AN APPRAISAL OF INDIGENOUS ANTS AS LIMITING AGENTS OF FOREST PESTS IN QUEBEC

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Abstract

Criteria is presented for selecting ant species as predators of insect pests, and a comparison is made between species occurring in Quebec and central Europe. In conclusion it is stated that none of the ants found in Quebec are promising as control agents against forest pests.

Introduction

It is only during the past 20 years that serious thought has been given to using ants in the control of forest pests in North America. In Europe, however, particularly the Alpine countries, the problem has been studied for over 50 years by such workers as Bruns (1958, 1959), Gosswald (1951, 1962), Kloft (1953, 1960), Lange (1958), Otto (1956, 1960), Pavan (1959, 1960), Stumper (1960), and Wellenstein (1954, 1957). These and other workers have succeeded in defining, in considerable detail, the bionomics of ants belonging to the *rufa* group of the genus *Formica,* and in developing elaborate techniques for collecting, rearing, and propagating these ants. Although the usefulness of ants, as limiting agents of forest pests, is still in controversy it has been concluded that at least some species are beneficial, and should be encouraged for maintaining a well-balanced biocoenose.

Perhaps the main obstacle to the solution of the problem in both Europe and North America is the taxonomic confusion which exists with various races and species particularly in the genus *Formica* (the group showing most promise in biological control). Betrem (1960), Lange (1958), and Yarrow (1955) have helped to clarify the situation for European species, but in North America there is still much confusion. This paper reviews the status of ants as biological control agents in Europe and assesses the potential for similar work in Quebec.

Criteria used in Evaluating Predacious Species

Most of the investigations in Europe have centered on red wood ants (*Formica rufa* group). Attention was given to this group from the beginning because of obvious desirable qualities of the various species such as abundance, nest size, and aggressiveness, rather than to an ecological appraisal of the whole family. Although there is no reason to doubt the soundness of this choice, it is worthwhile to establish logically, some of the various qualities desirable in the selection of ant species as predators of insect pests. The most important of these qualities are:

(*a*) Ant size. Large size of individual ants is usually considered a desirable quality. This is particularly true when the prey is itself large, hairy, or well anchored or protected in places such as needle clusters (e.g. sawfly larvae), webbed shelters (e.g. tent caterpillars), or in forest litter (e.g. adult sawflies emerging from cocoons). The first encounters with the prey are usually by individual foraging ants. When the ant is sufficiently large, the prey has little chance of escaping this initial attack and a "kill" results. However, when the ant is of small stature, the struggling prey often succeeds in liberating itself, sometimes only temporarily, but at times completely as is the case when adult sawflies capable of flying, are emerging from cocoons in the soil. When the attack is by a group of ants, the size of individuals is not considered as important.

(*b*) Food requirements and nest populations. Forage areas vary with species, colony size, food abundance, season, and the food requirements of the colony. The latter two are related as the period of greatest food requirement is usually the season of brood development. Therefore, species which normally maintain high nest populations are considered the better choice.

(*c*) Colonial nests. Some species establish colonies of nests with a certain amount of communication and exchange of individuals between the various nests. Very large populations of ants per unit area can be achieved where this type of association exists, and the colony is particularly stable.

(*d*) Queens. The number of ovipositing (mated) queens in a nest is of prime importance. Many species of ants tolerate only one queen, and the survival of the nest depends on this queen, for it will usually not be replaced in case of death. However, some species maintain from a few to several thousand queens at one time, all of which may be fertile and productive, thus favouring colony survival.

(*e*) Ant–aphid relationships. Many ants collect honeydew from aphids feeding on plant juices. As a result of care given by the ants (protection from predators, and improved living conditions due to the continuous removal of excess honeydew from the aphid colony) the population of aphids sometimes increases considerably. If the plants fed upon are useful to man, both aphids and ants are usually considered harmful. However, these relationships are complex and it is necessary to balance the total of undesirable and beneficial effects to arrive at a reasonable conclusion. On coniferous plants, aphid damage is seldom very serious and may be acceptable if the gross benefits derived from the presence of ants is compensatory. Such may be the case in central Europe, where the production of "Tannin Honig" by bees collecting honeydew from aphids is of considerable economic importance in some rural areas. This honey is considered a delicacy and sells at premium price on the local market.

(*f*) Miscellaneous. Such factors as the ability for one nest to accept individuals of the same species from other nests, the tolerance of species to such factors as temperature, moisture, insolation, competition from other ants, the ease of breeding queens and brood in laboratory and establishing them in the field, and seasonal habits and aggressiveness are all important in determining the choice of species to be used.

Ants as Predators of Forest Pests

(*a*) In Europe. The species of ants selected for study in Europe have been limited almost completely to the *F. rufa* group. There are eight species within this group, and of these only one, *F. polyctena* (Foerst.), is generally recognized as a potential controlling agent of forest pests; another species, *F. lugubris* (Zett.), has been studied to a lesser extent (mostly by Pavan (1959, 1960)) but the results although encouraging, are inconclusive. In a recent review of research done in Europe on the *F. rufa* group, Adlung (1966) states "An objective analysis of the published information shows only one clear unambiguous case where the ants are of value in controlling a forest pest. This is *Panolis flammea* (Schiff.). Observations on all other listed insects are in some degree contradictory or not very convincing. Finally it can be stated that red wood ants (*Formica polyctena* only!) have a certain limited, beneficial value in pine forests. Establishment of ant nests in spruce plantations would have no advantage, and would definitely be injurious in the case of broadleaf forests, especially beech, because of the protection afforded harmful aphids." Perhaps the main reason for this

strong criticism is that most observations have been made without a sound knowledge of prey species density and diversity in the study areas before and after experimentation, and also to a lack of sufficient controls. Sampling techniques have been crude and different from one area to another, thus discouraging comparisons. The overall effect (beneficial vs. harmful) of ant predators on the forest composition has rarely been considered, even though it is known that most species have many diversified activities. There is also a general lack of knowledge by experimentation of the basic response of the ant species to prey density. The shape of response curves could provide valuable clues to the potentialities of species as regulators.

To the "one clear unambiguous case" referred to by Adlung, should be added at least another of more recent vintage. Gosswald and Horstmann (1966) having studied the effect of *F. polyctena* on populations of the green oak leaf roller, *Tortrix viridana* L., showed rather convincingly that there is a strong relationship between the degree of defoliation of individual oaks and the number of ants that climb each tree. They state that "a large ant nest keeps the foliage green on an average of 11.5 old oaks, . . . [which] . . . would have been completely defoliated without its presence." They found that the trees most frequently visited by ants were not necessarily those nearest the nest, although this was generally the case. Gosswald and Horstmann do not give an explanation of this phenomenon, which may be important. Some trees are, perhaps, neglected by ants because they shelter a low aphid population, which could be due to a paucity of foliage. If the leaf roller is responsible for the limited foliage, the cause versus effect becomes somewhat complicated and more difficult to resolve. It would be conceivable under such circumstances to have a situation where leaf rollers, by partly defoliating trees, reduce aphid populations, which results in a reduction of leaf roller predation by discouraging the ants from climbing the trees.

The natural range of *F. polyctena* extends roughly from the Baltic Sea in the north to the Alps and the Balkan mountains in the south, and from France in the west to Lake Baikal in the east. Although it is not the largest of the *F. rufa* group it is still sufficiently robust to cope with most immature forms of insect pests. Its nests are usually built in sunny openings in the forest or along the edges of stands or plantations. The size of the nest is at times quite large, measuring 7 or 8 ft in diameter and 4 or 5 ft in height. Nests may divide repeatedly to form a large colony of up to 100 nests, for a total of as many as 2,000,000 ants and 5,000 queens. This species can easily be colonized; since queens can be bred artificially, nests which have suffered a loss of individuals due to natural catastrophies, can be reinforced by the addition of extra queens reared in the laboratory.

(*b*) In Quebec. Although about 80 species of ants are known to occur in Quebec, little ecological work has been carried out, so it is difficult to assess them as potential predators of forest pests. However, using the criteria mentioned above and keeping in mind the apparent success in Europe with *F. polyctena,* some decisions may be made.

The ants belonging to the subfamilies Ponerinae, Myrmicinae, and Dolichoderinae (about 37 species in Quebec) are generally small and slight in stature. Except for *Myrmica americana* Weber, they all build small nests and do not have the bio-mass necessary to consume a large quantity of prey. Although many of the species will feed on dead or dying insects found in the field, none are known to be aggressive predators of large insects. *M. americana* is a common ant over most of its range and at times can be very abundant. It is moderately aggressive, and feeds

on a variety of food from dead and living insects, animal matter, plant juices and honeydew from aphids, and in the laboratory it has been observed attacking full grown insect larvae. It is probably important as a limiting factor of insect populations in areas where it occurs abundantly. Since it prefers warm, dry, sandy sites, its numbers are quite limited in central Ontario and western Quebec, which is near the north-eastern limit of its range. Artificial propagation of this species would also likely prove difficult since it is not polygynous.

In the remaining subfamily Formicinae, there are about 43 species native to Quebec. Those belonging to the genera *Brachymyrmex, Paratrechina, Lasius,* and *Acanthomyops* (about 25 species) are all small in size, build small nests, and are somewhat timid. They are actively associated with aphids both on branch and root systems, and spend little time foraging for small dead or dying insects. For these reasons they are not considered as efficient predators of insect pests.

Only in the genera *Camponotus* and *Formica* can species with several desirable qualities be found. These are mostly large ants, capable of attacking and transporting most of the major defoliating forest insects. Individual nests and colonies are sometimes quite large containing as many as 25,000 ants; a group of species within the genus *Formica* (group *rufa*) is particularly aggressive, both in the vicinity of their nests and along foraging trails; most species are active, foraging long distances from the nest either by establishing well-defined scented trails or by searching randomly.

Several desirable qualities, however, are lacking. Perhaps the most important is that only a few species are polygynous, i.e. having several or more queens in one nest. As a result, most *Camponotus* and *Formica* spp. are difficult to collect, breed, and propagate. The sole queen must always be included and kept in good condition, or the nest will perish.

One species *F. fusca* L. may have 20 or 30 queens per nest, but it is timid (unless enslaved by another more aggressive species such as *F. sanguinea* L.). It spends much of its time tending aphids both in the soil and on trees, and is generally considered inefficient in hunting prey.

Conclusions

(*a*) A thorough review of the voluminous European literature (Adlung 1966; Cotti 1963) on the use of ants in biological control work indicates that more objective research is necessary before a proper evaluation of their usefulness can be made. Much valuable work has been done in systematics, and in bionomics and species requirements in breeding and propagation, but a proper understanding of the role played in response of ants to changes in prey density is still lacking.

(*b*) An appraisal of the ants native to Quebec, in the light of European experience, indicates that none of these species are promising. This conclusion probably holds for all the native species occurring east of Manitoba in Canada and in the eastern United States. The necessary combination of such desirable qualities as polygynous nests, colonial structure of nests, size of ants, aggressiveness, activity with respect to climatic conditions and site, foraging area covered, plasticity of species in collecting, breeding, and propagating, do not exist for any species. Unless some of the weaknesses of our native species can be overcome by manipulating the environment (such as supplying artificial nesting material in areas where none exists, or by protecting the ants from predators and other enemies), there is no clear prospect of using them successfully in biological control work on a large scale.

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