GUEST EDITORIAL

INTRODUCTION OF ANTS AS POTENTIAL BIOLOGICAL CONTROL AGENTS, WITH PARTICULAR REFERENCE TO COCOA

JONATHAN D. MAJER, School of Environmental Biology, Curtin University of Technology, GPO Box U1987, Perth WA 6001, Australia.

ABSTRACT

Although the value of the local ants for the limitation of the cocoa pests is already appreciated, there is now an interest in augmenting these ants by introduction of additional ants species into Papua New Guinea from overseas. The introduction of ants from another geographical area presents some potential and possibly irreversible threats. Some of the problems which might arise from such introductions are here reviewed in the hope that agencies which might be considering such an initiative can take them into account when deciding whether to proceed. The points raised in this article are also relevant in other areas in the Pacific.

INTRODUCTION

The use of organisms as biological control agents can take three main forms. The most common strategy is to introduce an agent from another country or geographic zone in order to parasitise or predate the pest organism. Another approach is to alter environmental conditions so that a beneficial species which is already present in the area is favoured, leading to it exploiting the pest species more effectively. The third approach involves the routine mass production and repetitive release of control organisms, such as the bacteria *Bacillus thuringiensis*, into the environment where the pest is found.

Ants have long been appreciated as useful biological control agents in various parts of the world, both temperate (Goesswald 1941a,b) and tropical (Groff and Howard 1924). Where ants have been used, control has generally involved encouraging the spread of a native ant into areas where it is absent or restricted in its distribution. The ant, which has previously been demonstrated to limit the abundance of a particular pest or pests, then reduces their levels within the crop system. This method of using ants, which conforms to the second category of biological control, has been extensively reported on in the reviews of Leston (1973), Gotwald (1986), Majer (1986) and Way and Khoo (1992).

Guide-lines for elucidating which ants might be useful biological control agents and for encouraging their spread have been presented by Room (1973) in an issue of the precursor to this Journal. Essentially, the encouragement of a beneficial native ant is an exercise in ecological management of the ant community. The use in PNG of the tramp ant species, *Anoplolepis longipes*, to control the weevil *Pantorhytes albopunctulatus* (Moxon 1983) is an example of this type of biological control program. Although there are potential hazards, such as an increase in abundance of mealybugs or certain coconut pests (Moxon 1983), what is really at stake with this type of control is that it might fail to be effective. In such a case, the main loss would be the expenditure involved in researching and implementing the scheme.

The efficacy of *A. longipes*, otherwise known as the crazy ant, in limiting cocoa pests in PNG has been questioned by some, although other observers have considered this ant to be an effective limiting agent. Reasons for conflicting viewpoints appear to result from some growers using pesticides in a manner incompatible with the well-being of the ant species. If pesticides are not used, the ant appears to limit pests to a satisfactory extent. Notwithstanding this point, the doubts concerning the efficacy of this species have lead to an interest in introducing a more effective ant species from overseas. The species which has attracted a certain amount of interest is the black ant, *Dolichoderus thoracicus (= D.bituberculatus)*, which is an effective limiting agent of cocoa mirid pests in Indonesia (Bakri *et al.* 1986, R.N.B. Prior pers. comm.). This ant is also known from other areas such as the Philippines and Malaysia and, in the latter country, is the focus of considerable research as a biological control agent (Khoo and Chung 1989, Way and Khoo 1989, Khoo and Ho 1992).

Since this ant is apparently not found in PNG, the idea of introducing it has gained some support. The concept of introducing ant species from other countries falls into

the first category of biological control, and has been attempted in various parts of the world. Examples of such introductions include: the Brazilian ant, *Paratrechina (Nylanderia) fulva,* introduced into Columbia's coffee growing area in 1969-70 as a biological control agent of leaf-cutting ants (Zenner-Polania 1990); another Brazilian ant, *Ectatomma tuberculatum,* introduced into the USA to control cotton boll weevils (Weber 1946); and the Italian ant, *Formica lugubris,* introduced into Canada in an attempt to control forest pests (Finnegan 1975).

The introduction of ants from one country to another presents some potential, and possibly irreversible, threats which are not associated with the use of indigenous ant species. I will now outline some of the potential problems of introducing new ant species so that agencies which might be considering ant introductions can take them into account when deciding whether to proceed. My comments refer to ant introductions in general, although particular emphasis will be placed on *D. thoracicus*.

CAUTIONARY WORDS

Obviously, a decision must first be made on which species to select for introduction. Species which are known to limit pests within their home country are obvious candidates and it was on this basis that *F.lugubris* and *E.tuberculatum* were selected for introduction (Weber 1946, Finnegan 1975). This, however, is no guarantee that the species will play a beneficial role in its new range. Environmental conditions may be sub-optimal for the species to either establish or to achieve the vigour that it exhibits in its area of origin. Application of predictive tools such as BIOCLIM (Busby 1985) would help predict if the species will tolerate and thrive under the conditions in the area where it is to be introduced.

The second approach would be to screen ants in areas which are of known environmental similarity to see whether any species might be useful biological control agents. Finnegan (1971) listed the criteria which may be used for screening which predacious ant species might be useful control agents. These criteria are listed in Majer (1986) and will not be repeated here. It is, however, important to note that although potentially useful ants are usually dominant species, that is species which numerically predominate in an area, normally to the exclusion of other such species, recent work has indicated that sub-dominant species may also play an important role in limiting certain pest species (Way *et al.* 1989). This complicates the search somewhat because, although the number of dominant ant species within a crop may range from two to more than seven (Majer 1992), the number of sub-dominant species may be much greater.

Even if environmental conditions are suitable for the introduced ant, the ability of the ant to compete with members of the local ant community must be considered. In the tropics, most expanses of crop are dominated by a range of ant species, whose territories are juxtaposed in a three-dimensional mosaic fashion (Majer 1992). The mosaic tends to occupy most of the crop, with few trees not supporting dominant ants. So if new ants are to be introduced into the crop, they should either be able to displace the native dominants or gaps must be artificially created. For the ant to displace a local dominant, it should ideally occupy a higher position in the competitive hierarchy of dominant ants, at least under the conditions where the crop is grown. This could present an extremely dangerous situation since a highly competitive ant would have the potential to displace native ants in areas outside the tree crop. This is precisely what has happened with accidentally-introduced ants such as *Pheidole megacephala* in Hawaii (Fluker and Beardsley 1970), *Linepithema humile* (the Argentine ant) in the USA (Ward 1987) and *A. longipes* in the Seychelles (Haines and Haines 1978). The consequences of these introductions are displacement of local ant faunas, invasion of dwellings and, because dominant ants have such a large influence on associated invertebrates, threats to what are often unique invertebrate communities. There are therefore undesirable conservation, as well as pest, implications if introduced species become feral.

Many species of ants are involved in mutualistic associations with Homoptera, some species-specific, others more general (Way 1963). There is therefore some danger that the encouragement of a particular ant species could lead to detrimental effects on the crop associated with an upsurge in Homoptera abundance. In Malaysia, *D. thoracicus* is associated with the pseudococcid, *Cataenococcus hispidus* (Khoo and Chung 1989) and the vigour of the ant colonies appears to be at least partly dependent on the presence of large pseudococcid numbers (Khoo and Ho 1992). This does not appear to present a problem in Malaysian cocoa as the suppression of mirid numbers by *D. thoracicus* far outweighs any problems associated with high mealybug populations. This does not, however, guarantee that adverse effects would not occur in other countries where introduced ants might tend homopteran species with which they were not formerly associated.

An associated problem is the fact that tended homopterans may be associated with various pathogens within the crop. For instance, by constructing soil or plant debris tents over the Homoptera which they tend, certain ant species may inadvertently spread cocoa blackpod disease (*Phytophthora palmivora*). This is a problem in PNG cocoa, where the tent building

ant *Technomyrmex albipes* is associated with blackpod damage (McGregor and Moxon 1985). Fortunately, *D. thoracicus* is not a tent-building species and, by excluding other tent-building ants, it is linked with reductions in the incidence of blackpod (Khoo and Ho 1992).

A number of homopterans are also vectors of plant viruses such as swollen shoot virus disease in Ghana (Strickland 1951). The tending of these homopteran vectors by ants may thus lead indirectly to the spread of plant diseases. Entomologists need to be aware of potential ant-homopteran associations in the country of introduction in order to predict whether any plant pathogens might be encouraged. Of even greater danger would be the accidental introduction of infected homopterans at the time when an ant is introduced into a new region. In view of this possibility, it would be extremely unwise to introduce entire nests, which might contain homopterans, into a new region.

The most important pollinators of cocoa are midges of the families Ceratopogonidae and Cecidomyiidae (Young 1986). It has been suggested that high populations of ants might deter midge attendance at flowers and therefore impede pollination of the cocoa (Khoo and Ho 1992). Furthermore, the recent discovery of anti-fungal secretions associated with ants (Beattie *et al.* 1986) means that the physical presence of ants at flowers could inhibit pollen activity, and hence lead to poor fruit set (Khoo and Ho 1992). To the best of my knowledge, this has not been demonstrated to be a problem with *D. thoracicus* but entomologists should be aware of its potential to adversely affect the crop.

Even if a candidate ant is cleared of all these potential problems, there is no guarantee that it will become established outside its present range. I have already mentioned that the interaction of the introduced ant with the native ant fauna would need to be understood. The ant would also need to be able to tolerate the climatic conditions in the area where it is introduced. This would probably not be a problem with *D. thoracicus* in PNG as it is already widespread in south-east Asia and occurs across a range of climatic conditions. Additionally, once an ant has been established within a region, conditions which must be provided for its spread throughout a crop can be surprisingly complicated - the various graduate theses on *D. thoracicus*, which have been carried out in Malaysia under the supervision of Dr K. C. Khoo, testify to this.

If it can be demonstrated that all of these potential problems have been, or can be, overcome, preparations for introduction may proceed. The introduction would need to follow all the quarantine protocols which now apply to the introduction of exotic species (Commonwealth Department of Primary Industries 1987). It would be safer to consider the introduction of fertilized queens rather than entire nests as this would minimize the possibility of introducing associated homopterans, inquilines or pathogens. The introduction would be better carried out on a small remote island in the first instance since, if undesirable side effects are realised, the exercise could be abandoned. It might then also be possible to eradicate the ant from the island, although ants are notoriously difficult to remove once they have become established.

The emphasis of this account of the factors which should be considered before introducing exotic ants is that extreme caution should be taken before any decision is made to proceed with such a plan. Social insects are notoriously effective at colonising new areas where they have been accidentally introduced, and serious pests have arisen amongst all groups, namely ants, bees, wasps and termites. There is a real danger that any ant which has been introduced as a biological control agent could become a pest itself, with disastrous economic and ecological consequences.

REFERENCES

BAKRI, A. H., ASID, M. and REDSHAW, M. J. (1986). Pemberantasan *Helopeltis* secara terpada dengan penggunaan semut hitam dan bahan kimia pada tanaman coklat di Sumatera. (Using black ants and chemicals in an integrated approach to control of *Helopeltis* in cocoa in North Sumatra). Temu Ilmiah Entomologi Perkebunan Indonesia, Medan 1986: 11pp.

BEATTIE, A. J., TURNBULL, C. L., HOUGH, T. and KNOX, B. (1986). Antibiotic production: a possible function for the metapleural gland of ants (Hymenoptera: Formicidae). *Annals of the Entomological Society of America* 79: 448-450.

BUSBY, J. R. (1985). *Bioclimate Prediction System. Users Manual Version 1.2.* Bureau of Flora and Fauna, Canberra.

COMMONWEALTH DEPARTMENT OF PRIMARY INDUSTRIES (1987). *Summary of Australian Plant and Animal Quarantine Requirements.* Australian Government Publishing Service, Canberra. 42 pp.

FINNEGAN, R. J. (1971). An appraisal of indigenous ants as limiting agents of forest pests in Quebec. *Canadian Entomologist* 103:1489-1493.

FINNEGAN, R. J. (1975). Introduction of a predacious red wood ant, *Formica lugubris*, from Italy to eastern Canada. *Canadian Entomologist* 107:1271-1274.

FLUKER, S. S. and BEARDSLEY, J. W. (1970). Sympatric associations of three ants, *Iridomyrmex humilis, Pheidole megacephala and Anoplolepis longipes* in Hawaii. *Annals of the Entomological Society of America* 63:1290-1296.

GOESSWALD, K. (1941a). Ist nun die Rote Waldameise nützlich oder schadlich? (Is the red wood ant really useful or harmful?). *Anzeiger für Schadlingskunde* 17:1-17.

GOESSWALD, K. (1941b). Rassenstudien an der Roten Waldameise *Formica rufa* L. auf systematischer, ökologischer, physiologischer und biologischer Grundlage. (Systematic stud-

les on the red wood ant, *F. rufa* on a taxonomic, ecological, physiological and biological basis). *Zeitschrift Für angewandte Entomologie* 28:62-124.

GOTWALD, W. H. Jr (1986). The beneficial economic role of ants. pp. 290-313. In: *Economic Impact and Control of Social Insects* Ed. S.Bradleigh-Vinson. Praeger, New York.

GROFF, G. W. and HOWARD, C. W. (1924). The cultured citrus ant of South China. *Lingaam Agricultural Review* 2: 108-114.

HAINES, I. H. and HAINES, J. B. (1978). Pest status of the crazy ant, *Anoplolepis longipes* (Jerdon) (Hymenoptera: Formicidae), in the Seychelles. *Bulletin of Entomological Research* 68:627-638.

KHOO, K. C. and CHUNG, G. F. (1989). Use of the black cocoa ant to control mirid damage in cocoa. *The Planter, Kuala Lumpur* 65:370-383.

KHOO, K. C. and HO, C. T. (1992). The influence of *Dolichoderus thoracicus* (Hymenoptera: Formicidae) on losses due to *Helopeltis theivora* (Heteroptera: Miridae), black pod disease, and mammalian pests in cocoa in Malaysia. *Bulletin of Entomological Research* 82:485-491.

LESTON, D. (1973). The ant mosaic - tropical tree crops and the limiting of pests and diseases. *PANS* 19:311-341.

MAJER, J. D. (1986). Utilising economically beneficial ants. pp. 314-331. In: *Economic Impact and Control of Social Insects* Ed. S.Bradleigh-Vinson. Praeger, New York.

MAJER, J. D. (1992). Comparison of the arboreal ant mosaic in Ghana, Brazil, Papua New Guinea and Australia - its structure and influence on arthropod diversity. pp. 115-141. In: Hymenoptera and Biodiversity. Eds. J.LaSalle and I.Gould. CAB International, Wallingford.

MCGREGOR, A. J. and MOXON, J. E. (1985). Potential for biological control of tent building species of ants associated with *Phytophthora palmivora* pod rot of cocoa in Papua New Guinea. *Annals of Applied Biology* 107: 271-277.

MOXON, J. E. (1983). Pests of cocoa-use of crazy ants for control of *Pantorhytes*. *DPI Entomology Bulletin* No. 4:159-164.

ROOM, P. M. (1973). Control by ants of pest situations in tropical tree crops: a strategy for research and development. *Papua New Guinea Agricultural Journal* 24:98-103.

STRICKLAND, A. H. (1951). The entomology of swollen shoot of cacao. 1. The insect species involved, with notes on their biology. *Bulletin of Entomological Research* 41: 725-748.

WARD, P. S. (1987). Distribution of the introduced Argentine ant (*Iridomyrmex humilis*) in natural habitats of the Lower Sacramento Valley and its effect on the indigenous ant fauna. *Hilgardia* 55:1-16.

WAY, M. J. (1963). Mutualism between ants and honeydew-producing Homoptera. *Annual Review of Entomology* 8:307-344.

WAY, M. J., CAMMEL, M. E., BOLTON, B. & KANAGARATNAM, K. (1989). Ants (Hymenoptera: Formicidae) as egg predators of coconut pests, especially in relation to biological control of coconut caterpillar, *Opisinia arenosella* Walker (Lepidoptera: Xyloryctidae), in Sri Lanka. *Bulletin of Entomological Research* 79:219-233.

WAY, M. J. and KHOO, K. C. (1989). Relationships between *Helopeltis theobromae* damage and ants, with special reference to Malaysian cocoa small holdings. *Journal of Plant Protection in the Tropics* 6:1-11.

WAY, M. J. and KHOO, K. C. (1992). Role of ants in pest management. *Annual Review of Entomology* 37:479-503.

WEBER, N. A. (1946). Two common ponerine ants of possible economic significance, *Ectatomma tuberculatum* (Oliver) and *E.ruidum* (Roger). *Proceedings of the Entomological Society of Washington* 48:1-16.

YOUNG, A. M. (1986). Cocoa pollination. *Cocoa Grower's Bulletin* 37: 5-23.

ZENNER-POLANIA, I. (1990). Biological aspects of the "*Hormiga Loca*", *Paratrechina (Nylanderia) fulva* (Mayr), in Columbia. pp. 290-297. In: *Applied Myrmecology: A World Perspective*. Eds R. K. Vander Meer, K. Jaffe and A.Cedeno. Westview Press, Boulder.