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Research Needs and Priorities: Genetic Control, Including the Sterile-Male Technique

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All proposed methods of genetic control, including the techniques of sexual sterilization, share one common requirement: insects bearing the abnormal genetic characteristics must mix with natural populations and compete with normal individuals for mates. In this discussion, the term " abnormal " is used to include any characteristic not occurring in the strain native in the control area, although the same characteristic might be " normal " in other strains and in other areas. In the species that mate only once, the all-important requirement is that the mixing of populations take place before mating can occur. With a multiple-mater, such as *Aedes aegypti* (Linnaeus), this may or may not be important. With each individual strain that is to be released, and with each chemosterilant treatment that is to be used in the field, it will be essential to determine what proportion of the zygotes will bear the abnormal genetic constituents, and what proportion the normal ones when matings with normal individuals precede and/or follow matings with abnormal ones. It will also be necessary to determine, in field studies with each strain or treatment, whether the abnormal individuals disperse as well, live as long, behave in the same manner and mate as frequently as the normal individuals. Finally, it will be necessary to learn what the ratio of abnormal to normal individuals in the control area must be in order to obtain the desired effect on the progeny of the normal population. A good starting-point would be a comprehensive field experiment with one or more marked strains released among a relatively isolated population.

To evaluate the effect of given numbers of abnormal insects in the normal population, it is essential to obtain as precise an estimate as possible of the number of normal insects in a unit area. Much research has been carried out on methods of estimating animal populations; all methods leave something to be desired, but it would be extremely helpful to begin, as soon as possible, the development of methods for accurate quantitative assessment of *A. aegypti* populations.

More research is urgently needed on attractants and arrestants, and on feeding, mating and oviposition stimulants for *A. aegypti*. Such research is, in fact, under way by various agencies, but knowledge in these fields cannot be considered adequate until there are means to attract a high proportion of the males and females over an extensive area and to induce them to rest, feed and oviposit in the places selected. Such attractants and associated agents are not only needed in connexion with population estimates and surveillance of eradication efforts, but are basic to the successful use of chemosterilants in the field.

All the methods except the use of chemosterilants in the field require the rearing and release of large numbers of insects. Methods for rearing *A. aegypti* in terms of hundreds of thousands per week are available; further improvements and advances in automation will be required if the numbers should be increased to tens of millions per week. For releases on this scale, almost complete separation of the sexes would be required, since even a small percentage of females would constitute a hazard unless their vectorial capacity had been destroyed. The sexes differ in size in the pupal stage, but the available methods of separation will have to be greatly improved before they are suitable for the separation of millions of pupae per day with an acceptable percentage of error.

The percentage of females that could be tolerated in a release programme would be greatly increased if genetic characteristics could be incorporated into the strain which would make it incapable of vectoring any of the *A. aegypti*-borne diseases. Genetic research to find such characteristics, as has already been done for susceptibility to filariae, should be

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expanded. If possible, the infection-refractory gene should be combined with a visible marker. The rearing and release of such strains could, *per se*, constitute an important phase of disease control, if not *A. aegypti* control.

Some effort would be justified to attempt to find cytoplasmically incompatible strains of *A. aegypti* or closely related species that would mate with *A. aegypti*, or to find strains or related species that would produce sterile hybrids.

A great amount of basic genetic research, closely correlated with field observations, is needed to select strains incorporating all the characteristics desired in insects to be released. These features include favourable survival and behavioural characteristics for strains that are to be sterilized and released, but also deleterious genes that would be unfavourable in the natural population or would lessen its vectorial capacity.

More research is needed to find better chemosterilants. Highly stable compounds are needed for some purposes, e.g., treatment of areas where mosquitos may be induced to rest, whereas compounds that are quickly metabolized might be useful in others, such as treatment of natural breeding waters. Since safety will be a limiting factor, toxicological research must keep pace with the synthesis and evaluation programmes. The need for intensive research on attractants and associated behavioural control agents has already been mentioned; this work is as vital to the development of chemosterilization measures as research on the chemosterilants themselves.

Research programmes should take account of the possibility of utilizing the various genetic and sterility techniques as part of an integrated programme and should include such field or laboratory studies as may be appropriate. For example, if experience in some area indicates that insecticides will greatly reduce, but not eliminate, an infestation, and release of sterile males is to be attempted, the incorporation in the strain to be released of resistance to the insecticide in use will permit both methods to be used concurrently.