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Fence and plough for Lapwings: Nest protection to improve nest and chick survival in Swiss farmland

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Zusammenfassung: In den 1970er Jahren umfasste der Brutbestand des Kiebitzes in der Schweiz ca. 1000 Paare. Heute sind es schätzungsweise nur noch ca. 200. Für diesen dramatischen Rückgang dürfte in erster Linie der viel zu geringe Reproduktionserfolg verantwortlich sein (0.2-0.4 flügge Junge pro Brutpaar und Jahr). Um den Bruterfolg auf ein populationserhaltendes Mass von ca. 0.8 Jungen pro Paar zu steigern, wurde bei einem Restbestand in der Zentralschweiz (10-25 Paare) ein Artenförderungsprogramm in Angriff genommen. In den Jahren 2004-2006 wurden alle Kiebitzgelege markiert und auf diese Weise von der Feldbearbeitung ausgespart. Dank der ausgezeichneten Zusammenarbeit mit den örtlichen Landwirten ging in dieser Zeit kein Kiebitzgelege bei landwirtschaftlichen Feldarbeiten verloren. Wenn allerdings die Bodenbearbeitung während der Gelegeproduktion erfolgte, wurden verhältnismässig viele Bruten aufgegeben. Hier kann es ratsam sein, die landwirtschaftliche Bearbeitung hinauszuzögern bis die Vögel mit dem Bebrüten des Vollgeleges begonnen haben. 2005 und 2006, nicht aber 2004, wurden Kiebitzgelege zusätzlich mit einem Elektrozaun, wie er bei Schafhaltern üblich ist, gegen Raubsäuger gesichert. Eingezäunt wurden in der Regel ganze Felder. In den so gesicherten Kulturen schlüpften 95 % der Gelege, in den nicht eingezäunten nur 39 %. 2006 wurden 81 Kiebitzküken besendert, um deren Überlebensraten und den Einfluss der Prädation zu untersuchen. Die Küken konnten den Elektrozaun ohne weiteres passieren (bodennahe Maschen 10x15 cm). Kükenverluste durch Prädation ereigneten sich überwiegend nachts (73 % aller Verluste) und außerhalb der Elektrozäune (87 % aller Verluste). Von 46 in der Nacht prädierten Küken stammte nur eines aus einer Elektro-Umzäunung. Kükenverluste, die durch tagaktive Prädatoren verursacht wurden, spielten eine untergeordnete Rolle (27 % aller Verluste). Sie traten innerhalb und außerhalb der Elektroumzäunungen in gleichem Umfang auf. Der Bruterfolg des Kiebitzes lag in 2005 bei einem bestandserhaltenden Wert von 0.8 Küken pro Paar. In 2006 führten hohe, prädationsbedingte Kükenverluste zu einem Bruterfolg von lediglich 0.25 Küken pro Paar.

Summary: Switzerland had up to 1000 Lapwing pairs breeding in the 1970s. Actually, there are some 200. The crash was mainly due to a poor productivity of 0.2 to 0.4 fledglings per pair and year. To achieve a fledging rate of at least 0.8 required for population stability, a Recovery Programme was initiated to support a small population of 10-25 pairs breeding in central Switzerland. In 2004 to 2006 all nests were marked and spared during field labour by the farmers. As a result of a well established cooperation with the local farmers, not a single nest was destroyed by agricultural activities. However, there was a high risk of nest desertion when farming activities took place during the period of egg laying. Therefore, it might be worth to postpone field labour for some days to allow clutch completion. In 2005 and 2006, but not in 2004, most nests were protected from ground predators by surrounding entire fields rather than individual clutches with electro-fences as used in sheep farming. While 95 % of clutches within the fences hatched successfully, 61 % of unprotected nests were predated. In 2006 the influence of predation on chick survival was investigated by radio-tagging 81 chicks soon after hatching. They had no difficulties to cross the electro-fences. Predation occurred mostly at night (73 %) and outside the fences (87 %). Of 46 chicks predated at night only one was taken inside an electro-fence. Daytime predation played a minor role (27 % of all chick predations) and occurred at the same rate inside and outside the electro-fence. Reproductive success in 2005 was an estimated 0.8 fledging young per pair and year. In 2006, however, it dropped to 0.25 due to heavy chick predation.

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1 Introduction

In Switzerland, 50 bird species were identified as Priority Species for Recovery Programmes (Keller & Bollmann 2001, 2004). 40 % of them depend on farmland, among them the Lapwing *Vanellus vanellus.* This species originally lived in marshland. As a result of habitat loss due to draining, the population breeding in Switzerland dropped to very low numbers by the 1930s (Glutz von

Blotzheim 1959). Nevertheless, as Lapwings turned to breed in farmland, they recovered in the 1950s and reached a peak of 1,000 pairs in 1972-1976 (Glutz von Blotzheim 1962, Imboden 1971, Schifferli, Géroudet & Winkler 1980, Schmid et al. 1998). However, Lapwings reproducing in Swiss farmland fledged merely some 0.2 to 0.4 young per breeding pair and season (Imboden 1970, Heim 1978, Matter 1982). This is well below the rate of 0.8 fledglings required for population stability (Peach et al. 1994, Catchpole et al. 1999). For a long time, the Swiss population has therefore been a sink population and its growth was probably driven by immigration from other European countries. After the mid-seventies, the Lapwing declined in Western Europe (Hagemeijer & Blair 1997, van Strien, Pannekoek & Gibbons 2001). In Switzerland, the numbers dropped to 450 (Birrer & Schmid 1989, Schmid et al. 2001); today there remain an estimated 200 pairs.

Which are the reasons for the poor productivity of the Lapwing in Swiss farmland? Clutches on the ground and the flightless, nidifugous young are susceptible to predation and many are destroyed by farming (Baines 1990, Bellebaum 2002, Flodin & Hirsimäki 1990, Köster & Bruns 2004, Sálek & Smilauer 2002, Schifferli 2001, Teunissen, Schekkerman & Willems 2005). The chicks need a rich supply of surface dwelling invertebrates on soils with a low and sparse vegetation (Beintema et al. 1991). However, intensively farmed crops and meadows grow so densely that small chicks are unable to move and forage in the vegetation. In addition, feeding conditions deteriorate when the soils dry out in late spring as the invertebrate prey for young Lapwings disappears from the surface. As a result of a low hatching success and a high chick mortality, breeding success in Swiss farmland has for decades been below 0.4 fledglings per pair and year (Imboden 1970, 1971, Matter 1982, Leuzinger 2001, Schifferli 2001).

Recovery programmes to improve the living conditions, especially for priority species, have been put forward to reverse or at least stop negative population trends. Trolliet (2003) reviewed the literature to pinpoint the major key factors and bottlenecks in the population dynamics of the Lapwing. He and others present elements for an action plan with suggestions for farmland management (Belting et al. 1997, Berg et al. 2002, Boschert 1999, Kooiker & Buckow 1997, Lyons et al. 2002) and nest protection (Musters et al. 2001, Moseby & Read 2005).

The aim of a future Recovery Programme for the Lapwing in central Switzerland is to help the small breeding population of some 10 to 25 breeding pairs in 2004 to 2006 to achieve a fledging rate of at least 0.8 young per pair and year. In 2004 to 2006, we attempted to increase the hatching success from below 40 % at present to above 50 %, first by minimising losses due to agriculture in close cooperation with local farmers. Second, fields with Lapwing nests were protected by electric fences to reduce predation on clutches and small chicks. After hatching, the precocial Lapwing chicks need adequate energy and nutrient resources (Galbraith 1988, Schekkerman & Visser 2001). Poor feeding conditions in dry farmland and crop cultivation reduce chick growth and survival. Long-term management should therefore focus on Lapwing friendly farming, providing suitable habitats with an adequate and accessible food supply (Kooiker & Buckow 1997, Trolliet 2003, Teunissen, Schekkerman & Willems 2005).

2 Methods

The study, which is still in progress, has been carried out on farmland in the plain of Wauwil, Canton Lucerne in central Switzerland (47°11 N/8°01E; 500 m asl). The total area of 18 km^2 is farmed intensively. In most years, Lapwings breed within a core area of some 5.3 km^2. In 2005 and 2006, 60 % and 53 % were meadows, 29 % and 28 % maize, 5 % and 14 % cereals, 4 % and 3 % potatoes, respectively and 2 % sugar beet in both years.

Lapwing nests were found by locating birds sitting on eggs and marked by two 60 cm tall sticks set at a distance of 2-3 m from the nest. The farmers were informed on nests on their land. Whenever they worked in their fields with machines, clutches were protected to avoid egg loss or damage. In 2004, the study started in May, when crops had been planted. There were no active nests suggesting that clutches initiated in April had been destroyed before the beginning of the project. In 2005 and 2006, field work was carried out from March to August. Laying started in the first week of April. Early nests were in fields which had not been treated by agriculture since the harvest in the previous autumn. The soil was sparsely covered by very low vegetation. In 2005, the farmers ploughed and harrowed around the nests, leaving the original vegetation on some 2 m by 3 m wide 'islands' untreated (cf. photographs in Schifferli & Spaar 2006). By contrast, in 2006 the entire fields were ploughed, harrowed and the crops planted also in the immediate surroundings of the nest. Thus, unlike in 2005 the structure and vegetation around the nest were changed completely within a few hours. In both years, the eggs and some of the nest lining material were rescued just before the machines moved in and put back as soon as the nest site had been treated.

In 2005 and 2006, but not in 2004, most nests were protected from ground predators. Entire fields with Lapwing nests, rather than individual clutches, were surrounded by electro-fences used in agriculture. We initially used a simple equipment with three plastic wires, 15 cm, 35 cm and 50 cm above ground, containing metal wires to carry the current. Three nests within such a fence were predated at night within two weeks. Foot prints showed that foxes freely crossed the fence. We therefore replaced this unsatisfactory type of fence by a 90 cm high netting used as an electrofence for sheep. It had vertical and horizontal woven plastic strings 10-15 cm apart containing fine wires. All horizontal strings, except for the base line and the vertical strings, were under electric power (more information on predator behaviour at electric fences and implications for management in Balharry & MacDonald 1999, McKillop & Sibly 1988, Moseby & Read 2005, Brenning & Nehls 2006 and in references therein). The power was supplied by a 9 V battery. The tension was usually > 4 V, but dropped to 2 V when the growing vegetation came in contact with the wires.

In 2005 and 2006, most nests were equipped with thermologgers recording the temperature 1-3 cm below the nest 2-3 times per hour. During incubation, a drop in temperature at night or a marked change during the day together with direct observations allowed us to distinguish an egg loss during the day from predation at night.

Tab. 1: Nest sites of Lapwings in the plain of Wauwil (Canton Lucerne, Switzerland) in 2004-2006. Cultures are given at the time of clutch initiation. Fallow vegetation refers to arable fields left untreated after the harvest in the previous autumn. *In 2004, the study was started in early May. By this time most crops had already been planted and there were no active nests.

	2004	2005	2006	2004-2006
Fallow before cultivation	?*	5	8	13
sugar beet	3	7	8	18
potatoes	0	5	3	8
maize	5	7	2	14
tobacco	1	0	0	1
(autumn sown) cereals	0	0	0	0
meadow	2	2	6	10
Total	11	26	27	64

3 Results

3.1 Nest protection from farming activities

In 2004 - 2006 we located a total of 64 nests with eggs. 41 were in arable crops, namely 18 in sugar beet, 14 in maize and 8 in potato fields (Tab. 1). None were in cereals, even though this crop covered some 10 % of the farmland. Cereals were sown the previous autumn and the plants were growing densely by the time of egg laying in April. 10 nest sites were in grassland, 4 of them in newly sown meadows. 13 clutches laid in early April were in fallow fields which had been untreated after harvest in the previous autumn. Their vegetation was sparse and the sward height well below 5 cm at the time of egg laying. The surface structure of such fields clearly meets the habitat requirements of nesting Lapwings (Kooiker & Buckow 1997). However, the earliest clutches laid before cultivation are often destroyed when the soils are ploughed and harrowed in mid-April.

To minimise losses due to agriculture, all nests were marked to assist the farmers' intentions to safe the nests from damage by cultivation. In 2005, they ploughed and harrowed around six nests, sparing some 2 m by 3 m of the original vegetation around the nest site. Two nests were deserted after cultivation, both incomplete clutches. In one clutch in the laying stage and in four during incubation the parents continued their breeding activities.

In 2006, the entire fields including the surroundings of the nests were ploughed, harrowed and the crops planted. Thus, unlike in 2005 the structure and vegetation around the nest were changed completely within a few hours. Lapwing eggs and some of the nest material were rescued just before the machines moved in and put back as soon as work at the nest site had been completed. In three clutches incubation had started shortly before. The parents accepted the new situation and continued to incubate. However, two clutches which had just been completed, were deserted.

We therefore conclude that during incubation Lapwing clutches can be saved from damage by agriculture. The parents resume incubation, regardless of whether or not the immediate surroundings of the nest were excluded from cultivation. However, if field labour takes place during laying, half or more clutches were deserted ($\chi^2 = 7.5$, df = 1, Fisher's exact p = 0.015). Sparing the nest site from cultivation did not improve the success rate. It is therefore not justified to take some extra time for selective treatment around the nest (ca. 20 minutes per nest). However, the high risk of desertion during laying suggests that it might be worth postponing field labour for some days to allow an undisturbed clutch completion and start of incubation, but this has to be weighted against the probability of new clutches being started during this waiting period. When working in the fields after plantation e.g. to fertilise and spray, the farmers cooperated extremely well to avoid damage to Lapwing nests. As a result, no nests with eggs were harmed by farming machines in 2005 and 2006.

3.2 Nest protection from predation

In 2005 and 2006, but not in 2004, Lapwing nests were protected from ground predators by electro-fences. In early April 2005, we set 3 electric wires around a field with 6 nests. This type of fence, successfully used e.g. in seabird islands (Brenning & Nehls 2006), did not stop ground predators in our study area in mixed farmland. It had to be replaced by an electric fence consisting of a netting used in pastures for sheep (cf. Method section). Alltogether, 38 of 56 nests were protected by an electro-fence netting. 15 were not protected at all and 3 merely with a fence of 3 wires mentioned above. This group of 21 nests was considered as unprotected in the following analyses.

Electro-fences were set around fields with active nests. As shown below, clutches laid in fields after the electric fence had been set were on average at least 30 m from the fence. We therefore suggest distances of 30 m between fence and nest, or more if possible. Under these preconditions, surrounding fields rather than individual nests is clearly the optimal option, as illustrated in the following example. On 20 April 2006 there were 6 active nests on some 5 ha of fallow land. Protecting each individual nest with a minimum distance of 30 m from the fence (i.e. a radius of 30 m) would have required some 200 m. Instead, we set a fence along the boundaries of the whole field with a total length of 900 m, less than an individual solution. The mean of the minimum distance of the six nests from the fence was 32 ± 23 m. One was only 7 m from the fence and was deserted following cultivation. Five of the six clutches hatched. After crop plantation, a total of 16 additional Lapwing clutches were laid inside the existing nest protection, at a mean minimum distance of 31 ± 18 m from the fence. The closest nest was just 5 m from the existing fence and all 16 clutches hatched. An additional advantage of fencing around fields is that no extra work has to be invested in fencing and there is no additional disturbance in the colony.

To test for the efficiency of the electric-fences against predation, we excluded 7 deserted and 1 flooded nests from the analysis, but included 1 additional unprotected nest which was overlooked until after hatching. 36 of the 38 clutches protected by an electric netting fence hatched (95 %, Tab. 2). In the two failing clutches, the eggs disappeared all at once during the day (presumably predation by Carrion Crows *Corvus corone*, Bellebaum & Boschert 2003) and over a number of days, respectively, as is typical for the Stoat *Mustela ereminea* (Teunissen et al. 2005). 7 of 18 unprotected clutches hatched (39 %), 11 disappeared almost certainly due to predation (61 %), among them 6 equipped with a thermologger recording the temperature below the nest cup. The temperature curve indicated that 4 clutches had been taken at night and 2 during the day (cf.

Tab. 2: Nest protection and hatching rate of 56 Lapwing clutches in the plain of Wauwil (Canton Lucerne, Switzerland) in 2004 - 2006. * predated unprotected controls include 3 clutches surrounded by an electro-fence of 3 vertical wires which did not keep out ground predators (cf. text).

Number of clutches	hatched		predated	
Electro-fence (netting)	36	(94.7 %)	2	(5.3 %)
Unprotected controls	7	(38.9 %)	11*	(61.1 %)
Total	43	(76.8 %)	13	(23.2 %)

Teunissen et al. 2005, Bellebaum & Boschert 2003, Eikhorst 2005). In conclusion, significantly more clutches were predated in unprotected nests ($\chi^2 = 21.4$, df = 1, p < 0.001).

3.3 Chick protection from predation

The chicks were able to cross the electro-fence without any difficulties, as the bottom line was not under power and the mesh diameter of 15 cm was large enough for the chicks to slip through. Nevertheless, since we set the fences around the fields with Lapwing nests rather than around individual nest sites, the families stayed within the fenced area of 1 - 3 ha in the first days or weeks after hatching. This was apparent in 2006, when 81 chicks were equipped with radio transmitters. They were located twice a day. Great effort was taken to find dead chicks to estimate daily survival rates and to obtain information on the causes of mortality.

Predation occurred mostly at night (73 %, Tab. 3) and outside the fences (87 %). At night, the young inside a fence were well protected from ground living predators. Of 46 chicks predated at night only one was taken inside an electro-fence ($\chi^2 = 17.0$, df = 1, Fisher's exact probability = 0.0002). By contrast, day-active predation inside the fence was almost as frequent as outside, suggesting that mainly avian predators were involved which are not kept outside by the electro-fences. Hence, the chicks benefited from nest protection, as long as they stayed within or returned to the fenced area.

4 Conclusions and perspectives

The aim of the project is to help the Lapwing to raise 0.8 chicks per pair and year to fledging, by minimising nest and chick losses due to predation and agriculture. In close cooperation with the farmers and by nest protection against predators, we were able to increase the hatching rate of clutches, which is usually some 40 %, to 54 % in 2005 and to as much as 82 % in 2006. In these two years, 3.1 and 3.4 chicks hatched per pair and season. In 2005, 17 breeding pairs raised an estimated 0.8 chicks per pair to fledging. In 2006, however, heavy predation on chicks more than counterbalanced the unusually high hatching success. As a result, merely 0.25 chicks per pair were raised to fledging.

Tab. 3. Time and location of predation of 63 radio-tagged Lapwing chicks in the plain of Wauwil (Canton Lucerne, Switzerland) in 2006.

Chick predation	within electro-fence		outside	
At night (73 %)	1	(2 %)	45	(71 %)
During day (27 %)	7	(11 %)	10	(16 %)

The study will continue to find out whether the high chick mortality in 2006 was an outlier. Moreover, we will test and improve soft and non-invasive methods to reduce chick predation and increase their survival to a rate allowing the population to produce sufficient offspring for stability. Finally, we will continue to monitor food availability for Lapwing chicks in farmland habitats and to study the effects of habitat management on surface dwelling invertebrates.

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