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Integration of Biological and Chemical Control

Opportunities Against Medically Important Arthropods [1]

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In the field of public health entomology, the concept of integrated arthropod control has not emerged as a working principle to the extent that it has in agriculture. Part of this lag is due to economic considerations as well as to a marked preference for (a) rote operations and for (b) curative means as opposed to preventive measures. Except in states where the tourist trade is a major economic factor, vector control programs in the United States rarely provide benefits that are clearly measurable in terms of dollars.

The absence of monetary benefits is not true of countries where control of disease vectors represents a significant factor in the economic life of the country. However, in these situations the abatement or eradication endeavor is directed chiefly towards control of the disease and whether the insect populations are reduced or eliminated is purely incidental to the main objective of raising the health level of the population.

The "rote" approach to arthropod control operations signifies an attempt to achieve abatement by the routine application of insecticides without regard to the habits or abundance of the species. Economic considerations also are partially responsible for this approach, since a single chemical or method for all purposes is cheaper. In addition, less-qualified personnel are required to supervise such a program.

The "preventive concept" of control receives approval from many groups but while an "ounce of prevention is worth a pound of cure", it usually is difficult, if not impossible, to obtain the necessary "ounces" to establish preventive measures. Public support, including that of the governing authorities, often is sadly lacking for "preventive" control. However, any suggestion that a current community infection is possibly insect-borne or that an insect population threatens the comfort of the public causes immediate, and sometimes unwise, approval of curative (usually chemical) measures.

With this brief introduction, let us examine some instances of the effect of chemical measures upon the prevalence of medically important arthropods. With the appearance of resistance to DDT, dieldrin and other chemicals in populations of *Musca domestica* Linnaeus, there were reports of situations where this species not only regained but greatly surpassed, its former prevalence. At Savannah, Georgia, several insecticides such as dieldrin, BHC and chlordane were shown to increase house fly breeding in privies (table 1). In contrast untreated privies had only a minor amount of house fly breeding

[1] From the Technical Development Laboratories, Technology Branch, Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Savannah, Georgia.

Table 1.—House fly production in untreated and dieldrin-treated privies.

Month	Average Number *M. domestica* per Privy	
	Dieldrin-treated	Untreated
May	193	3
June	254	13
July	1,374	5
Aug.	1,204	16
Sept.	1,946	10
Oct.	420	7

(Kilpatrick and Schoof 1956). House fly infestations apparently were associated with privy pits that had semi-dry media and few larvae of a soldier fly *Hermetia illucens* (Linnaeus). Repeated tests showed that chemical treatment of pits that had semi-liquid media and heavy populations of soldier fly larvae killed all of the *H. illucens* larvae. These media soon reverted to a semi-dry condition and became heavily infested with *M. domestica*. By regulating the water content in untreated privies, it was shown that this characteristic of the media was the limiting factor (Kilpatrick and Schoof 1959). In essence, the breeding of *H. illucens* reduced the media in privies to a semi-liquid state that was unsuitable for house fly production; dieldrin, chlordane and other toxicants destroyed the *H. illucens* but not *M. domestica* and the latter adapted readily to the now-favorable media. Similar competition between *H. illucens* and house flies in chicken excreta has been observed here at Savannah and elsewhere by other workers. Other instances of increased house fly production following insecticide treatments were reported from Phoenix, Arizona and Charleston, West Virginia (Schoof et al. 1951; Schoof and Siverly 1954). At Phoenix, Arizona, the increased house fly production in dieldrin-treated privies was interpreted as being partially due to the detrimental effect of the pesticide on *Muscina*, the larvae of which prey on *M. domestica* larvae.

With mosquitoes, there have been similar instances where chemical treatment, particularly against anophelines, has resulted in the increase of other annoying pests such as mites, bed bugs, or flies. Unfortunately, many of these complaints are based on circumstantial evidence rather than related to specific data on prevalence. Nonetheless, the frequency of such reports suggests that the application of residual treatment inside homes for malaria eradication has disturbed the balance that existed between other species and their parasite-predator complex.

Larvicide treatments for mosquito control have at times met with opposition from groups interested in the preservation of wildlife and fish. The harmful effects of insecticides on many elements of the aquatic fauna besides the pest involved are well known. In some instances, the problem resolves itself into the relative importance of the harmful effects upon aquatic organisms versus the benefits derived from mosquito control. Normally, however, the judicious use of insecticides is compatible with preservation of wildlife and fish, and it is to the advantage of both mosquito control and wildlife groups to emphasize the proper integration of the chemical measures and the reported biological control afforded by predators such as fish. Unfortunately, in many instances the normal predation of fish or insects has only a partial effect on the mosquito population and does not maintain it at a level compatible with human comfort. Despite this fact, there has been great emphasis on the effect of fish in suppressing mosquito populations, but part of this is conjectural, particularly as it relates to anopheline mosquitoes. Predation by animals other than fish often is stressed; but the validity of many claims is questionable, particularly where they concern laboratory tests in which competitive food sources were not present.

For long-term residual larvicidal action, pesticides such as DDT and dieldrin are applied at heavy dosages that are completely destructive to other insects and to fish. Such treatments are never recommended where this animal life is of value. However, among the chlorinated hydrocarbon insecticides, benzene hexachloride has been found to be highly effective for controlling the mosquitoes, yet at these dosages it does not have an adverse effect on fish survival as is true for DDT or dieldrin (Mathis and Quarterman 1953).

Now that we have reviewed a few of the instances of the adverse effects of chemical measures against arthropod populations, let us look at instances of integration between chemical and biological control. From a practical standpoint, there are none in operation today. The basis for this lies in the reasons previously outlined (rote approach, tendency toward curative measures) plus the factor that minor attention has been given to this phase. As yet there is little to offer in the way of an effective biological control agent. This statement is somewhat strange when you consider that Jenkins (1960) listed about 500 parasites and almost 700 predators of arthropods of medical importance. Twenty species of bacteria and 16 genera of fungi are known to be injurious to mosquitoes. Similar figures could be quoted for other arthropods, such as ticks and fleas.

The difficulties in effecting integrated control are considerable, particularly since relatively sparse knowledge exists on the ecology of most insects—whether harmful or beneficial. There has been a distinct lack of long-range field studies on insect pests and their interrelationships with other faunal constituents.

It is encouraging that this state of affairs has recently received the attention of many scientists involved in medical entomology. In 1960, at a conference on biological control sponsored by The American Institute of Biological Sciences, The Armed Forces Pest Control Board, The Office of Naval Research and The Army Chemical Corps, it was concluded that: "Pathogens, parasites and some predators offer a real potential for natural control of medically important insects. Tests and experiments to date have shown promise, and have also demonstrated the absolute requirement for basic knowledge of the ecology and life history of the pathogens, parasites, or predators, and insect hosts." Other comments from the Conference stressed the need for emphasizing study of the various aspects of biological control including the necessity for additional funds for that purpose. One comment of pertinent value to this symposium was the suggestion that combinations of pathogens, and of pathogens and insecticides, be considered.

In reviewing the utilization of integrated control measures in medical entomology, one is struck by the marked developmental lag in the field of biological control as compared with control through the use of insecticides. Yet there is great demand in many quarters for a better recognition of biological measures by control supervisors and by individuals concerned with the evaluation of

insecticides. Without question, the procedures for insecticide evaluation could include assessment against insect parasites or predators that were of value in suppressing the densities of pest species. However, Pepper (1955) stated, "Without a knowledge of the true relationships of both the host and the enemy to their environment as well as an understanding of the interrelationships between the two populations, there is no basis for postulating any effects, either detrimental or beneficial, of parasites or predators on the host populations." Thus, until more is known about the relative significance of these parasites and predators in biological control, it is difficult for the research worker or the control operator to give a great deal of time and effort to selecting insecticides that are harmful to the pest and compatible with the survival of beneficial insects. When data are available on the relative significance of the different beneficial species upon the injurious species, these species can be included in the insecticidal evaluation. Related work of this type has already been done on the effect of insecticides upon humans and upon other animals, with particular reference to the toxicity to fish of chemicals used in treating aquatic habitats. Mulla (1961) listed the relative degree of safety of 16 insecticides to *Gambusia affinis* (Baird and Girard) and also reported that application of parathion as granules (rather than spray) greatly reduced the toxic hazard of this toxicant to honey bees.

At the Puerto Rico Field Station of the Communicable Disease Center, various potential molluscicides for control of the snail intermediate host of schistosomiasis, *Australorbis glabratus* (Say), are evaluated routinely against fish. One aspect of significance in the Puerto Rico work is the use of a predator snail, *Marisa cornuarietis* Gray, upon the snail intermediate host, *A. glabratus* (Oliver-Gonzalez et al. 1956, Oliver-Gonzalez and Ferguson 1959). *M. cornuarietis* eats the eggs of *A. glabratus* as well as the young. Numerous tests are being conducted to evaluate this predator, not only as to its effect upon *A. glabratus* but also as to its effect on aquatic plants and on crops that may be under aquatic cultivation. In certain areas, the predator snail alone has brought about a substantial reduction in the densities of *A. glabratus*. In other areas an effective molluscicide has been used to reduce the population of *A. glabratus* to such a level that *M. cornuarietis*, when introduced, can prevent its resurgence.

While opportunities for integrated control are apparent in medical entomology, there is a tremendous gap between the present state of development of chemical control measures in comparison with biological control techniques. It is obvious that, until advances are made in biological control along the lines of sound data on the ecology of the beneficial species and their significance in the biotic potential of the pest species, the possibility of utilizing integrated control measures against medically important arthropods is remote. It requires an abrupt awakening among entomologists as to the potential of biological means in insect control coupled with extensive ecological research on these means, particularly field evaluation, to enable us to exploit fully the possibilities that exist for activating integrated control in public health entomology.

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