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ORIGINAL RESEARCH ARTICLE

Habitat selection by two species of dung beetle, *Anoplotrupes stercorosus* (Scriba) and *Trypocopris vernalis* (L.) (Coleoptera: Geotrupidae), changes with stand age in a fresh pine forest

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Abstract. In Poland, *Anoplotrupes stercorosus* (Scriba) and *Trypocopris vernalis* (L.), are very common throughout the whole country and belong to the most numerous representatives of the Geotrupidae family. Research on the habitat selectivity of *Anoplotrupes stercorosus* (Scriba) and *Trypocopris vernalis* (L.) was conducted in the years 2004–2006 in the Wipsowo Forest Inspectorate (Regional Forest Department in Olsztyn). The dung beetles were collected using Barber traps installed in a clearcut comprising, 2, 3, 5, 8, and 16 year old thickets and tree-stands aged 30, 45, 60, 80, 100 and 135 years. According to phytosociology these tree-stands are a plant community of fresh continental pine forest (*Peucedano-Pinetum*), while typologically all sites are within the fresh coniferous forest. During the course of this research 29197 individual dung beetles were captured, including 23137 individuals of *A. stercorosus* and 6060 individuals of *T. vernalis.* Both species were caught at each research site. At nearly all sites *A. stercorosus* dominated. Only within the clearcut area were the number of *T. vernalis* was higher than at other sites. Very many individuals of *T. vernalis* were present in the clearcut area but their numbers decreased gradually with increasing tree-stand age. An opposite situation was noted for *A. stercorosus*. There was an interesting statistically-significant decrease in the abundance of both species in the middle-aged tree-stands – 30, 45 and 60-year-old. Analysing the seasonal dynamics revealed one peak in the population of *T. vernalis* in July, whereas there were two peaks in the population of *A. stercorosus*: a small peak in July and a much larger peak in September. There was a significant negative correlation between the numbers of *T. vernalis* and tree-stand age ($p<0.05$, $r=-0.57$), and a significant positive correlation between the *A. stercorosus* population size and tree-stand age ($p<0.05$, $r = 0.48$).

Key words: Geotrupidae, *Anoplotrupes stercorosus*, *Trypocopris vernalis*, ecology, afforestation, NW Poland

1. Introduction

The Scarabaeidae (Geotrupidae), as members of the group of trophic saprophages, play a critical role in forest ecosystems (Rembiałkowska 1980; Rojewski 1980). Both species discussed in this paper are very common in Poland and represent the most multiple species of the Scarabaeidae family in the country (Stebnicka 1976; Burakowski et al. 1983).

Anoplotrupes stercorosus (Scriba) is a forest species; its larvae feed mainly on dead plant matter, particularly litter, which the adults bury in their corridors and brooding burrows (Stebnicka 1976). Tischler (1976), L. and M. Erbeling (1984) also observed this species feeding on carrion. A second species – *Trypocopris vernalis* (L.), also feeds on dead organic matter, but prefers the feces of herbivores (Szyszko 1983).

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Scientific literature has devoted much attention to the ecology of both species. Borowski (1960) studied the composition of the species and role of Scarabaeidae in forest management. Szwałko (1995) analysed the possibility of using Scarabaeidae to monitor the Białowieża Forest. Skłodowski et al. (1998) studied the occurrence of Scarabaeidae species in pine stump fields after clearcutting, while Klimaszewski and Szyszko (2000) analysed the Scarabaeidae inhabiting sparsely growing pine stands. Plewińska (2007) conducted experiments using attractant traps, designed to demonstrate the impact of food availability on populations of *Anoplotrupes stercorosus*. Byk (2004, 2005) undertook a study on the impact of afforestation in former farmland and forests on changes in the numbers of *Anoplotrupes stercorosus* and *Trypocopris vernalis*. This author also researched the changes in size and composition of Geotrupidae in relation to the age of pine forests (Byk 2011). Byk and Semkiw (2010) additionally analysed the habitat selectivity of *Anoplotrupes stercorosus* in the Białowieża Forest.

The aim of this study was to determine the numbers and co-occurrence of two species of Geotrupidae: *Anoplotrupes stercorosus* and *Trypocopris vernalis* in continental pine forest habitat in relation to differences in the age of tree stands.

2. Study area

The study was conducted in north-eastern Poland (UTM DE85) in the Warmia and Mazury Voivodeship; and the research sites were located in the Nerwik forest, part of the Wipsowo Forest District (Fig. 1). The District is 25,027,23 hectares in size, with the Nerwik forest occupying 1,322,4 hectares of this area. The dominant species in the study area is pine (*Pinus sylvestris* L.), mixed with Common spruce (*Picea abies* L.), Silver birch (*Betula pendula* Roth.), oak (*Quercus* sp), Common hornbeam (*Carpinus betulus* L.) and larch (*Larix* sp.) The habitat is dominated by mixed coniferous forests - comprising about 56% of the area. Phytosociologically, the tree stands in this habitat are classified as continental pine forest (*Peucedano-Pinetum*) (Matuszkiewicz 2001), although the species composition and proportions of the plant species of the forest floor differ depending on the age of the tree stand (Szujecki 1971). Typologically, all the study sites were located in pine forests growing in forest soils.

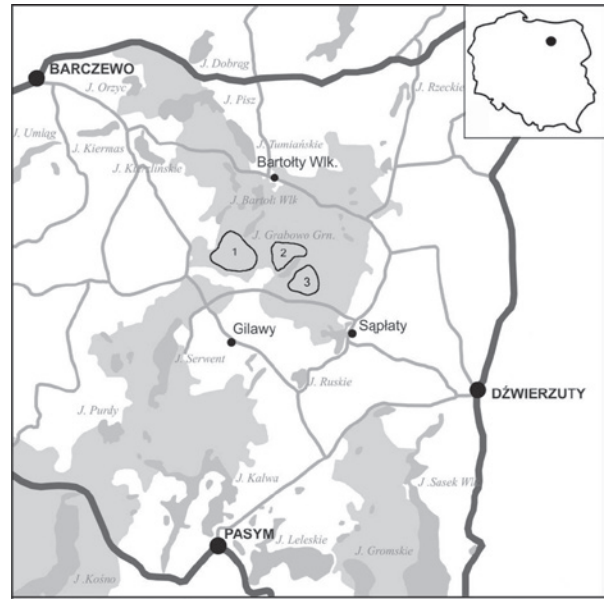

Figure 1. The study area: 1 – thickets at the age of 5 and 16 years, stands at the age of 30 and 60 years; 2 – clearcut and, thickets at 2, 3 and 8 years; 3 – stands at 45, 80 and 135 years

Twelve sites were selected for the study, differing by tree stand age – from a clearcut in a continental pine forest to a mature pine stand intended to be logged. Younger stands were studied in smaller age intervals due to the rapid changes occurring in the structure of the substrate (composition of the litter, appearance and disappearance of the moss substrate) associated with changes in exposure to light, which is mainly influenced by the development of young trees' lower branches, whose density blocks the amount of light reaching the forest floor. The class of pine plantations of 2, 3, 5, 8 and 16 years of age were chosen for the study. The next class of plots included middle-aged stands 30-, 45 and 60-years-old, chosen in larger age intervals due to the smaller changes occurring within these stands at these ages. The old tree stand class was represented by 80-, 100- and 135-year-old stands.

3. Materials and methods

Field studies were carried out in 2004–2006. To catch these epigeic beetles, Barber traps were used (Barber 1931). This is a standard method and widely used in such studies (Thiele 1977).

Plastic cups with a capacity of 500 cm^3 were used as single traps. The diameter of the upper part of the cup was 10 cm and served as the entry into the trap.

Each trap was placed in the ground so that its upper edge was flush with the ground level, ensuring that the beetles could fall into them easily from the soil surface. The traps were filled with 200 ml of ethylene glycol to kill and preserve the insects. A few drops of detergent were added to the ethylene glycol to reduce surface tension.

Ten traps were installed in each tree stand studied, placed in a linear pattern at 10 m intervals.

Beetles were collected during the growing season, lasting from April until the first frost in the fall. The specific dates for successive years were as follows:

– 05.05.2004 – 11.11.2004,
– 28.04.2005 – 23.10.2005,
– 25.04.2006 – 16.11.2006.

The traps were emptied regularly about every 10 days. The specimens from the traps were sorted and tagged.

For each site, the ratio of the dominance of both species, as well as the percentage of each species in the grouping were calculated. An analysis of the capture of both types of the taxa beetle was performed, based on the total number of individuals caught in all the traps during each month of the study correlated to the age of the tree stand. An assessment was also made of the qualitative and quantitative similarity of beetle assemblages inhabiting the research sites based on the Bray-Curtis index (1957). The Student's *t* test was used to determine the statistical significance of the differences found in the numbers of both species in the studied sites ($p<0,05$). The statistical analysis was performed using the Statistica and BiodiversityPro programs.

4. Results

During the study, 29197 beetles were caught, including 23137 *A. stercorosus* individuals and 6,060 *T. vernalis* individuals. Both species were caught in each research site.

An analysis of the species' domination confirmed that *A. stercorosus* dominated in almost all the sites. A greater proportion of *T. vernalis* was observed only in the clearcuts (Fig. 2). The structure of the dominance of both species in the tree thickets of 2, 3 and 5 years of age was fairly constant, with *T. vernalis* comprising about 30% of the total and *A. stercorosus* and about 70%. *A. stercorosus* was found in the largest proportion in mature tree stands of 80 and 135 years of age.

The number of captured *T. vernalis* was greatest in the clearcut, and decreased with increasing tree stand age (Fig. 3). Another increase in the numbers of this species occurred again, but not significantly, only in stands over 80-years-old. The opposite situation was noted for *A. stercorosus* (Fig. 3), although in middle-aged stands, i.e. 30, 45 and 60-years-old; an important, statistically significant decrease was noted in the number of trapped beetles of both species (Fig. 3). There were significant differences observed in *T. vernalis* abundance at different research sites. In the case of *A. stercorosus*, statistically significant differences were found in the number of captured specimens between the clearcut and thicket class (2, 3, 5, 8 and 16-year-old trees) and the mature forest stands (80, 100 and 135-year-old trees).

Seasonal dynamics of both species differed: in the case of *T. vernalis*, the peak population was noted in August, while *A. stercorosus* exhibited two peaks –

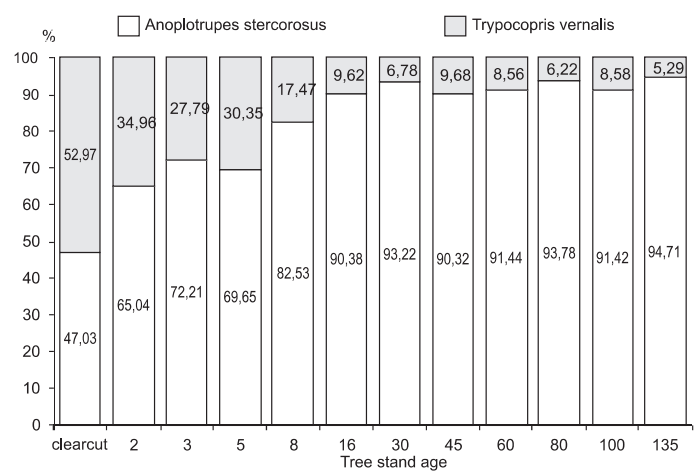

Figure 2. The domination structure of *A. stercorosus* and *T. vernalis* on the research sites

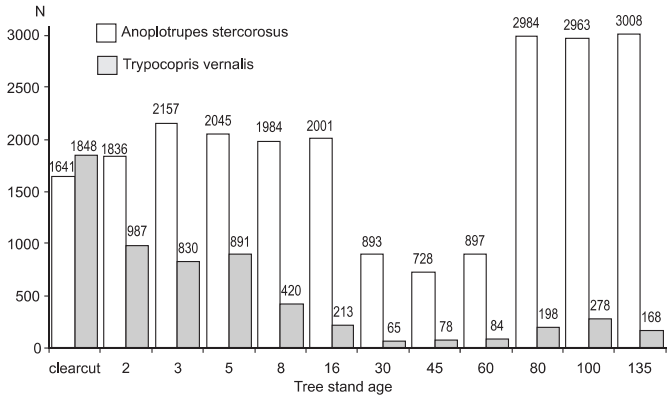

Figure 3. Changes in numbers of *T. vernalis* and *A. stercorosus* on the research sites

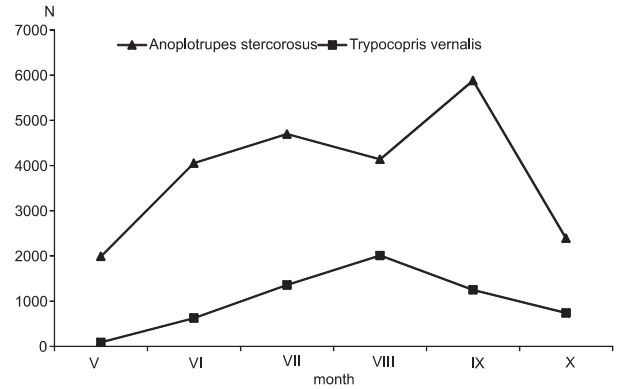

Figure 4. Seasonal dynamics of *A. stercorosus* and *T. vernalis*

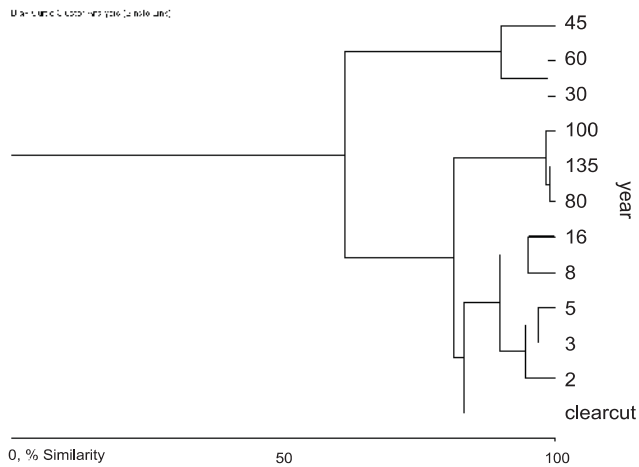

Figure 5. Dendrogram of quality-number similarities of the research sites according to the Bray-Curtis method

a smaller one in July and a significantly greater one in September (Fig. 4).

A significant negative correlation (-0,57) was found for *T. vernalis* abundance and tree stand age ($p<0,05$), while a significant positive correlation (0,48) was revealed for *A. stercorosus'* abundance and age of the forest stand ($p<0,05$).

A dendogram of the qualitative and quantitative similarities grouped the research sites into two clusters of about 60% similarity (Fig. 5). The first cluster comprised of beetle assemblages inhabiting 30, 45 and 60-year-old tree stands. Two sub-groups were able to be distinguished in the second cluster, which grouped the remaining sites. The first comprised of beetle assemblages occurring in clearcuts and thickets of 2, 3, 5, 8 and 16 years of age, while the second was formed by an assemblage in mature stands of 80, 100 and 135 years of age.

5. Discussion

The dominant species in each of the studied assemblages, except for the clearcut, was *A. stercorosus*. The proportion of this typical forest species in beetle assemblages ranged from 47,03% in the clearcut to 94,71% in the 135-year-old tree stand. High number of this species in the forest is associated with the prevalence and availability of large amounts of dead organic matter feeding on a specific diet (Stebnicka 1976; Burakowski et al. 1983, Byk 2004, Byk and Semkiw 2010). The proportion of *A. stercorosus* in recently planted stands was smaller than in mature tree stands. The positive result for the correlation of abundance with tree stand age indicates the habitat specialization of this species, with a preference for older, uniform stands. Similar observations were made

by Koch (1991). In his research on changes in the number of *A. stercorosus* related to the extent of afforestation in the Człuchowski Forest, Byk (2004) also noted greater numbers of captured beetles with an increased age gradient of the forest - from a clearcut, through thickets, to mature tree stands. Similar results were also obtained in afforested former farmlands. In studies of Geotrupidae assemblages in the Człuchowski Forest pine stands, Byk (2011) also found a marked increase in the numbers of this species in the older stand age classes. Szyszko (1983) showed that *A. stercorosus* was not present in clearcuts or thickets, and only appeared in 18-year-old stands, with its greatest numbers reaching in 60-year-old tree stands. In the study presented here, *A. stercorosus* occurred in each of the three age classes studied, with the highest proportion reached in mature stands.

According to Burakowski et al. (1983) *A. stercorosus* appears as an imago in spring (from April–June) and autumn (from July to October). This is confirmed by the findings of other authors (Błażejewski 1956, Borowski 1960; Kočárek 2003). L. & M. Erbeling (1984) state that the beetles breed more in spring than in autumn. Their research also presents two peaks of observed abundance, i.e. a smaller one in July and a greater one in September. Similar results were also obtained by Byk (2004, 2011) in his Człuchowski Forest studies.

The second species, *T. vernalis*, represented the largest portion of the number of beetles captured in the clearcut – 52,97%; this number decreased as the tree stands aged. *T. vernalis* is a species associated with younger stages of forest development, which is confirmed by the negative correlation between its numbers and age of tree stand. It occurs in different environments. More individuals of this species are found in thickets than in the mature forest, but it is also present in older stands, indicating a habitat preference for the ecotone zones, i.e. open areas adjacent to forests (Aleksandrovich, Pisanenko 1987). Byk (2011) also noted the increased numbers of this species in younger age group of trees, but in his study, the species is also abundant in mature stands. On the other hand, Szyszko (1983) indicated that the largest number of *T. vernalis* was found in 11 and 14-year-old tree plantations. Perhaps this is due to the fact that Szyszko (1983) conducted research in afforested former farmlands, where the succession process differs from that in forest sites used for logging.

As a saprophage, *T. vernalis* is associated with animal feces. Klimaszewski and Szyszko (2000) draw attention to the increased numbers of *T. vernalis* on one hand, and deer, on the other hand, in atypically developed pine stands. They captured many more *T. vernalis* in degraded and sunny forests where there were many more animals than in the dense tree stands. An analogous situation probably exists in clearcuts and thickets: a larger population of deer is supported, (roe and red deer) in comparison to dense forests, and following this, a greater food base is available for this beetle species.

The peak of abundance for this species occurred in August, differing slightly from Byk's studies (2005, 2011) in the Człuchowski Forest, where most individuals were caught from June to August.

The analysis of faunistic similarity using the Bray-Curtis method clearly distinguished a cluster of beetle assemblages inhabiting middle-aged tree stands (30, 45, and 60 years of age). The numbers of both species of beetles was clearly much smaller in these tree stands. In the case of *A. stercorosus*, this is probably due to the small amount of dead organic matter in the litter. At this stage of forest growth, the ground is completely shaded, mosses withdraw and the scant litter is made up of fallen pine needles. In the absence of undergrowth vegetation, stands of this age are reluctantly used by animals; hence the lesser numbers of *T. vernalis*, which are dependent on the feces of large herbivores (Klimaszewski and Szyszko 2000). This age of tree stand is quite a critical period in the cycle of forest reconstruction for various groups of organisms: saprophages and predators.

6. Conclusions

The study conducted leads to the formulation of the following conclusions:

1. The number of *T. vernalis* changes with the tree stand age gradient. It finds its most optimal habitat conditions in clearcuts and thickets, where it is observed in decidedly greater numbers than in young pole wood, pole wood or mature tree stands.
2. The number of *Anoplotrupes stercorosus* also changes with the tree stand age gradient. Its optimal habitat conditions are in older and mature tree stands, where it reaches its greatest numbers.
3. The adults of both studied species are most numerous between July and September.
4. The distinctly smaller population numbers of both species in middle-aged tree stands (30, 45 and 60 years of age) is most likely due to the smaller food base found there than in clearcuts, thickets or mature tree stands.

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