Chapter 2
Improving Extensive Green Roofs for Endangered Ground-Nesting Birds

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Abstract Cities are considered hotspots of biodiversity due to their high number of habitats such as ruderal areas, wastelands and masonry works hosting peculiar bio-coenoses. Urban biodiversity represents a challenging and paradigmatic case for contemporary ecology and nature conservation because a clear distinction between nature reserves and anthropogenic lands is becoming obsolete. In this context, extensive green roofs may represent suitable habitat for ground-nesting birds and wild plants, providing suitable conditions occur. In this paper, case studies are used to show how existing extensive green roofs can be improved in order to make them function as replacement habitat for endangered ground-nesting birds. The setup of an uneven topography, combined with hay spreading and seed sowing, significantly enhanced the reproductive performance of the northern lapwing (*Vanellus vanellus*), one of the most endangered ground-nesting birds in Switzerland.

Keywords Hay transfer · Seeds sowing · Green roof vegetation · Breeding success · Ecological compensation

The original version of the chapter has been revised. A correction to this chapter can be found at https://doi.org/10.1007/978-3-030-75929-2_28

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C. Catalano et al. (eds.), *Urban Services to Ecosystems*, Future City 17,
https://doi.org/10.1007/978-3-030-75929-2_2

2.1 Introduction

2.1.1 Extensive Green Roofs: An Unexpected Space for Wildlife

The rapid urban population growth and the consequent massive urbanisation are stressing our natural life-support system and negatively affecting global biodiversity. However, integrating conservation goals into urban planning might help to reduce this alarming trend and combat habitat loss and fragmentation (Müller and Werner 2010). Studies of species-habitat relationships of birds occurring in areas lost to urbanisation would inspire ecologically informed design. For example, Stagoll et al. (2010) showed the importance of keeping and implementing habitat structural complexity in urban and peri-urban green space (through tree regeneration, the creation of *stepping-stone* sites, etc.) to support woodland birds.

Green roofs can enhance urban biodiversity by providing suitable habitats for plants and animals, especially for those species which are able to cope with difficult conditions and mobile enough to reach the rooftops (Brenneisen 2003). However, the plant communities growing on green roofs are seldom planted or sown with the specific purpose of supporting biodiversity and plant assemblages and are rarely monitored to see how their composition, structure and functioning change over time (Catalano et al. 2016; Köhler 2006; Ksiazek-Mikenas et al. 2018; Thuring and Grant 2016).

In Switzerland, there are several directives and guidelines which support public administrations (cities, towns, cantons and the Confederation), planners, architects, construction engineers, landscape architects and horticulturalists, in the design and construction of biodiverse green roofs (Brenneisen 2013). Moreover, the building codes of several German-speaking cantons and municipalities explicitly require both new and retrofitted flat roofs to be green. This is for several reasons, as follows: they support and promote plant and animal diversity, reduce the effect of the urban heat island (UHI), regulate water flows, filter pollutants, save energy, represent an aesthetic improvement and increase the longevity of the waterproof layer of the roof by 40 years or more by protecting it (Berardi et al. 2014; Francis and Jensen 2017; Oberndorfer et al. 2007; Partridge and Clark 2018).

From an ecological perspective, urban green roofs can be viewed as green islands embedded in an urban matrix (Blank et al. 2017). In other words, they provide life cycle opportunities for many species and offer therefore a new chance for nature to improve biological diversity in urban areas.

Research carried out by the Research Group of Urban Ecology of the Zurich University of Applied Science (ZHAW) has focused over the last 20 years on the ecological value of green roofs using arthropods as bioindicators (Brenneisen 2003; Pétremand et al. 2018) but also on the identification of key design features which could maximise the ecological value of green roofs (MacIvor et al. 2018). These studies were the origin to what is now more widely known as *biodiverse green roofs*, characterised by an uneven topography, the use of different substrate types (including topsoil), the use of different mixtures of local seeds or hay spreading/transfer and the creation of additional microhabitats, e.g. deadwood piles, stony areas, sand or gravel bands (Brenneisen 2008; Catalano et al. 2018).

2.1.2 The Role of Vegetation Patterns on Green Roofs

The plant assemblages of extensive green roofs must be able to withstand water shortages; for this reason, plant species occurring in naturally dry biomes like ephemeral and ruderal habitats, dry grasslands and the seasonally dry margins of rivers may match the ecological conditions of most extensive green roofs (Catalano et al. 2013; Dunnett 2015; Lundholm 2006; Thuring and Grant 2016; Van Mechelen et al. 2013).

As suggested by several authors, it is possible to create a fairly diverse flora on extensive green roofs in inner cities and peri-urban zones as well as in rural areas (Lundholm et al. 2010). Plant diversity can be even higher if various microclimates (especially sunny and shady areas) are created, initial planting or seeding is enhanced and a minimal amount of irrigation and maintenance are provided during establishment (Buckland-Nicks et al. 2016; Lundholm 2015). The water retention capacity of the substrate affects the speed and the final result of roof vegetation dynamics: the higher the retention, the denser the vegetation (Nagase and Dunnett 2012). Of course, rainfall patterns must also be considered. For example, 3–5 years after planting, a roof subject to average Swiss rainfall conditions with a ≥10-cm-thick substrate is likely to support a meadow-like plant community (Nagase and Dunnett 2013). Also, the variability of substrate thickness, particle size and soil type and the percentage of organic matter may strongly influence plant diversity (Chenot et al. 2017; Dunnett et al. 2008).

2.1.3 The Northern Lapwing: An Emblematic Endangered Ground-Nesting Bird

Globally, more than 700 vertebrate animals are confirmed or presumed to have become extinct since 1500, and the same has happened to around 600 vascular plant species. This confirms that humans have increased the global rate of species extinction by at least tens to hundreds of times faster than before they started to impact planetary ecosystems (Díaz et al. 2019).

The northern lapwing (*Vanellus vanellus*, Fig. 2.1) is a wader bird of the plover family. Native to temperate Eurasia, it is highly migratory over most of its range. It sometimes winters further south in northern Africa and India, whilst lowland breeders in the westernmost areas of Europe are resident (Kooiker and Buckow 1997).

Fig. 2.1 Male Northern Lapwing (*Vanellus vanellus*), looking out for predators. (Photo credit: Zurich University of Applied Sciences 2010)

V. vanellus breeds almost exclusively on crop fields and in other low-growing and/or regularly mown or grazed plant communities, such as wet meadows. The first clutch (three to four eggs, Fig. 2.2) is laid in a scrape in the ground. If the first brood is unsuccessful, the adult birds can lay up to seven replacement clutches on a new site or on the same site but several metres away from the first nest. The chicks hatch out after 26–27 days of brooding (Fig. 2.3); they leave the nest early, and after 42 days they are able to fly away. From day one, when they leave the nest, they have to find their food and water by themselves. Food mainly consists of average-sized and not too mobile arthropods, mostly spiders and insects (larvae, nymphs and adults) (https://www.vogelwarte.ch/de/voegel/voegel-der-schweiz/kiebitz, last accessed: 29.05.2020). However, these invertebrate species have been reduced by agricultural intensification (Kooiker and Buckow 1997).

The northern lapwing experienced a significant increase in numbers when it colonised central Switzerland between the 1950s and 1970s. According to the data issuing from last available census (2013–2016), 140–180 pairs of *V. vanellus* currently occur in Switzerland (Knaus et al. 2018).

Following IUCN criteria, *V. vanellus* is currently listed as a critically endangered (CR) bird species in the Swiss Red List (https://www.vogelwarte.ch/de/voegel/voegel-der-schweiz/kiebitz, last accessed: 29.05.2020), mainly because of the loss of its primary habitat, i.e. wet meadows, which were drained for agricultural purposes. This led to a rapid decline in its population, even though the species has adapted to colonise new habitats by breeding in crop fields and even on green roofs. For this reason, lapwing is a high-priority species according to several nature conservation European directives and is considered 'vulnerable' (BirdLife International 2015) and *Spec 1*, i.e. European species of global conservation concern (BirdLife International 2017), thus requiring urgent conservation measures.

Fig. 2.2 A nest with eggs of the Northern Lapwing on an extensive green roof. (Photo credit: Nathalie Baumann 2009)

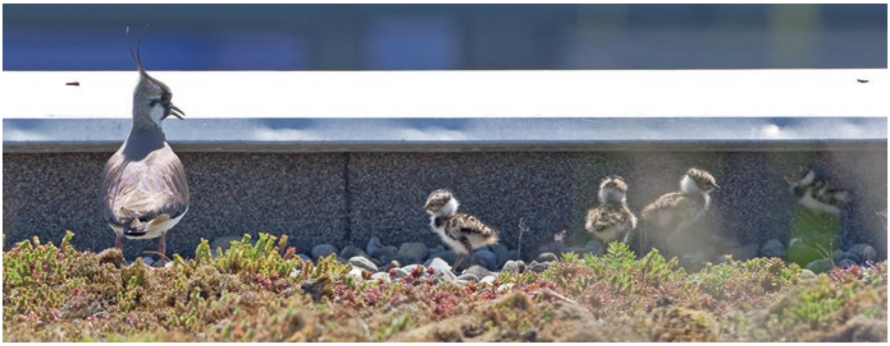

Fig. 2.3 Female Northern Lapwing (*Vanellus vanellus*), with chicks on the extensive green roof in Steinhausen (Hotz AG) with *Sedum* spp. in foreground. (Photo credit: Zurich University of Applied Sciences 2010)

Unfortunately, the intensification of agriculture and the increase of urban sprawl have led to further declines. However, following observations of northern lapwings using flat green roofs as breeding sites (Baumann 2006), there have been several initiatives in Switzerland to encourage ground-nesting birds, for instance by creating suitable replacement habitats on rooftops (Brenneisen et al. 2010).

2.1.4 Aims of the Research

In this work, we review and discuss the results obtained in a project that ran from 2006 to 2010, which had the aim of increasing the reproductive success (from egg-laying to fledging) of the northern lapwing on green flat roofs in the central and eastern Swiss Plateau (Baumann 2006). In particular, the project considered whether or not there was a correlation between the increase of plant species diversity, plant biomass and substrate thickness and the habitat use (behaviour) of the young and adult individuals of the northern lapwing. However, what we present is not a replicated and controlled investigation, but an observational study, like the research carried on in the UK on brown roofs (Bates et al. 2013).

2.2 Material and Methods

The nine green roofs included in the study were located in the suburban and industrial areas of three Swiss cantons: Bern (Schönbühl and Moosseedorf), Zug (Steinhausen, Rotkreuz and Hünenberg) and Lucerne (Emmen) (Table 2.1).

2.2.1 Roof Shaping and Environmental Improvements

The spatial heterogeneity of five out of the six roofs was changed by adding substrate and shaping topography (eventually creating a patchwork mosaic of open and densely vegetated areas; on all of the nine roofs, small shallow containers of water were added (Table 2.2)). The original substrate of four roofs was amended by adding a 4-cm layer of local recycled commercial substrate for extensive green roofs (blend of bark compost, crushed expanded clay and lava-pumice); on one of the other roofs, 4 cm of topsoil (and seed bank) was added from a nearby organic farm (Figs. 2.4 and 2.5).

Three methods were used to increase the species richness and the plant biomass on the roofs, as follows: laying a 2-cm-thick turf, sowing a commercial mixture of wild seeds (Swiss ecotype) for green roofs and distributing overlapping layers of

Table 2.1 Green roof descriptions. The substrate type refers to that existing before intervention

Name of the roof	City	Coordinates	Area [m^2]	YGRC	YGRI	Type of substrate
Hotz AG	Steinhausen	47°11’25.0”N 8°28’57.3”E	240	n.a.	2007	Lava-pumice
3M/Sidler Transport AG	Rotkreuz	47°09’07.9”N 8°25’58.3”E	11’000	c. 1968	2007	Gravel
Migros Aare (Shoppyland)	Schönbühl	47°00’57.3”N 7°29’37.7”E	8’000	c. 2003	2007	Lava-pumice
OBI (Shopping centre)	Moosseedorf	47°00’56.3”N 7°29’24.6”E	9’000	2007	2009	Crushed brick and compost
ALSO I	Emmen	47°04’55.6”N 8°18’20.3”E	2’100	n.a.	2009	Lava-pumice
ALSO II	Emmen	47°04’54.5”N 8°18’18.7”E	4’200	n.a.	2009	Lava-pumice
ALSO III	Emmen	47°04’57.8”N 8°18’16.7”E	3’600	2007	2009	Crushed brick and compost
Bösch I	Hünenberg	47°09’43.7”N 8°26’10.8”E	1’500	n.a.	2009	Lava-pumice
Bösch II	Hünenberg	47°09’46.0”N 8°26’06.7”E	1’400	n.a.	2009	Lava-pumice

n.a. data not available, *YGRC* year of green roof construction, *YGRI* year of green roof improvement

fresh and/or dry hay sourced from nearby dry grasslands. These techniques were applied separately or combined (Table 2.2).

After hatching, the chicks can survive by feeding on the yolk remains just for 3–4 days after their birth; then they need to find enough water and food on the roof. Thus, in 2008, to prevent the stress due to many consecutive days without rainfall and daily temperatures above 25 °C for the nesting birds and chicks, a rainwater irrigation system and two 9 m^2 shallow water containers were installed on each roof. Water availability on the roofs was increased through irrigation to reduce plant stress, to support the survival of soil arthropod fauna and to provide water for both adult and chick lapwings but also, importantly, to create the right conditions to encourage insects, specifically chironomids and other dipterans – an important food source for nidifugous chicks.

2.2.2 Vegetation Surveys

Before the interventions, the vegetation was surveyed in order to make a census of the lichens, mosses and vascular plants already present on each roof. Both the floristic composition and the cover of the vegetation on the roofs were regularly monitored and qualitatively assessed over 4 years (2006–2010).

Table 2.2 Interventions on the green roofs and basic information on the nesting and fledging activity of the northern lapwing and on the distance of the roofs from the nearby nesting and foraging sites

Name of the roof	Green roof interventions	FN	FF	MDNS (km)	MDFS (km)
Hotz AG	Substrate/morphology: 4-cm-thick extensive green roof substrate added to form several patches	2006	2009	c. 1	0.1
	Plants: hay transfer (4 cm)				
	Water supply: two temporary shallow pools				
3M/Sidler Transport AG	Substrate/morphology: 11 circles and 6 half-circle patches of 4-cm-thick extensive green roof substrate added on the top of the gravely substrate	2006	none	none	0.1
	Plants: turfs and hay mulch (4 cm)				
	Water supply: two temporary shallow pools				
Migros Aare (Shoppyland)	Substrate/morphology: 4-cm-thick extensive green roof substrate added on two big surfaces	2006	none	c. 0.8	0.3
	Plants: commercial seed mixture (Swiss ecotypes);				
	Water supply: two temporary shallow pools				
OBI (Shopping centre)	Substrate/morphology: topsoil transfer from an organic farmland added on a single large surface	2008	2010	0.8	<0.2
	Plants: fresh cut hay mulch from a semi-dry grassland + topsoil seed bank				
	Water supply: two temporary shallow pools				
ALSO I	Water supply: two temporary shallow pools	2008	none	c. 1	0.1
ALSO II	Substrate/morphology: some mounds of expandable slate added on the top of the lava-pumice substrate	2008	2008	c. 1	0.1
	Plants: different plugs planted on each of the abovementioned mounds				
	Water supply: two temporary shallow pools				
ALSO III	Substrate/morphology: 4-cm-thick extensive green roof substrate added on several patches to form mounds	2010	none	c. 1	0.1
	Plants: hay mulch				
	Water supply: two temporary pools				
Bösch I	None	2008	none	none	<0.1
Bösch II	Substrate/morphology: some structural elements, like wooden boxes, where placed	2009	none	none	<0.1
	Water supply: two temporary shallow pools				

FN year of the first nesting event, *FF* year of the first fledging event, *MDNS* minimum distance from the nearest primary nesting sites, *MDFS* minimum distance from the nearest foraging sites

Fig. 2.4 Setup of uneven topography on a green roof. In order to enhance plant and animal (e.g. arthropod) biomass, the environmental conditions of some of the selected roofs were improved by adding a layer 8–16 mm-thick of expanded slate on the pre-existing substrate (30 mm-thick layer of pumice lava and clay) hosting sparse 'moss and *Sedum* spp.' vegetation. (Photo credit: Nathalie Baumann 2009)

Fig. 2.5 One of the six roofs with a remarkable increase of plant cover following from both sowing and planting carried out between 2008 and 2010. For the first time, in 2010 two young Northern Lapwings, born from two different nesting pairs, fledged from this roof and migrated south. (Photo credit: Nathalie Baumann 2010)

2.2.3 Arthropod Monitoring

The arthropods occurring on two roofs were sampled with ten pitfall traps (plastic cups set into the substrate containing a solution of soap, water and salt) on each roof once the chicks were observed fledging. Sampling was undertaken in 2007 (May–June) on the roof located in Steinhausen and in 2008 (June–July) on one of the roofs located in Emmen. The traps were emptied every two weeks; then the arthropods were counted and sorted to class level, with Carabidae identified to species level (Chinery 1984).

2.2.4 Bird Monitoring

From 2005 to 2010, the use of the roofs by breeding birds was monitored from the end of March until mid-July. From the time of arrival of the breeding pairs, observations were made weekly for 3 h at the same time of the day with binoculars and telescopes. During the breeding period, observations were made three times per week, and when the chicks hatched, the frequency was further increased to 4 h per day at each site. Observations continued until the chicks died, disappeared or fledged. The replacement broods were assessed using the same method. Many parameters concerning bird occurrence on the roofs were regularly monitored. Foraging behaviour, movement patterns, habitat use and other behavioural activities were recorded, and the results of roof enhancements were taken into account and correlated with bird breeding performance. In order to avoid disturbing the birds, observations were mostly carried out from adjacent buildings with a good vantage point. The high fidelity of northern lapwings to their nesting sites facilitated the planning of field surveys, with a focus on the most successful roofs.

2.3 Results and Discussion

2.3.1 Effects of Roof Enhancements and Plant Species Transfer on Vegetation and Invertebrates

Before the interventions, the roofs supported various vegetation types, which ranged from mosses and lichens on gravel to a more or less continuous cover of mosses and *Sedum* spp. on very thin and purely mineral substrates, made of a mixture of lava-pumice and expanded clay with almost no water retention. The most species-rich roofs supported *Dianthus carthusianorum* and grasses, including *Arrhenatherum elatius*, *Holcus lanatus* and *Lolium perenne*.

Our results showed that by using different plant establishment methods or applying them on different parts on the same roof by shaping and varying the topography and the substrate used, a mosaic-like patchwork of vegetation was created. Moreover, the overall length of the flowering season was extended from Spring to Autumn. Since the roofs were not irrigated, plants that can withstand dry periods were favoured.

Plants were able to establish themselves from hay transfer quickly and successfully, probably because the hay mulch prevented the seeds from being blown away or drying out. Consequently, very high vegetation cover rates (90–100%) were recorded on all the studied roofs during the first 2 years after the hay was transferred onto the roof. Additionally, the hay mulch, in comparison with the other plant species transfer techniques (seeding and turfing), significantly improved the seed germination rate, the retention of both rainwater and the maintenance of humidity during the dry season.

Generally, roofs with low plant diversity host very few insects and spiders, which are usually attracted by flowers (Brenneisen 2003). In contrast, the use of hay transfer accelerated the colonisation of arthropods, which represent the main food resource for nesting birds, especially for the chicks. Hence, the increase of both plant species richness and cover facilitated the creation of a rather complex food web, improving the feeding opportunities and the survival rate of young chicks (Partridge and Clark 2018).

Considering the low number of arthropods usually found on green roofs (Schindler et al. 2011), the total amount of spider and insect species recorded after the interventions was remarkable and probably related to the vegetation improvements, which in turn induced a longer flowering season (Table. 2.3). The medium-sized (>5 mm large) arthropods probably represent the best prey for chicks because they provide a higher energy intake.

Table 2.3 Summary of the total and daily numbers of arthropods (spiders, beetles and other insects) collected on two roofs during two different sampling campaigns (from Brenneisen et al. 2010, modified). Ind = individuals

Arthropods	Hotz AG (May–June 2007)	ALSO II (June–July 2008)
Spiders		
Tot. ind.	94	648
Tot. ind./day	0.27	2.09
Tot. ind. >5 mm	52	165
Tot. ind. >5 mm/day	0.15	0.63
Beetles		
Tot. ind.	76	65
Tot. ind./day	0.22	0.22
Tot. ind. >5 mm	28	32
Tot. ind. >5 mm/day	0.08	0.09
Other Insects (e.g. cicads, ants, etc.)		
Tot. ind.	113	150
Tot. ind./day	0.33	0.48
Tot. ind. >5 mm	27	50
Tot. ind. >5 mm/day	0.08	0.16

Table 2.4 Comparison of the total values of some proxies of the reproductive success of northern lapwing on the studied roofs (2005–2010)

Name of the building	City	NPrs	NClt	NRClt	NChk	NFChk
Hotz AG	Steinhausen	10	11	8	38	1
3M/Sidler Transport AG	Rotkreuz	15	18	9	63	0
Migros Aare (Shoppyland)	Schönbühl	6	7	0	16	0
OBI (Shopping Centre)	Moosseedorf	3	6	4	14	3
ALSO I	Emmen	3	5	2	15	0
ALSO II	Emmen	2	2	2	11	6
ALSO III	Emmen	1	1	0	2	0
Bösch I	Hünenberg	2	4	2	7	0
Bösch II	Hünenberg	1	2	2	3	0

NPrs nb. of nesting pairs, *NClt* nb. of clutches, *NRClt* nb. of replacement clutches, *NChk* nb. of chicks, *NFChk* nb. of fledged chicks

Fig. 2.6 Female Northern Lapwing (*Vanellus vanellus*) nesting on *Sedum* sp. tussock surrounded by dense moss cover on an extensive roof which had plant cover improved after the first records of nests in order to increase breeding and fledging success. (Photo credit: Nathalie Baumann 2006)

2.3.2 Trends of the Northern Lapwing Reproductive Performance on Green Roofs

The proxies reported in Table 2.4 provide some clues to the reproductive performance of *V. vanellus* on the nine green roofs monitored between 2005 and 2010. Northern lapwings preferred to lay their eggs on a nest built on low-growing plants, instead of moss, gravel or topsoil (Fig. 2.6). Thanks to the improvement of the green roofs and the sharp increase in vegetation cover, a sudden increase of chicks was recorded on many roofs (Fig. 2.7); unfortunately, most of these chicks did not survive, probably because they did not find enough food or water or simply fell off the roof. This could explain the sharp contrast between the numbers of hatchlings and fledglings on the Holz AG (240 m^2) and 3M (11000 m^2) roofs as well as the high

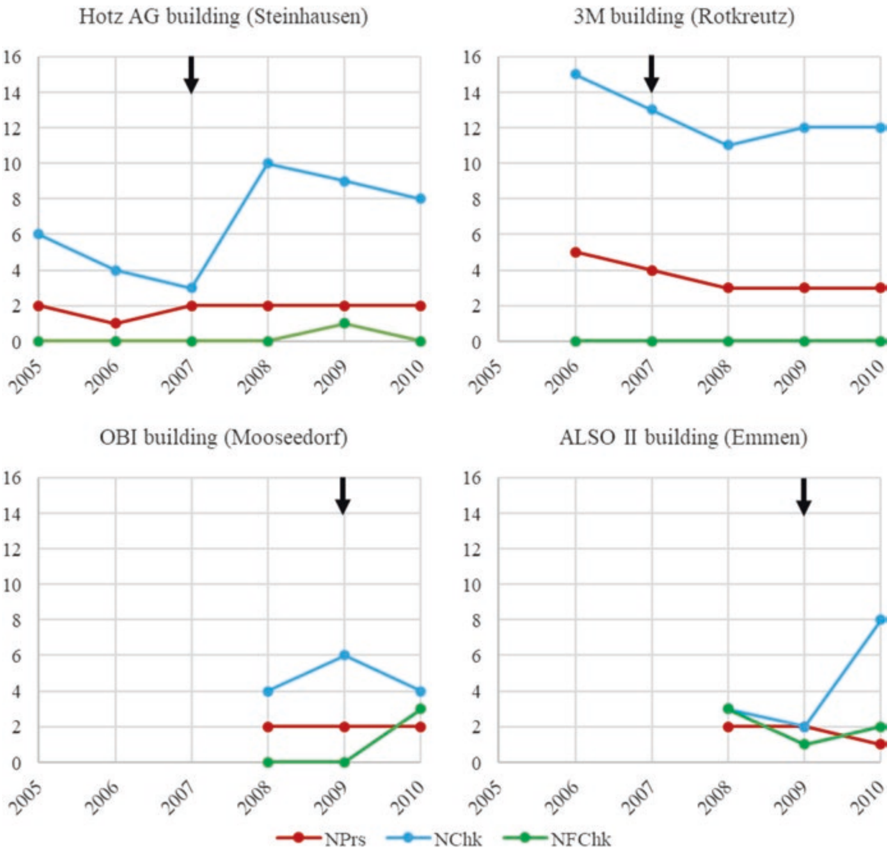

Fig. 2.7 Trend of several indicators of the reproductive performance of northern lapwings on four of the 9 roofs improved and monitored. *NPrs* number of nesting pairs, *NChk* number of chicks, *NFChk* number of fledged chicks. The black arrow indicates the year of the intervention on each roof

number of replacement clutches. These last two cases suggest that both the roof size and the absence of a parapet to prevent chicks from falling off the roof might have compromised the final success of the intervention (in terms of the total number of fledglings).

Nevertheless, the lessons (from failures) learned from the roofs in 2005 led to technical solutions for the problems by 2009. Ultimately, the two most successful roofs, on the OBI and the ALSO II buildings, were where the first pairs began nesting in 2008, with a total of five chicks being able to fledge in 2010 (Fig. 2.7). Moreover, after the interventions, the chicks recorded on three out the nine roofs experienced an increase in terms of days survived and a decrease on four roofs and remained steady on the other two (Table 2.5).

The improvement of chick performance appears to be linked to the increase of plant species richness and the vegetation cover. Plants attracted spiders and a variety

Table 2.5 Average age (in days) of the chicks before and after roof improvement and success of the improvement in terms of average age (days) of the chicks

	Before improvement	After improvement	
Name of the roof	Chicks age in days (year of the survey)	Chicks age in days (year of the survey)	Success
Hotz AG	4 (2006)	10 (2008)	↑
3M/Sidler Transport AG	4 (2006)	13 (2008)	↑
Migros Aare (Shoppyland)	4 (2006)	3 (2008)	↓
OBI (Shopping centre)	4 (2008)	45 (2010)	↑
ALSO I	6 (2008)	4 (2010)	↓
ALSO II	42 (2008)	42 (2010)	=
ALSO III	8 (2009)	0 (2010)	↓
Bösch I	4 (2008)	0 (2010)	↓
Bösch II	0 (2009)	0 (2010)	=

of insects, with many spending their entire life cycle (including larval stages) on the roofs, constituting the basic food resource for the young lapwings, allowing them to fledge 40 days after hatching.

2.4 Conclusions

Our study shows that it is currently possible and affordable to design and build a green roof of high ecological value providing several ecosystem services. Such green roofs may represent an effective ecological compensation measure, being able to host fully functioning near-natural habitats supporting a diverse flora and fauna. By using a mixture of native annual and perennial herbs, the plant species assemblages created provide an almost continuous vegetation cover and flowering activity from Spring to Autumn, thus combining desirable aesthetic results with a significant increase in animal (arthropods and birds) diversity (Fernández-Cañero and González-Redondo 2010).

In further research, the technical characteristics of the green roofs, including their size and isolation/distance from near-natural habitats (Partridge and Clark 2018), as well as the complex interactions involving the diverse living components of the ecosystems they host, should be more carefully recorded. For example, in order to better fit with the ecological purposes of the intervention, an accurate survey of the initial substrate characteristics should be done. In some cases, data-loggers should be placed on the roofs in order to quantify the daily, monthly and annual variation of several physical parameters such as soil and air humidity and temperature. Moreover, when plant species are transferred by hay and seeds onto green roofs, the local physical features such as aspect, climate (e.g. seasonal and daily thermal range, rainfall seasonality, etc.), the floristic composition of the donor grasslands/meadows, etc., should also be taken into account (Kiehl 2010).

Finally, rigorous, standardised and replicable methods should be adopted to carry out regular monitoring activities, too (Fernández-Cañero and González-Redondo 2010). Vegetation surveys should be carried out *before* soil and vegetation improvements and be repeated on a regular base (i.e. once a year during the first 3–5 years and every 5 years later on) on standard-sized permanent plots (geo-referenced) in order to obtain reliable and verifiable data on the ongoing trends.

Acknowledgements The Open Access of this chapter was funded by the Zurich University of Applied Sciences (ZHAW). The research project presented in this paper was partially funded by the Swiss Federal Office for the Environment (FOEN): *Entwicklung eines neuen Systems von Dachbegrünungen, die die Funktion von Ersatzhabitaten für bodenbrütende Vögel erfüllen (Dachbegrünung für Vögel)* [Improvement of existing green roofs to fulfil the function of substitute habitats for ground-nesting birds (green roofs for birds)], Project Number UTF 189.19.06.

Author Contributions N.B. suggested the topic, provided the raw data and the images, and prepared the first draft of the manuscript; C.C. and S.P. carried out data interpretation, prepared the tables, revised the manuscript, and adapted the final version according to the remarks and suggestions of the reviewers. S.B. supervised the 2006–2010 project and was responsible for the original data analysis. All authors revised the final version of the manuscript.

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