The biological method and

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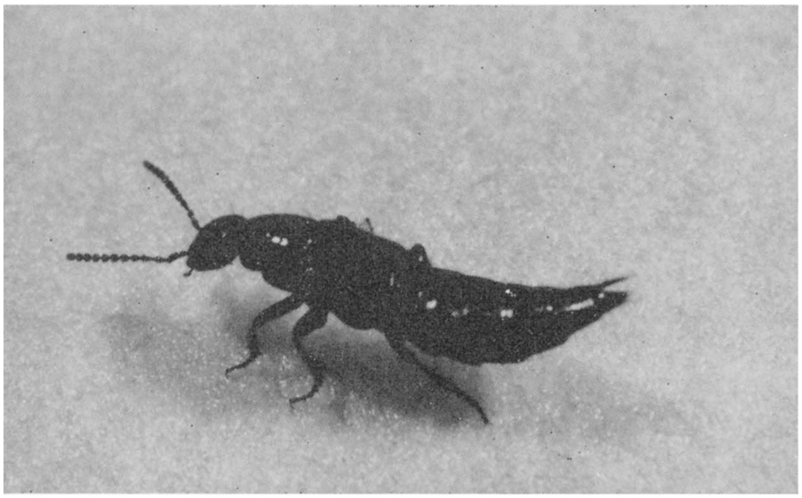
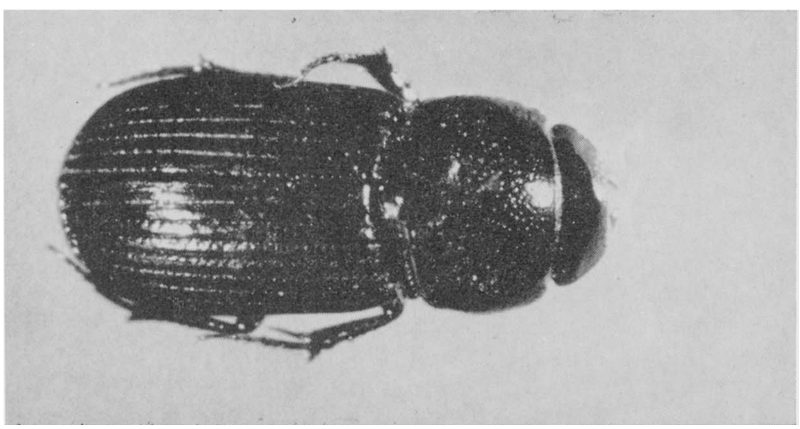
Full utilization of the biological method in fly control requires the preservation of existing predatory and parasitic enemies in animal dung. The use of residual poisons to control adult flies did not interfere with natural enemy complexes in these tests. Alternating the removal of manure deposits, and abstaining from chemical treatment of manure were essential procedures in maintaining largest populations of predators and parasites.

Common predatory histerid beetle, *Carcinops pumilio* **(Erichson), shown feeding on the eggs of the common house fly.**



Widespread species of staphylinid or rove beetle, *Philonthus sordidus* **Gravenhurst.**

BIOLOGICAL METHODS for fly control have been used in the past with varying degrees of success but the extent of control achieved has often been entirely adequate to preclude the necessity for integration of cultural and pesticidal control measures. In our present society, where fly breeding sources are often found close to human dwellings, the biological method alone has often been inadequate to meet the standards set by local health statutes. It is usually necessary to supplement, or add to, the existing natural balance between flies and their natural enemies. However, in almost all fly control programs, the cost can be considerably minimized if a general understanding of the breeding of flies and their natural enemies is obtained. Research at several campuses of the University of California during the past four years has resulted in an integrated plan for fly con-



Native scarab beetle, *Ataenius californicus* **Horn, very active as a casual feeder on immature flies and excavator of animal dung.**

Photos below show two of several predatory Anthocoridae or "bugs" widely active as egg predators. Here a nymph, left, and an adult, right, are shown piercing eggs of the common house fly.

integrated control of house and stable flies in California

trol that offers maximum effectiveness at a minimum cost in most fly-breeding situations at commercial dairy, poultry, feed-lot and stable environments.

Scientists studying the habits of adult house flies in Denmark and at Berkeley concluded that a very high percentage of emerging flies remained in the area of larval breeding long enough to come in contact with many surfaces that could be treated with residual insecticides or poison baits. If the application of such poisons was properly spread out over most of the fly resting sites, satisfactory control was achieved during peaks of fly populations. Such practices did not interfere with beneficial flies such as *Ophyra*.

Scientists at Illinois and Riverside, studying the resistance problem of flies to insecticides, concluded that development of resistance was slowed down considerably if the kill were directed against adult flies instead of larvae.

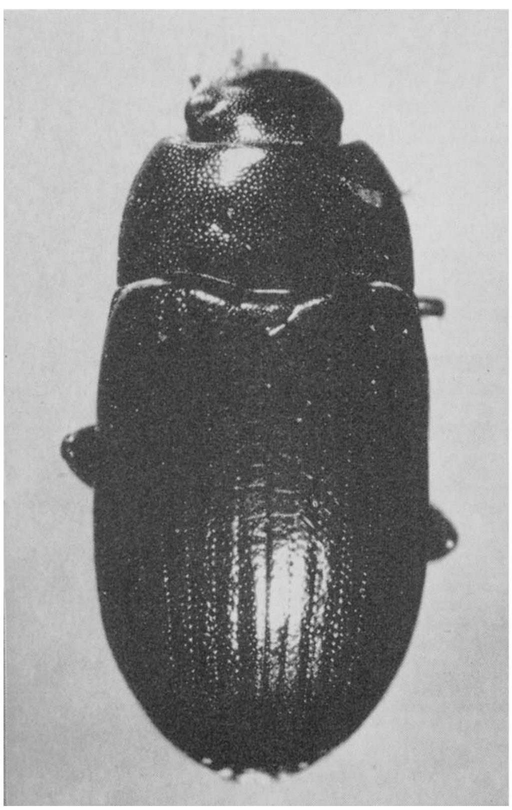
Research at the Department of Biological Control, Riverside, indicated that because of parasitism and physical mortality factors, fly larval counts were not adequate indicators of potential fly emergence, and showed conclusively that insecticides applied to the fly larvae at their breeding sites destroyed almost 100 per cent of the natural enemies, both predatory and parasitic. These natural enemies can contribute to more than 95 per cent destruction of fly populations. The reestablishment of such a natural enemy complex requires many months, during which time subsequent generations of flies are able to develop unchecked to the limits of their available food supply. This build-up leads to the requirement for more frequent applications of insecticides, and ultimately to increased dosages as resistance develops in the fly populations. This resistance is capable of spreading to adjacent areas so that every ranch in a valley may be affected.

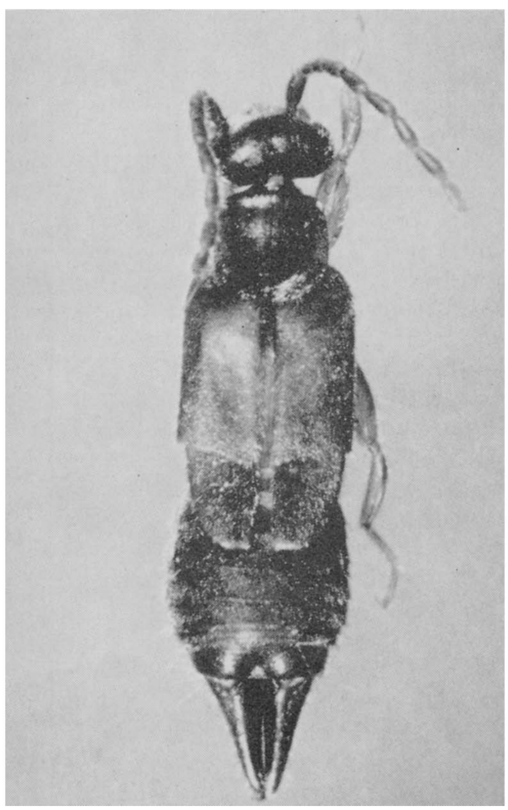
The two types of natural enemies that can be used for biological control of flies include: (1) the predators that attack fly eggs, immature larvae, and some pupae; and (2) parasites that attack larvae and pupae.

Some predators spend their entire lives in the fly larval breeding sites (manure, garbage, decomposing vegetation), passing through various developmental stages themselves. Other predators spend a portion of their developmental period in the surrounding fields and reenter the fly breeding sites as full-grown adults.

Most predators are able to exist on alternative sources of food, such as fungi and dead organic matter when flies become scarce. This habit assures their persistence in a potential breeding site until conditions become more favorable for a fly population increase. All predators, merely by virtue of numbers (often thousands per gallon of manure) also aid in the aeration and hasten the rate of decomposition of the breeding site, finally making it unsuitable for fly breeding.

California's principal predatory and scavanger species belonging to several insect families are: Staphylinidae (*Oxytelus sculptus* Gravenhurst, *Philonthus*





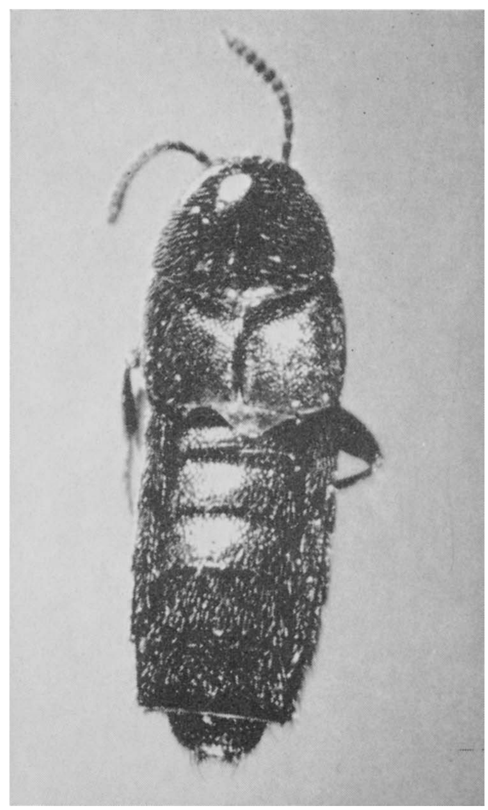


Photo above, left, tenebrionid beetle, Alphitobius diaperinus (Panzer), **valuable as both a predator and dung excavator. Photo above, center, predatory earwig,** Euborellia annulipes (Lucas), **often abundant at widely scattered sites in the Southwest. Photo above, right, parasitic staphylinid beetle,** Aleochara sp., **which passes its larval stage in the puparia of flies, and feeds on fly eggs and young larvae as an adult.**

politus L., *Philonthus sordidus* Grav., *Platystethus americanus* Erichson, *Platystethus spiculus* Er., *Staphylinus maxillosus* Grav.) ; Histeridae (*Carcinops pumilio* (Er.), *Gnathoncus nanus* (Scriba), *Margarinotus merdarius* (Hoffman), *Saprinus lugens* Er.) ; Scarabaeidae (*Aphodius fimentarius* (L.), *Aphodius granarius* (L.), *Aphodius lividus* (Oliv.) ; Anthocoridae (at least two species) ; Hydrophylidae (several species) ; and Tenebrionidae (*Alphitobius diaperinus* (Panzer)—see photos. In addition, predatory earwigs, mites, flies and ants are often prominent.

Parasites

The other type of natural enemy, parasites, attack young and full-grown larvae and pupae of flies. Parasites live in the fly breeding sites where they search for, sting, and deposit eggs in their hosts. The eggs hatch inside the immature flies and the parasite larvae rapidly consume the contents. Female parasites of a number of species prefer to attack robust, potentially more fecund flies. They are also able to accelerate their rate of kill and their own developmental time in response to increases in fly populations. By being selective in the time they have available to kill, they have a considerable effect on the fecundity and abundance of the next generation of flies, since more of the "weakling" flies escape parasitism. The weaklings not only find it more difficult to lay larger numbers of eggs than their parasite-killed sisters, but they transmit more weak inheritance characters (genes) to their offspring. Parasites also kill many flies that they do not lay eggs on, so their effectiveness in fly mortality is greater than the number of parasitized pupae would indicate.

The principal parasitic species active in California on house and stable flies are *Muscidifurax raptor* Girault and Sanders (a large and a small type), *Spalangia cameroni* Perkins, *S. endius* Walker, *S. nigra* Latreille, *S. nigroaenea* Curtis and *Aleochara* sp. (see photo). The *Fannia* group of flies also possess one or two species of *Stilpnus* which attack larvae. Although most of these parasites are active at all low elevations in the state, only the *Aleochara* sp., *Stilpnus* and *S. nigroaenea* appear to become prominent above 4,000 ft. None of the native parasites and few of the predators, are very active when the mean temperature drops below 60°F. There is comparatively less activity between December and April. However, in most areas fly problems are minimal during this period.

Prospects

A number of parasitic natural fly enemies obtained throughout the world are now being introduced into California by University scientists to strengthen the existing natural enemy complex. The species are: three reproductively isolated forms of *Muscidifurax raptor* from Puerto Rico, Central and South America showing varying characteristics of gregariousness, fecundity and uniparentalism; *Spalangia longepetiolata* Boucek from East Africa, *Sphegigaster* sp. from South Africa, *Tachinaephagus zealandicus* Ashmead from Australia and New Zealand, and *Aleochara taeniata* Erichson from the West Indies.

Some of these were very active in cold climates while others required intensely hot and dry environments. By distributing them through all climatic areas of the state, it is expected that parasite activity will be increased where it is now low, and that winter fly problems on the south coast can be reduced by the addition of the cold-hardy species.

Predator complexes in animal excrement in the Ethiopian and Neotropical regions differ considerably from the Holarctic region in the species they contain. Future efforts will be directed toward the introduction of key species into California.

The "inundation" method involving the periodic release of laboratory-reared cultures of parasites in a direct attempt to reduce the increasing fly populations, shows some promise but must be investigated further. Test results indicate that effective use of the adapted complexes of natural enemies is the best biological control method at this time. Since peaks in fly activity are correlated with seasonal weather conditions in each locality, these variations must be considered. Otherwise, the method involves the preservation of existing natural enemy complexes in animal excrement by alternating the removal of manure, and abstaining from chemical treatment of the manure; and favoring coned manure deposits for poultry. When frequent manure removal practices require stockpiling in an adjacent area (environmental poultry houses, dairy industry, etc.), a high steeply sloping mound will assist maximum natural enemy activity and also be least suitable for fly breeding.

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MASTITIS

. . . *a six-year*

SINCE 1955, the average herd size in the Fresno County Dairy Herd Improvement Association (DHIA) has increased from 105 to 256 cows per herd. This expansion has been accompanied by an increase in production of milk from 9,433 to 13,592 pounds and of butterfat from 391 to 509 pounds per cow. Mastitis is one of the problems in dairy management which becomes more complex as herd size increases. Clinical mastitis cases can be recognized readily; however, it is also of great economic importance to determine which cows in a herd have nonclinical cases of mastitis.

The Fresno County DHIA decided in July, 1961 to use the California Mastitis Test (CMT) in determining the degree of mastitis within a herd. The CMT has been well accepted and demonstrated throughout the world as a simple, economical, and practical method for estimating the mastitis cell count in milk.

Bucket milk testing (milk samples by the DHIA tester) proved to be an excellent device for screening individual cows in a herd. CMT scores were rated as follows: samples scoring negative (no mastitis cells detected) and trace (N+T) were combined into one group; samples scoring one were listed separately; samples scoring two and three (2 + 3) were also combined. Standardization procedures were established with quarterly checks made on tester procedure.

CALIFORNIA AGRICULTURE
Progress Reports of Agricultural Research, published monthly by the University of California Division of Agricultural Sciences.

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