Fertility, natality, immigration, and the source-sink problem in populations of the Barn Owl *Tyto alba*

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Introduction

If we regard the total population of a species, there are only two factors regulating its size: birth and death. If we instead study only a part population, as it usually is the case in local or regional studies, two more factors must be considered: emigration and immigration.

Birth in birds preferably – as already done by BEGON et al. (1996) – is described as the succession of two stages: the egg stage, including incubation by the female, and hatching. These shall be studied in connection for two populations in North Germany. Then will be examined, whether it is possible for the Barn Owl, to define single part-populations as being such with a birth surplus (source) or with a deficit (sink). DE BRUIN (1994) in this connection has communicated calculations for two populations in the Netherlands.

Material and definitions

Two northern German part-populations of the Barn Owl in extent have been described, together with their biologic data under the names “Lachendorf” and “Einbeck” (KNIPRATH 2007, KNIPRATH & STIER-KNIPRATH 2014). These data are used here as well. More restricted data from other part-popuöations in North Germany are included as well.

The number of eggs in a clutch in relation to the number of parent birds (more precisely of course of the ♀) is called fertility. The young hatched mostly spend the time of growth in the nest, if the circumstances do allow also in its nearer vicinity (mostly under the roof of a building). Having fledged, they then leave the nest definitely and will be fed by their parents until independence.
If the young owls then are independent, they spread over smaller or greater distances. This spreading is called dispersal (for the Barn Owl see KNIPRATH 2012; 2013). At the end of the dispersal the owls then are in the region, in which they intend to bread (KNIPRATH 2016b). They settle and so become part of the respective (breeder-) population. The number of birds settled in a defined region in relation to the population magnitude of the parent generation is defined as natality. As the number of the really integrated birds only can be found at the quantitative control of the new population, these owls then – after their settling during autumn – already have survived their first winter.

Results

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Fertility
In a well controlled part-population it seems to be fairly simple to find the numbers needed. This indeed fits for the number of eggs. Indeed, to whom should we relate them, to the total number of broods=total number of ♀? Then eventual second and replacement broods figure as new broods with eventual different parents. As a result, the fertility of a population is estimated to low. Here we ascertain the number of controlled ♀ and then the entire egg production of these during the respective year. This latter one we then don't relate to the number of ♀, but to the number of parent birds (table 1, column ♀♂), i.e. we multiply it with 0.5.

area	♀	♀♂	eggs	fertility
Lachendorf	88	176	650	3,69
Einbeck	310	620	3521	5,68
Salzgitter	69	138	631	4,57

Table 1: Mean fertility in three populations studied in southern Lower Saxony/Germany (eggs/♂♀)

The figures 1 & 2 show the fertility development of of the pairs in the two study areas Lachendorf and Einbeck in southern Lower Saxony/Germany.

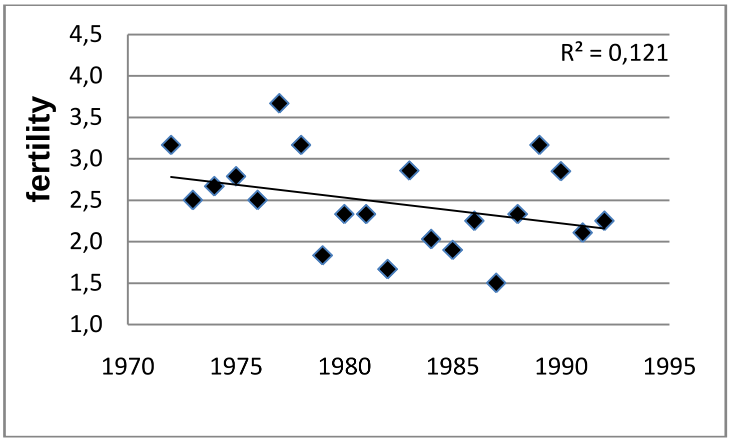

Figure 1: Fertility development of the pairs in the study area Lachendorf over the years (n_{pairs}=344)

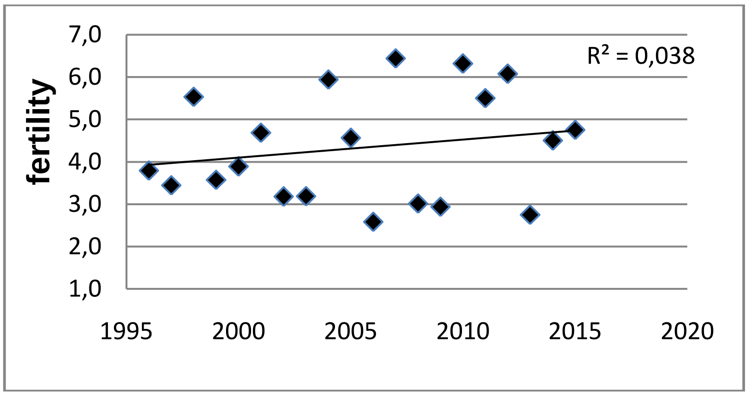

Figure 2: Fertility development of the pairs in the study area Einbeck over the years (n_{pairs}=135)

Natality

In both stages of birth losses are registered (see KNIPRATH 2007, KNIPRATH & STIER-KNIPRATH 2014). These indeed her are neglected. To calculate the natality of a population we first need the number of descendants, which have been integrated into the breeder-population. This number then is related to the number of parent birds. Here we only use known parents and their descendants integrated. Whether these descendants originate in first or second broods is of no relevance.

As table 2 shows, the natality values for all three study areas compared in agreement are very low.

area	♀♂	recruits	natality
Lachendorf	222	23	0,104
Einbeck	1018	121	0,119
Salzgitter	130	13	0,100

Table 2: Natality values of three studied in southern Lower Saxony/Germany (eggs/♂♀)

Now the question arises, whether we can find factors, which influence the natality values. To get these we asked north German Barn Owl ringers, which part in their population had the breeders born there (table 3).

area	km^2	time	boxes	box density	breeding time controls	% own ones	% own ♂	% own ♀	nam
Lachendorf	222	1972-1992	22	9,91	157	23,57	36,23	18,80	Altmülle
Minden	586	1995-2012	175	29,86	698	13,32	19,08	10,94	Neuhau
Northeim	1000	1990-2012	600	60,00	615	32,36	28,57	25,53	Kniprat
Salzgitter	230	2001-2012	38	16,52	118	25,42	14,81	12,12	Wallisc
Schaumburg	125	2000-2013	31	24,80	247	9,31	8,06	9,49	Otten
Uelzen	1454	2002-2010	580	39,89	499	14,43	19,54	7,92	Golnik
Wolfsburg	2500	1992-2012	616	24,64	2404	29,99	43,78	22,71	Seeler

Table 3: Parts of the breeders hatched in the study areas in northern Germany following the resp. ringers; box density/100 km^2

In addition to the values in table 3 we ascertained, how high in the resp. best years the occupation value of the boxes present was. For all study areas this value in part was clearly beyond 50%. So there always were sufficient free boxes for a settlement near to the birth site.

Logically it can be expected that with an increase of the study area expansion also the part of the breeders born there increases (with the limit 100% (or 1.0 as probability) for the total area of the species) Figure 3 confirms that this assumption is valid. The relation is closer for the ♂ (R^2 = 0.4). But in addition the real (fig. 4) and the relative numbers /fig. 5) of boxes installed play a role. The more boxes are installed in the study area, the higher is the part of breeders born there.

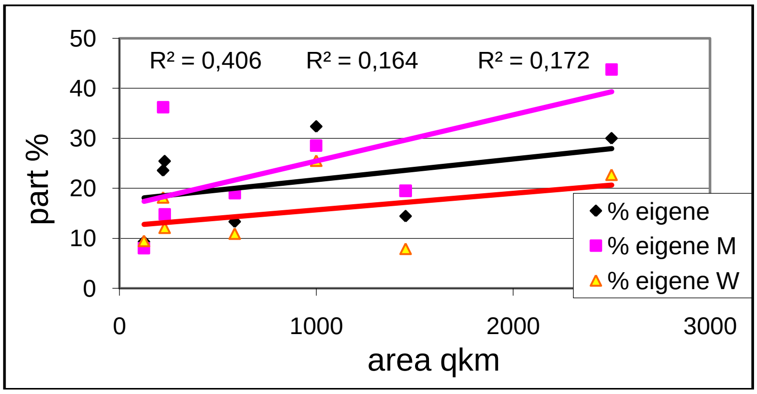

Figure 3: The relation between the extent of the study area and the part of breeders born there (values from table 3)

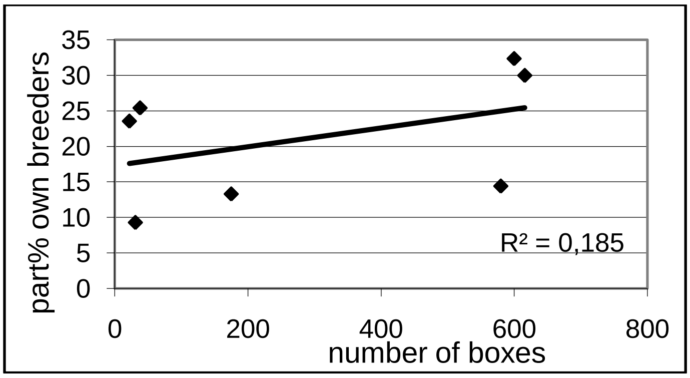

Figure 4: Relation between the real number of boxes in the study area and the part of own breeders (values from table 3)

We indeed expected that the yearly natality oscillates per years (figs. 6 & 7). It reaches from zero in not few years to 0.5 in 1989 in Lachendorf and up to clearly above 1.0 in Einbeck in the year 2005. The high values only then were reached, if there was an extreme increase of the breeding pair numbers from the basic year.

The curves of the two study areas distinctly differ. For Lachendorf we find an increase over the study interval, which for Einbeck can be neglected. The increase only small for Einbeck obviously solely depends on the extreme values in the two years 2005 and 2015. In the first study area still until 1979 boxes were installed, in the second one their number was constant. We should point to the fact that the two study periods do not overlap.

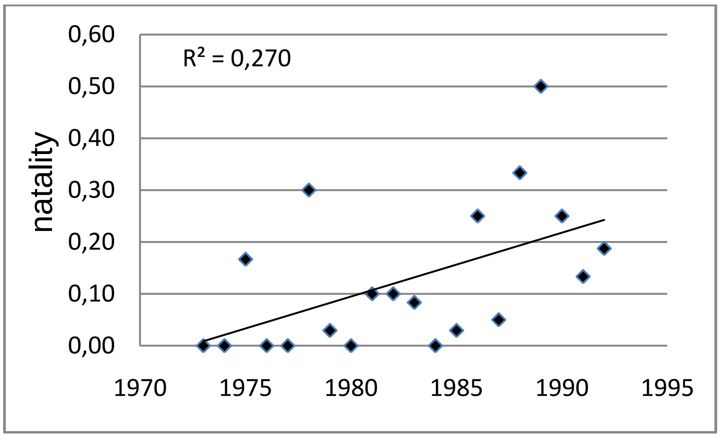

Figure 6: Natality in the study area Lachendorf by years (n=33)

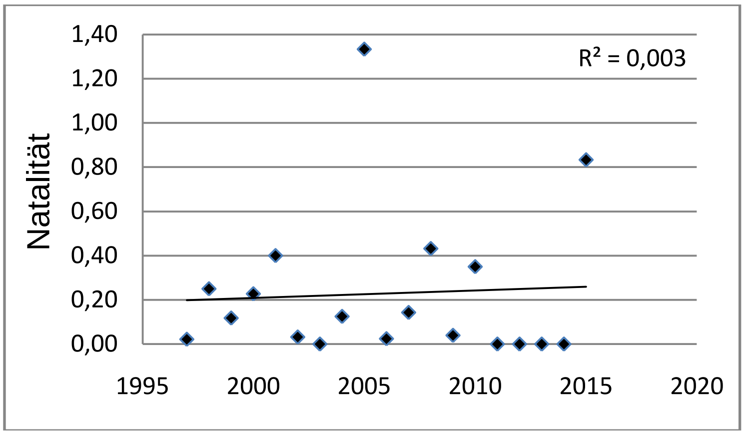

Figure 7: Natality in the study area Einbeck by years (n=137)

Immigration

As the part of own recruits (natality) only slightly exceeds 10% for the three populations studied (table 2) and the total part of breeders in some populations (table 3) amounts up to ca. 30% we indeed should have a closer look to the other part of supply in breeders, the immigrants. As definition we could see these immigrants – in contrast to the "internal" natality – as "external" natality for we deal with individuals, which had been born outside the resp. study area. Certainly we cannot relate it their parent generation, as we don't know the magnitude of the latter one. So we relate the numbers of immigrants to the same parent generation as that of the own recruits. We indeed study the role in the resp. population.

As was expected, the extent of the external natality in the area Einbeck oscillated from year to year (fig. 8), but at a clearly highe level (mean 0.73) than the internal one (mean 0.19; fig. 7). There is no recognizable tendency. We found the higher values for 2005, 2007, and 2015, all years with a strong increase of the broods after a low value. For Lachendorf (fig. 10) is true: Oscillation on a similar level as in the area Einbeck, but without any special peak. Here we find the highest values in the initial years of the study, during which the number of boxes clearly has increased.

If we put into relation internal and external natality for both study areas (figs. 9 & 11), a different picture results. (For a better comparison the scales of the two figures are adjusted.) Certainly the values for both areas mostly are fairly close together, but only for Einbeck there are clearly deviating ones. These indeed do not coincide for natality and external natality. The development in the study area Einbeck seems to be different from that in the farer regions.

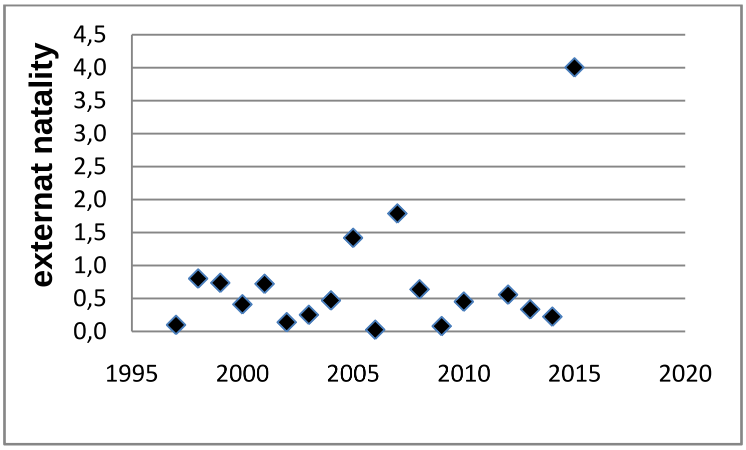

Figure 8: Immigration (external natality) in the study area Einbeck by years (n=369)

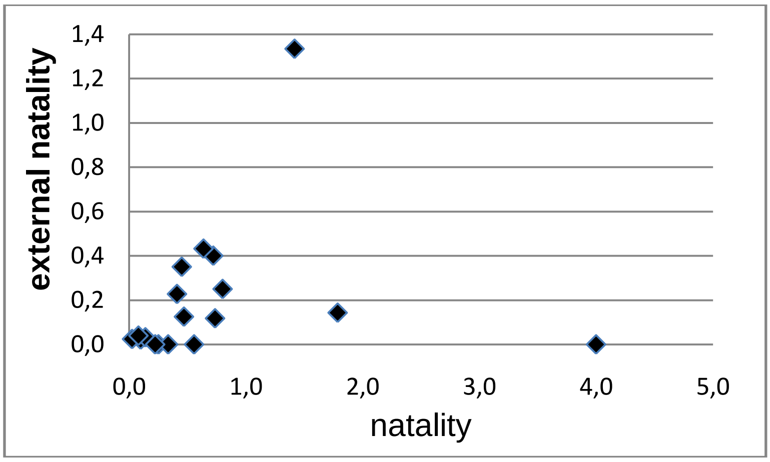

Figure 9: Relation of natality and external natality in the study area Einbeck

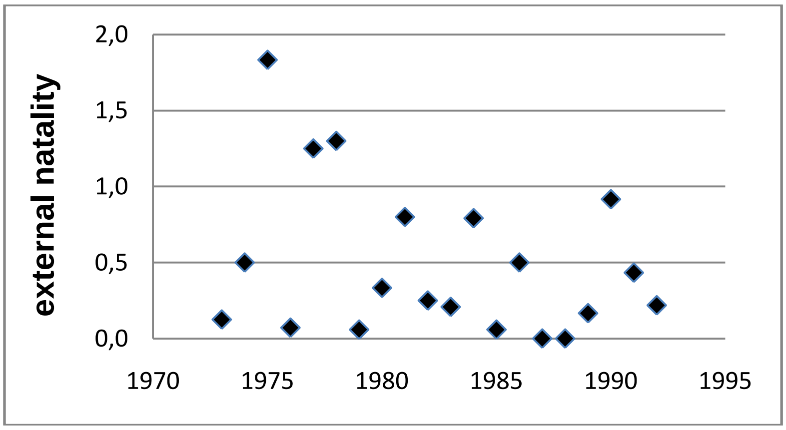

Figure 10: Immigration (external natality) in the study area Lachendorf by years (n=119)

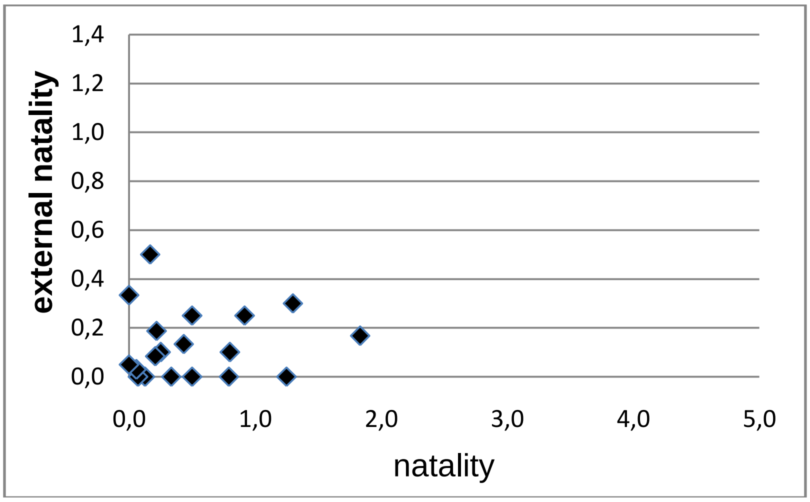

Figure 11: Realtion of natality and external natality in the study area Lachendorf

Discussion

We certainly can relate the indeed very clear differences in fertility between the populations compared (table 1) to a differing prey density. But indeed an influence of the control dates should be considered. For Lachendorf (KNIPRATH 2007) and Salzgitter (WALLISCH pers. comm.) it is known that the controls were made fairly late. A part of the eggs or the already hatched pulli originally present thus could have "disappeared". In Einbeck the controls were made earlier (KNIPRATH & STIER-KNIPRATH 2014). So a higher part of the eggs originally present was found. This leads to a higher value of fertility.

The earlier statements (TAYLOR 1994, KNIPRATH 2012, KNIPRATH & STIER.KNIPRATH 2014) that the settling distance of disperging young owls is correlated with the number of nest boxes installed, also helps in the interpretation of the influence of nest boxes onto the internal natality: The greater the density of nest boxes, the nearer settlement is possible and the more young owls settle in the rep. study area. Additionally the areas with higher nest box numbers often are those, in which adult birds are controlled. So the natality is ascertained better. We may expect that areas with a greater nest box density are attractive for dispersing young owls. This indeed doesn't influence natality but immigration, meaning external natality. Immigration of older owls, which originally were own descendants, which would simulate a higher natality, was not found (KNIPRATH & STIER-KNIPRATH 2014). Additionally it has been shown that adult Barn Owls mostly move only over minimal distances (KNIPRATH 2009, KNIPRATH & STIER-KNIPRATH 2014).

How a mean intern natality of less more than 0.1 has to be judged in relation to the development of the respective population? To keep up the original magnitude merely by its internal natality, in place of the real values, each of these populations should have produced multiple quantities. If we calculate back from the 23 young owls integrated (of 469 hatchlings) in the population Lachendorf (KNIPRATH 2007) we would come to 2952 fledglings or 3662 eggs. With these values we calculate for the real 222 breeders, which we equal to 111 broods, 33 eggs per brood.

Using the same calculation way, for the study area Einbeck we come to a number of 30 eggs per brood to equalize the deficit of 667 individuals found here. This number is astonishingly near to that for the area Lachendorf.

These crazy numbers of fictive clutch sizes properly only prove that calculating an internal natality, necessary to maintain a local population, for some bird species with a regularly high dispersal and with a corresponding high number of immigrant, not leads further. By this way it cannot be stated, whether the population studied preferably could be counted as source or as sink population. The further supposition, a relation of any kind between natality and immigration could be valuable for such a differentiation, must be rejected: Natality is in its value not only depending on the extent of the study area but also on the number of nest boxes installed there. We her don't doubt that there are regions with a higher and such with a lower breeding pair density and also natality. Those differences indeed do exist in very short distances within study areas, as can be seen in figure 5 in KNIPRATH & STIER-KNIPRATH (2014).

Perhaps the trial made here, to include immigration as "external" natality into consideration, leads further. The immigrated breeders in a well controlled population easily are recognizable as such: They are, if we disregard the rarely observed already ringed owls, not ringed. And these immigrants are yearlings (Kniprath & Stier-Kniprath 2014).

Regards

I especially wish to thank Dr. Klaus-Michael Exo for his very helpful comments to different issues of this work. In addition I thank the ringers mentioned in table 3 for rendering to me their data, Christopher Husband for his help in producing the summary.

Summary

The figures concerning fertility of Barn Owls in the areas studied in northern Germany differed greatly. These differences are partly explained by the amount of available prey, but also partly by the timing of the breeding checks.
The natality is dependent on the one hand on the size of the study area, and on the other hand depends on the number of installed nest boxes. Natality only "produces" a very small part of the recruits necessary for maintenance of the population size. The deficit is made up by the very high portion of immigrants that occur regularly in this species. It therefore does not appear possible on the basis of these data to attribute to a particular subpopulation the property of a "source" or "sink" population. For the respective population, the immigrants represent an external natality.

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