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Living beyond the limits of survival: wood ants trapped in a gigantic pitfall

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Abstract

A unique accumulation of workers ('colony') of the wood ant *Formica polyctena* Först., trapped within an old bunker for storing nuclear weapons, is described. The source of the 'colony' is a large colony nesting outdoors, on top of the bunker. Individuals that have fallen down through a ventilation pipe are not able to find their way back to the mother nest. In total darkness, they have constructed an earthen mound, which they have maintained all-year-round by moulding it and keeping the nest entrances open. Judging from the huge deposits of wood-ant corpses in the bunker, the 'colony' has survived for years. Through these years, the mortality has been more than compensated by new workers that fall down during the active season of the free-living colony outside, and at present the number of the bunker workers is counted in hundreds of thousands. The 'colony' has evidently produced no offspring, which is due to low (though relatively stable) temperatures and scanty food in the bunker.

Keywords

Adaptability, caves, continuous darkness, flexibility of nesting, *Formica polyctena*, lifespan, low temperatures, marginal habitats, scarce food resources

Introduction

In the boreal and temperate coniferous and mixed forests, territorial wood ants of the genus *Formica* L. are organising centres of multi-species ant assemblages, wherever the physical environment is suitable for them (Dlussky 1981, Savolainen and Vepsäläinen 1988). Territorial species need a stable and productive environment for constructing nests and colonies of high energy demand (see Hölldobler and Wilson 1977). Consequently, the territory of typical wood-ant colonies – with several hundred thousand or a million workers – ranges over several hectares (Savolainen and Vepsäläinen 1988). The base food of workers, honeydew of aphids, is abundantly available especially on coniferous trees and harvested at a distance up to over 100 metres from the mound (Rosengren and Sundström 1991, Vepsäläinen and Savolainen 1994).

In studies of the ants in the Tvärminne archipelago, in the Gulf of Finland in the Baltic Sea, wood ants were found only on forested islands (Vepsäläinen and Pisarski 1982). The explanation for the finding seems evident: the high energy demand of wood ant colonies restricts them to the largest islands with a stable and productive environment. When, however, colonies were artificially established on smaller islands with no wood ants, to search for the limits of their living conditions, colonies were found to survive on islands with a seemingly suboptimal environment (Czechowski and Vepsäläinen 2010). At its extreme, a colony has survived close to 30 years on a barren islet of less than 0.2 ha, where the only permanent and relatively rich food is provided by aphids on the islet's only pine tree (Czechowski and Vepsäläinen 2009 and unpublished). It is possible that the harsh conditions on the islet do not allow production of sexual offspring; thus the continued survival of the colony may depend on replenishment of young, fertilised queens born in colonies on the nearby mainland or large islands. Especially after having lost its own queen(s) a wood-ant colony is open to adopting new wood-ant queens, whatever their species identity (Czechowski 1994, Pisarski and Czechowski 1994, Czechowski and Vepsäläinen 2010).

Here we report on a unique wood-ant 'colony', which has survived in conditions beyond the limits of existence of wood ant colonies. This paradoxical situation is caused by a gigantic pitfall trap in the forests of Poland, originally constructed by the Soviet military to store nuclear weapons. Although the aggregation of wood ants described in this report superficially looks like a colony, it is a far cry from a fully functional colony; thus we use here the notion of 'colony' only for convenience.

Study area and methods

The observations were made at Templewo (52°27'N; 15°23'E) near Międzyrzecz in western Poland, close to the German border. There, a Soviet nuclear base existed from the late 1960s to 1992. Part of this military complex ("Special object 3003 Templewo" according to military nomenclature) with a total area of ca. 370 ha was dismantled in the beginning of the present century. Two underground two-level ammunition

Figure 1. Partly blocked entrance to the bunker system. In the background, pine-spruce forest overgrowing the hillock built to camouflage the structure. Photo taken on 17.07.2014 (Wojciech Stephan).

bunkers, 300 metres apart (26 m × 42 m each), which constituted the core of the base and where nuclear weapons were kept, have survived (Sadowski 2011, Rutko 2015). From the outside they are visible as flat-topped hillocks overgrown with spruce forest, densely populated by the wood ant *Formica polyctena* Först. Until recently the entrances to the bunkers were blocked, and only openings for bats were left (Rutko 2015). At present, however, the bunkers are accessible – some illegally dug cracks allow volunteers to squeeze inside (Fig. 1), to count bats hibernating there. One-metre thick ferroconcrete walls and ceilings keep the temperature inside at a relatively steady level: around 10 °C in summer and a few degrees above zero in winter.

Within the bunker under discussion, a corridor leads to a small 2.3 m high room, with a base area of 3 m × 1.2 m. The room is connected to an adjacent, somewhat larger space by two openings in the wall – one at the bottom (Fig. 2) and another higher up (Fig. 3). The walls are covered with flaking paint and limewash (calcium hydroxide) swellings. The terracotta floor is covered with soil, concrete rubble and rubbish. A vertical ventilation pipe, 40 cm in diameter and about five metres long, connects the bunker chamber through an outlet in the ceiling with the outside world (Fig. 3).

The bunker interior has been visited annually since 2012 as part of a campaign to count overwintering bats. Starting from 2013, when the bunker population of ants was discovered, several summer inspections have been made. During these examinations, the temperatures, both internal in the bunker space with ants, and external, above the bunker, were measured.

Voucher samples are stored in the Museum and Institute of Zoology, PAS, Warsaw (a sample of *Formica polyctena*) and the Natural History Collections, Faculty of Biology, Adam Mickiewicz University in Poznań (samples of all arthropods collected in the bunker).

Figure 2. The earthen mound inhabited by the *F. polyctena* 'colony' in the bunker. Photo taken on 11.01.2015 (Wojciech Stephan).

Results

A 'colony' of *Formica polyctena* was found in January 2013, during winter counts of hibernating bats in the underground bunker. It nested in the small room mentioned above, under the ventilation pipe (Figs 2, 3). In the summer of 2015 it was revealed that the top of the ventilation pipe (slightly below the ground outside) was covered by a huge elliptical mound of *F. polyctena* (height 60 cm, conjugate diameters of the base ca. 3 m and 2 m; Fig. 4). A bottom sight of the pipe outlet suggested that formerly it was covered with a metal plate which had rusted almost completely over the course of time (Fig. 5). Thus the origin of the underground wood ant 'colony' under discussion became clear: inside of the bunker, ants falling down from the hole in the ceiling were seen every now and then.

A majority of the surface area of the floor of the chamber was occupied by a rather flat earthen mound (25 cm at the highest point), irregularly shaped but evidently constructed and inhabited by ants, with many entrance or exit holes (Figs 2, 6). The mound contained a negligible amount of nest material typical of wood ants. During observations, both in winter and summer, teeming crowds of *Formica polyctena* workers were seen in the space with the nest, in the adjacent room and partly in the corridor in between; they also dispersed around neighbouring spaces of the bunker. The ants were fairly active in winter, both in respect of their numbers and vigour (Fig. 7), though less than in summer. In summer, they were seen climbing walls (Fig. 3), probably stimulated by the temperature that increased upwards. For instance, on 24 July 2015, when the external temperature was about 30 °C, the internal temperature was 9.5 °C at a height of 45 cm, and 11.4 °C at a height of 160 cm above floor level. In turn, on 21 February 2016, the external temperature was 10 °C, and the internal ones were 6.7 °C and 7.7 °C respectively.

Figure 3. The upper part of the bunker space with the *F. polyctena* 'nest'. In the middle of the ceiling, the input of the ventilation pipe. Ants climbing walls (and hardly reaching the ceiling) en masse within and outside the room are visible (especially well on the door frame). Photo taken on 24.07.2015 (Wojciech Stephan).

The ants, however, were never seen walking on the ceiling (Fig. 3), and thus they were not in reach of the pipe inlet. Consequently, when once trapped underground, they could not find their way back to the maternal nest. Flat parts of the earthen

Figure 4. The mound of the free-living *F. polyctena* colony built on the outlet of the ventilation pipe; the source of the bunker 'colony'. Photo taken on 24.07.2015 (Wojciech Stephan).

Figure 5. Bottom sight of the ventilation pipe outlet. Photo taken on 21.02.2016 (Wojciech Stephan).

mound and the floor of the adjacent spaces (including the room with the mound, the neighbouring chamber and a part of the corridor) were carpeted with bodies of dead ants (Figs 6, 8). Locally the deposits were a few centimetres thick. Because the total volume of these wood-ant 'cemeteries' was at least 250–300 dm^3, and a one cubic decimetre sample contained ca. 8,000 ant corpses, the number of dead *Formica polyctena* workers probably amounted to about two million. The cemeteries comprised also remnants of other insects, most probably those caught by foragers of the free-living upper colony that had fallen down. Of other ants, only a head of the *Leptothorax* sp. worker was found. Extraction of the cemetery samples in a Tullgren funnel also included living invertebrates; acarids, mainly Prostigmata and Mesostigmata (normally living in dead plant material), occurred in large numbers. Interestingly, we also found some myrmecophiles alive even in winter. These included rarely met myrmecophilic spiders and numerous beetles (these findings will be described separately). No empty ant cocoons were found during a manual search of the cemetery material.

During an inspection made in July 2015, we estimated the size of the bunker 'population' of *Formica polyctena* to be at least several hundred thousand workers, perhaps close to a million. That time, the earthen mound was partly dug up, paying attention to the possible presence of ant brood (larvae, pupae or empty cocoons) and queens. Nothing like these was found. By the next visit in January 2016, the damage caused by us to the mound had been repaired by ants.

Discussion

Ants are known to be flexible in their choices of nest site and nest construction, and to take advantage of exceptional opportunities. For example, myrmicines have been found nesting in big mushrooms, *Myrmica rugulosa* Nyl. in *Sparassius crispa* Fr. (Czechowski 1979) and *M. rubra* (L.) in *Gyromitra esculenta* (Pers.) Fr. (K. Vepsäläinen, unpublished). A colony of *Lasius niger* (L.) nested in a chassis of an immobilised car, from where the ants found their way to the cabin. The nest was built of particles of mud and dry plant remnants stuck to the underbody of the car (P. Skórka, pers. comm.). Wood ants, with considerably larger nests than those of myrmicines, have been known to construct a mound in an abandoned barn (Yle uutiset 2015). A smaller mound has been found in almost complete darkness within a cubic wooden box with one-metre edges but no floor or openings apart from a narrow slit at the bottom of one side (W. Czechowski, unpublished). In all the above cases, however, the foragers of the colony had access to the outside world, and each specific mode of nesting was the choice of the ants. The masses of *Formica polyctena* workers trapped in the bunker had no choice. They were merely surviving and continuing their social tasks on the conditions set by the extreme environment.

Wood ants are able to adapt themselves to notably suboptimal living conditions, as told in the Introduction. Likewise, after severe degradation of their environment, e.g. after forest clear-cuttings or splitting of the habitat by urbanisation, the colonies

Figure 6. The mound of *F. polyctena*'s bunker 'colony' in close-up. In the background, against the wall, an ant 'cemetery' is visible. Photo taken on 24.07.2015 (Wojciech Stephan).

with large mounds move to new, smaller ones (Vepsäläinen and Wuorenrinne 1978, Sorvari and Hakkarainen 2007, Sorvari 2013). By such means they increase the probability of survival of at least some mound(s) through the period with not enough food

Figure 7. *Formica polyctena* workers active on their mound surface in winter, keeping nest entrances open. Photo taken on 11.01.2015 (Wojciech Stephan).

to maintain large, stationary nest units (Vepsäläinen and Wuorenrinne 1978). More generally, any kind of degradation of the environment – including the limits set by central place foraging of the growing colony – may lead to the founding of temporary nests ('food stations') which in favourable conditions can develop to permanent sister nests (e.g. Mabelis 1979, Savolainen and Vepsäläinen 1989).

The bunker ant 'colony' described here seems, however, to be unique in all respects. First, the old military bunker has served (and still serves) as a gigantic pitfall trap for wood ants nesting on the top of the bunker. Second, the workers involuntarily trapped in total darkness have maintained their basic activities of nest maintenance, constructing and moulding the earthen mound, and keeping nest entrances open (Figs 6, 7). Third, without access to the outside world, the foragers have not been able to feed the whole workforce, and consequently the mortality rate has probably been much higher than in natural conditions. Normally, workers of wood ants live up to ca. three years (Czechowski 1996, see also Godzińska et al. 1999). It is hard to tell how long an individual worker can survive under the bunker conditions, but the existence through years of the underground 'colony' shows that they have been able to survive at least from one vegetative season to another – up to the new supply of workers falling down through the ventilation pipe. Fourth, neither queens nor any ant brood was

Figure 8. View from the bunker corridor over the space with the *F. polyctena* 'colony'; in the foreground, a vast ant 'cemetery'. Photo taken on 19.01.2016 after reopening the repaired mound for a second search of offspring (Wojciech Stephan).

seen in the bunker 'colony', though their occasional falling down cannot be excluded. Nevertheless, the low temperatures prevailing inside the bunker would scarcely allow production of any offspring. True, it is known that wood ants are effective in managing the inner temperatures of the mound and optimise the nest environment of each developmental stage and caste (Horstmann and Schmid 1986, Rosengren et al. 1987, Kadachová and Frouz 2014), but that would necessitate huge amounts of food in order to raise the organisational level of the colony to that observed in natural environments (Vepsäläinen and Wuorenrinne 1978, Pisarski and Vepsäläinen 1989, Sorvari and Hakkarainen 2007, Sorvari 2013, Sorvari et al. 2014). Because wood-ant workers of queenless colonies as a rule produce workers (e.g. Czechowski 1996), the lack of male offspring in the bunker indicates extremely difficult conditions.

The amount of potential food in the bunker, suitable for wood ants, is not known, but the smaller arthropods living there could hardly be enough to allow the workers both temperature regulation of the mound and feeding of offspring. Under Central-European climatic conditions, development of permanent arthropod communities in the bunker under discussion is rather impossible. The mites which occur there seem to be first of all ant-dependent detritivores (mainly Mesostigmata) feeding amongst ant cemeteries. The amount of another possible resource, the bat guano, is too scarce there to play any role as substrate for a detritivore fauna. Predatory forms (Prostigmata) can forage on smaller mites. The question arises whether and to what extent these much larger wood ants (ca. 4–8 mm in length) are able to forage on such small mites. Although some exploitation by the ants cannot be excluded, it seems rather unlikely.

In all its uniqueness, the conditions within the bunker seem to be closest to deep caves. Wilson (1962) explained why it is unlikely that any truly cavernicolous (troglobiotic) ant species existed. Simply, social insects seem to be unable to maintain sufficiently large populations in caves (though see Roncin and Deharveng 2003). In spite of quite a few reports on ants found in caves (e.g. Espadaler and Gelabert 1983, López 1988, Cokendolpher et al. 2009), most of the many species reported seem to be stray individuals that have entered the cave through its entrance or dropped in through cavities (Espadaler and Gelabert 1983). For such species, the food supply of caves is too meagre to sustain even a single colony (Wheeler 1924). As a rule, the ants have been found close to the cave entrance, where there is still some light (Wilson 1962). This can be explained by the fact that the majority of 'cave ants' nest outside caves and only a few opportunistic foragers in search of food penetrate the cave. Finally, most of the caves harbouring ants are in the tropics or subtropical regions, where benign temperatures and copious nutrient (mainly guano) support a diverse fauna of cave arthropods. Indeed, the few finds of functional ant colonies nesting deep within a cave are from the tropics, where probably some species may have their nest far from the entrance in complete darkness (Wilson 1962, Roncin and Deharveng 2003) or, e.g. from the Mediterranean, like the cavernicolous *Hypoponera ragusai* (Em.) with all-year-round colonies of workers, queens and males (Tinaut 2001).

To conclude, the wood-ant 'colony' described here – although superficially looking like a functioning colony with workers teeming on the surface of the mound – is rather an example of survival of a large amount of workers trapped within a hostile environment in total darkness, with constantly low temperatures and no ample supply of food. The continued survival of the 'colony' through the years is dependent on new workers falling in through the ventilation pipe. The supplement of workers more than compensates for the mortality rate of workers such that through the years the bunker workforce has grown to the level of big, mature natural colonies.

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