

# The difficulty of getting accurate and precise estimates of population size: a response to Sulkava *et al.*

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In this issue of *Annales Zoologici Fennici* (pp. 521–526), Sulkava *et al.* raise an important issue regarding the problems and difficulties of estimating the accurate size of an animal population. Sulkava *et al.* tried to evaluate the accuracy of the national population estimation survey of the Siberian flying squirrel, which was carried out within the range of the species in Finland (Hanski 2006). The national field survey was based on winter-time faecal pellets alone, not also on scent marks as Sulkava *et al.* erroneously state (p. 522).

In their article, Sulkava *et al.* refer to their ear-tagged nest-box population of flying squirrels, which had been closely monitored, especially in 1981 and 1998 (Mäkelä 1999, 2001), and the number of breeding females in the population was known. The knowledge of the population estimate (minimum and maximum number of breeding females) and the known sites with faecal pellets of flying squirrels within the 114 km<sup>2</sup> study area was used to test the national survey methodology. From that area, 100 km<sup>2</sup> was said to have been selected for sampling with the same method as in the national survey (for the methods and sampling assumptions see Hanski *et al.* 2000, Hanski 2006, Sulkava *et al.* 2008). According to Sulkava *et al.*'s resampling, the national survey method overestimated the true population size of flying squirrels.

All the original articles concerning the study areas and capturing flying squirrels cited in

Sulkava *et al.* (Mäkelä 1996, 1999, 2001) and the paper on the population estimation (Hanski 2006) are in Finnish, which unfortunately restricts their usability for most international readers.

## The population estimation of Sulkava *et al.*

Sulkava *et al.* give a strong impression that the nest-box area covered their entire study area of 114 km<sup>2</sup> (and the nested 100 km<sup>2</sup> area that was used in the analysis) and that most of the flying squirrels used nest boxes at least part of the time and were ear-tagged. However, in the original Finnish articles (Mäkelä 1996, 1999, 2001) it was clearly stated that the nest-box and ear-tagging area was only 27 km<sup>2</sup> and was situated within the 114 km<sup>2</sup> study area (see e.g. fig. 1 in Mäkelä 1999). Thus, Sulkava *et al.*'s ear-tagging of flying squirrels had been done in a much smaller area — covering only 24% of the entire study area — than they state in their paper. For the other 76% of the area, the estimation of breeding females was based on faecal pellets. Their estimation was not based on ear-tagged animals as presented but, instead, for most of the area on an indirect interpretation based on faeces. Further, the search for the faecal pellets of flying squirrels was carried out in suitable forest stands only (see Mäkelä 1999: p. 56),

which may underestimate the true population size. These examples describe the difficulties of getting an accurate estimate of the population size of the flying squirrel even in a small area.

## Methodological test

Sulkava *et al.* applied the estimation method of the national survey to their study area. According to Sulkava *et al.*, the method overestimated the true population size 2–3-fold at two different densities, in 1981 and 1998. Further, the sampling test done by Sulkava *et al.* can be interpreted so that the result of the national survey method depends on the density or size of the population sampled. This affects the generalization of Sulkava *et al.*'s results.

According to Sulkava *et al.* referring to their own results (Sulkava & Sulkava 1998, and their unpubl. data), the main reason for the overestimation is that males move in larger areas than females and leave their pellets en route when they move among sites in their home ranges. However, in Sulkava and Sulkava (1998) not a single word about male movement and defecation is mentioned nor are any data given on these topics. At present, no data exist to measure the effect of male movement on the population estimate. For this, we need detailed radio-tracking data for winter and a comparison of locations of sites with faeces. Based on our radio-tracking data for winter, males spend most of their time close to females and much of that together in the same nests. Faeces accumulate at those sites where the animals spend most of their time. Males move between sites or mature forest stands fast (Selonen & Hanski 2003) probably leaving only few faeces. In their movement, males also use young forest stands, which were not screened for pellets in the national survey. Most likely, the effect of male movement on the estimate is small.

There were two important differences in the sampling between the national survey and that of Sulkava *et al.* First, in Sulkava *et al.* all sites with faecal pellets were always identified, but in the field work for the national survey apparently some occupied sites remained undiscovered. No estimate of the number of false negative cases was

attempted, but this fact results in slightly lower estimates in the national survey. A small number of pellets make a discovery more unlikely.

Second, in the national survey of flying squirrels the total number of 100 km<sup>2</sup> areas sampled was 1011 (Hanski 2006), which were distributed over a land area of 209 920 km<sup>2</sup>. In Sulkava *et al.*, a single area of 100 km<sup>2</sup> was sampled. Therefore, the generalization that the very restricted sampling result of Sulkava *et al.* (i.e. 1/1000 of National Survey) could be applied to cover the population estimate of the entire area of the national survey (roughly 2/3 of the entire area of Finland) and detect a 2–3-fold bias is not justified.

## Monitoring population trends

Resampling results of Sulkava *et al.*, based on estimates at two different densities in different years in their 100 km<sup>2</sup> study area, suggested that the population estimation method used in the national survey gave a biased, overestimated result. From that result Sulkava *et al.* concluded that the method cannot be used for monitoring population trends. I fully agree, and although Sulkava *et al.* may argue otherwise, such monitoring was never suggested in Hanski (2006). Monitoring has to be based on sampling plots or areas, preferably in a large geographic setting, in which the occupancy of flying squirrels is carefully inspected yearly or at certain time intervals. Reliable population trends can be obtained only using this kind of monitoring method, which at present is applied in the national survey.

## Conclusions

The resampling of Sulkava *et al.* in their small study area cannot be generalized over the large distribution area of the flying squirrel in Finland. The use of the national survey method for small areas was clearly cautioned in Hanski (2006), and apparently the result is affected not only by the density but also by the distribution of animals. Unfortunately, Sulkava *et al.* did not suggest any improvements for the method nor a new method to estimate the population size of the Siberian flying squirrel. Estimation of the

population size of the Siberian flying squirrel is a demanding task, taking into account its nocturnal habits and the large distribution area of the species in Finland. At present, a modelling approach to further develop the method and test the effects of different assumptions behind the estimation is in progress in the national survey.

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