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Dynamics in the sand lizard (*Lacerta agilis*) population at Forteiland, IJmuiden, The Netherlands

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Abstract. In 2000, an isolated population of sand lizards (*Lacerta agilis*) was discovered on an island in the Netherlands. The population-size was estimated at 57 adult individuals. Subsequently, the area has been improved to make the habitat more suitable for sand lizards. After 5 years of monitoring the population-size was estimated again. There are no indications for major population-size changes, for the population-size is estimated at 59 adult individuals. There is no significant difference in the population structure, although males were more abundant in 2005 than in 2001. Males outnumbered females in both years. The newly made dunes are populated by males, females and sub-adults. Gulls do not seem to conduct a predator stress, as there were no lizards seen there with autotomy. Nevertheless, gulls are believed to negatively influence habitat quality for the lizards. On the short term, cats seem to be the biggest threat to the sand lizards as there are strong indications that they have killed 10 % of the whole population within six weeks.

Introduction

A small island (4 ha) in the mouth of the North Sea Channel inhabits a population of sand lizards that lives isolated from the neighbouring dune-populations since the construction of the North Sea Channel about one hundred years ago.

The population-size was estimated at 57 $\pm$ 13 (mean $\pm$ SD) adult individuals in 2001 (Boere et al., 2001). Genetic analysis showed clear indication for isolation and inbreeding (Boere et al., 2002). Habitat alterations in favour of the sand lizard were made as a compensation for economic activities since 2001 (Zuiderwijk, 2002).

Possible threats nowadays are: (1) increasing numbers of visitors to the island; (2) loss of habitat for sand lizards; (3) increasing numbers of breeding gulls in the newly created habitats; three wild cats living on the island and predating on lizards.

It was our aim to make a population-size estimation in 2005 and compare these results with former data to see if there has been any change in population size and population structure. Other questions were: (1) Do the lizards use the area that was created especially for them? (2) Are the breeding gulls or the wild cats a direct threat to the lizards?

Population-size estimation

Capture-recapture was based on photos of the unique back pattern of adult lizards. Peterson's method (Begon, 1979) was used: $N = M (n+1) / (r+1)$

N = Estimated total population size
M = Number of already identified animals
n = Number of observed and captured animals in that particular observation day/period
r = Number of recaptures in "n"

Results

The whole island was searched on 13 days during the period 5th of May – 8th of June 2005 (table 1, 2). In 2005, the estimated population size of Sand lizards on the Forteiland was estimated as 59 $\pm$ 17 adults (table 2).In 2001, this was 57 $\pm$ 13 adults (*Boere et al.*, 2001)

The sex-ratio was highly skewed towards males. The ratio male/female 1:1 was rejected using the Binomial test ($p = 0.002$; fig. 2). Also in 2001, relative more males than females were observed, although to a lesser extent (fig. 3).

Fig. 1 shows how the population is distributed over the island. Most lizards were seen on the southern part on southern exposed slopes of the Fortress and Pillboxes. Also the new dunes were occupied, in spite of the presence of a colony of breeding gulls in this area (mainly by herring gulls, *Larus argentatus*).

Discussion

Population structure

157 lizards were observed of which 84 were males, 24 females, 38 sub-adults and 11 adults of whom the gender was unknown. The most outstanding feature (table 1) is the significant high rate of observed males. This ratio can partly be explained by the sampling period. Males are easier to observe at the beginning of the mating season in April and May, while females are easier to observe in June. In that case random sampling of both, males and

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Table 1. List of all observationsand numbers of different photographed lizards.

Numbers:	Males	Females	Unknown sex	Subadults	Total
Observations	84	24	11	38	157
Photographed individuals	32	11		11	54

Table 1. Estimated population size, Standard deviation (SD) and Relative Standard deviation for each observation day and for two periods (5th of May -23rd of May and 25th of May - 8st of June), following Peterson-Bailey's Method. In bold the two best estimates.

Observation day	M	n	r	N	SD	Rel. SD
5th of May		2				
10th of May	2	1	0	4,0	2,0	50,0
12th of May	3	7	0	24,0	15,9	66,1
13thof May	9	2	1	13,5	4,5	33,3
18th of May	10	1	0	20,0	10,0	50,0
19th of May	11	5	2	22,0	7,8	35,4
23rd of May	14	2	1	21,0	7,0	33,3
25th of May	15	8	5	22,5	4,9	21,8
26th of May	18	3	1	36,0	14,7	40,8
27th of May	20	3	0	80,0	49,0	61,2
28th of May	23	10	3	63,3	22,6	35,7
1st of June	30	9	3	75,0	26,0	34,6
8st of June	34	6	3	**59,5**	**17,4**	**29,3**
Two periods:						
5th-23rd of May		16				
25th of May-8st of June	15	30	7	**58,1**	**16,7**	**28,7**

females was not done. However relatively more females than males were recaptured: 18 captures of 11 females versus 45 captures of 32 males. Thus, the recapture rate was higher in females(1.6) than in males(1.4). This supports that there are indeed significantly more males than females.

From a DNA-analysis it became clear that the population on the Forteiland is inbred (Boere et al., 2002). In sand lizards females are the heterogametic sex (ZW), not males (ZZ). In that situation the production of daughters is associated with an increased risk of offspring inviability due to the expression of paternal, detrimental recessives on the Z chromosome. Inbreeding (and outbreeding) can cause offspring sex ratios biased towards sons (Olsson et al., 2005; Berglind, 2005). It is possible that this phenomenon is happening on the Forteiland.

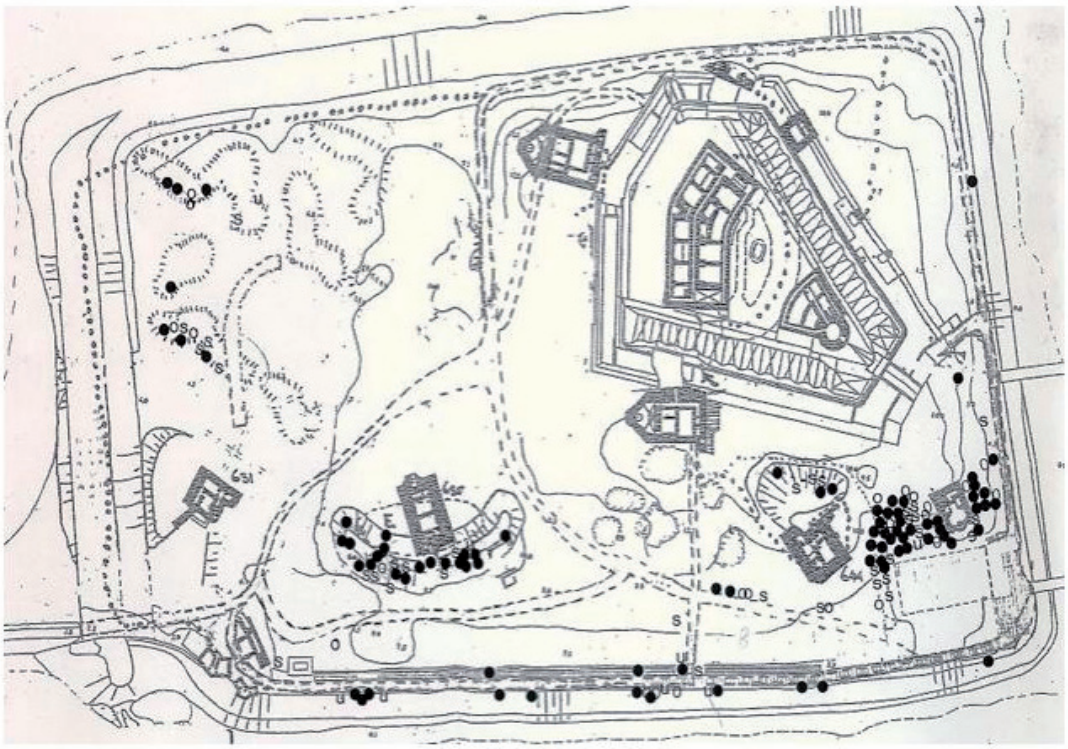

Figure 1. Forteiland IJmuiden. Spots are indicated were lizards were observed in 2005. Black dots are males, open circles females and subadults were given an "s". The big building (NE) is the fortress. Other smaller buildings are pillboxes. The northwestern quarter of the island has the newly built dunes.

Population size and predators

The population, in between 44 and 76 adult sand lizards (13 per ha), has been stable since 2001. Positive and negative alterations occurred since then. Negative is the increased pressure of predators and human activities. Positive is the laying-out of 1 ha of dunes. Sand lizards occupied them, however more animals did so as well. 140 pairs of gulls were breeding there in 2005. Gulls are said to be predators of lizards but this is highly rarely observed by bird-catchers (Zotaar, 2005, pers. com.) nor was it observed by us. The percentage of autotomy we found in the new dunes was much lower than the 33% that we found in general on the island. We presume that the gulls have another negative effect, namely in reducing the suitable habitat for the lizards. The faeces of the gulls enriches the soil and makes it less suitable for European beach grass (*Ammophila arenaria*). Open

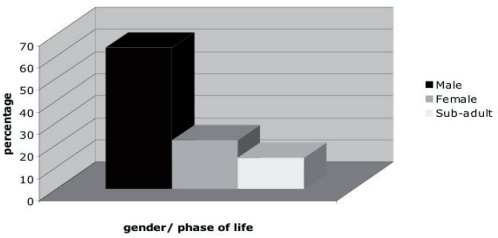

Figure 2. Relative occurrence of marked males, females and sub-adults on the Forteiland in 2005.

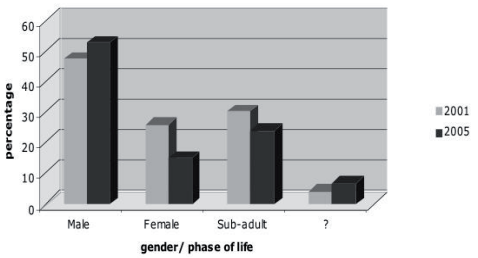

Figure 3. Comparison of the relative number of males, females, sub-adults and unknown gender for the years 2001 and 2005

spots get overgrown faster and nesting sites disappear quicker.

Cats were recognised as the most important predators. Four cats occur on the small island. They are fed by people but three of them hunt in the wild mostly. Six dead lizards were found during the six weeks of research, which is 10% of the whole estimated population. Cats were most probably the cause of death, because two times a cat was seen with a lizard in its mouth and the other cadavers were found on typical cat spots and recognised as cat prey.

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