Towards integrated population monitoring based on the fieldwork of volunteer ringers: productivity, survival and population change of Tawny Owls Strix aluco and Ural Owls Strix uralensis in Finland

Saurola, Pertti Lauri

2018

Saurola , P L & Francis , C 2018 , ' Towards integrated population monitoring based on the fieldwork of volunteer ringers: productivity, survival and population change of Tawny Owls Strix aluco and Ural Owls Strix uralensis in Finland ' , Bird Study , vol. 65 , no. supplement 1 , pp. S63-S76 . https://doi.org/10.1080/00063657.2018.1481364

http://hdl.handle.net/10138/303622
https://doi.org/10.1080/00063657.2018.1481364

. (! & % ! $ $! # % ,!& " * (/ * 0 % & $ + 0 & 0 0! ! $ $! +"! % * .!((& ! 2 ! (& 3 !

! ! 4 5"! & 3 ! + &

. + " & ! +
! " # $ # % & % '(% %
') *) (+ '(,-& (,. /,(
0)1&2 3 ,.,-/2 2 4 .,4

. / " & ! +

! "# "$ %&' (!) "# &# & 2 &
*+ , (-) &))$# . /)&0
1

3 "($) 0# 4 &)# 0# 5 6

7 6 8 () 9)) 8 &) 0# 7 6 0 &) 0#

/ ## (. 8 & & ')00)& 0)& " ' &)
666)& ' &# & 0 ( )0 & 4 &)#%&' () &:4 &)#8 ; "

BIRD STUDY
2018, VOL. 65, NO. S1, S63–S76
https://doi.org/10.1080/00063657.2018.1481364

Towards integrated population monitoring based on the fieldwork of volunteer ringers: productivity, survival and population change of Tawny Owls Strix aluco and Ural Owls Strix uralensis in Finland

Pertti Saurola[a] and Charles Francis[b]

[a]Finnish Museum of Natural History, University of Helsinki, Helsinki, Finland; [b]Canadian Wildlife Service, Environment and Climate Change Canada, National Wildlife Research Centre, Ottawa, Ontario, Canada

ABSTRACT

Capsule: Monitoring of demographic parameters by volunteer ringers provides insight into the factors driving population changes in owls.

Aims: To assess the value of national ringing, recapture and recovery data from volunteers to understand population dynamics.

Methods: We analysed 49 years of ringing, recapture and recovery data from throughout Finland for Tawny Owls Strix aluco and Ural Owls Strix uralensis and compared them with annual population and productivity indices from other volunteer-based surveys.

Results: Volunteer-based ringing data show that all aspects of the demography of Ural and Tawny Owls fluctuate dramatically in relation to an approximately three-year cycle of voles. When voles are abundant, a high proportion of owls breed and many young are produced; however, few of those young survive because vole populations crash the following winter. Survival of adults fluctuates less than that of young, suggesting that adults are better able to survive on alternative prey. In 2005, when vole populations remained high two years in row, many young were produced and survived, leading to a peak in owl breeding populations four years later at the top of the next vole cycle. This was immediately followed by a crash in populations suggesting a density-dependent interaction with vole abundance. Changing climate could affect owls both directly, by influencing winter survival, as well as indirectly through impacting prey availability.

Conclusion: Encouraging similar, volunteer-based national-scale ringing efforts for owls elsewhere in Europe, especially for Tawny Owls which occur in most countries, would be a cost-effective way to understand how factors such as changing prey availability, climate and habitat availability are influencing the population levels of this and other raptors.

ARTICLE HISTORY
Received 30 June 2017
Accepted 22 February 2018

Well-planned long-term ecological monitoring programmes provide the foundation for effective conservation and management of our natural world (Baillie 1990). Humans have an enormous capacity to change the physical, chemical and biological environment of the Earth. Many human activities have negative effects on animal and plant populations. Short-sighted focus on immediate economic and social gain often leads to longer term negative impacts not only on ecosystems, but also on the interests of future human generations. Effective ecological monitoring programmes can be used to identify potential concerns before they become irreversible and also to provide information necessary to identify potential approaches to addressing concerns. Reliable information on changes in animal and plant populations is also important to evaluate the effectiveness of conservation and management actions, and adjust them as necessary (Williams 2011).

Monitoring of diurnal and nocturnal raptors can be used to provide information on the overall state of the environment, as well as directly benefiting conservation of the species concerned (Newton 1979). Because raptors are at the top of their food chains, changes in their numbers, productivity and survival may reflect changes in the ecosystem that also affect many other species including humans (Sergio et al. 2006). For example, dramatic declines in populations of several raptor species including Peregrine Falcons Falco peregrinus and Ospreys Pandion haliaetus provided strong evidence of the serious negative impacts of organic pesticides such as DDT (Dichlorodiphenyltrichloroethane) on ecosystems (Newton 1979, Risebrough 1986), which motivated efforts to control their use. Consequently, raptors have

CONTACT Pertti Saurola pertti.saurola@helsinki. Finnish Museum of Natural History, University of Helsinki, P.O. Box 17, Helsinki FI–00014, Finland

been proposed for use as environmental sentinels (Helander et al. 2008). In addition, many raptors have suffered from other environmental contaminants, habitat destruction, persecution and other negative impacts caused by humans (Newton 1979), with a result that many species have become endangered.

While many monitoring programmes focus on trends in population size, monitoring of demographic parameters such as survival and productivity can provide information on the underlying causes of population change (Baillie 1990, 1995, Baillie & Schaub 2009, Robinson et al. 2014). Among raptors, one of the most intensive studies has been the 30-year study in the northwestern United States of the demography of the Northern Spotted Owl Strix occidentalis. This very intensive (and hence expensive) study involved monitoring a range of demographic parameters with a large team of professional researchers, providing detailed information on the causes of population change to inform conservation planning for this threatened species (Forsman et al. 2011).

In this paper, we show how data collected by volunteers at a national scale can provide similar insight into raptor population dynamics. Many ecological monitoring programmes depend heavily upon the efforts of volunteers, often under the guidance of a government programme. For example, the North American Breeding Bird Survey, which now provides the foundation for much landbird conservation planning in North America, depends heavily upon volunteer field surveyors (Downes et al. 2016). Similarly, many programmes run by the British Trust for Ornithology and other programmes elsewhere in Europe depend upon the efforts of volunteers (Baillie 1995, Baillie & Schaub 2009, Vrezec et al. 2012, Robinson et al. 2014, Derlink et al. 2018).

In Finland, an exceptional network of volunteers has developed to monitor a range of demographic parameters for both diurnal and raptor species for more than half a century. Pioneering fieldwork in the early 1950s on both diurnal and nocturnal raptors by a well-known nature philosopher and voluntary ringer, Pentti Linkola, provided the stimulus and motivation for extensive voluntary work carried out by bird ringers and other bird watchers interested in raptors (Linkola & Myllymäki 1969). Since the early 1970s, the Finnish Ringing Centre has encouraged ringers to ring nestlings and to ring or recapture breeding adults at the nests of raptors for analysing annual survival and dispersal (Saurola 1987a). In 1982, a raptor monitoring project, the Raptor Grid, was started to obtain information from volunteer ringers on annual fluctuations and long-term changes in breeding populations of diurnal and nocturnal birds of prey, based on 10 × 10 km study plots (Saurola 1985). Further, in 1986 a Raptor Questionnaire project was started to obtain additional information on numbers of occupied territories, active nests, clutch and brood sizes (Saurola 2006).

This tremendous volunteer effort has been complemented by research and analyses by university and government researchers. Following Linkola's stimulus, long-term local population studies were started by a series of professional researchers, including many on two species of owls: the Tawny Owl Strix aluco and Ural Owl Strix uralensis. These included local studies starting in the 1960s on both species (Saurola 1987b, 1989); further studies started in the 1970s on the Ural Owl (Pietiäinen et. al. 1984, 1986, Pietiäinen 1988, Brommer et al. 2002, Pavón-Jordán et al. 2013) and Tawny Owl (Karell et al. 2009); and more in the early 1990s on the Tawny Owl (Solonen 2005, Solonen & af Ursin 2008). In addition, a number of studies have examined population change and demographic parameters of both Tawny and Ural Owls at a national scale using the large-scale databases of the Finnish Ringing Centre (Francis & Saurola 2002, 2004, 2009, Saurola & Francis 2004, Saurola 2007, 2008, 2009, 2012, Lehikoinen et al. 2011; see also Sundell et al. 2004).

These combined efforts have produced an exceptional database that can be used to estimate the full range of demographic parameters of these two species of owls, far exceeding data available elsewhere in Europe. In a recent review of raptor monitoring in Europe, Derlink et al. (2018) found that the breeding performance of the Tawny Owl has been monitored regularly (at least 10 years) in 12 of the 41 European countries (32%) where it breeds. Similarly, the breeding performance of the Ural Owl has been monitored in 8 of the 22 European countries (36%) where it breeds. In contrast, Newton et al. (2016) found in a recent review only four published studies on survival estimates of the Tawny Owl (three of which were from Finland) and one of the Ural Owl (also from Finland).

The objectives of our paper are (1) to provide details on the tremendous amount of demographic information that can be gained on raptors by combining the extensive field effort of dedicated amateur and professional bird-ringers with modern statistical analytical methods, using the Tawny Owl and Ural Owl as examples; (2) to encourage the national Ringing Schemes to use the 'free' and enthusiastic power of volunteer ringers for monitoring not only population size, but also demographic parameters of raptor populations elsewhere in Europe; and (3) to propose a Pan-European project for monitoring the demography of one or both of these species of owls. Expanding the geographic coverage of this project to cover much of the natural range of these species would be particularly valuable for assessing the impacts of new and emerging threats such as climate change.

Methods

Study species

The Tawny Owl and Ural Owl are both Palearctic medium-sized generalist predators. Although they can feed on a wide range of prey, for successful breeding both of them are highly dependent on microtine rodent populations, which tend to fluctuate more or less cyclically (Linkola & Myllymäki 1969). In Finland the most important species are the Field Vole Microtus agrestis, Bank Vole Myodes glareolus and Water Vole Arvicola terrestris (Saurola 1995). The Tawny Owl and Ural Owl are year-round residents and short-distance dispersers; about 90% of fledglings that were recaptured as breeders were found less than 50 km from their natal nest, and about 90% of breeders stay all their lives in the same territory (Saurola 1995, Saurola & Francis 2004).

Study area

The study area samples most of the breeding range of both Tawny and Ural Owls in Finland (Valkama et al. 2014). The Tawny Owl is a relatively recent arrival in Finland from the south, first recorded in 1875, with the first nest found a couple of years later (Saurola 1995). The present distribution of the Tawny Owl covers the southern quarter of Finland. The Ural Owl breeds throughout the mainland of the southern half of Finland but is rare along the southern and southwestern coastal areas (Saurola 1995). The nest-box programmes of ringers cover much of the Finnish distribution of both species (Saurola & Francis 2004).

Raptor grid

The Raptor Grid was started in 1982 by the Finnish Ringing Centre for monitoring all species of both diurnal and nocturnal raptors, with an emphasis on widespread and common species; prior to this, only selected endangered species were monitored (Saurola 2008). For the Raptor Grid, volunteer ringers devoted to raptors were asked to join in teams and select a 10 × 10 km study plot based on the Finnish National Grid. Within each plot, each year they try to locate all occupied territories of raptors and find as many active nests as possible (Saurola 1985). This provides information on the numbers of territorial pairs in the population, as well as the proportion of those that attempt to breed.

To accomplish this, volunteers: (1) listen for territorial hoots of owls; (2) watch for aerial displays of buzzards and hawks; (3) search for nests; (4) listen for fledged broods and (5) report all of their data in September to the Ringing Centre (Saurola 1985). Data reported include information on the numbers of observers and hours of effort expended in addition to the total numbers of birds, nests and broods detected. Most participants also provide information on the precise location of each nest, along with a nest record card providing details on the nest. To achieve fairly thorough coverage of all raptor species, about 300–500 person-hours/study plot/breeding season are needed in southern Finland with its mixture of boreal forest, agricultural land and lakes. Volunteers are encouraged to keep the effort within a study plot more or less the same from year to year; it is not necessary (or possible for some species) to have enough effort to detect every territorial raptor each year within each plot, but consistency over time in the amount of effort and spatial coverage is important.

The number of Raptor Grid study plots surveyed during 1982–2016 averaged 130 per year with, most recently, 142 in 2015 and 123 in 2016 (Meller et al. 2017).

Raptor questionnaire

Since 1986, additional information on productivity has been requested from bird ringers using the Raptor Questionnaire (Saurola 2006). Information requested includes: (1) the total numbers of potential territories and nests checked, including nest boxes and natural cavities for owls; (2) the total number of occupied territories found (including those where birds did not breed) as well as the number of active nests and (3) the productivity of occupied nests, in terms of clutch and brood sizes. At almost all of these nests, the young are also ringed. This information is collected both from Raptor Grid study plots, as well as from additional areas where ringers are working. The number of completed forms varies between years. In 2016, 226 individual ringers or teams filled 317 Raptor Questionnaire forms. To complete these forms, just for 2016, a total of 38 358 potential nest sites of raptors and owls were inspected, including 3241 nest boxes for Tawny Owls, 4121 for Ural Owls, 5190 for the Pygmy Owls Glaucidium passerinum, 4914 for the Boreal Owls Aegolius funereus and 1629 large and 1535 small natural cavities suitable for owls. Altogether 7627 occupied territories including 5406 active nests of common diurnal raptors and 4955 occupied territories including 3005 active nests of owls were found and reported (Meller et al. 2017).

Most raptor ringers survey their ringing territory with about the same intensity from year to year, which means that at least a part of the Raptor Questionnaire, which is a much larger data set than that of the Raptor Grid, is also comparable and useful for monitoring changes in the breeding population. In any case, the Raptor Questionnaire is a vital source of data for monitoring population trajectories of rare, northern and nomadic species and for monitoring productivity of all raptor species.

Ringing, recapture and recovery data

Particularly since the early 1970s, the Finnish Ringing Centre has encouraged ringers to ring nestlings and ring-and-recapture breeding adults at nests of all raptor species (Saurola 1987a). This has been particularly effective for both Ural and Tawny Owls, as most individuals of both species in Finland now nest largely in nest boxes provided by ringers. This makes it relatively easy to check the nests and to ring the young and to catch the female by trapping her inside the box. Some ringers make the additional effort to also capture the male (Saurola 1987b). Since the inception of the ringing scheme in the early 1900s until the end of 2016, a total of 66 404 Ural Owls have been ringed and 18 811 encounters recorded. Corresponding totals for the Tawny Owl are 54 561 and 14 604 (Valkama & Piha 2017).

In our survival analyses, for the period 1968–2006 inclusive, we used data from 60 500 Ural Owls ringed as nestlings and 5420 ringed as breeding adults. Of these, 5345 were recaptured at least once in subsequent years (for a total of 14 492 live recaptures including birds caught in multiple years), usually by ringers at a nest box, and 3244 were recovered dead, usually by members of the public (we included recoveries for which condition was not known, most of which were likely dead). For Tawny Owls, the totals were 46 791 ringed as nestlings and 5171 ringed as breeding adults, of which 4176 were recaptured alive at least once in subsequent years (with a total of 8258 live recaptures), and 5369 were recovered dead.

Statistical analysis

Population trends

Data from the Raptor Grid were used to estimate changes in population size. Calculations of the population indices were based on both occupied territories, called here the territory-index, and on numbers of active nests, called here the nest-index. While an effort was made to retain the same set of study plots over time, many plots became inactive and new ones emerged during 36 years, because of the voluntary basis of the fieldwork.

We used program TRIM (Pannekoek & van Strien 2004) to estimate the annual indices for each species, as has been done since 2007 (Saurola 2009, 2012). Program TRIM imputes missing values for sites that were not surveyed in every year, thus allowing inclusion of the complete data set. Within the program, the options time effects, overdispersion and serial correlation were selected. We used program PIA (Anders Bignert, Swedish Museum of Natural History; Bignert 2003) to estimate the average annual change per year in indices on the basis of ordinary log-linear regression.

Productivity

Average annual productivity was calculated on the basis of national data gathered by the Raptor Questionnaire. The total number of large young produced was related to (1) the total number of occupied territories, (2) the number of active nests (i.e. nests in which eggs were laid) and (3) the number of successful nests (i.e. nests in which large young were produced).

Survival analysis

We estimated survival, recapture and recovery probabilities using the joint recapture and recovery model of Burnham (1993) in a hierarchical Bayes framework, using the methods described by Francis & Saurola (2009). These combined models allow estimation of relatively precise age-specific survival probabilities with little apparent bias due to emigration from the study areas (Francis & Saurola 2002). These models estimate four classes of parameters: survival ( ) – the probability that an animal alive at the beginning of the year (here defined as 1 June) will be alive the following year; recapture (p) – the probability that a marked individual alive and present in the study population will be recaptured in a particular year; recovery (r) – the probability that an individual that dies in a particular year will be found and its ring number reported to the ringing office and 'fidelity' (F) – the probability that a marked surviving individual that was in the local population the previous year is still in the population available for recapture. In this study, the fidelity parameter is difficult to interpret biologically because both recaptures and recoveries occurred over a large geographical area (Francis & Saurola 2004); hence it does not actually provide an estimate of fidelity to a particular breeding location. Rather, it estimates the probability that a bird will return to breed in an area where a ringer is working.

We used models in which survival and recapture probabilities were allowed to differ with age over four age classes, while recovery probabilities and fidelity parameters were allowed to differ only between young birds and older birds. Birds ringed as 'adults' were treated as if they were all in the highest age class, although a few of them were probably in their second or third year (Francis & Saurola 2002).

All parameters were assumed to vary between years and estimated with hierarchical Bayesian models fitted using the Markov chain Monte Carlo (MCMC) option in program MARK (White & Burnham 1999). For each set of age-specific parameters, we imposed a hierarchical structure to the annual parameters by defining hyper-distribution priors using a hyperdesign matrix (White et al. 2009; see Francis & Saurola 2009 for more details on the models). For the graphical analyses presented here, we assumed a simple normal prior, with the logit transformed annual survival, recapture, recovery and fidelity parameters for both first year and adults assumed to come from a normal distribution with a specific mean and variance but no covariates. This approach tends to shrink imprecise estimates towards the mean, thus reducing the impacts of annual variation in sample size. Following Francis & Saurola (2009), we modelled second and third year survival and recapture parameters to be equal to those of adults minus a difference parameter (on a logit scale). The difference parameters were allowed to vary among years, but with a prior hyper-distribution imposed on the differences, thus tending to reduce them towards the mean difference. This results in survival estimates for these age classes that tend to fluctuate in parallel with adults unless strong data indicate to the contrary.

We also ran models in which we added covariates to the hyper-distributions to estimate the impacts of vole abundance on survival and recapture probabilities, following Francis & Saurola (2009). Vole abundance in each year was classified into one of three categories. For capture probabilities, voles were modelled as Poor – scarce in spring; Moderate – moderately abundant in spring; and Good – abundant in spring. For survival, they were modelled as Poor – abundant in spring but crashing after the breeding season; Moderate – low at the start of the year, but gradually increasing over the year; and Good – moderate early in the year and increasing over the rest of the year. Years were categorized based on general field observations of voles throughout southern Finland (Meller et al. 2017), because long-term quantitative prey abundance data were only available from a few local studies. To complete the hierarchical model, standard non-informative priors were placed on the coefficients of the means and variance parameters (σ^2) for the hyper-distributions, as well as any parameters constrained to be constant over time, as described by White et al. (2009).

Because of the complexity involved with editing the large Parameter Index Matrices, the Design Matrix and the Hyperdesign Matrix, the input files for the analyses were created using custom-written programs in SAS 9.4 (SAS Institute 2003), and run using the MARK batch facility. All MCMC models were run with the default options in MARK, using a random starting point, 1000 burn-in samples, 4000 tuning samples, and 10 000 iterations in each chain with a minimum of two chains for each model. We have previously shown (Francis & Saurola 2009) that this is sufficient to get reliable estimates with 2 or 3 significant digits. We also used SAS to summarize the output from the MCMC coda files. We graph the resultant parameters together with their 95% posterior credible confidence intervals.

Results

Population trend

For the Ural Owl, during 1982–2016, the territory-indices fluctuated between 0.67 and 2.01 and the nest-indices between 0.29 and 2.07 (Figure 1, left). The cyclic pattern of fluctuations was as follows: five cycles of three years (two high years and one low), followed by two cycles of four years (three and one) and then two more cycles of three years. The index of breeding pairs reached an all-time peak in 2009, followed by a deep crash in 2010. Subsequently, the amplitude of annual fluctuations has been reduced. The nest-indices fluctuated much more than the territory-indices, indicating that even in years when few birds breed, many were still available to be counted on their occupied territories. Ordinary log-linear regression analysis shows that the territory-index increased by an average 1.1% ($P < 0.01$) and the nest-index by 1.6% ($P < 0.05$) per year during the last 36 years.

During 1986–2016, the annual totals of occupied territories (range = 422–1710), active nests (range = 198–1566) and successful nests (range = 168–1341) recorded by the Raptor Questionnaire for this species varied considerably. The much larger, but less consistent data from the Raptor Questionnaire gave the same pattern of fluctuations of both territory and nest-indices of Ural Owls during 1986–2016 as the Raptor Grid (correlation $r = 0.99$).

For the Tawny Owl, the territory-index fluctuated between 0.63 and 1.97 and the nest-index between 0.46 and 1.97, both without showing any long-term trends (Figure 1, right). As with the Ural Owl, the nest-index showed much larger fluctuations than the territory-index.

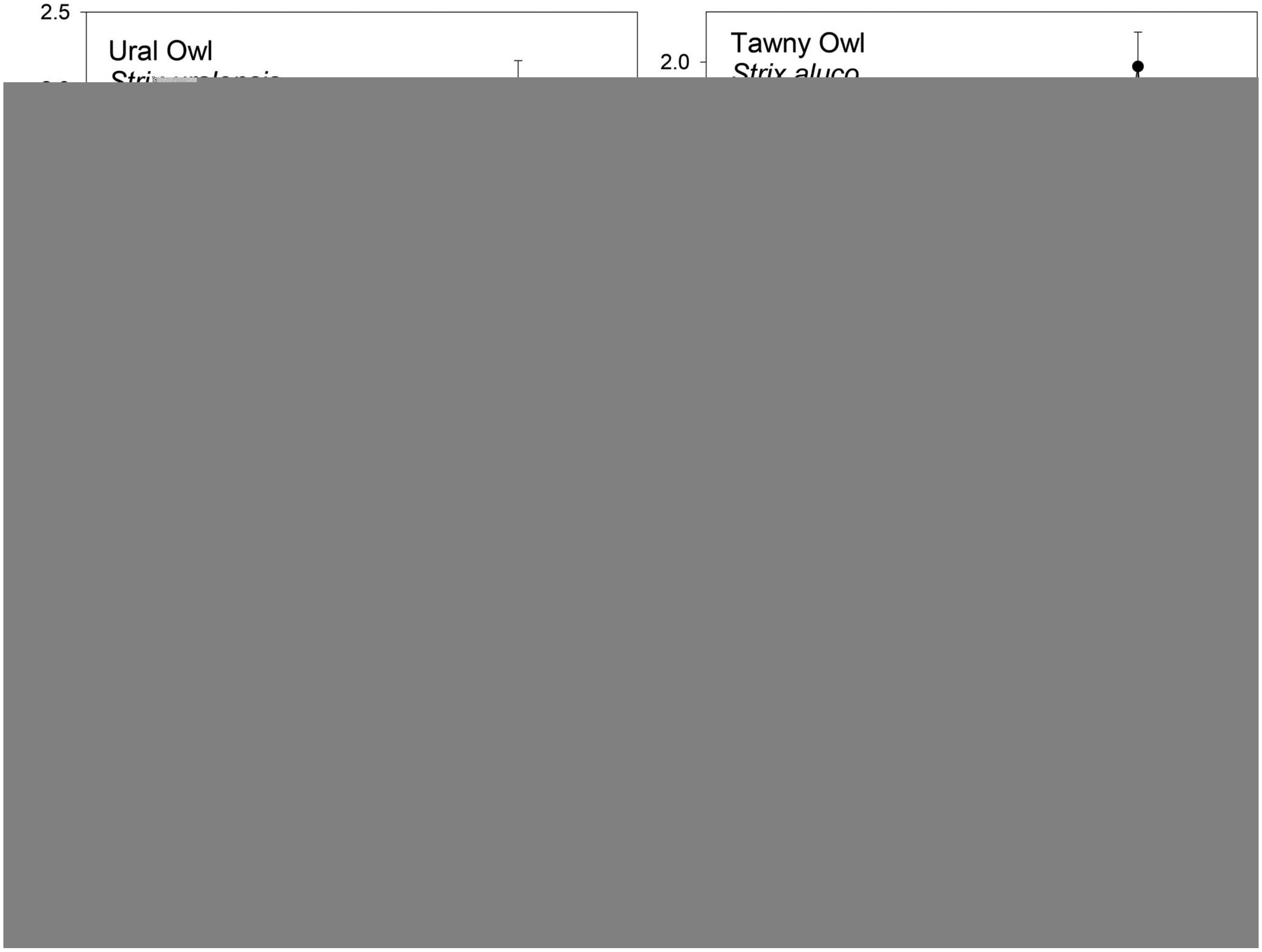

Figure 1. Annual population indices of Ural Owls (left) and Tawny Owls (right) in Finland calculated from the numbers of occupied territories (top) and active nests (bottom) recorded in the Raptor Grid study plots during 1982–2016. Vertical bars indicate standard errors. Thick line = log-linear regression line. Ural Owl: Annual change 1982–2016 of territory-index = 1.1% / year ($P < 0.01$ and of nest-index = 1.6% / year ($P < 0.05$). Tawny Owl: Annual change 1982–2016 of both territory and nest-indices = 0.2% / year (NS).

Annual totals of occupied territories (range = 287–857), active nests (range = 125–807), and successful nests (range = 98–681) of the Tawny Owl recorded by the Raptor Questionnaire in 1986–2016 varied largely as in the Ural Owl. Also, as in the Ural Owl, the Raptor Questionnaire data gave very precisely the same general pattern (r = 0.99) of the annual fluctuations of the Finnish Tawny Owl population indices during 1986–2016 as the Raptor Grid.

The time-series of both the territory-index (r = 0.99) and nest-index (r = 0.96) of the Tawny Owl are highly correlated with those of the Ural Owl. The synchrony of the two species is not surprising, as the data come from heavily overlapping study areas and the breeding performance of both species is highly dependent on cyclic vole populations. The lower fluctuations in the time-series of nest-indices for Tawny Owl suggest that this species is a bit less dependent on voles than the Ural Owl.

Productivity

The national time-series on the productivity of Ural and Tawny Owls (Figure 2) based on the Raptor Questionnaire data 1986–2016 resembled the general pattern of corresponding population indices (Figure 1). The correlation between the time-series of population indices and productivity (young per active nest) was quite high (0.74 in the Ural Owl and 0.71 in the Tawny Owl). Thus, when the number of breeding pairs was high, the number of young birds produced per breeding pair was also high. As a result, the total number of new individuals produced into the population was up to 10–15 times higher in a peak year than in a low year.