Experimental fawns could be used as control fawns in other experiments.

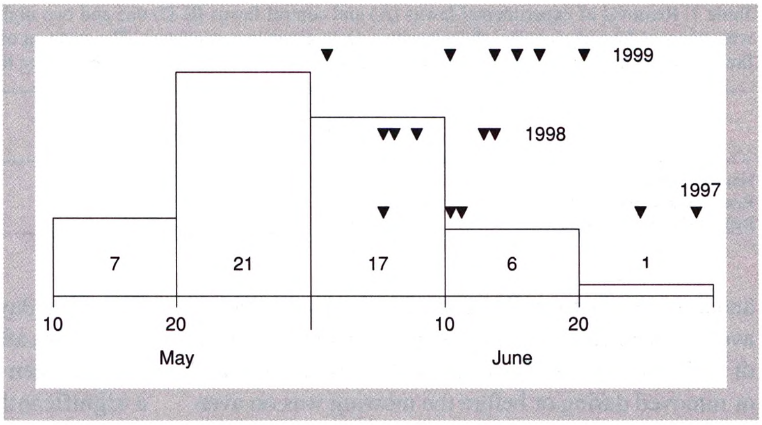

Figure 1. Birth dates for 52 of the 54 fawns tracked during 1997-1999 shown for 10-day periods in May and June and mowing dates (▼) in the respective year. Two births in July and one mowing event in mid-July are not included in the figure.

Results

Estimate of mortality caused by mowing

Mowing mortality was estimated during the summers of 1997, 1998 and 1999. The number of marked fawns for the three years was 18, 20 and 16, respectively. Mean birth date was 31 May (range: 13 May - 7 July) with 91% of fawns born before 15 June (Fig. 1). Mean age at capture was six days (range: 1-19 days). Mowing was performed on five dates both in 1997 and 1998 starting on 5 June and ending on 29 June and 14 June, respectively (see Fig. 1). In 1999 mowing took place on six dates between 2 and 21 June plus a remaining field being cut in mid-July.

Out of the 18 fawns in 1997, six were removed by hand from a hay field immediately before an announced mowing, and two were accidentally killed because the mowing was not announced in advance. In 1998 five out of the 20 fawns had to be removed, and in 1999 four of the 16 fawns were removed from a hay field immediately before mowing. Hence the estimated mortality caused by mowing ranged between 25 and 44% (Fig. 2) giving an average potential mowing mortality for the three-year period of 31% (SD = 11). The major cause of mortality was predation by red fox *Vulpes vulpes* (28 of 54 marked fawns; ~52%), whereas starvation/hypothermia was of minor importance (one fawn during the three years).

Of the 54 fawns marked during the three-year study, 22 were found and marked in fields of clover hay, 19 in other agricultural fields, eight in forests and five in clearcuts. Fawns removed or killed during mowing used hay fields as bed site habitat more frequently than other fawns ($t = 4.93$, $df = 45$, $P < 0.0001$) and forest or clearcuts less frequently ($t = 2.42$, $df = 45$, $P = 0.020$). There was no significant difference in the frequency of use of forest or clearcut between fawns caught in these habitats and fawns caught in hay fields ($t = 0.69$, $df = 29$, $P = 0.50$).

Fawns removed before or killed during hay cutting had an average birth date of 26 May (median: 24 May)

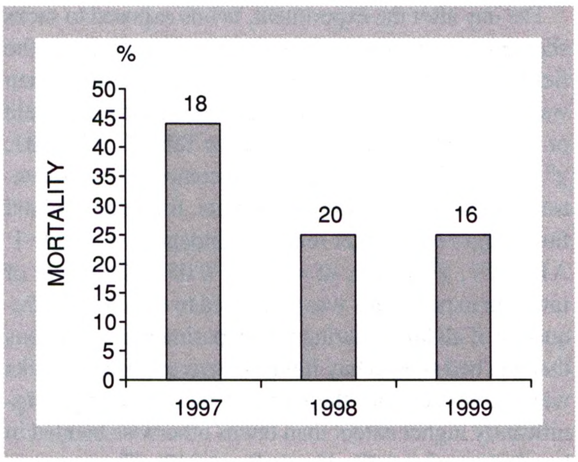

Figure 2. Estimated fawn mortality caused by mowing during 1997-1999. The figures above the columns give number of fawns in the respective year.

Table 1. Removal of experimental fawns (A) and control fawns (B-D) one and two nights after initiation of the experiment, respectively, with removal frequencies after the respective night given in parentheses. The removal of control fawns is given for both totals (B) and for fawns bedded in open habitat (C) and forest (D). * indicates that one fawn died during the second night.

	A Experimental fawns	B Control fawns, total	C Control fawns in open habitats	D Control fawns in forest
Number of fawns	22	51 / 50*	40	11 / 10*
Removed after one night	18 (0.82)	30 (0.59)	23 (0.58)	7 (0.64)
Removed after two nights	21 (0.95)	36 (0.72)	28 (0.70)	8 (0.80)

and thus were born earlier than other fawns that had an average birth date of 4 June (median: 3 June; t = 3.01, df = 52, P = 0.0040). The estimated age of fawns killed or removed during or before the mowing was on average 17 days (the youngest being 9 days, the oldest 28 days old; SD = 7.2). The two fawns actually killed were 12 and 28 days old, respectively.

Experiments with scaring devices

In 1998 and 1999, 10 families (14 individual fawns belonging to 10 individual mothers) were exposed to sacks. In addition to the 10 experiments with first time exposure, four experiments with families earlier exposed to sacks were conducted (referred to as repeated experiments) making a total of 14 experiments. One family was exposed to scaring devices another two times and two families one more time. Hence the experimental numbers of fawns and females used in the analysis, including these four repeated experiments, were 22 and 14, respectively. Fawn age at the start of the experiments was on average 19 days (range: 6-47 days). As controls 24 individual fawns were used. Also these fawns were used in more than one experiment, and therefore the total number of control fawns used in the analysis was 51. Of the 14 individual experimental fawns, 13 were also used as control fawns in other experiments.

The day after the experiment, fawns exposed to sacks showed a tendency to have been removed from the field to a higher extent (18 of 22 fawns; Table 1) than were the control fawns displaced from their initial field or forest stand (30 of 51 fawns; see Table 1: A1 vs B1; $\chi^2 = 3.61$, df = 1, P = 0.057). Also compared to the control fawns bedded in open habitats, the experimental fawns showed a higher removal tendency (see Table 1: A1 vs C1; $\chi^2 = 3.75$, df = 1, P = 0.053). Removal of fawns in experiments was compared to the removal frequency of all fawns during non-experimental conditions that had bed sites in hay fields. Fawns exposed to sacks were removed from the experimental fields to a significantly higher extent than fawns otherwise bedded in hay fields ($\chi^2 = 6.37$, df = 1, P = 0.012). Three experimental fawns were removed on the second day and the remaining fawn had to be taken off the field by hand on the second day since the field actually was to be mowed. Two nights after the start the experimental fawns (21 of 22) had been removed from the experimental field to a significantly higher extent than were the control fawns from their initial sites (36 of 50; see Table 1: A2 vs B2; $\chi^2 = 5.10$, df = 1, P = 0.024). There was also a significant difference in removal after two nights when compared to the control fawns bedded in open habitats (see Table 1: A2 vs C2; $\chi^2 = 5.55$, df = 1, P = 0.019). After two nights the experimental females (14 of 14 females) had shown a stronger tendency to remove their fawns from the initial field compared to the control females (28 of 40; $\chi^2 = 5.40$, df = 1, P = 0.020).

After the fawns had been removed by their mothers, the average distance to the nearest sack was 256 m (SD = 160; range: 50-620 m). Excluding the four repeated experiments, the average distance to the nearest sack after movement was 318 m (SD = 134; range: 200-620 m). The average distance between the starting position at the onset of the experiments and the next recorded position (Fig. 3), was significantly longer for experimental fawns (mean = 283 m) than the corresponding distance for control fawns (152 m; t = 3.73, df = 70, P = 0.0004). The repeated experiments excluded, the average distance moved for 13 experimental fawns was 346 m compared to 162 m for 34 control fawns (t = 4.45, df = 45, P < 0.0001). The average distance between the

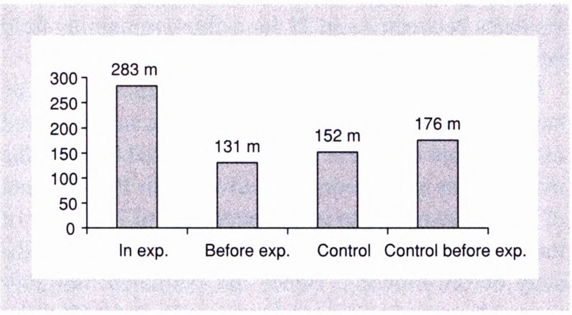

Figure 3. Average distances (in m) that 1) fawns were moved from their starting point during experiments (In exp.), 2) the same fawns were moved the days before the experiment (Before exp.), 3) the control fawns were moved during the first night of the experiments (Control), and 4) the average distance between positions in the days before the experiments (Control before exp.).

starting position and the next recorded position in the experiment was also significantly longer than the average distance (131 m) moved by the experimental fawns between each observed position during the days before the experiments ($t = 4.12$, $df = 40$, $P = 0.0002$).

In 1998, one female and her three fawns were used in three experiments. Even though she always removed her fawns from the field with sacks, she tended to move the fawns a shorter distance for each repeated experiment (330, 197 and 75 m). In 1999, two females were exposed to sacks two times. These females showed a slight tendency to decrease the moved distance when the experiment was repeated (550 to 460 m and 260 to 170 m, respectively).

A few females returned to the experimental fields while the sacks still were in position. In two experiments the fawns were back in the field two days after the experiments were started. The distance to the nearest sack for the four fawns then varied between 135 and 150 m. Two females had moved their fawns back close to the plastic sacks (35 and 60 m) on the third day after the experiments started.

Discussion

Fawn mortality caused by mowing

The estimate of mowing-caused mortality was higher than might be expected. This was especially the case in 1997 when 44% of the marked fawns could potentially have been killed during mowing. Also in 1998 (25%) and 1999 (25%) the estimated mortality has to be considered as high. These estimates are, however, close to the 26% that was established in a Polish study (Kaluzinski 1982). In West Germany, Kittler (1979) calculated mowing mortality to be 14.5% of the annual hunting bag. Although not directly comparable to the figures in my study, this percentage still indicates a considerable loss of roe deer fawns to the mower. The mortality in my study is also close to the 27% mortality that has been found for leverets of European hare *Lepus europaeus* (Milanov 1996).

The most important mortality factor for roe deer neonates in Scandinavia is red fox predation. At least in heterogeneous landscapes, such as forest and farmland, approximately 50% of fawns are killed by red foxes (Cederlund & Liberg 1995, Aanes & Andersen 1996). Neonatal mortality caused by starvation/hypothermia and diseases has been reported to be of low magnitude in Scandinavia (Liberg, Johansson, Lockowandt & Wahlström 1993, Cederlund & Liberg 1995, Aanes & Andersen 1996) - but see Andersen & Linnell (1998) for an exception. The pattern of red fox predation as the major mortality factor and starvation/hypothermia as a minor factor has been confirmed at Ekenäs (A. Jarnemo & O. Liberg, unpubl. data). Mowing-caused mortality appears to be the second most important mortality factor for roe deer neonates in areas of intensive agriculture. It might even be of the same magnitude as red fox predation. In a forest dominated landscape mowing mortality should be of less importance. However, even in an area largely dominated by forest, females with a home range including hay fields may suffer a substantial loss of fawns. The extent of mowing mortality suggests a strong impact on roe deer population dynamics, at least locally. However, without knowing whether it is of an additive or a compensatory nature in relation to red fox predation and other causes of mortality, the effects on population dynamics remain unclear.

Fawns that were killed or had to be removed before mowing had on average an earlier birth date than other fawns. Fawns born early, before the mowing season starts, are more likely to encounter mowing in their home range, perhaps more than once. The later a fawn is born, the greater is the chance that mowing has already been performed in its home range or that the mowing season is over.

Roe deer fawns seem to be vulnerable to mowing for at least up to one month of age. One of the fawns that actually was killed was 28 days old. The tendency for a hidden fawn to flush when approached is initiated at the age of 10 days (Linnell et al. 1998). At the age of 20 days the probability that a hidden fawn will flush is approximately 25% and at the age of 30 days the probability is 50%. Still, the average flush distance to an approaching human is less than 1 m at the age of 20 days and 2 m at the age of 30 days. Even if the fawns flushes, a distance of 1-2 m to the mower might not be enough to successfully escape. At Ekenäs almost all mowing is performed in June (in this study 16 of 17 mowing dates were in June), predominantly during the first half of the month. Thus fawns might be at risk also when they are older than one month, but since mowing already is over when most marked fawns have reached that age, this remains unclear. Linnell et al. (1998) report that fawns older than 40 days consistently flush when humans approach within 10 m. Some fields are mowed a second time, but this is done in late summer when even late born fawns should have reached an age at which the tendency to flee is stronger than the tendency to hide. From 1986 to 1999 no marked fawns were killed or removed at Ekenäs during the second round of mowing.

A potential risk of overestimating the mortality caused by mowing could lie hidden in the assumption that all fawns that were removed just before mowing would have been killed otherwise. Although the fawns allowed themselves to be picked up or touched, perhaps some of them would have reacted differently towards a machine and would have been able to get up and escape from the mowing machine. On the other hand, it is possible that the strange appearance of a mowing machine - as opposed to an approaching predator - will strengthen the tendency to remain hidden instead of the tendency to flee. The killing of a 28-day-old fawn might be an indication of this.

Most fawns in my study were found by observing female roe deer and waiting for them to visit their fawns. This method restricts the searching for fawns to open areas where the roe deer are easily observable. At Ekenäs this is largely synonymous to land used for agriculture. Since a large part of the agricultural land is used for the production of clover hay and since these fields are preferred habitat for roe deer, a large proportion of the fawns were caught in such fields. It is therefore well justified to ask whether fawns of does with a preference for hay fields, are overrepresented in the material. In fact, 15 of the 17 fawns that had to be removed from or were killed in hay fields had originally been caught in such fields. Hence, there is a risk that the estimated mortality might be an overestimate. However, the magnitude of this bias is reduced by the fact that most of the marked fawns had home ranges including both forest and agricultural fields. Observations and radio-tracking of marked adults support this pattern (A. Jarnemo & O. Liberg, unpubl. data). There was no difference in the use of forest or clearcuts as bed site habitat between fawns caught in hay fields and fawns caught in forest or clearcuts.

Sacks as a scaring device

The method of setting out plastic sacks in fields in order to decrease the mortality of fawns was found to be surprisingly effective. If mowing had been performed in the afternoon the day after the sacks were put out, 18 of 22 exposed fawns would have survived. Given one more day, all but one of the fawns would have been in safety from the mower. The experimental fawns were moved to a higher degree and further away from the starting position than the control fawns. They were also moved longer distances than during the days before the experiments, and they were removed from the field to a higher extent than were fawns bedded in hay fields and not exposed to sacks. The results suggest that if plastic sacks are left in the field for two nights, almost all fawns will be removed and thereby avoid being killed by mowing.

In most experiments the fawns were moved by their mothers within 24 hours, but three fawns were not removed from their initial position before the second day. This should not be interpreted such that the females did not care about the scaring devices. Rather it seems that the females initially were too scared by the sacks to enter the field to fetch their fawns. Of the three females in these experiments two were marked and of known age. Both were only two years old and thus first time breeders. It is possible that young mothers are more insecure and therefore need more time to overcome their fear of the scaring devices, and therefore it may take longer before they dare fetch their fawns in the field. A positive relationship between maternal age and survival of fawns has been found in white-tailed deer *Odocoileus virginianus* indicating the importance of maternal experience in preventing predation on the young (Ozoga & Verme 1986, Mech & McRoberts 1990, Nixon & Etter 1995). A similar relationship has also been indicated in roe deer (Kjellander 2000).

The one fawn which was not removed belonged to a litter with a two-year-old mother. The doe moved the sibling, and it seems likely that she also would have moved the second fawn later the same day, but since the mowing actually was going to take place, the fawn had to be removed by hand. As the sacks were placed between the fawn and the forest, the doe would have had to pass the sacks at a short distance to reach the fawn, and this may have prolonged the time necessary for her to overcome her fear of the sacks.

Among some farmers there seems to be a belief that the scaring devices should be put up along the edges of the fields to prevent females from placing their fawns in the field. However, this does not take into account that many fawns are already hiding in the field and that this type of placing might prolong the time needed for the females to fetch the fawns, and thus will increase the risk that fawns already lying in the field when the mowing starts will be killed.

In two experiments the fawns were back in the experimental field on the second day after the experiment started, and in two experiments the fawns were back close to the sacks on the third day. In these cases the females obviously had adapted to the sacks. This possibility that the roe deer will soon lose their fear of the sacks or adapt to them was also indicated by the behaviour of the one doe exposed to three experiments in 1998, and perhaps also by the two does exposed to sacks twice.

My results indicate that correct timing is of crucial importance. If the sacks are put up too long before mowing, the roe deer might adapt to them and ignore them at the time of mowing. On the other hand, if the sacks are put up too soon before the mowing starts, the does might not be given the time necessary for them to cope with their fear and enter the field and fetch their fawns, perhaps having to pass the sacks at close distance. Thus the scaring devices should not be put up too long before mowing and the use of them should be restricted to the periods when they are absolutely necessary. The scaring devices should preferably not be out in the fields for more than three days before mowing.

The sacks were placed at a distance of 100 m in order to mimic a distribution of one sack per hectare in a squared spacing. The results suggest that this was dense enough. Also the black plastic sack design of the scaring devices seemed adequate to achieve the desired effect. A similar use of plastic sack flags has been found to reduce mortality risk for ground-nesting birds during mowing (Kruk, Noordervliet & Ter-Keurs 1997) and to repel birds from crops in order to reduce grazing-caused damage (Mason, Clark & Bean 1993). The sacks seemed to be scary enough to be effective for at least 2-3 days. It is possible that this time can be prolonged if the design is altered (Koehler, Marsh & Salmon 1990), for instance with white sacks or clothes. Wind might enhance the effect through the flapping of the sacks. A few observations supporting this assumption were made. This could, however, also lead to delays in the collection of fawns in periods of windy conditions.

My study clearly suggests that a correct use of scaring devices is effective in saving roe deer fawns from being killed by mowers. The advantages of this model are its simplicity and the low costs involved. According to the estimated mortality caused by mowing, a widespread use of the method would significantly enhance the survival possibilities of roe deer fawns in areas of intensive agriculture. In Appendix I, I summarise my results in guidelines on how to use the method to its best advantage.

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Appendix I

Management guideline

- Put up the scaring devices at least the day before and preferably two full nights before mowing;
- do not leave the scaring devices in the field for more than three days before mowing;
- use a density of one sack per hectare;
- restrict the use of the scaring devices and use them only when absolutely necessary; if mowing is postponed for some days, remove the devices from the field;
- do not place the scaring devices as a 'wall' along the edges of the field;
- avoid disturbances at or near the field when the scaring devices have been put up as the does must be permitted to collect their fawns without disturbance.