ANTS AS COLONIZING AGENTS OF PINE STUMPS IN SAN JUAN DE LA PENA (HUESCA, SPAIN)

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FOURMIS
PINUS SYLVESTRIS
COLONISATION
SUCCESSION
SOUCHES

RÉSUMÉ — Un total de 68 souches de *Pinus sylvestris* qui avaient été coupées entre 1 et 16 ans avant cette étude ont été analysées afin de décrire la succession des Invertébrés. Dans la même zone plusieurs microhabitats ont été également étudiés à la recherche des Fourmis. Un total de 25 espèces de Fourmis a été recensé mais 16 espèces seulement nidifient dans les souches. L'occupation de l'écorce et de l'espace subcortical commence l'année suivant la coupe des arbres et arrive à son maximum (100 % des souches) quatre ans plus tard. L'invasion du bois commence à ce moment et atteint son maximum (54 % des souches) 13 ans après la coupe. Dans tous les micro-habitats la forme d'occupation coïncide avec celle de la faune édaphique.

ANTS
PINUS SYLVESTRIS
COLONISATION
SUCCESSION
STUMP

ABSTRACT — A total of 68 stumps of *Pinus sylvestris* cut between 1 and 16 years before this study were analysed in order to describe the invertebrate succession. Within the same area several microhabitats were also studied in search of ants'nests. The number of formicid species found was 25 although only 16 were nesting on pine stumps. The ants occupation of the bark and underbark begins the year after the thinning and reaches a maximum (100 % of the stumps) four years later; the invasion of the softwood starts at this time and reaches a maximum (54 % of the stumps) 13 years after the cutting. In all microhabitats this pattern of occupation coincides with that of the edaphic fauna.

INTRODUCTION

As part of the broad ecological study M.A.B. project n. 150 (Balcells, 1983a) one of us studied the decomposition of pine (*Pinus sylvestris*) stumps in the forest of San Juan de la Peña (Franch, 1985). The invertebrate succession colonizing them was studied in depth and it was seen that the presence of formicids is an important element of the succession.

In the same area several microhabitats (i.e. soil, under stones, piles of dead branches) were independently studied in search of formicid nests. A general but not quantitative sampling was also carried out looking for individual specimens.

DESCRIPTION OF THE STUDY AREA

The San Juan de la Peña massif is situated in the province of Huesca in the north of Spain. It is the remains of a massive conglomerate synclinale that rests of the marls of the Interior Depression, constituting an inverted relief through differential erosion. Steep cliffs border the synclinale, but its interior relief is relatively smooth with an altitudal difference of nearly 400 m between the highest and lowest points. San Salvador, at the western most end, is the highest peak with an altitude of 1 556 m above sea level. Coniferous forest occupy the upper part of the conglomerate shield, with *Abies alba* and beech trees in the depressions and drainage channels and *Pinus sylvestris* in the ridges. A forest of *Pinus sylvestris* with beech trees in the depressions and an undergrowth of holly trees, occupies the lower part, known as Monte Pano. *Pinus clusiana* trees appear on the steeper sunny slopes.

Groves of evergreen oaks are found at the foot of the south-facing cliffs, colonizing the colluvium and the sunny slopes to the left of the Santa Cruz gorge. Mixed forest, with a rich variety of tree species, such as beech, lime, ash, maple and hazel, etc... appear at the foot of the north-facing steep rocks. Mossy pine groves, with *Pinus sylvestris* and box in the

undergrowth are found further down, always on the shady side. Prickly pads of *Echinospartium horridum* occupy the crest which border the synclinale. For a more detailed description of the massif see Puigdefabregas (1973) and Balcells (1983b).

For the most part our research was carried out in an area occupied by a *Pinus sylvestris* forest with an undergrowth of *Ilex aquifolium*, but in order to include pine stumps of ten years of age we also took some samples in a *Pinus sylvestris* forest with an undergrowth of *Buxus sempervirens*, as well as in a mixed forest of *Pinus sylvestris* and *Fagus sylvaticus*.

MATERIAL AND METHODS

1. The sampling of pine stumps

The pine stumps were taken from thinnings done periodically by ICONA (Instituto para la Conservacion de la Naturaleza), thus their age (i.e. the number of years since they had been cut off) was precisely known. Field work was carried out throughout the period 1976-1977; monthly distribution of sampling is summarised in Table IA, and information about stump ages and their quantities is contained in Table IB. It should be noted that although each thinning was sampled during both years (1976-1977) only the specimens arising from the 1975 thinning were studied separately. The size departures of samples from different ages are a consequence of the availability of stumps. On average, pine stumps were of some 30 cm in height and 45 cm in diameter.

Table I. — A, number of stumps sampled during different months ; B, number of stumps (A), mass of hardwood (B), softwood (C), bark (D) and area (m^2) of underbark studied (E). Mass in kg.

A

Year of thinning	Month of sampling 1	2	3	4	5	6	7	8	9	10	11	12	Total
1960	1	1	3	1	2	-	-	2	-	-	-	-	8
1963	-	-	4	2	3	-	-	1	-	2	1	-	13
1966	-	-	4	-	4	3	-	6	-	-	-	-	17
1969	-	-	2	1	-	3	-	5	-	-	-	-	11
1972	-	-	-	5	-	1	-	4	-	-	-	-	10
1975	-	-	2	3	-	1	-	3	-	-	-	-	9
TOTAL	1	1	15	12	9	8	0	21	0	2	1	0	68

B

Year of thinning	Stump age	A	B	C	D	E
1975	1	3	21	42	4.4	1
1975	2	6	42	83	8.6	1.9
1972	4-5	10	66	114	14	3
1969	7-8	11	47	65	10	2.2
1966	10-11	17	98	138	22	4.7
1963	13-14	13	52	51	13	2.7
1960	16-17	8	44	42	9.8	2.1

The method of sampling consisted of a through search of the aerial part of the stumps in an attempt to collect any invertebrate present. Sampling started with a quick removal of species of bark which were placed on a white cloth where all the specimens were collected by one person using standard procedures (i.e. aspirator, paintbrush, forceps); meanwhile another collector was doing the same on the lateral surface of the stumps just exposed. The specimens collected in such a way were considered to be underbark inhabitants. The next step was to break down the bark on the white cloth and collect all the bark inhabiting individuals; three or four pieces of bark of about 300 g were put into paper bags and transported to the laboratory for an extraction of the microfauna with a Tullgren funnel. The stump without bark was then sawn off as near as possible to the ground, cut into pieces and each piece cut by axe into 1 cm slices in order to extract the inhabitants of the softwood and hardwood. If the only aim of the study had been to locate ants nests, field procedures could have been much more simple, but this was not the case.

2. The sampling of other microhabitats

Other suitable microhabitats for ants (under stones, rock crevices, logs of all sizes, directly on the ground, on rotting wood and beneath the bark of living trees) were searched, as is usual in qualitative myrmecological studies, during the summers of 1978 and the period 1980-1983. In addition, a year-long (1977) pitfall (Barber) sampling programme with traps visited weekly provided a useful picture of the ant community (Pedrocchi, 1982). Both pitfall-trapping and hand-collecting produce similar yields (Pisarski *et al.*, 1982), but in our case, also complementary results.

RESULTS

1. The pine stump succession

Since general invertebrate succession is the frame in which ant nesting takes place, we will start by giving some information about it. Though the number of different biological forms that have been separated is 223, only 152 have been identified. However, an underestimation of the total number of

species collected could be 300; acari, collembola, diptera and several insect larvae are the most abundant groups that have not been identified.

In Table II the frequency distribution of the main groups of macrofauna and big mesofauna is given. Without considering the Formicidae, the Coleoptera, with 72 species, five of which are abundant, is the best represented group in terms of number of species, specimens and biomass. There is a broad variety of taxonomical groups represented among the microfauna and small mesofauna : acari, collembola, diptera, pseudoscorpions, annelida, chilopoda, psocoptera, thysanoptera, araneida, symphila, diplura, thysanura, protura and nematoda. Acari are, at any time during the succession, the most abundant group, followed by collembola and diptera. The number of specimens per kg obtained by Tullgran funnel extraction are represented in fig. 1.

The general trends of the succession are as follows : during the first two years there is a strong invasion of the bark and underbark space by ipidae larvae (not identified), cerambycid larvae of *Rhagium inquisitor* (L.) and the curculionid larvae of *Hylobius abietis* (L.) . In the fourth year the occupation of the softwood by cerambycid larvae *Criocephalus ferus* (Muls.), *Ergates faber* (L.) and *Leptura*

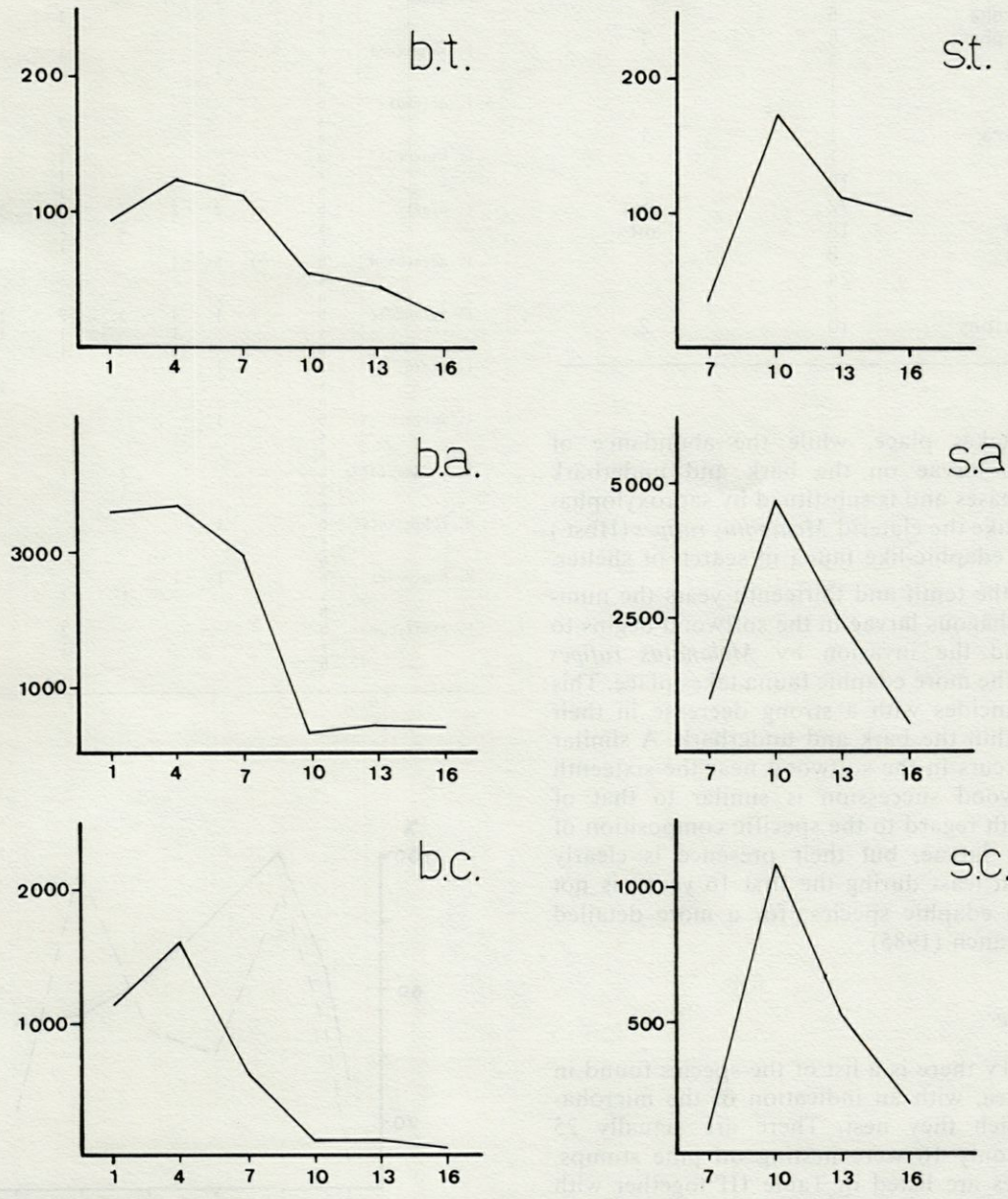

Fig. 1. — Number of specimens extracted (27-VIII-77) per kg with a Tullgren funnel. S : softwood. Mean weight of total samples for each age is 1.9 kg; mean number of samples for each age is 7.5. B : bark. Mean weight of total samples for each age is 2.2 kg; mean number of samples for each age is 7.6. T : total microfauna except acari and collembola. A : acari. C : collembola.

Table II. — Distribution of macrofauna and large mesofauna species into taxonomic groups. A species is considered abundant if the number of individuals collected during the whole study was greater than 40. The range of body size considered are the following : microfauna (within 20 μm and 200 μm); small mesofauna (200 μm to 0.5 cm); big mesofauna (0.5 cm to 1 cm); macrofauna (greater than 1 cm).

	Number of species	Number of abundant species
Gastropoda	5	
Annelida	2	1
Isopoda	7	
Diplopoda	7	
Geophilomorpha	5	
Lithobiomorpha	5	1
Dictyoptera	3	
Orthoptera	1	
Dermaptera	1	
Raphidioptera	1	1
Lepidoptera	1	
Diptera	15	5
Coleoptera	72	5
Hymenoptera	18	ants
Heteroptera	8	
Araneida	24	
Opiliones	2	
Pseudoscorpions	10	2

rubra (L.) takes place, while the abundance of xylophagous larvae on the bark and underbark greatly decreases and is substitued by saproxylophagous larvae like the elaterid *Melanotus rufipes* (Hbst.) and a more edaphic-like fauna in search of shelter.

Between the tenth and thirteenth years the number of xylophagous larvae in the softwood begins to decrease and the invasion by *Melanotus rufipes* (Hbst.) and the more edaphic fauna takes place. This invasion coincides with a strong decrease in their presence within the bark and underbark. A similar reduction occurs in the softwood near the sixteenth year. Hardwood succession is similar to that of softwood with regard to the specific composition of xylophagous larvae, but their presence is clearly lower and, at least during the first 16 years, is not occupied by edaphic species; for a more detailed study see Franch (1985).

2. *Formicidae*

In Table IV there is a list of the species found in the study area, with an indication of the microhabitat in which they nest. There are actually 25 species but only 16 were nesting on pine stumps. These species are listed in Table III together with the amount present in the different microhabitats at different stump ages. Table V provides a summary of the intensity of ants colonisation of the stumps (see also figs. 2,3).

Table III. — List of species nesting in the different microhabitats of the pine stumps of varying ages and number of nests found in the microhabitat indicated on the left margin; b : bark; s : softwood; h : hardwood.

		Age of stump							
		1	2	4-5	7-8	10-11	13-14	16-17	Total
Species									
C. herculeanus	b		3	1					
	s						1		
	h								
C. ligniperda	b	1				1	1		3
	s						2		2
	h								
C. vagus	b		2	3					5
	s					1	1		2
	h						1		1
F. fusca	b		1	1	1				3
	s						1		1
	h								
F. sanguinea	b						1		1
	s			1					1
	h								
L. alienus	b								
	s						2		2
	h								
L. brunneus	b						1		1
	s						1		1
	h						1		1
L. niger	b		1	2	2	3		1	9
	s					5	1	2	8
	h						1	2	3
L. acervorum	b		1	5	1				7
	s								
	h								
L. nylanderi	b		2	1	4	3	2	1	13
	s				1		1	1	3
	h				1		1		2
L. nadigi	b			1					1
	s							1	1
	h								
L. tuberum	b			1					1
	s								
	h								
L. unifasciatus	b					2	2		4
	s					1			1
	h								
M. lobicornis	b			1					1
	s								
	h								
M. ruginodis	b			1	1				2
	s					1	1		2
	h								
T. erraticum	b						3		3
	s						1		1
	h								

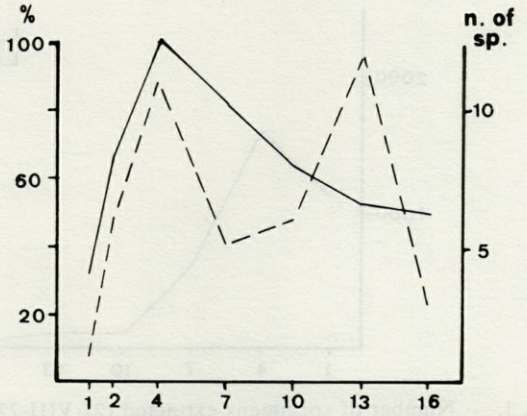

Fig. 2. — Evolution through time of the percentage of stumps with nests (----) and number of ant species present (- - -).

Table IV. — Ant species and nest microhabitat found in the study area as a result of qualitative sampling (careful search plus pitfall traps). A : under stone; B : under bark of living trees; C : rock crevice; D : rotten log; E : in soil; F : among grasses; G : pitfall trap.

	A	B	C	D	E	F	G
Myrmica ruginodis Nyl.	+					+	
M. lobicornis Nyl.							+
Stenamma westwoodi auct.							+
Leptothorax nylanderi (Forster)		+					+
L. unifasciatus (Latr.)		+					+
L. affinis (Mayr)		+					+
L. nadigi Kutter		+					
L. acervorum (Fab.)		+		+			+
L. gredosi Esp. & Collingwood		+					
L. kraussei Emery		+					
Tetramorium caespitum (L.)	+						+
Pheidole pallidula (Nyl.)	+				+		+
Camponotus vagus (Scop.)				+			
C. herculeanus (L.)				+			
C. ligniperdus (Latr.)	+						+
C. pilicornis Roger	+						+
C. cruentatus (Latr.)	+						+
Lasius niger (L.)	+			+			+
L. brunneus (Latr.)							+
L. fuliginosus (Latr.)				+			+
L. meridionalis Emery							+
L. flavus (Fab.)	+					+	
Formica sanguinea Latr.	+			+			
F. fusca L.	+						+
Tapinoma erraticum (Nyl.)	+						

DISCUSSION

Two ant species, *Lasius niger* and *Leptothorax nylanderi*, are the most abundant and colonize stumps of many different ages (from 2 to 16 years) and all possible microhabitats, from bark to hardwood; *L. niger* is one of the most adaptable and abundant ants in Europe (Wilson, 1955) and *L. nylanderi* is a small, but well-known, wood inhabitant (Plateaux, 1970); the three *Camponotus* species and *Formica fusca* are also known to occur in rotten

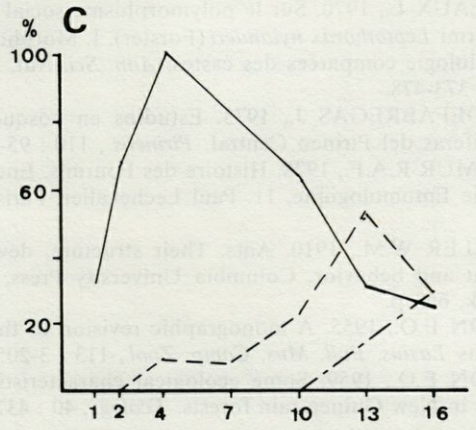

Fig. 3. — Evolution through time of the percentage of stumps with nests in their different microhabitats. Bark and underbark (----), softwood (- - -) and hardwood (-.-.-.).

Table V. — The intensity of the colonisation of stumps of varying ages by ants (n : number of stumps with nests in the microhabitat indicated on the top of the column). Column 1 : age of stump. Column 2 : number of studied stumps . Column 3 : total number of stumps with nests. Column 4 : % of stumps with nests. Column 5 : attack in different microhabitats. Column 6 : number of nests per stump (upper row) and number of stumps that present this number. Column 7 : number of ant species.

1	2	3	4	5			6							7
				bark underbark		softwood	hardwood							
				n		n	n	1	2	3	4	5	6	7
1	3	1	33	1				1						1
2	6	4	66	4				1	1	2				6
4-5	10	10	100	10		1		2	5	2	1			11
7-8	11	9	81	9		1		6	3					5
10-11	17	11	64	11		4		4	2	4	1			6
13-14	13	7	53	4		7	2	3		1		1	1	12
16-17	8	4	50	2		2	2	1	2	1				3

stumps (Collingwood, 1979; Kutter, 1977); the other species show a decreasing level of presence both in the age of the stump and in the microhabitat occupied, and can be classified as occasional inhabitants of pine stumps in San Juan de la Peña.

The most suitable place for ants to nest are in the bark and particularly within the underbark : 60 % of the stumps studied are colonized in these microhabitats, and all the stumps aged between 4-5 years; this last stage coincides also with the maximum of saproxylophagous and edaphic fauna. Diversity (Shannon Weaver's index) of the whole community in this phase is as high as 4.43, very near to the maximum of 4.51 attained at 7-8 years. After the 4-5 year stage, when the underbark space loses its normal nesting conditions, ants shift from bark to softwood, but as it is still relatively hard, they never reach the previous levels. At the age of 13-14 years, softwood degradation provides another rise in the number of ant species. The occupation of the hardwood begins after 11 years, when it becomes softer; but the lack of data beyond the 17th year does not allow any further comment.

Ant's nests can be described as devices constructed and maintained in order to achieve some kind of isolation from the external milieu; in more elaborate cases, ants can manipulate microclimatic conditions in a fairly sophisticated way (Brian, 1983). Tree stumps have been recognized since the 18th century (Reaumur, 1928) as advantageous places for temperate ant species to nest in, whilst foraging outside (Elton, 1966); they act as a kind of subsitute when stones are scarce (Wheeler, 1910). Of the species listed in Table IV, 12 out of 16 were already found to nest in tree stumps by Forel (1920, 1922) (one species, *L. nadigi*, was still undescribed); so, our results do not differ from those in Switzerland. Moreover, Forel (loc. cit.) talks about several species coexisting in the same old stump, just as we have found.

Comparing table III and table IV it can be seen that several species present in the biotope do not appear to live in stumps. Some species for example *C. cruentatus, C. pilicornis, L. flavus, P. pallidula , S. westwoodi* and *T. caespitum*, nest solely under stones or directly in the soil under fallen leaves; others, such as *L. affinis, L. gredosi* and *L. kraussei*, nest under the bark of living trees and it is probably a matter of chance not to find them in the stumps. Some *L. meridionalis* females, a temporary parasitic species of *L. alienus*, were collected from pitfall traps and we do not know anything about their nesting habits in North Spain. However, in North Europe it seems to be a species which nests in soil (Collingwood, 1979). *L. fuliginosus* is not present in the stumps; it was found in decaying wood and in pitfall traps but not in the stumps involved in the study. There is no apparent reason for this absence since elswhere it is a well known inhabitant of live, dead and decaying wood (Lorber, 1980).

Apart from the unobtrusive *Leptothorax* species, *Camponotus*, *Lasius* and *Formica* form the majority of ants found nesting in the stumps and, so, play an important part in its decomposition as Mamaev (1960; *in* Dlusskii, 1967) states when speaking of the « formicidal » stage in the decomposition of wood. Since the fauna of tropical rain forests is so rich and diverse, we could not expect to find a strict parallel between the five stages of the microsere of the ant inhabitation of large rotting logs as described by Wilson (1959), nor between the less diverse but still richer-53 species and subspecies - fauna of Colorado ants (Gregg, 1963) which establishes a minimum of 6 stages in the colonisation of wood. It is, however of interest to note that there is a similar trend in the time in which there is a maximum of colonised stumps : not in the first years, nor in the last ones, but in the intermediate stage (zorapteran stage, Wilson, 1959); (stages 2-4, GREGG, 1963), corresponding to our 4-5 year-old stumps. On the other hand, even the impoverished British ant fauna (notable for the absence of *Camponotus*) offers the genera *Myrmica, Lasius, Leptothorax* and *Formica* as inhabitants of dead wood (Elton, 1966).

To summarize, we can interpret the relation between ants and pine stumps in San Juan de la Peña (Huesca, Spain) as follows :

1. No species of ant seems to specialise in colonising pine stumps and their microhabitats; the picture is one of a progressive colonization of microhabitats as they become available.
2. The stumps provide shelter for a vast array of ant species already present in other microhabitats; only a few terricolous species are absent.
3. The intermediate stages of the process of wood decomposition are those best suited to colonisation by ants. The pattern of occupation of pine stump microhabitats by ants is very similar to that of the edaphic fauna; both reach maximum abundance at the same time and both leave together.

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