Is *Aphodius contaminatus* (Herbst) (Coleoptera: Scarabaeidae) a threatened species in Finland?

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The dung beetle *Aphodius contaminatus* has been considered extinct in Finland, owing to the decline in the horse stock. In 1995, I found the species to be widespread in Åland, though it showed an aggregated spatial distribution. I suggest that *A. contaminatus* is not to be considered a critically threatened species in Finland. Neither does it seem to be a specialist on horse dung — the larva is probably a generalist saprophage. The most likely explanation for the apparent extinction of the species is a seasonal bias in the sampling of dung beetle communities.

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1. Introduction

The agricultural landscape of Finland is rapidly changing. Over the past 35 years the cattle stock and the number of cattle farms have decreased by 37% and 86%, respectively. At the same time, the total area of grazed pastures has dropped to a small fraction of its former extent (National Board of Agriculture 1896–1985, Information Center of the Ministry of Agriculture and Forestry 1986–1995). Such changes affect the hundreds of species adapted to open habitats produced by grazing. According to Rassi *et al.* (1992), the cessation of cattle grazing and the concomitant overgrowth of meadows is as a menace to the survival of 204 (31%) out of a total of 664 threatened insect species in Finland. The disappearance of meadow habitats appears to be the most important threat to 161 (24%) of them.

The beetle fauna living in cattle dung seems particularly vulnerable to the decline and redistribution of the cattle stock. Drastic population declines have recently been observed in several species in the dung beetle genus *Aphodius* (Biström *et al.* 1991). Of a total of 36 species of *Aphodius* encountered in Finland, almost half (15 species) are currently thought to be threatened (Rassi *et al.* 1992). Six species are considered extinct, one endangered and seven are thought to be in need of monitoring (Rassi *et al.* 1992).

In this paper, I focus on one *Aphodius* species, *A. contaminatus* (Herbst), which has been classified as extinct in Finland (Rassi *et al.* 1992). I report the rediscovery of this species on the Åland islands. I then try to evaluate the conservation status of the species in the light of all available information on its biology and on its past and present distribution in Finland. I suggest that the species is not to be considered critically endangered in Finland.

2. Material and methods

In 1995 I studied dung beetle migration on the Åland islands. As I examined how the density of dung beetles relate

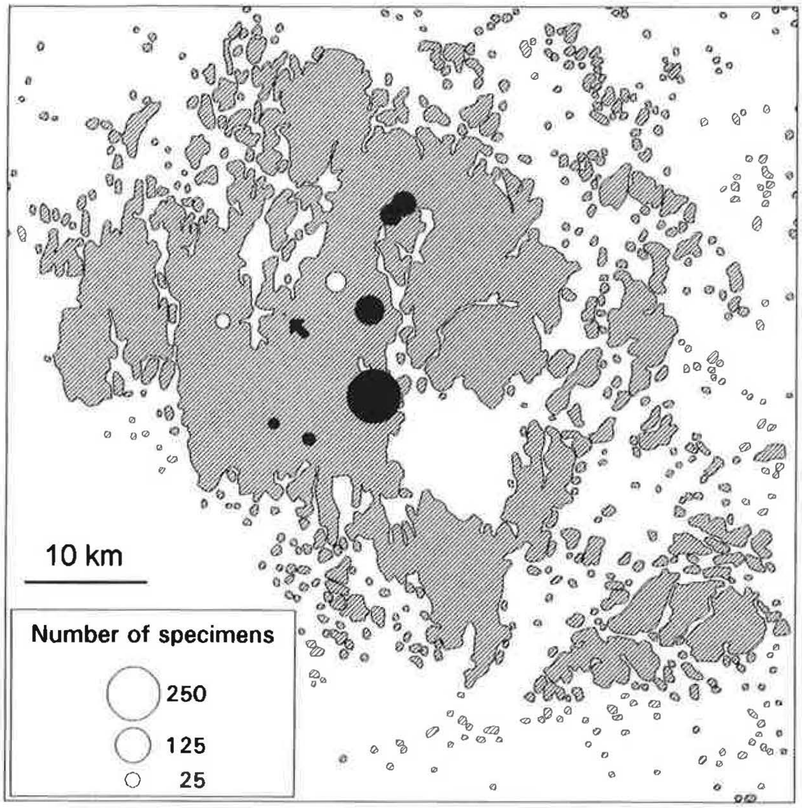

Fig. 1. Findings of *Aphodius contaminatus* in Åland in 1995 (black circles) and prior to 1995 (white circles). The size of the circle is proportional to the number of individuals encountered. Note that *A. contaminatus* was found at all six study sites in 1995. The white circle furthest to the left summarizes the individuals vaguely labelled "Hammarland" in coll. Lindberg. The arrow indicates a finding of one single individual in 1944.

to the distance from a pasture, I chose six cattle pastures isolated from all other grazed areas by a distance of more than 1.6 km in at least one direction. The study sites were also selected so as to be surrounded by open, cultivated landscapes. This was done in order to minimize the effect of habitat discontinuities on the dispersal of the beetles. The six sites are shown by the black circles in Fig. 1.

At each site there was a total of six traps. One trap was placed immediately outside the border of the pasture. The other five traps were placed at distances of 50, 100, 200, 400 and 800 meters from the pasture, respectively. All traps were placed in an apparently identical microhabitat. Each trap consisted of a tinplate funnel with the largest diameter 35 cm and smallest 4 cm, and a depth of 25 cm. I buried the funnel in the ground so that its upper brim was at the level of the soil surface. A cow pat of standard size (ca. 2 kg fresh weight) was placed on a metal grid (mesh size 2.5 cm) on top of the funnel to attract beetles. I made the bait-pats using fresh dung collected in a cow barn on the same morning. Beetles attracted by the bait fell down into a 1-litre plastic bottle half-filled with a saturated saline solution. The baits were changed on average every 13th day. At the same time the catch of beetles was collected. I continuously operated the traps from 25.V. to 5.VII. and from 19.VIII. to 16.IX.1995.

When I had found *A. contaminatus* in my material, I compiled all available data on its past occurrence in Finland. Most of the *A. contaminatus* specimens collected in Finland are held at the Zoological Museum of Helsinki. All the specimens, collection sites and dates in this material were examined. Olof Biström, Hans Silfverberg and Ilpo Rutanen kindly provided me with their extensive data sets on the occurrence of *Aphodius* in Finland (Biström *et al.* 1991).

3. Results

In the autumn of 1995, I caught a total of 475 individuals of *A. contaminatus*. The species occurred at all six study sites, even though the sites were geographically well separated from each other (Fig. 1). The species thus seems to be widespread on the main island of Åland. However, there were striking differences in the abundance of *A. contaminatus* at different sites: the number of individuals ranged from 15 to 256 per site (Fig. 1). As both the trapping effort and the habi-

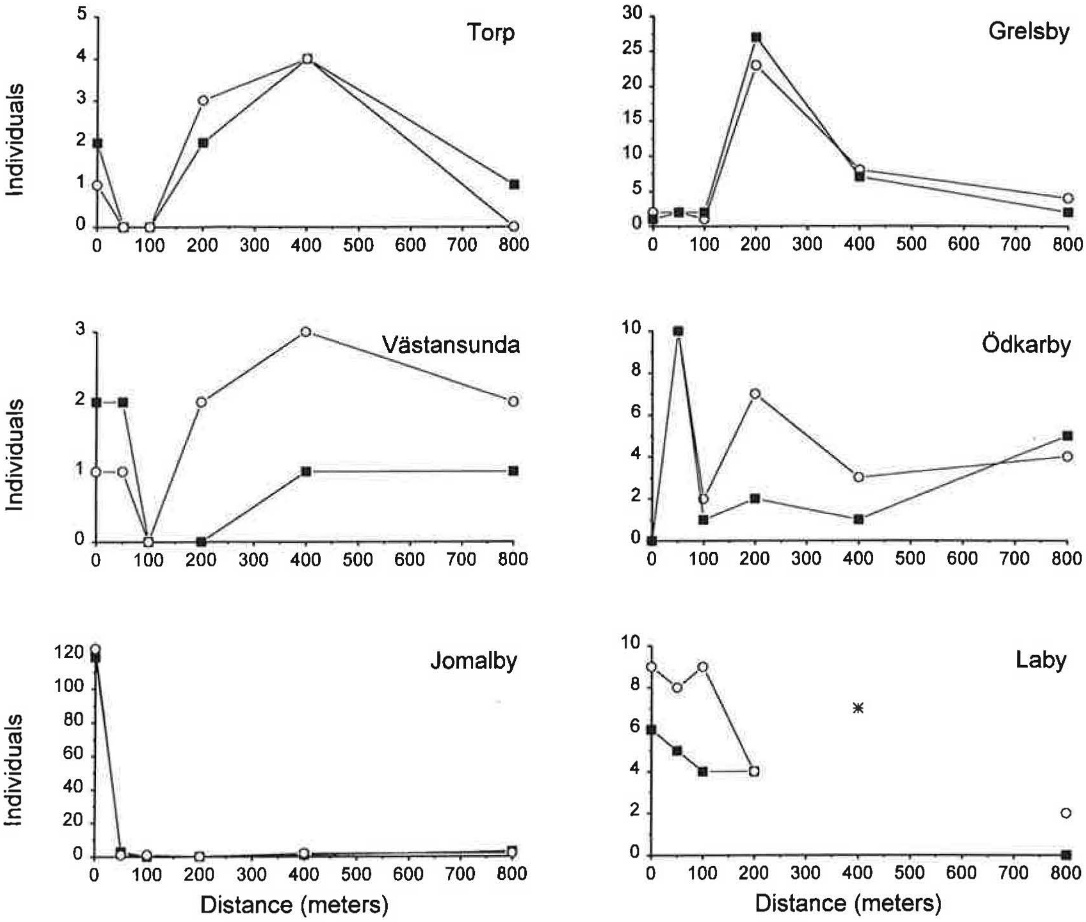

Fig. 2. The number of male (—■—) and female (—○—) *Aphodius contaminatus* trapped in relation to the distance to the nearest pasture. Note that the scale of the Y axis differs between sites as more than half of the individuals were found at one site, Jomalby (lower left corner). The individuals caught at a distance of 400 m from the pasture in Laby (lower right corner) could not be sexed, and thus the total number of individuals (seven) is indicated with a star.

tat was the same at all sites, the species appears to have an uneven spatial distribution with local "hotspots" of high abundance.

There was no consistent relationship between the distance from the pasture and the number of *A. contaminatus* individuals trapped. Neither was there any consistent difference in the 'migration rate' of males and females from the pasture (Fig. 2). More than 5% of the total number of individuals were encountered as far as 800 m from the nearest pasture. Over half of the individuals were caught at one single site (Fig. 1). Here, the population density was high in the pasture, but dropped very sharply to a low level within a distance of only 50 m.

4. Discussion

In Finland, *Aphodius contaminatus* has only been found on Åland. Some 80 specimens of *Aphodius contaminatus* were collected on these islands in the early 1940s (Fig. 1). Subsequently, there were no records of the species for more than half a century. *Aphodius contaminatus* was consequently considered extinct in Finland by Rassi *et al.* in 1992. In the autumn of 1995, I found *A. contaminatus* to be abundant in several parts of the Åland islands. What actually happened to the species in the intervening years?

It seems plausible that *A. contaminatus* was simply overlooked by coleopterists because of its phenology. The species seems to be univoltine all over Europe (Landin 1957, 1961, Horion 1958, White 1960, Hanski 1980, Vlug & Dreteler 1994). The eggs hibernate (White 1960, Landin 1961) and hatch in May (but cf. Vlug 1983). Pupae have been found from late July to the end of August (White 1960). The adults of *A. contaminatus* occur late in the summer and in the autumn. In 1995, I trapped the first three specimens between 19 and 31.VIII. The main flight period seemed to start in early September as 472 individuals were caught between 31.VIII. and 16.IX. In Sweden, the adults occur from the end of August to November (Landin 1961).

The adults of *A. contaminatus* thus occur in a season when few dung beetle collectors have been active up to now. A closer look at the temporal distribution of the earlier findings of the species seems to support this view. Prior to 1995, the species had only been found in the three consecutive years 1942–1944. All specimens were taken by the Lindberg family of beetle collectors: Harald Lindberg and his sons Per Harald and Håkan Lindberg. The family visited Åland year after year from the 1920s onwards. However, a check of collection dates in Lindbergs' insect collection in the Zoological Museum in Helsinki reveals that most specimens were collected in June and July (H. Silfverberg, pers. comm.). Thus, 1942–1943 were obviously the only years in which the Lindbergs visited Åland late enough to find *A. contaminatus*.

After the 1940s, relatively few beetle collectors seem to have visited Åland in September or even during the second half of August (H. Silfverberg, pers. comm.). There has thus been a serious seasonal bias in the sampling of the dung beetle communities of Åland. This could explain the strange "disappearance" of *A. contaminatus*.

Of course, we cannot rule out the possibility that the year 1995 was, in some respect, exceptional for the species. *Aphodius contaminatus* could be an outbreak species, which persists at low numbers for long periods, reaching high densities only in particular years. Vlug (1983) and Vlug and Dreteler (1994) have indeed found extremely high densities of *A. contaminatus* larvae in some years in the Netherlands. In Åland, the species occurred in very uneven numbers at the six study sites (Fig. 1). On a finer scale, there was large variation in the number of individuals encountered on different distances from the pastures (Fig. 2). Such spatially aggregated distributions may result in high spatial variance in survival, and in increased temporal variability in population densities (Hanski 1987, Hunter 1995). Unfortunately, I know of no study in which the population density of *A. contaminatus* would have been monitored for any considerable time span.

The larval food of *A. contaminatus* has been the subject of some debate. Although the adults seem to be attracted by a large variety of dung types ranging from rabbit dung (Vlug 1983) to fresh dog droppings (Jones 1984), most of these dung types are unlikely to provide a suitable microhabitat for the larvae. Landin (1957, 1961) considers the species to be particularly common in horse droppings. Rassi *et al.* (1985) consequently proposed that *A. contaminatus* has suffered from the recent drastic reduction in the Finnish horse stock (National Board of Agriculture 1951–1985, Information Centre of the Ministry of Agriculture and Forestry 1986–1995). In view of my results, *A. contaminatus* does not, however, appear to be a specialist of horse dung in Åland. All beetles caught in 1995 were attracted by baits made of cow dung, and they all seemed to emanate from cow pastures. The traps were placed outside cow pastures and neither horses nor sheep grazed closer than 1 km from any of the traps. At the site where the population density was highest, there was a sharp drop in density within 50 m from the border of the pasture (Fig. 2; Jomalby). Thus, if the larvae of *A. contaminatus* are coprophages, these local populations could hardly be sustained by any other dung type than cow droppings. Larvae of *A. contaminatus* have indeed on occasion been found in old cow pats (Landin 1961).

There was, however, no consistent relationship between the distance from the pasture and the density of *A. contaminatus* (Fig. 2). On the contrary, the species showed an aggregated spatial distribution outside the pastures in five of the six sites (Fig. 2). Three explanations could account for this pattern. These explanations are not mutually exclusive:

1. *Aphodius contaminatus* could be an extremely good disperser. This would imply that the scale of this study was too small, and that any distance dependence in the movements of the species would only be observed if traps were

placed further away from the pastures. This explanation seems unlikely regarding the pattern observed at the site with the highest local abundance of *A. contaminatus* (Jomalby in Fig. 2). Even if the density was very high in this pasture, a very small fraction of the individuals was found to emigrate to any considerable distance.

2. The species could be a microhabitat specialist. Thus, small differences in the microhabitat around the traps could override any effect of the distance from the pasture. Even though there were no obvious differences in the immediate surroundings of the traps, this possibility cannot logically be excluded.
3. The species might not be a specialist coprophage at all — potentially it is a generalist saprophage. Vlug and Dreteler (1994) have recorded high densities of *A. contaminatus* larvae in the soil of Dutch grasslands, and *A. contaminatus* larvae have also been found in turf (Jerath & Richter 1959). The occurrence of *A. contaminatus* may consequently not be restricted to pastures. Circumstantial evidence is provided by Hanski (1991: 86): he found the species to be twice as abundant in central Oxford as in any of the five pastures that he sampled outside the town.

Pastures are nonetheless likely to be crucial for the survival of the species, due to at least two factors. Firstly, grazing creates the habitat suitable for the species, i.e. open, preferentially sandy meadows (Landin 1957). Secondly, the population densities of the species do seem to be highest in pastures. In my study, more than half of the individuals were caught in the traps placed immediately outside the border of the pasture. Only one sixth of them would have been found here if the beetles had distributed themselves evenly in the landscape. The observed distribution is strongly affected by one site (Fig. 1; Jomalby). Here, the population density was very high in the pasture, but dropped rapidly within 50 meters from the pasture. This suggests that some pastures are high-productive "source" areas, which could be sustaining populations in nearby "sink" habitats (Pulliam 1988, 1996). If this is the case, then the species population could collapse regionally if the high-productive pastures were removed.

The main threat to *Aphodius contaminatus* thus appears to be the ongoing reduction in the numbers of grazing cattle. The cattle stock in Åland has not decreased quite as drastically as the horse stock; still, the numbers of cattle halved between 1950 and 1990, and the decline seems to continue (National Board of Agriculture 1951–1985, Information Centre of the Ministry of Agriculture and Forestry 1986–1995). Even if there is no convincing evidence of a collapse in the Finnish population of *A. contaminatus* up to now, the species is still a habitat specialist, and its occurrence in Finland is restricted to a small geographical region. Thus, it certainly deserves monitoring at a national level.

On a larger scale, *Aphodius contaminatus* is widely distributed in Western, Southern and Central Europe. It is also found in all Fennoscandian countries as well as in Northern Africa and in Asia Minor (Landin 1957, 1961, Horion 1958, Lindroth 1960, Balthasar 1964, Baraud 1977, 1979, Silfverberg 1992). In parts of Eastern Europe the occurrence of *A. contaminatus* is reported to be sporadic or local (Horion 1958). In most parts of its range *A. contaminatus* is thought to be both widespread and abundant (Baraud 1977), and no decline has been reported outside Finland. Unfortunately, most of the accounts on the occurrence of the species are quite old or unprecise. As a result of changing agricultural policies, the amount of cattle has declined in several European countries. This could potentially affect the abundance and distribution of dung-living insects, and these species should thus be monitored throughout Europe. At present, there seem to be serious gaps in our knowledge of the occurrence of dung-dwelling insects. If an entire species manages to go unobserved for half a century in Finland, then what changes may actually take place before we notice them?

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