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A Note on Ants Visiting Bracken at the Post-fire Stand

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Abstract : A preliminary study of ants and other free-living arthropods which visited bracken at a post-fire stand was conducted. Eight species of ants visited bracken at the post-fire stand, one month after forest fire. In contrast, only one species visited bracken at the fire-free stand. Ants and other arthropods which visited bracken changed with growth stages of bracken fronds. These findings suggest that ant foraging activity may be affected by environmental conditions, such as vegetation, microclimate, and alternative food resource for ants.

Key Words : Ants, Arthropods, Bracken, Extrafloral nectaries, Forest fire,

Introduction

Forest communities show a mosaic structure formed by various disturbances (Bormann and Likens, 1979). Forest fire is a common disturbance in southwestern Japan (Nakagoshi *et al.*, 1987) and directly destroys most of the above-ground community but less of the under-ground community (Touyama and Nakagoshi, 1992 b). At post-fire stands, some species succeed and others fail because of forest fire-induced environmental alterations.

Bracken fern is common and often a very successful species in disturbed areas (*e.g.* Sugawara and Iizumi, 1954 ; Nakagoshi *et al.*, 1987), and has been noted for possessing extrafloral nectaries accompanied by ants (Lloyd, 1901).

Ants play significant roles in ecosystems as a result of their high diversity, abundance, and special behavioral attributes. They act as important predators, herbivores, and scavengers. Furthermore, it is well-known that some species of ants play a role in protecting plants against herbivorous insects since olden times (*e.g.* Lubbock, 1888). In such ant-plant mutualistic interactions, the adaptive significance of ants visiting extrafloral nectaries deterring herbivores has had its share of attention in the debate (Inouye and Taylor, 1979; Stephenson, 1982; Koptur, 1984; Barton, 1986; Rico-Gray and Thien, 1989). Ants are dominant and important groups in devastated and/or disturbed ecosystems as well as in forests, grasslands and farmlands. Nevertheless, few investigations have addressed the food habit of ants in devastated and/or disturbed areas (*e.g.* Yoshimoto and Yamane, 1990).

In this paper we report on (1) aggregation of ants and other arthropods visiting bracken at a post-fire stand and (2) changes of arthropods including ants with unfurling of bracken frond, and (3) investigate ant foraging activity and the value of bracken possessing extrafloral nectaries for ants at the early post-fire stand.

Study Site and Methods

Research was conducted at a post-fire stand at Nigata, *ca.* 10 km east from downtown Kure in Hiroshima Prefecture (Fig. 1). Topographical outlines of this stand have been described by Touyama and Nakagoshi (1992 a) : this stand is located on a slope *ca.* 280 m above the sea, facing N 70 ° W and inclining of *ca.* 25 °.

Before the fire, this stand had been dominated by Japanese red pine, *Pinus densiflora.* Fire occurred for one day on April 14, 1986 and killed the most part of the above ground vegetation. Vegetational outlines after fire have been described in detail by Touyama *et al.* (1989). The early post-fire vegetation of this stand was sparse and dominated by bracken (*Pteridium aquilinum* var. *latiusculum*) : both coverage of bracken and total vegetation were 1 %, and SDR_2 of bracken was 100 on May 31, 1986; and coverage of bracken was 8 %, coverage of total vegetation was 20 % and SDR_2 of bracken was 92 on November 19, 1986. We established a fire-free stand adjacent to the post-fire stand for comparison. This fire-free stand was a parcel of grassland mixed with bracken surrounding the burnt area. All of the post-fire stand was clear-cut and reforested in 1987. Therefore we could not continue our study at this stand.

We designated three growth stages from fiddlehead to mature frond to facilitate the study of bracken growth (Fig. 2). Stage I is the early fiddlehead stage, during which the bracken stipe lengthens, but the frond does not unfurl. Stage II is the partly unfurling stage, during which the major pinnae and pinnules begin to unfurl. Stage III is the mostly or fully unfurling stage, during which fronds are approximately fully unfurled and matured.

Research were conducted during May 1986, one month after fire, when bracken fronds began to unfurl and during August 1986, three months after fire. Most of the bracken fronds were fully unfurled by August 1986. Presence or absence of ants and other arthropods on bracken was recorded. Ant activity is expressed as ant occupancy: Ia/Io , where Ia is the number of bracken recorded with ants and Io is the total number of bracken observed. Other arthropod activity is expressed as arthropod occupancy. Occupancy, in this report, corresponds to the frequency of capture in Touyama *et al.* (1991).

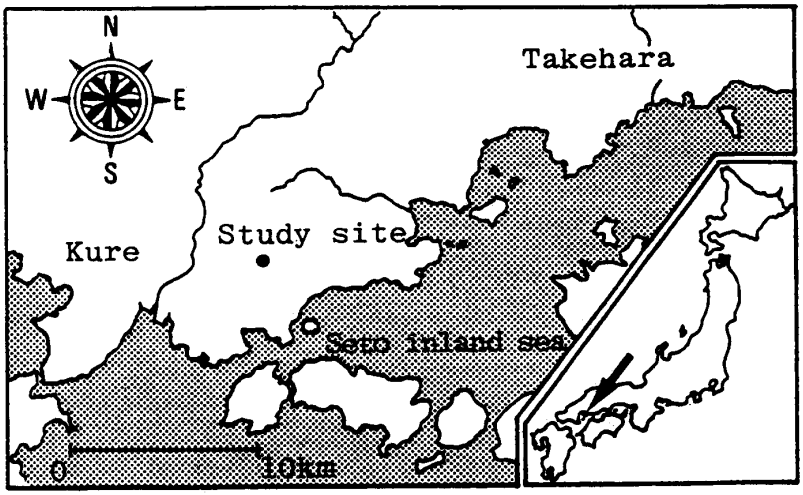

Fig. 1. Location of study site.

Results and Discussion

1. Ant aggregation on bracken at the early post-fire stand

Forest fire affects plant and animal communities in two ways. Initially there are direct effects of the heat and smoke; that is 'primary disturbance'. Following these, and more long lasting, are the effects caused by the fire modifying the forest habitat and environmental condition; that is 'secondary disturbance' (Touyama and Nakagoshi, 1992b). Results derived from prescribed burning studies (Iwanami, 1972; Kamada *et al.*, 1987), disclosed that increased soil temperature during a fire is not always lethal to soil animals. Therefore some species, especially ants, are often not killed by heat directly. However, habitat devastation, such as removing standing vegetation and litter by fire may have important indirect effects (Huhta *et al.*, 1967; Daubenmire, 1968).

Ahlgren (1974) pointed out that cryptic habits allow ants to survive fire below the level of intense heat. A high tolerance of dry soil condition make ants well-adapted to post-fire devastated land and their social habits are conductive to rapid re-establishment on post-fire stands.

Table 1 shows ants and other arthropods which visited bracken at the post-fire stand on May and August, 1986. On May 1986, 8 ant species, out of 16 species occurred here by October 1986, visited bracken. Two common ant species on bracken fronds, *Monomorium intrudens* and *Camponotus japonicus*, are eurytopic and are particularly common species at post-fire stands. On the other hand, *Iridomyrmex itoi* appears to be resistant to fire, but not resistant to fire-induced habitat devastation (Touyama and Nakagoshi, 1992 a).

2. Arthropod aggregational changes with bracken growth

Aggregation of ants and other arthropods changed with the growth stage of bracken fronds at both stands (Tables 1 and 2). On initial and intermediate stages (stages I and II), total ant occupancy (*i.e.* ant activity) and diversity were comparatively high. On the last stage (stage III), ant

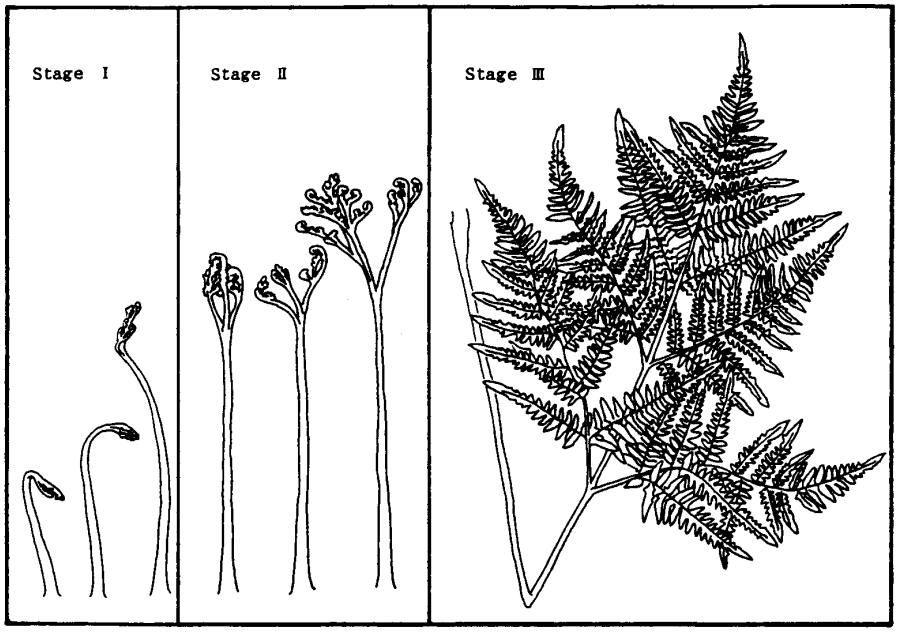

Fig. 2. Growth stages of bracken.

occupancy and diversity were relatively low. In the case of other arthropods, occupancy appeared to increase with frond development, and faunal richness was highest at stage Ⅲ (Tables 1 and 2).

On bracken fronds at the post-fire stand, two species of ants are frequent: *i.e. M. intrudens* and *C. japonicus*. At the early growth stage of bracken frond, *M. intrudens* which is a smaller species (1.5 mm), dominated on fronds. At the latter growth stage, *C. japonicus* which is a larger species (7-12 mm), displaced *M. intrudens* (Table 1) . This displacement and increase in size of ant species might affect patterns of arthropod aggregation (Rico-Gray and Thien, 1989; Oliveira *et al.*, 1987). But we could not confirm such tendency in this investigation.

The aggregation patterns of ants and other arthropods mentioned above, were observed in both May and August. These aggregation patterns may be explained by the conditional changes of bracken frond with growth, as described below.

First, chemical defense of bracken against herbivorous insects, especially quantity of cyanide and thiaminase in bracken fronds are higher in early stages and/or season than that in later stages and/or season (Lawton, 1978; Schreiner *et al.*, 1984). Second, architectural, microclimatic and nutritional conditions of bracken frond become more complex with later growth stages, and thus, insect species diversity on bracken builds up gradually (Lawton, 1978). Third, nectar secretion rate

Table 1. Ants and other arthropods on bracken at a post-fire stand.
Numerical value is the occupancy.

Date	May 16-17, 1986			August 8-10, 1986		
Developmental stage of frond	Ⅰ	Ⅱ	Ⅲ	Ⅰ	Ⅱ	Ⅲ
Number of brackens observed	17	17	10	3	11	41
Formicidae (Ant)						
Monomorium intrudens Fr. Smith	0.5	0.1	·	0.3	0.4	0.1
Camponotus japonicus Mayr	0.1	0.3	0.4	·	0.2	0.3
Iridomyrmex itoi Forel	0.2	0.2	0.1	·	·	0.1>
Crematogaster osakensis Forel	·	0.1	·	·	0.1	·
Pheidole nodus Fr. Smith	·	0.1	0.1	·	·	·
Aphaenogaster famelica Fr. Smith	·	0.1	·	·	·	·
Paratrechina sakurae Ito	·	·	·	·	0.1	0.1>
Crematogaster laboriosa Fr. Smith	·	·	·	·	0.1	·
Total	0.8	0.6	0.6	0.3	0.6	0.4
Araneae	·	0.1	0.2	·	·	·
Aphidoidea	0.1	0.4	0.7	·	·	0.1>
Coleoptera	·	·	0.1	·	·	0.1>
Lepidoptera, larvae	·	·	·	·	·	0.1>
Others	·	·	·	·	0.2	0.1>
Total (excluding Formicidae)	0.1	0.4	0.8	·	0.2	0.1

Note. Species names of ants are refferred to The Myrmecological Society of Japan (1988).

of bracken was higher in the fiddlehead and partly-unfurling stages than in full-unfurling and mature stages. Hence, ant occupancy, *i.e.* ant foraging activity, was significantly higher in the early stages than in later stages (Tempel, 1983).

3. Ant foraging activity in disturbed and/or devastated areas

Ant occupancy and diversity on bracken fronds were much higher at the post-fire stand than at the fire-free stand. In contrast, occupancy and diversity of other arthropods were somewhat lower at the post-fire stand than at the fire-free stand (Tables 1 and 2).

In the case of ant aggregation, differences in abundance and diversity at both stands may indicate that foraging activity of ants appears to be circumstance-dependent. Indeed, it has been suggested and debated that the efficacy of ant-mediated herbivore defence may depend on ant activity, herbivore density, and plant density (Risch and Carroll, 1982; Boecklen, 1984; Barton, 1986; Nestel and Dickschen, 1990).

We suspect that there are three factors that may be reciprocally responsible for the difference in ant foraging activity: (1) the species composition of ants, (2) environmental conditions, such as vegetational structure and microclimate, and (3) value of the food resource for ants, *i.e.* abundance of other alternative food resources at the stand.

First, there may be a difference in ant fauna between both stands. However, we are confident that ant fauna at the fire-free stand is not significantly different than at the post-fire stand.

Second, abundant vegetation may limit ant foraging behavior. Kanda (1987) determined experimentally that an increase in height and density of grass reduced predation by wolfspiders. Similarly, ants which are also euryphagous predators, may have their foraging activity limited by abundant vegetation.

Table 2. Ants and other arthropods on bracken at a fire-free stand.
Numerical value is the occupancy.

Date	May 17, 1986		
Developmental stage of frond	I	II	III
Number of brackens observed	17	21	10
Formicidae (Ant)			
Monomorium intrudens Fr. Smith	0.1	0.1	·
Araneae	·	0.1	0.6
Aphidoidea	·	0.1>	0.5
Cicadelloidea	·	0.1>	0.2
Coleoptera	·	·	0.1
Orthoptera	·	·	0.1
Others	0.1	0.1>	·
Total (excluding Formicidae)	0.1	0.3	0.9

Third, removal of above-ground biomass by fire may cause a reduction in food resources for ants. Hence, nectar secreted from extrafloral nectaries of fresh-sprouting bracken fronds becomes more important as a food resource for ants at early post-fire stands than at fire-free stand. Furthermore, unfurling of bracken fronds causes an increase of habitat and food resource for herbivores, which in turn may cause an increase in herbivore populations. Such an increase in herbivore populations provide a readily available food resource for ants. Ant species observed on bracken in this study are polyphagous and can exploit both nectar secreted from extrafloral nectaries and other arthropod visitors on bracken. We hypothesize that these ants have an advantage in disturbed and/or devastated areas which are lacking abundant food resources.

The paucity of other arthropod visitors on bracken at the post-fire stand may be caused by fire disturbance, following removal and slow recovery of vegetation. Ant foraging may exert more negative impact on the abundance and diversity of other arthropods at post-fire stands than that at fire-free stands, because of increases in ant foraging activity.

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