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Effects of cold winters and roost site stability on population development of non-native Asian ring-necked parakeets (*Alexandrinus manillensis*) in temperate Central Europe – results of a 16-year census

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ABSTRACT

Asian ring-necked parakeets (*Alexandrinus manillensis*, formerly *Psittacula krameri*, hereafter RNP) first bred in Germany in 1969. Since then, RNP numbers increased in all three major German subpopulations (Rhineland, Rhine-Main, Rhine-Neckar) over the period 2003–2018. In the Rhine-Neckar region, the population increased to more than fivefold within only 15 years. Interestingly, there was no significant breeding range expansion of RNP in the period 2010–2018. In 2018, the total number of RNP in Germany amounted to >16,200 birds. Differences in RNP censuses between years were evident. Surprisingly, cold winters (extreme value, −13.7 °C) and cold weather conditions in the breeding season (coldest month average, −1.36 °C) were not able to explain between-year variation. This finding suggests that in general winter mortality is low – with exceptions for winters 2008/2009 and 2009/2010, and a population-relevant loss of broods is low in our study population.
Surprisingly, the social behaviour in terms of spatio-temporal stability of roost sites could well explain positive and negative population trends. Years of spatially stable and regularly used roost sites seem to correlate with increasing population sizes. In contrast, known shifts of RNP among different roost sites or the formations of new roost sites by split are related to population stagnation or a decrease in numbers. Climate change may lead to further range expansion as cities not suitable yet for RNP may become so in the near future."

KEYWORDS

Invasive alien species; birds; population trends; weather conditions; climate change.

INTRODUCTION

Study species: Asian ring-necked parakeet (*Alexandrinus manillensis*)

The Asian ring-necked parakeet (*Alexandrinus manillensis*), hereafter abbreviated as RNP, is one of the most successful invasive bird species in the world (Lever 2005; Braun 2009, 2014). Native to the Indian subcontinent, the first breeding of the RNP was recorded in Norfolk, England, in 1855 (Lever 2005). Since 1966, the RNP became established in Belgium, followed by the Netherlands (1968), the United Kingdom (1969), Germany (1969), France (1974), Italy (1970s), Spain (1982), Portugal (1986) and Greece (1992) (Braun 2009).

The total European population is estimated to exceed 85,000 birds, of which the United Kingdom holds >30,000, Belgium >10,000, the Netherlands >10,000, Germany >10,000, Italy >9,000, France >7,000, Spain >3,000, Turkey >1,000, Greece >1,000 and Portugal >800 individuals (Pârâu et al. 2016).

The taxonomy of the *Psittacula* parakeets was recently revised, with *A. manillensis* being synonymous with the two Asian subspecies of the former *Psittacula krameri*, which was split into an African and an Asian species. The paraphyletic genus *Psittacula* was split, as it phylogenetically includes the distinct genera *Tanygnathus* and *Psittinus*, and the paraphyletic species *P. krameri* was split, as it phylogenetically includes the Mauritius parakeet *Psittacula* (*eques*) *echo*, which is itself considered full species (Braun et al. 2016). Rapid morphological changes and successful breeding behaviour seem to contribute to the establishment and spread of this species in Europe (Braun & Wink 2013; Le Gros et al. 2016). Despite increasing RNP numbers in Europe (Pârâu et al. 2016), effects of RNP on native species are assumed to be relatively low, suggesting a generally low competition level (Czajka et al. 2011; Newson et al. 2011). Yet, one study suggests competition between RNP and nuthatches (*Sitta europaea*) for breeding sites (Strubbe & Matthysen 2006). However, Nuthatches are known to take over

RNP nest sites in Germany (pers. Obs.). In their invasive range in Central Europe, woodpecker holes in facades with thermal insulation are a key factor for breeding colonies away from old landscape parks (Braun 2007).

Public perception of the RNP in Central Europe is mostly considered 'exotic' and often positive, although negative comments are made on their loud voice, the damage to facades or the damage to fruit trees (Braun & Wegener 2008; Braun et al. 2010).

1. ASIAN RING-NECKED PARAKEET POPULATIONS IN GERMANY

In Germany, the first breeding of RNP took place in Cologne (1969), followed by Worms (1974), Neckarhausen (1974), Wiesbaden (1975), Brühl near Cologne (1975), Mainz (1970s), Bonn (1979), Düsseldorf (1984), Frankenthal (1985), Heidelberg (1990), Mannheim (1993), Ludwigshafen (1995), Duisburg (2000), Krefeld (2007), Frankfurt/Main (2007), Zweibrücken (2008), Speyer (2009), Karlsruhe (2013) and Torgau (2015) (Gorgas 1976; Zingel 2000; Braun 2009; Braun et al. 2017).

We define three larger spatially distinct subpopulations in Germany, the Rhineland population (Düsseldorf, Leverkusen, Cologne, Bonn), the Rhine-Main population (Wiesbaden, Mainz, Frankfurt a. Main) and the Rhine-Neckar population (Worms, Heidelberg, Mannheim, Ludwigshafen, Speyer), see Figure 1. RNP visit large roost sites at night, which makes it easier to obtain a population estimate. There is also a spatial structure within subpopulations, but actual population exchange amongst different roost sites cannot be quantified on an individual level as only a small fraction of the birds was marked individually.

RNPs are highly gregarious and social birds. The local population of a city regularly roosts together in a few trees, often near rivers or illuminated streets, where hundreds or even thousands of birds can congregate (Braun 2004, 2009; Koch et al. 2013). All RNPs of a city population usually roost at a single place every night. Breeding females and chicks that have not fledged do not join the roost site, but otherwise all other birds are found all-year-round at these special places (Braun 2009). RNP roost site censuses are an established method in Europe and were carried out in different studies (Braun 2004, 2009; Luna et al. 2016, 2017, Pârâu et al. 2016; Braun et al. 2017). The establishment of new roost sites in the Rhine-Neckar region was only recently documented (Braun 2015).

Cold frosty winters and cold weather during the breeding season seem to be a negative key factor for a tropical

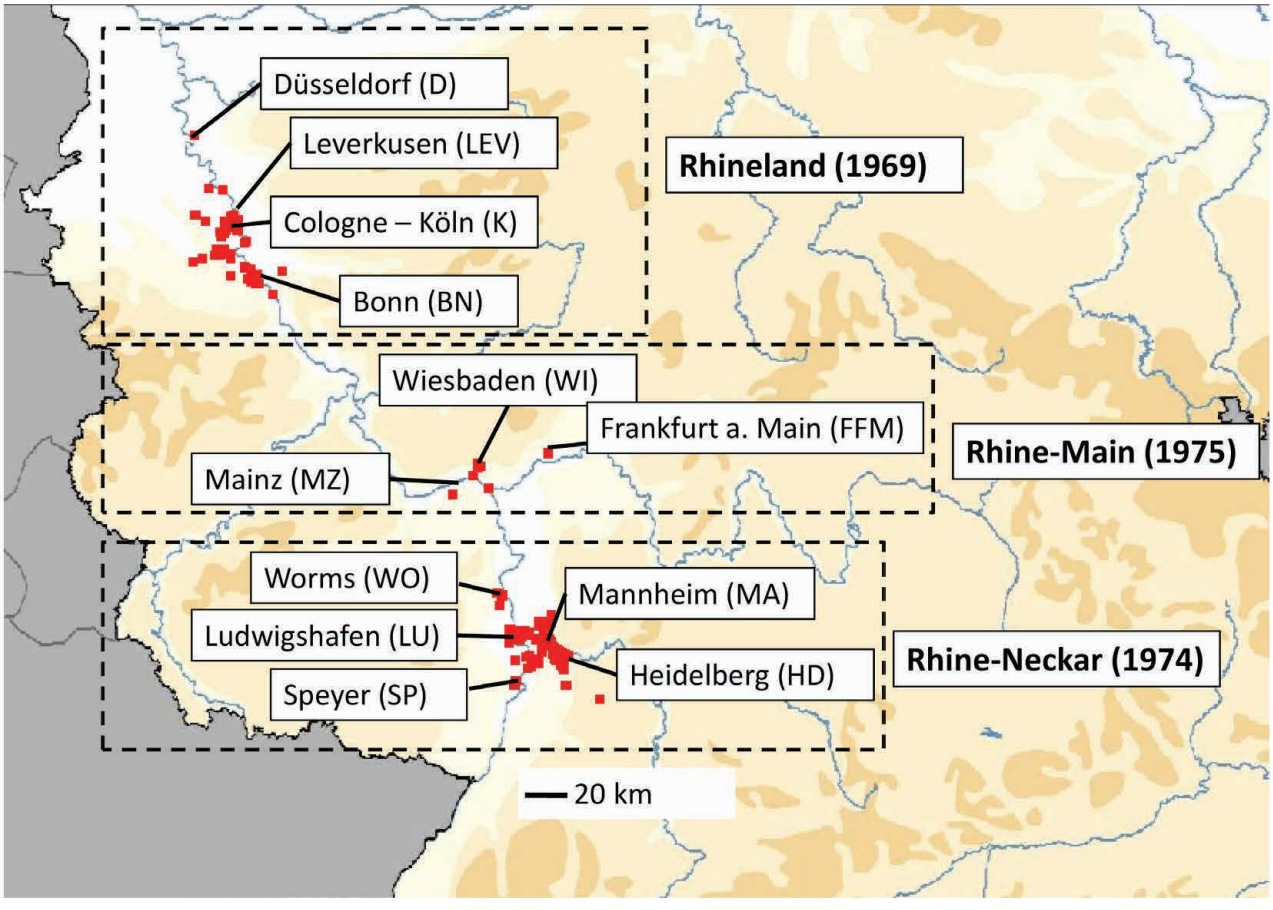

Figure 1. Three subpopulations of Asian ring-necked parakeets (A. manillensis) in Germany (Rhineland, Rhine-Main and Rhine-Neckar). Year of the first RNP breeding record per region is given in brackets. A scale of 20 km is given at the bottom.

bird in temperate climate. RNPs suffer from frostbite after cold winters. Frostbite usually affects the sensitive feet (Ernst 1995; Braun et al. 2017). Furthermore, cold temperatures lead to reduced hatching success in RNPs (M. P. Braun, unpublished data; Shwartz et al. 2009).

Herein, we present a current estimation of the national population size of RNPs in Germany. Moreover, we quantify population trends for the different subpopulations within Germany for the past 16 years. We relate these trends in a descriptive way with two different factors: (1) extreme cold weather conditions during the breeding season and the winter before the breeding season and (2) social behaviour expressed as roost site stability and the formation of new roost sites by split of existing roosts.

2. MATERIALS AND METHODS

We counted RNPs at roost sites in summer after the breeding season, mostly in July or August. Participants of the census had to be on site at least 30 min before sunset in order to count the incoming flocks of RNPs (Braun 2004). Regular roost counts took place from 2003 to 2018 with a main emphasis on the Rhine-Neckar population. Largely synchronous counts of the total German RNP population were started only in 2017 and repeated in 2018.

Climate data were taken from the archive of http://archiv.mannheim-wetter.info (last accessed 07.12.2018). 'Winter' was defined as the period of November to March that largely coincides with the time before the beginning of the breeding season. We used climatic extreme values (lowest winter temperature) or mean values for the coldest month of winter. The coldest temperature measured during the study period 2003–2018 was −13.7 °C (December 2010), the coldest month was January 2009, with an average of −1.36 °C.

Given the fact that large-scale synchronous censuses were only performed for the past 2 years, we prefer to omit obvious statistics such as models or correlation analyses.

3. RESULTS

The 2017 census revealed a population of 14,300 birds in Germany. In 2018, >16,200 birds were counted, see Figure 2. An overview of the trends for each subpopulation is given in Figure 2.

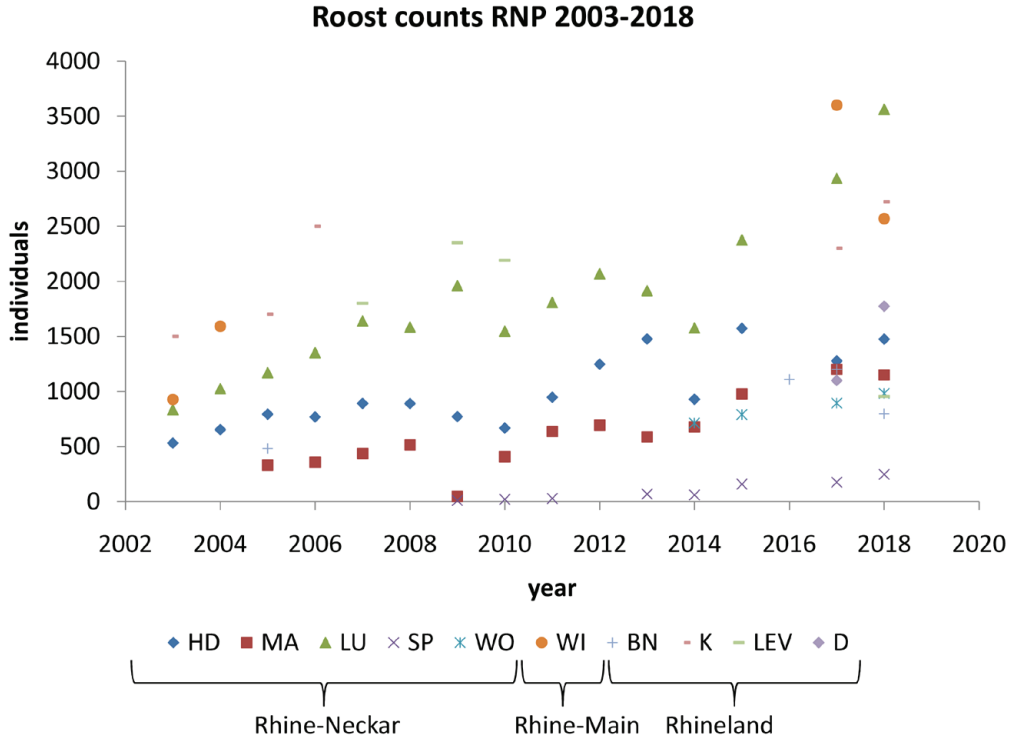

Figure 2. Annual censuses of Asian ring-necked parakeets (A. manillensis*) in Germany, 2003–2018. Note that a complete census for Germany was established in 2017 and 2018.*

3.1. Climate

Cold weather conditions for the Rhine-Neckar region during the breeding period (March and April) and cold winters are given as extreme values (minimum) or mean values in Figure 3. Mean and minimum temperatures (°C) of (a) the breeding season (March and April) and (b) the winter before the breeding season (November to March) in Mannheim.

3.2. Rhine-Neckar population

During the study period, 2003–2018, the Rhine-Neckar population increased from 1,300 birds at two roost sites to >7,000 birds at five roost sites (Figure 4). There are several years with population increase alternating with years of stagnation or decrease.

3.3. Birds and climate

A combination of climate data and bird counts in the Rhine-Neckar region shows that extreme cold weather conditions are neither inevitably connected with population decreases nor phases of population stagnation (Figure 4). Exceptions might be the winters of 2008–2009 and 2009–2010.

3.4. Social behaviour

Over the years, most of the time, the roost sites are stable and do not vary greatly. In some years, however, there is a formation of a new roost site or a switch of RNPs amongst different roost sites, or both. Changes in roost sites result in differences of the daily flight routes, which most of the time are highly conserved in RNPs. Formations of new roosts by spatial split of a larger roost site resulted in stagnation or decrease in total numbers. The same is observed for switches of birds between roost sites. Interestingly, in phases of stable roost sites, RNP numbers increased almost every year (Figure 5). Roost site situation for ring-necked parakeets in the Rhine-Neckar region, 2003–2018. For the abbreviations for roost sites, refer to Figure 1. Dashed arrows indicate the formation of new roost sites or the shift between roost sites. Continuous arrows indicate that there was a confirmed shift of birds between the roosts of Mannheim (MA) and Ludwigshafen (LU).

4. DISCUSSION

We have shown that population trends of RNPs in our study populations are most likely related to roost site stability, whilst extreme weather events seem to be of less importance. However, our data do not exclude the possibility that there is an interaction between roost site stability and severe cold weather. In addition, our data are not based on firm statistics. Furthermore, the actual mechanism that relates population decreases with instability of roost sites remains unknown. The formation of new roost sites may provoke elevated individual stress levels. New roosts could also be of lower quality than the existing ones because of other factors such as longer flight distances for the birds, higher predation pressure or different microclimatic conditions. For example, the RNP population in Innsbruck, Austria (570 m above sea level), survived extreme cold of −23.8 °C but collapsed after the loss of the thermally favoured roosting site near the ventilating system at the conference centre (Niederwolfsgruber 1990; Pollheimer et al. 2006). RNP in Heidelberg choose the warmest parts of the cities as roost sites, such as high traffic places and trees close to the river Neckar (Wegener 2004). Nevertheless, effects on mortality or lower breeding success must remain speculative. Finally, it is noteworthy that our results focus on trends in possibly unsaturated populations. In the future, population growth and spread of the species might be limited by climatic and other factors. In

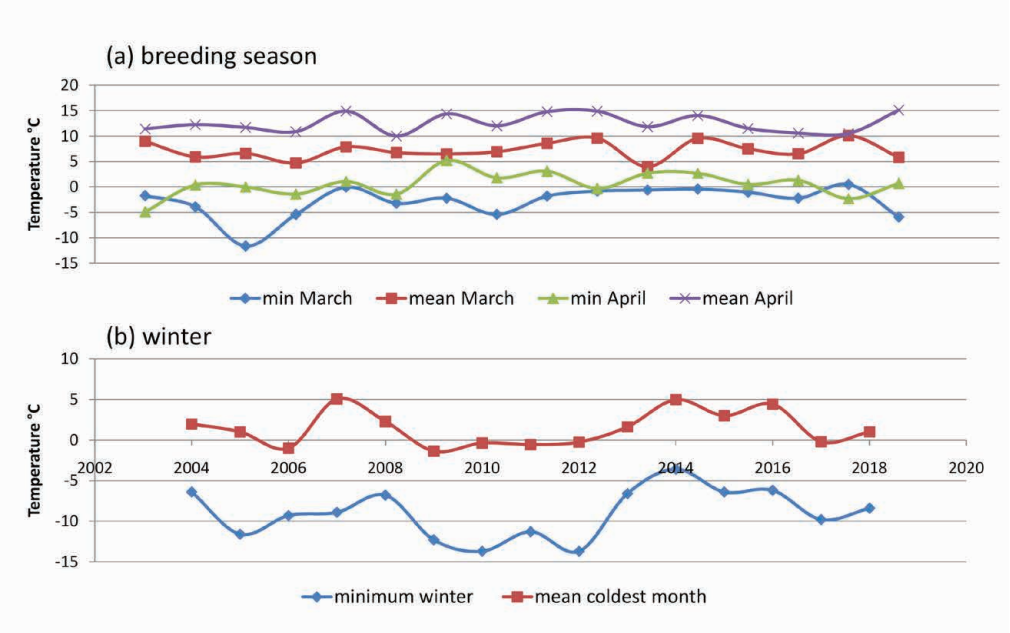

Figure 3. Mean and minimum temperatures (°C) of (a) the breeding season (March and April) and (b) the winter before the breeding season (November to March) in Mannheim.

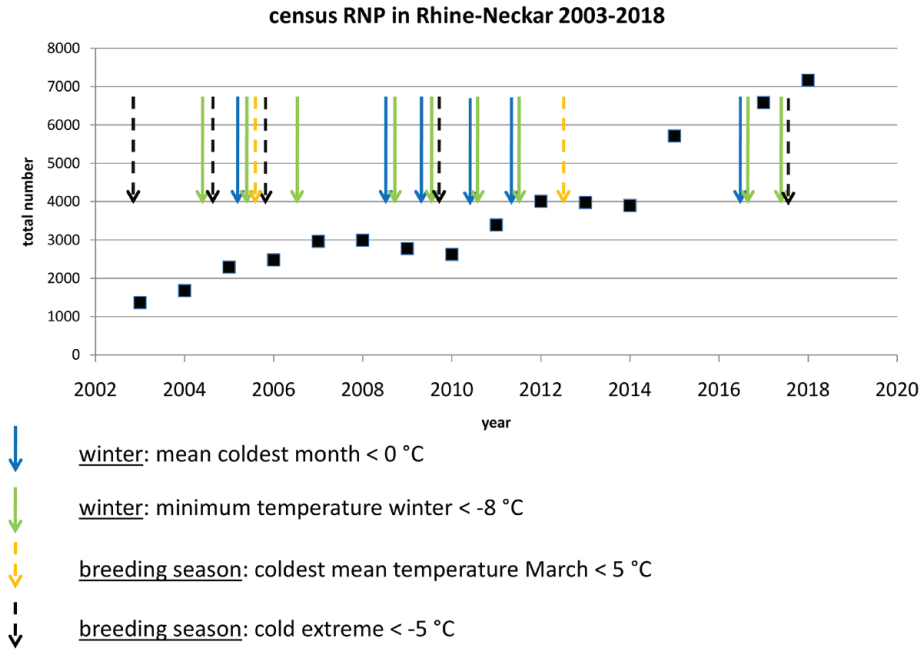

Figure 4. Censuses of Asian ring-necked parakeets in the Rhine-Neckar region, 2003–2018. Black squares indicate summarised population counts from different roost sites. Blue and green continuous arrows indicate cold weather conditions in the winter before the breeding season, and yellow and black dashed arrows cold weather conditions during the breeding season itself.

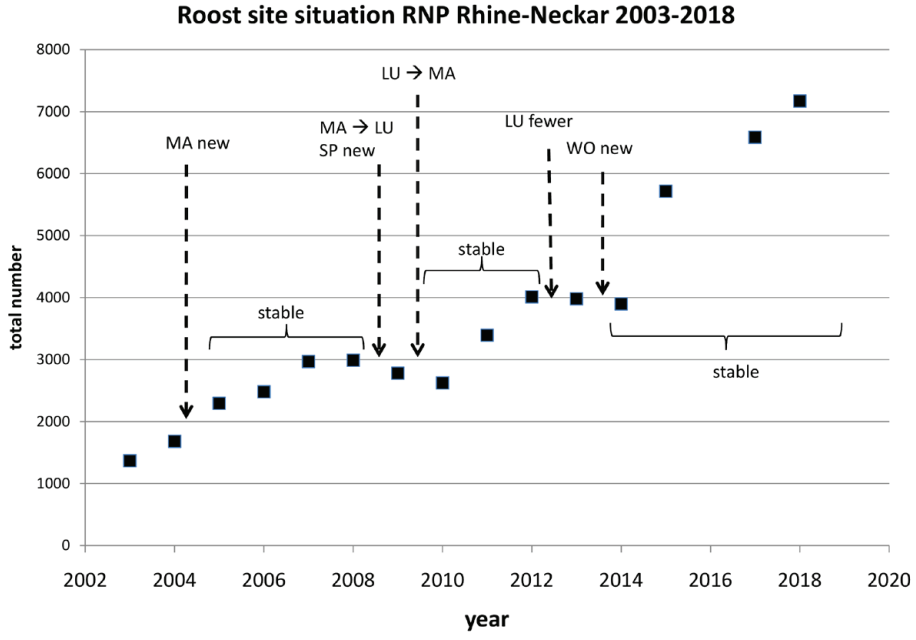

Figure 5. Roost site situation for Asian ring-necked parakeets in the Rhine-Neckar region, 2003–2018. For the abbreviations for roost sites, refer to Figure 1. Dashed arrows indicate the formation of new roost sites or the shift between roost sites. Continuous arrows indicate that there was a confirmed shift of birds between the roosts of Mannheim (MA) and Ludwigshafen (LU).

this regard, it is noteworthy that all established populations are limited to the 'urban heat islands' in the climatically favoured Rhine valley (Gedeon et al. 2014). Therefore, we highlight the importance of an ongoing large-scale monitoring as high-quality database for testing the hypotheses raised in this study.

On the basis of both extreme values and mean values for cold winter and cold breeding season (March and April), the roost counts in the 15-year period have been evaluated. Cold winters or cold weather during the breeding season could not explain variation in RNP population size between years. This may lead to the conclusion that winter mortality and population relevant loss of broods is low within established RNP populations in Europe. Attacks of wintering Goshawks (*Accipiter gentilis*) on RNP at the roost site have effects on the behaviour of the parrots as they change their flight mode and – in the most extreme case – shift their roost site within a few days. Not only the predation itself but also, more importantly, the disturbance of RNP at the roost site is known to cause a shift to another site. Peregrine falcons (*Falco peregrinus*) are known to predate RNP. Surprisingly, RNP roost sites are often found near peregrine nesting sites. Whilst goshawks may attack sitting RNP in the tree, peregrines prefer flying prey. RNP react to peregrines by staying in trees and flying low above the ground (Braun 2004). If goshawks appear, large flocks of hundreds of RNP congregate and fly above the predator, so it cannot attack from below.

Nonetheless, it is obvious that the RNP range in Germany is still restricted to the 'heat urban islands' in the mild Rhine valley. Furthermore, climate change may lead to new colonisations of cities where RNP have failed to establish so far.

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