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The course of artificial colonization of red wood ants in the Gorce National Park

Abstract. In the Gorce Mts. (Western Carpathians) spruce forests within the National Park were destroyed by *Cephalcia falleni* DALM. (Symphyta). Because of that some experimental works (since 1985) and practical operations on artificial colonization of *Formica polyctena* FOERST. (since 1987) have been conducted there. The natural upper range of the occurrence of red wood ants in Gorce reaches up to 800-900 m above sea level; they have been taken 200-400 m above this altitude. About 100 nests of *F. polyctena* have been founded in the Park, being grouped in several artificially formed polycalic colonies.

CIRCUMSTANCES AND OBJECTIVE OF THE UNDERTAKING

An outbreak of *Cephalcia falleni* DALM. (Hymenoptera, Symphyta) feeding on spruce trees began in the Gorce National Park in 1979 (CAPECKI 1982, HONOWSKI, HUFLEJT 1988). This is a Euro-Asiatic species (BENEŠ 1976). In Europe it occurs in northern regions and in the mountains of the central part of the continent. Never before had it caused damages anywhere. In the late 1970's *C. falleni* appeared in great masses in several sites in the Polish Carpathians and Sudeten at an altitude of over 900 m, causing gradual dying out of the mountain spruce forests there. The pest had three strong centres persisting in the Gorce Mts. in 1979-1983, and these were in the massifs of Jaworzyna Kamienicka, Kudłoń, and Mostownica. The outbreak affected a total area of 2,800 ha, with 400 ha where trees had been left entirely bare, and this led to a complete dying out of the forests there (Fig. 1).

No chemical methods against *C. falleni* were used in the Gorce National Park. Attempts were made, though, at introducing some parasitic nematodes. An appearance of unidentified tribes of bacteria that infected pest larvae was recorded. In 1984, the manager of the Park, Mr. HONOWSKI, suggested to the Institute of Zoology, PAS in Warsaw undertaking studies on the possibilities of artificial colonization of red wood ants in the area affected by the outbreak. An introduction of ants of the *Formica rufa* L. group, very active predators, was meant to increase the resistance of the local forests to any future reappearance of primary pests.

CHARACTERISTICS OF THE AREA

The Gorce Mts. are a small range in the Western Beskidy Mts. (the central part of Western Carpathians). They rise up from 375 m in river valleys to 1310 m (Turbacz Mt.) above sea level. There are three zones of vegetation there: piedmont deciduous forests, beech forests, and spruce forests.



Fig. 1. The post-outbreak clearing of the spruce forest on the Kudłoń Mt. (1987) (Photo by W. CZECHOWSKI).

The zone of the piedmont deciduous forests (*Quercus-Carpinetum*) reaches up to 600 m above sea level. It has a mosaic character nowadays. In river valleys and on more gentle slopes forests have been cut out and the areas thus obtained turned into cultivation or into meadows and pastures. Places unsuitable for agricultural use (steep slopes, rocky areas, banks of streams, and sides of roads) still retain patches of woods or belts with tree stands.

The zone of beech forests (*Fagetum carpaticum*) grows at an altitude of 600–1150 m. Originally it was overgrown with beech forests and beech-spruce-fir ones. The natural tree stands have recently been replaced, over a considerable area, with artificially introduced spruce woods.

The zone of spruce forests (*Picetum tatricum*) is found in areas situated higher than 1150 m above sea level. In the highest parts of the mountains most of the forests have been cut down and the land turned into sheep pastures. At present, sheep do not graze in the National Park and the whole area is overgrown with thick tall grasses.

There are fundamental climatic differences between the zones (Table). The zone of beech forests corresponds with the zone of a moderately cool climate and that of spruce forests with the zone of a cool climate [MEDWECKA-KORNAŚ (ed.) 1968, 1970, MICHALIK 1989].

Table. Differences in the value of certain climatic parameters between the climatic zones in the Gorce Mts.: the moderately cool zone (A) where ants occur in their natural state, and the cool zone (B) where they are introduced artificially

Parameter	A	B
Mean annual temperature (°C)	4	3
Mean annual total of precipitation (mm)	1000	1200
Length of the vegetative period (days)	170	155
Length of the period with snow on the ground (days)	140	160

OCCURRENCE OF ANTS

The myrmecofauna of the Gorce Mts. is relatively poor, just as is the case in other ranges of the Beskidy Mts., which are formed mainly of flisch rocks. Species of a wide ecological amplitude and vast geographical ranges – mainly the Euro-Siberian element – predominate there. The distribution of ants in the habitats is very uneven. They generally occur in open places, in the zones of plateau and beech forests – in meadows and pastures, at the edges of forests, along the sides of roads, on shingly river terraces. About 20 ant species inhabit all these areas, and the density of their nests is relatively high – 0.5 per 1 m² on average. At some places, especially on the stony sides of roads or at the edges of forests it reaches 1/m². The myrmecofauna of the meadows in the zone of spruce forests is considerably poorer. Only several species can be found there and the density of nests is very low – 0.1 m². The forests in the beech wood zone, both beech forests and secondary spruce ones, are dense, shady and damp. They form a habitat that is not favourable to ants; only *Formica polyctena* FOERST., *Camponotus herculeanus* (L.), and *C. ligniperdus* (LATR.) are recorded there. No ants are found in the pure dense tree stands of the spruce wood zone.

Ants of the subgenus *Serviformica* FOR. are of vital importance to the distribution of red ants (the *Formica rufa* group). Five of these species occur in the Gorce Mts. They are: *Formica fusca* L., *F. lemani* BONDR., *F. rufibarbis* FABR., *F. cunicularia* LATR., and *F. cinerea fuscocinerea* FOR. The last of these species inhabits only the shingly terraces of streams. *F. fusca*, *F. rufibarbis*, and *F. cunicularia* are species widely distributed in open habitats up to 800–850 m above sea level. *F. fusca* prefers dry and stony pastures with not very lush vegetation, and it usually builds its nests under stones; *F. rufibarbis* and *F. cunicularia* occur both in dry pastures and in hay-grownig meadows with far more luxuriant vegetation, where they build nests with soil mounds. *F. lemani* inhabits meadows and pastures situated higher than 800 m above sea level.

Four species of the subgenus *Formica* s. str. occur in the Gorce Mts. and these are: *F. truncorum* FABR., *F. pratensis* RETZ., *F. rufa* L., and *F. polyctena* FOERST. Out of these, three species (*F. truncorum*, *F. pratensis*, *F. rufa*) build nests only in open areas (meadows, pastures), but always close to the edge of a forest or cluster of trees. *F. pratensis* is very rare, it occurs up to 800 m above sea level. *F. truncorum* and *F. rufa*, a fairly common species, are recorded up to 900 m above sea level.

F. rufa occurs in Gorce only in the monocalic form. Its workers are aggressive towards strange workers of its own species. Therefore, an assumption that it forms monogynic societies in this area is justified. Colonies of *F. rufa* are of medium size, their nests have a diameter of 50–100 cm and a height of up to 50 cm. These nests are distributed fairly regularly. They are recorded in one type of habitat only and therefore *F. rufa* from the Gorce Mts. may be considered a species of a low ecological flexibility (a stenotopic one).

F. polyctena from the Gorce Mts. generally forms polycalic societies that comprise several or even several dozen nests (the biggest, at Łopuszna near Nowy Targ, is composed of about 70 nests). Most societies consist of colonies with very high abundance; the diameter of their nests is 2–3 m and the height about 1 m (Fig. 2). Monocalic colonies are rare. *F. polyctena* occurs in forests, usually in spruce ones, up to 900 m above sea level. Polycalic colonies of this species may be found not only in dense, shady, camp young woods (30–40 years of age), but also in drier, light old spruce tree stands. They sometimes occur in very young tree stands and on the edges of forests, at dry and insolated places, and also in other types of forests (e.g. birch or poplar ones). Such a great variety of habitats utilized gives evidence of a considerable ecological flexibility of the species.

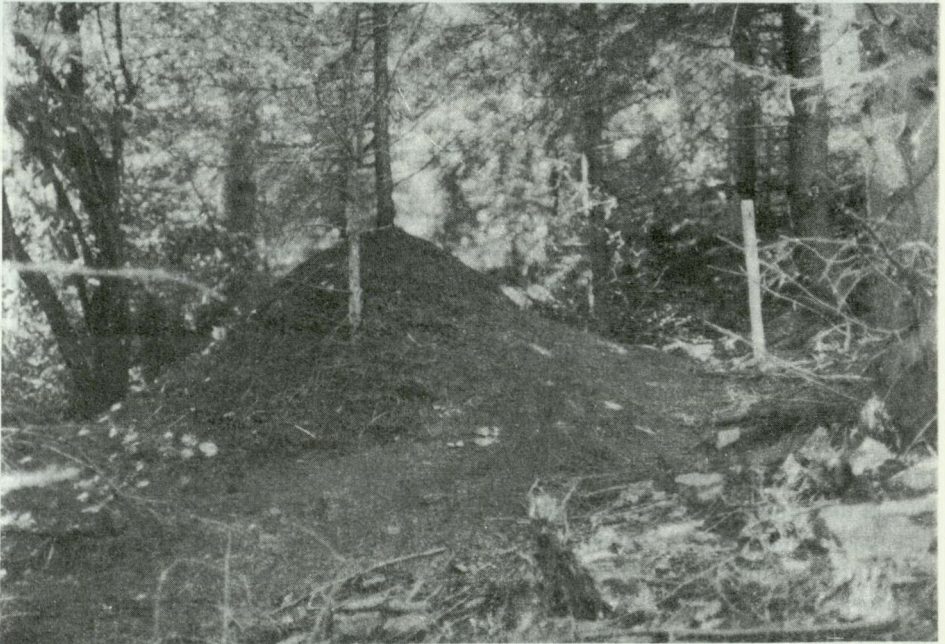


Fig. 2. A typical natural nest of *F. polyctena* in the Gorce Mts. (Photo by T. PŁODOWSKI).

It is well-known fact that red wood ants found new colonies in two ways: through moving a part of the swarm from its maternal nest and after the nuptial flight by queen-foundatrices through temporary parasitism in colonies of the subgenus *Serviformica*. This means that the expansion of red wood ants in a given area depends on the distribution of the colonies of *Serviformica* species. The latter occur

in the Gorce Mts. only in open areas, meadows and pastures, and on the edges of forests. This type of distribution of *Serviformica* ants is a condition for a population of *F. rufa* to reach a fairly high and even density of (monocalic) colonies in habitats suitable for the species (open ones). *F. polyctena*, on the other hand, finds in its suitable habitats (forests) no nests of *Serviformica* where the foundatrices could start new colonies. This is possible only on the edges of forests. And true enough, maternal colonies of polycalic societies of *F. polyctena* are generally situated in ecotones. However, due to their polycalism, ants of this species may inhabit considerable surfaces of a forest interior, founding new colonies by means of colony fission.

USEFULNESS OF SPECIES FOR ARTIFICIAL COLONIZATION

The above characteristics of the species of red wood ants recorded in the Gorce Mts. indicates that only *F. polyctena* meets all the requirements for being used in artificial colonization. It is a forest species that ecological flexibility is high, and thanks to this may be introduced into different types of forests – both shady ones and those thinned out because of damages caused by pests. It is a polygynic species so it is highly probable that a certain number of queens will be obtained in the course of taking a branch of the maternal colony (without much loss to it), and the newly formed colonies may accept additional queens after their nuptial flight. Since it is a polycalic species it may spontaneously create new colonies in the colonized areas, particularly in forests lacking *Serviformica* ants and thus inaccessible to other species of this group. And the last but not least – the Gorce (natural) population of *F. polyctena* is so abundant that it can be exploited (within reasonable limits).

The operation of the artificial colonization of *F. polyctena* in the Gorce forests was preceded by numerous laboratory and field experiments. Their objective was to study the adoption of queens by colonies with different social structures and the relations between swarms of different origins. Control colonies were established in various habitats, including those in mountain spruce forests at an altitude of 1250 m. Positive results of these experiments made it possible to undertake a practical colonization in selected, carefully chosen, post-outbreak areas in the Gorce National Park.

METHODS OF THE ARTIFICIAL COLONIZATION

The colonization of *F. polyctena* in the Gorce Mts. is carried out from mid-June through July. During this time the colonies there have a great number of worker pupae. The material for new colonies is collected from selected societies, polygynic

and polycalic ones, composed of adequately big colonies (nest diameter about 2 m or more, height about 1 m). The material is collected by hand, no less than 50 dec³ per one branch. This way of collecting material reduces the danger of damaging the maternal nest and makes it possible to arrive at an advantageous proportion of the number of ants (workers, pupae) to the amount of nest material in the branch taken (a high excess of ants is required). The branches are placed in cloth bags with spacers and immediately carried to the place of the new settlement. It is assumed that newly founded colonies usually have about a quarter million (mature) workers. With such a number of ants the "artificial" nests reach, within a few days, the proper structure of the mound, with its average dimensions: $\varnothing = 50$ cm, $h = 35$ cm.

As a rule, maternal nests yield not only pupae collected together with the nest material but also a number of "pure" pupae taken by means of sets of wax bee combs (PODKÓWKA'S method; WIŚNIEWSKI 1973). In this way the new colony immediately obtains several dozen additional pupae. At least two times are "artificial" colonies supplied with worker pupae in the same way: in August and in the following year. Some of the strongest colonies are also supplied with pupae of sexuals taken from natural nests in spring (May), by means of the same method. The emerging individuals go on their nuptial flight within the colonized areas and there is a chance for "artificial" colonies to increase their pool of fertilized queens.

THE SCOPE AND RESULTS OF THE ARTIFICIAL COLONIZATION

Jaworzyna Kamienicka Mt. was the first area to be colonized in Gorce. The spruce forest there had been greatly damaged by *C. falleni* - 80% of trees are dead. Three "artificial" polycalic colonies of *F. polyctena* were established there. The first (experimental) of these was founded as early as 1985. This is the colony designated with the symbol H, situated in the most difficult conditions, in a small gap within some relatively little damaged tree stand at an altitude of 1250 m. The herbaceous vegetation there is highly developed in the form of patches of grass and fern. During the first year of the investigations 6 nests were established at distances of 20-30 m one from another. Towards the end of the season, as a result of successive unions of particular colonies there remained 2 inhabited nest [H-II (Fig. 3) and H-IV] that maintained permanent contact with each other. Towards the end of the next season (1986) the swarm from H-II moved to H-IV. Thus what remained of the original polycalic colony was one inhabited nest with a diameter of 85 cm and a height of 50 cm. In 1989, the whole swarm moved, on its own, to a new place and expanded a foraging station (H-IV') built in the previous years, that was situated about 20 m away. Three new nests were founded within this area in 1987, and workers from H-IV were moderately aggressive towards them. Two of these colonies (H-VII and H-VIII) united into one after two years of intensive contacts. At present (1989) Colony H includes 3 independent colonies (H-IV', VII, IX) that produce a new generation of workers every year. The emergence of imagines takes place much later than in natural colonies - it begins in mid-August. The mounds of

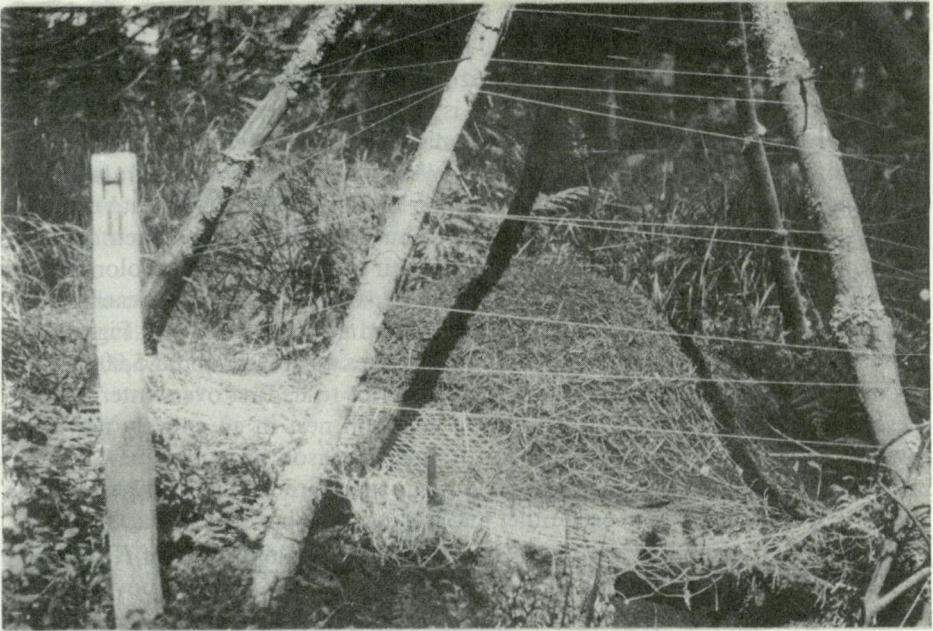


Fig. 3. The collective "artificial" nest H-II of *F. polycetena* on the Jaworzyna Kamienicka Mt. (1985)
(Photo by W. CZECHOWSKI).



Fig. 4. The collective "artificial" Nest P-I of *F. polycetena* on the Jaworzyna Kamienicka Mt. (1988)
(Photo by W. CZECHOWSKI).

the nests are permanently damp and frequently destroyed by woodpeckers. The colony penetrates an area of about 3,000 m².

The polycalic colony P was established in 1986 at 1240 m above sea level in an almost completely dead forest. This area is drier and better insulated than that of Colony H. During the first season 5 colonies were built there and these merged into one (P-I) in the same year. Three new colonies were established during the following season and this time two of them (P-VI and P-VII) merged into one. One colony was added in 1988 and one in 1989, but these maintained their independence in spite of removals and contacts with their neighbours. Thus Colony P now has 5 inhabited nests (P-I, VII, VIII, IX, X) and some of these have reached large dimensions (e.g. P-I has a diameter of 120 cm and a height of 70 cm; Fig. 4). The existence of the colony is successful and it penetrates an area of about 5,000 m².

Colony Ź with 5 nests was founded in 1988. Prior to its first overwintering all of these merged into one colony and built a common nest in an entirely new place (Swarm Ź-III started the removal). The following season brought 3 new colonies but these, too, united very quickly. At present there are 2 inhabited nests (Ź-III' and Ź-VII') 50 m away from each other and they seem to have no contacts.

Employees of the Gorce National Park carried out a colonization of *F. polyctena* on the Kudłoń Mt. in 1987 and 1988. In this area, at 1120–1240 m above sea level the forest had been completely ruined by the pest, and cut down as a result of this (Fig. 1). Forty-nine colonies were established on the edges of the clearing. The "artificial" nests were placed at greater distances from one another than was the case on the Jaworzyna Kamienicka Mt. Spontaneous removals and mergers of colonies finally left about 20 inhabited nests.

The Mostownica Mt. – the last post-outbreak centre in Gorce was the seat of colonization in 1989. Twenty-four colonies of *F. polyctena* were founded there. Spontaneous reshuffles are still going on there.

RECAPITULATION

The colonization of *F. polyctena* in the Gorce Mts. – both the studies and the operations – has yielded premises that are vital not only to the knowledge of social processes within the societies of red wood ants but to the practice of artificial colonization of these ants. The conclusions most useful in practice are as follows:

1. The end of the spring and the first part of summer (June–July) are the right time for colonizing *F. polyctena* under mountain conditions. Colonies founded during this period have at their disposal an abundant store of their work force (worker pupae). "Artificial" colonies have enough time to prepare their nests for the coming winter (even those founded in September overwintered successfully). Such colonies always have offspring during the following year and this means that the material obtained from the maternal nests did not lack queens or that queens are adopted the following spring.

2. During the first season artificially established colonies show a great tendency to unite, even though the material for such nests may have been taken from different polycalic colonies. That is the reason why nests should be built fairly close to

one another (<30 m), because this reduces the energetic cost of the inevitable removals. The fact that several "artificial" nests are founded simultaneously increases the chances of a potentially collective colony to choose the best nesting place for the ants.

3. New colonies established during successive years do not merge with the existing ones, even though the origin of all of them is the same. Therefore they should be founded at adequately greater distances (>30 m), as this provides the newly settled ants with the necessary living space and reduces the risk of any likely conflicts.

4. All the above reasons mean that colonization operations should be carried out several successive years. Only in such a case can the proper density of a nest network be achieved in a given area.

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STRESZCZENIE

Przebieg sztucznej kolonizacji rudych mrówek leśnych w Gorczańskim Parku Narodowym

Od 1985 r. w Gorcach (Beskidy Zachodnie) są prowadzone prace, zmierzające do osiedlenia mrówek w zniszczonych przez szkodniki lasach świerkowych tamtejszego Parku Narodowego. Na przełomie lat 70 i 80-tych wystąpiła tam, na wysokości >900 m npm, gradacja rośliniarki *Cephalcia falleni* DALM. Celem akcji kolonizacyjnej jest wzmocnienie zdolności samoregulacyjnych osłabionych biocenoz.

W Gorcach pospolite są 2 gatunki z grupy *Formica rufa*: *F. rufa* L. i *F. polycytena* FOERST. Górna granica ich występowania sięga 800–900 m npm. Gatunki te różnią się wybiórczością środowiskową i strukturą populacji. *F. rufa* zasiedla ekotony wśród mozaiki środowisk otwartych (łąk, pastwisk, pól uprawnych) i resztek zadrzewień (buczyn, świerczyn). Mrówki są monokaliczne i prawdopodobnie monoginiczne, rozmieszczone stosunkowo równomiernie, co jest uwarunkowane charakterem krajozrazu. *F. polycytena* występuje lokalnie, lecz zwykle w formie polikalicznej, wysoce poliginicznej. Kolo-

nie, złożone zwykle z ogromnych mrowisk, zasiedlają na ogół duże kompleksy lasów świerkowych - cienistych i wilgotnych.

Ze względu na strukturę społeczną mrowisk i zakresy tolerancji ekologicznej gatunków do kolonizowania w warunkach gorczańskich nadaje się tylko *F. polyctena*. Mrówki są przenoszone o 200-400 m powyżej ich naturalnego zasięgu, osiedlane w chłodniejszym piętrze klimatycznym w warunkach zwiększonej wilgotności, skróconego okresu wegetacyjnego i wydłużonego czasu zalegania śniegu. Praktyczna akcja kolonizacyjna (prowadzona od 1987 r.) była poprzedzona etapem prac eksperymentalnych. Pierwsza „sztuczna” kolonia *F. polyctena*, założona w miejscu o ekstremalnych warunkach siedliskowych, egzystuje (choć z trudem) już piąty rok. Inne, korzystniej usytuowane, rozwijają się pomyślnie.

Kolonizacją są objęte 3 główne ogniska postgradacyjne w Górcach: masywy Jaworzyny Kamienickiej, Kudłonia i Mostownicy. Obecnie są tam rozległe zżęby lub tzw. „martwy las”. Dotychczas (1989 r.) założono ok. 100 „sztucznych” mrowisk.

Colonization of the Gorce National Park (Gorce National Park, SW Poland) by the ant *Formica polyctena*. The colony was founded in 1987, first in a forest on a hillside and later in an open place. The colony was founded in 1987, first in a forest on a hillside and later in an open place. The colony was founded in 1987, first in a forest on a hillside and later in an open place.

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