ARTIFICIAL FAUNAL REPLACEMENT FOR IMPORTED FIRE ANT CONTROL

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The imported fire ant problem has proven to be one of the more difficult problems in entomology. Starting with a small introduction in the Mobile, Alabama area, probably in the late 1930's, in only 40-45 years *Solenopsis invicta* Buren, the red imported fire ant, has now occupied a range area of approximately 200-230 million acres in the southeastern and mid-southern states. *Solenopsis richteri* Forel, the black imported fire ant, present in the Mobile area in 1918 or earlier, now occupies only a relatively small area in northern Mississippi and northwestern Alabama. However, *S. richteri* occupies a very large area in eastern Argentina and is the dominant ant in that area (observations of the author). It is evident that this species also can be very successful if environmental conditions are favorable. Since *S. richteri* occupies a more southern range than *S. invicta* in the Southern Hemisphere, it could be expected that *S. richteri* might eventually occupy an extensively more northern range than *S. invicta* in the Northern Hemisphere.

The enormous ability of the fire ant populations to quickly resurge after environmental stress events makes these ants very difficult to control. It can be shown that repeated environmental stress events alternating with resurgence periods will lead to a larger population increase of the fire ants and a strong population suppression of native competitive ants which resurge less quickly (Buren et al., in prep.). "Insecticiding" is merely one among many types of environmental stress events which tend to increase the population resurgence of IFA. Certainly the possibility of a quick answer to the IFA problem by chemical means seems very bleak. Therefore, there should be increased emphasis on studies leading to biological management of the IFA populations.

Finding biological controls for fire ants appears to be a very different game than classical biological control in which very often one or 2 species of parasites are able to satisfactorily control pest populations (e.g. control of citrus blackfly in Florida). Control of fire ants by parasites does not appear very promising since parasite control of populations of ants, except on a limited or local basis, is not known anywhere in the world. Williams (1981) has reviewed the known parasites of the fire ants. None of these has been shown to provide population control of the fire ants. Perhaps one of these parasites or a commensal will prove to be a vector of an organism pathogenic to the fire ants, but this is speculation at this time. Pathogens may be more promising than parasites (Jouvenaz et al. 1981) but it may be very difficult to find and manage a pathogen which is both transmissible enough to spread rapidly through large populations of the ants and also cause sufficient mortality of the infected colonies to provide population control.

In this paper I suggest that a possible method of permanently suppressing fire ant population is by competitive displacement by predator and competitor ant species. The native ant fauna of the southeastern United States does not seem to be sufficently strong to provide this suppression. The native ant fauna itself may be somewhat unsuitable for the present environment since the southeastern states originally were mostly forested whereas at the present time croplands, pastures, and urban areas predominate. *S. invicta* may not have spread quite so rapidly, even aided by various environmental stress events, if the native fauna were better suited to its present environment. The South American homeland population of *S. invicta*, with an unknown but certainly very long period of existence, does not occupy a range area as large as the range area in North America only 40-45 years after introduction.

If we accept the hypothesis that other competitive ant species might be needed to displace IFA, we can also make the stipulation that replacing one strong dominant with another would not be acceptable. "From the frying pan into the fire" types of actions should not be encouraged. This excludes from consideration species such as *Iridomyrmex humilis* (Mayr), *Pheidole megacephala* (F.) and *Anoplolepis longipes* (Jerdon), which can occur in certain areas as overwhelming dominants, excluding other ant species.

All of the species of *Atta* and *Acromyrmex*, the leaf cutting ants, also would be unacceptable, since they are important agricultural pests. Moreover, their food sources are on a different trophic level and therefore there is little competitive interaction with *Solenopsis* spp. Most of the species of the subfamily Ponerinae and some of the Myrmicinae would be unacceptable, since these ants have dangerous and/or painful venomous stings. The Formicinae and the Dolichoderinae are left as 2 important groups, parts of which are available for study toward possible competitive displacement of fire ant populations. Neither subfamily has a sting and thus there is less likelihood of annoyance or danger to man. Many Myrmicinae might also be considered in the groups where the ants are too small or crytobiotic to interact directly with man or in the groups where the sting is modified or atrophied. It is evident that several hundred and possibly over a thousand species of ants from various areas of the world are available for consideration in the design of an artificial fauna.

A priori, certain basic assumptions can be suggested to guide this research effort.

1) Any ants selected as candidate biological control agents should be either beneficial or innocuous to man and agriculture.

2) Although it will be impossible to change an ant fauna without some environmental change it is assumed that a fauna can be selected which will be beneficial or at least not harmful to major elements of the native fauna and flora. Some displacement of the native ant fauna is inevitable but this fauna already has been displaced by the success of the IFA population.

3) Artificial ant faunas already are know to exist; for example, these include many elements of the ant fauna of south Florida and the entire ant fauna of the Hawaiian Islands. It is proposed here, however, that a scientifically selected ant fauna would be preferable to a fauna which has arisen by chance introductions from commerce.

4) Complex faunas consisting of 20 to 30 species or more seem more

likely to be able to achieve stability over long periods of time than simplified faunas consisting of only a few species. Simplified faunas seem much more prone toward the occurrence of large population perturbations, such as may be seen in the fire ant populations and in Argentine ant populations. Complex, many species faunas could also cushion the unexpected effects of any one species.

5) Contrary to what might be assumed, the candidate competitive species need not necessarily be from the homeland areas of the fire ants. Although studies in the homeland areas may be necessary to obtain greater understanding of the types of species which are sufficiently competitive, other species from other areas of the world may be equally or more suitable. The criteria would be the level of competitive action and the ability to form a long lasting component of a stable fauna.

6) Obviously, the search for candidate agents can be narrowed to areas of the world where the climatic and other abiotic conditions are reasonably similar to those of southeastern United States. This excludes vast areas from consideration, such as northern Europe and Asia, the Sahara and Arabian deserts, northern United States and Canada, most of Australia, and the Amazonian and other tropical rain forests. Remaining for investigation would be large areas of Mato Grosso, Brazil and much of Brazil south and east of this area, Uruguay, large areas in northwestern and western Argentina, western Paraguay, Bolivia in the eastern foothills of the Andes and some portions east of this area, parts of South Africa, parts of northern Mexico, parts of the foothills of various southwestern mountain areas, and parts of the foothills and uplands of some California and Baja California mountains.

Methodologies for this proposed research are all straight forward and require no new or unknown technics. Some technics would have to be improved or extended, perhaps. Essentially the steps in this research and development process would be as follows:

1) Observational studies on precandidate species in their homeland areas plus any necessary taxonomic and identification studies.

2) Selection of candidates on the basis of these observations and the conformity of the candidates to the necessary criteria.

3) Live collections of newly mated queens of candidate species during their mating flight season. In general, this is likely to be in June and July in the Northern Hemisphere and in November and December in the Southern Hemisphere.

4) Laboratory studies on the development of incipient and young colonies started by these captured queens.

5) In fire ant infested areas release of young candidate colonies and observation of fire ant-candidate interactions and persistence over at least a one year period.

6) Obtaining introduction permits for candidates still meeting all criteria including persistence against fire ant populations, and transport of these candidates to quarantine facilities in the United States.

7) After further laboratory studies in quarantine facilities, release of selccted candidates into IFA infested areas in the United States and follow-up studies on the persistence and rates of increase of the candidate populations.

8) Release of several different mixes of colonies of candidate species into

several areas with follow-up studies to determine the relative success of each type of mix.

9) From the research accomplished make decisions regarding the specific mixes of candidates recommended for a wide scale biological management effort. The mixes may not be the same for some states as for others.

A list of ant genera and species as examples of pre-candidates is appended. Their homeland areas are given with a few notes on the rationale for their inclusion in this list. The groups of species and genera listed are not in order of importance.

Species Name	Homeland Area
Group 1	
Camponotus (Tanaemyrmex) maccooki Forel	California
Camponotus (Tanaemyrmex) dumetorum Wheeler	California
Camponotus (Tanaemyrmex) vicinus Mayr	California & Rocky Mountains
Camponotus (Tanaemyrmex) ocreatus Emery	Mountains of Arizona & New Mexico
Camponotus (Tanaemyrmex) festinatus (Buckley)	Central Texas to Arizona
Camponotus (Tanaemyrmex) sansabeanus (Buckley)	Central Texas to Arizona
Group 2	
Camponotus (Myrmaphaenus) bruesi Wheeler	New Mexico & Arizona
Camponotus (Myrmaphaenus) novograndensis Mayr	Brazil, Bolivia
Camponotus (Myrmaphaenus) blandus (Fr. Smith)	Brazil, Bolivia, Argentina
Camponotus (Myrmaphaenus) denudatus Emery	Bolivia, Argentina
Camponotus (Myrmaphaenus) scintillus Forel	Paraguay, Bolivia, Argentina
Camponotus (Myrmaphaenus) spp.	Brazil, Bolivia, Paraguay, Argentina
Group 3	
Camponotus (Myrmothrix) abdominalis (F.)	Mexico to Brazil and Bolivia
Camponotus (Myrmothrix) bugnioni Forel	Columbia
Camponotus (Myrmothrix) rufipes (F.)	Brazil, Bolivia, Argentina
Camponotus (Myrmothrix) spp.	Brazil, Paraguay, Bolivia, Argentina
Group 4	
Formica gnava Buckley	Central Texas and west to Arizona
Formica occidua Wheeler	California
Formica pilicornis Emery	California, Baja California
Formica foreliana Wheeler	Arizona
Formica browni Francoeur	Mexico

Species Name		Homeland Area
Formica pachucana Francoeur		Mexico
Formica subpolita Mayr		California
Formica subcyanea Wheeler		Mexico
Formica retecta Francoeur		Mexico
Formica cunicularia Latr.		Southern Europe, Sardinia, Crete
Formica perpilosa Wheeler		Texas to Arizona
	Group 5	
Proformica nasuta (Nylander)		Portugal, Spain, Italy, the Balkans, Greece, Turkey, Central Asia
Proformica ferreri Bondroit		Southern France, Spain
Cataglyphis cursor Fonscolmbe		Mediterranean Europe, Central Asia
Myrmecocystus melliger Forel		Mexico, Big Bend Area of Texas
Myrmecocystus mendax Wheeler		Foothills and mountains of western United States
Myrmecocystus placodops Forel		Rio Grande Valley of Texas, west to Arizona
Myrmecocystus mimicus Wheeler		Kansas to California
Myrmecocystus wheeleri Snelling		Foothills of southern California Mts.
Myrmecocystus romainei Cole		Kansas to Arizona
Myrmecocystus spp.		Western United States and Mexico
	Group 6	
Paratrechina fulva (Mayr)		South America, Central America
Paratrechina spp.		South America, Central America
	Group 7	
Forelius foetidus (Buckley)		Central Texas to California
Forelius nigriventris Forel		Western Argentina
Forelius grandis Forel		Western Argentina
Forelius albiventris Forel		Western Argentina
Forelius andinus Kusnezov		Northwestern Argentina
Forelius braziliensis (Forel)		Brazil, Uruguay, Argentina
Forelius spp.		Brazil, Paraguay, Bolivia, Argentina
	Group 8	
Conomyrma pyramica (Roger)		Eastern Brazil
Conomyrma brunnea (Forel)		Brazil
Conomyrma platensis Gallardo		Argentina, Uruguay
Conomyrma wolffhuegeli (Forel)		Western Argentina, Bolivia
Conomyrma thoracica (Santschi)		Western Argentina, Bolivia
Conomyrma spp.		Texas to California, Argentina, Brazil, Bolivia, Paraguay
	Group 9	
Dorymyrmex planidens Mayr		Western Argentina

Species Name	Homeland Area
Dorymyrmex flavescens Mayr	Western Argentina
Dorymyrmex ensifer Forel	Western Argentina
Dorymyrmex morenoi Bruch	Western Argentina
Group 10	
Solenopsis (*Diplorhoptrum*) *pilosula* Wheeler	Texas
Solenopsis (*Diplorhoptrum*) *salina* Wheeler	Texas
Solenopsis (*Diplorhoptrum*) *krockowi* Wheeler	Texas, New Mexico
Solenopsis (*Diplorhoptrum*) *wasmanni* Emery	Bolivia, Argentina, Brazil
Solenopsis (*Diplorhoptrum*) *transformis* Forel	Paraguay, Brazil
Solenopsis (*Diplorhoptrum*) spp.	Western United States, Mexico, South America
Group 11	
Carebara spp.	South America, Africa
Paedalgus spp.	Costa Rica, Africa, Ceylon
Chelaner spp.	Puerto Rico, Australia
Oligomyrmex spp.	Worldwide
Tranopelta spp.	South America and Central America
Group 12	
Pheidole spp.	Worldwide
Crematogaster spp.	Worldwide
Myrmicaria spp.	Africa
Group 13	
Neivamyrmex harrisii (Hadelman)	Western Texas to Arizona
Neivamyrmex spp.	South America
Labidus spp.	South America

Species included in group 1 are all large, vigorous, non-stinging species, foraging mostly at night. They nest directly in the ground and thus may have some potential for becoming dominant predatory ants in pasture lands in the southeast if introduced to this area. *Camponotus* (*Myrmothrix*) *floridanus* (Buckley) is a dominant *Camponotus* already present in Georgia and Florida but is restricted to nesting in stumps and logs in wooded areas, and thus does not usually competitively interact with *Solenopsis invicta*.

The species included in group 2 are all larve vigorous ants notable for their excellance as insect predators and their very rapid movements. As in all Formicinae there is no sting. Disturbance of their nest areas produces extremely rapid and erratic avoidance reactions rather than bites or other defense. Some of these species can overcome stinging ants, however.

The ants of group 3 are larger robust species easily able to kill fire ants and other stinging ants. They live in large colonies and dominate large areas in the vicinity of their nests. However, most of the species of this group need stumps, logs, trash piles, or hollow stems such as bamboo to shelter their nests. For this reason only some of these species may be adaptable to pasture lands and open areas in the southeastern states. Some of the species do occur in grassland areas in South America. These ants bite severely, but only when their nests are disturbed.

In group 4 ants of the Formicine genus *Formica* are often dominant and numerous wherever they occur, and some species probably would provide much competitive interaction with the fire ants if they were present in the southeastern states. Unfortunately, the only *Formica* present in this area, *F. pallidefulva* Latr., *F. schaufussi* Mayr, and *F. archboldi* M. R. Smith, are rather timid species living in small colonies with sporadic distributions. Although most species of *Formica* occur in northern areas, the 11 species listed in group 4 occur in more southern areas and might be suitable for importation to the southeastern states.

In group 5 are several genera and species which probably could be competitive with fire ants if they could survive in the southeastern states. These ants are usually very quick and agile in their movements and in their interactions with other ants. They are rather xeric in their environmental requirements, and it is not known if they could adjust to the more moist conditions of the southeastern states. Some species of this group nest in rocky soils in semi-deserts or deserts. Probably the adaptibility of most of the suggested precandidate species could only be determined by trial and error.

The genus *Paratrechina* of group 6 is rather poorly known taxonomically. *P. fulva* (Mayr) and/or closely related species appear to be strong competitors of fire ants in their homeland areas. Due to the quickness and speed of *Paratrechina* spp., they often reach food sources before the fire ants and then exclude fire ants from these sources. *P. fulva* or a closely related species has already been introduced by commerce into the Miami, Florida area, but it has not yet been determined whether this species will spread and provide noticeable competition to IFA.

Groups 7, 8, and 9 are genera and species in the subfamily Dolichoderinae. They lack a sting but have either very rapid movements or chemical defenses which enable them to avoid attack and to compete with other ants. Some of the species are able to nest in close proximity to stinging ants and are able to avoid fighting with them. However, since they utilize a portion of the total food resources available to ants, they are competitors in a real sense. Some species in these groups, such as *Dorymyrmex planidens*, a diurnal predator, are large and vigorous enough, and have chemical defenses strong enough that large stinging ants retreat from encounters with them (observations of the writer). Other *Dorymyrmex* spp. may have similar chemical defenses and may be nocturnal foragers. All of the species in groups 7, 8, and 9 are probably fair to excellent predators on fire ant queens.

In group 10, which could be very greatly expanded in numbers of species, are listed a few of the *Solenopsis* (*Diplorhoptrum*) spp. which could be considered as precandidates. This group is poorly known taxonomically. There probably are several hundred species which exist in this group. They are all subterranean predators. By their attacks on the young nest founding queens of the fire ants they may have more influence on the fire ant populations than almost any other group of ants. In fact, the reproductive strategy of the fire ants may be keyed largely to the temporary demise of this subterranean fauna through environmental stress. Environmental stress events which greatly knock down the subterranean fauna are broadcast insecticiding, flooding, road building, plowing, and other strong disturbances of the soil. Some subterranean species are probably more resistant to these events than others. Therefore, an enrichment of the number of species of this subterranean fauna may make it less vulnerable to environmental stress. Only about 7 species are presently known from the southeastern states.

In group 11 are several genera with a large number of species which may be subterranean predators also. None of these species is presently known from the southeastern states. Species in this group also might be useful in enhancing and diversifying the subterranean fauna. Groups 10 and 11 are Myrmicinae and have poisonous venoms which are very useful to them in fighting with other ants and in killing prey. However, their extremely small size and cryptobiotic habits preclude direct interaction with man.

In group 12 are several additional Myrmicine genera which have numerous species which are very successful competitive ants and probably could provide much competitive interaction with the fire ants. In *Crematogaster* and *Myrmicaria* the apex of the sting is spatulate and useful only for topical application of poison to other ants, but this modification prevents its use as a piercing sting against man.

Finally, in group 13 I have listed 2 genera of Ecitoninae, the American driver ants or legionary ants. Some well known species in the Ecitoninae, such as the neotropical *Eciton burchelli* (Westwood), are devastating predators, able to kill many types of ants, wasps, bees, other insects, and caged mammals. Not as well known is the fact that many other species of the legionary ants are small and cryptobiotic and have no direct interaction with man. Some of these species are adapted for predation only on other ants and could be investigated for possible specialized predation on fire ants. One species, *Neivamyrmex harrissi*, from southwestern United States, is already known to be a predator on *Solenopsis* spp. (Mirenda et al., 1980).

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