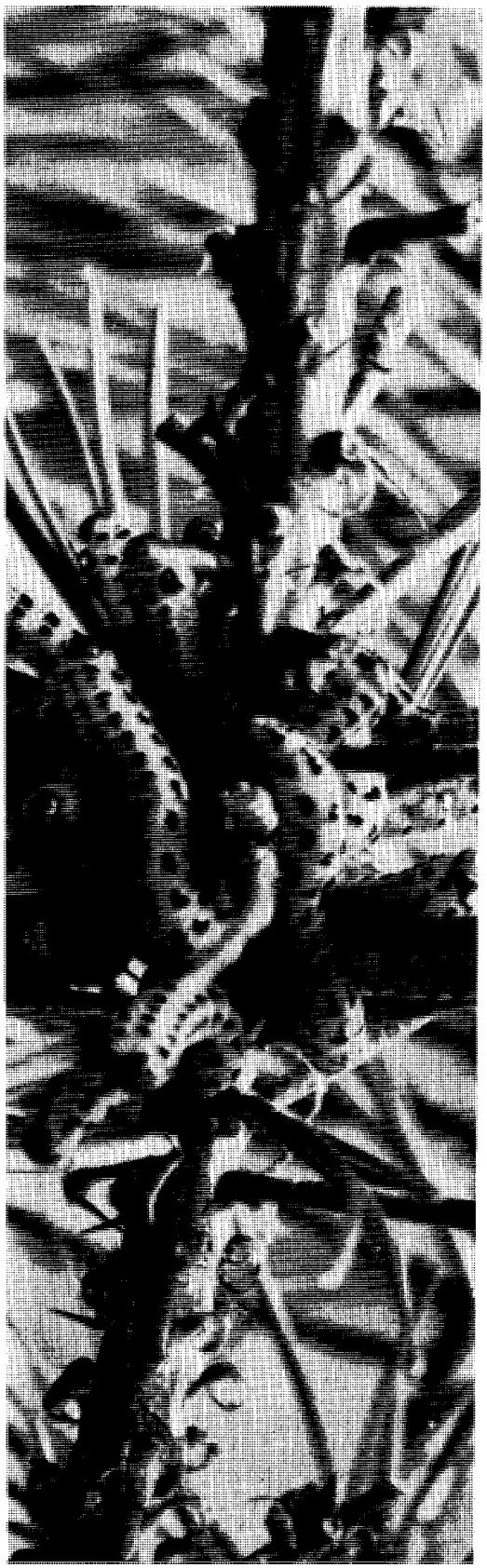
▶ Poison bait was used to counter a locust invasion of French Morocco in November 1954. Estimate is that each year insects produce more protoplasm than all other terrestrial forms of animal life together

▼ Pine caterpillars attacking a grove of trees in New Jersey



Don't Let the Insects Rule

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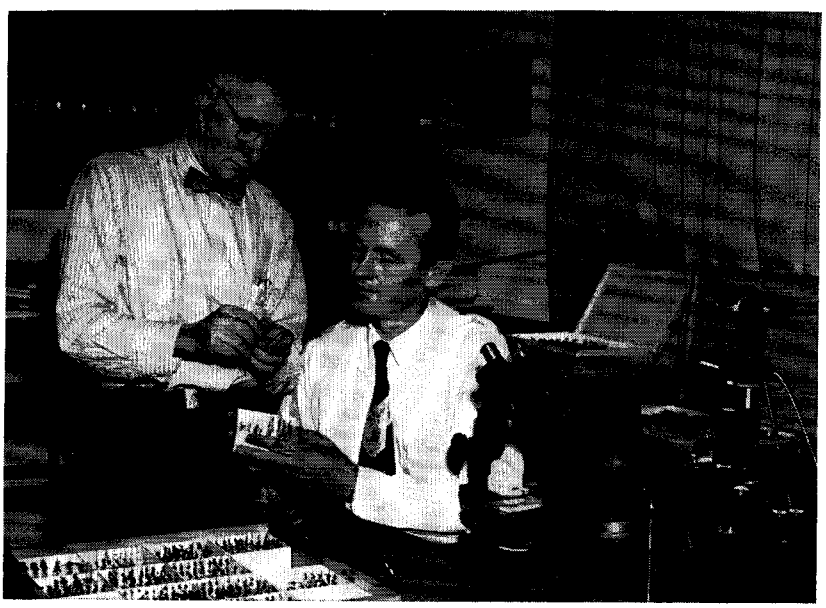
The struggle between man and insects never ends. While ecological or biological control may be the ideal, use of pesticides is the only practical weapon now available for combatting most of our injurious insect species

Research, such as this project in insect taxonomy sponsored by Dow, must continue undiminished; if there is to be progress, it must be expanded



WE WHO LABOR in the field of entomology wonder at times if our fellow scientists recognize the full potentialities of the insect world, or if they regard the whole lot of us as mere boys crying "wolf." But the battle for the upper hand over insects has been a serious one for many centuries, and modern man would be in even greater danger of extinction than he now is were there not still some agricultural leaders who regard insects as a menace to man's future.

When man appeared on the scene, he found insects in full possession of this planet. They had made their appearance ages earlier and had developed to a point of dominance in the animal kingdom through the exacting processes of evolution. Highly diversified and admirably attuned to conditions prevailing in their respective ecological habitats, insects were in a sense far better prepared for a battle of the survival of the fittest than man, who, poorly adapted as he is, must to a very great extent rely upon his far from infallible intellect not only to establish a defense against his enemies, but also in many cases to modify the environment in which he finds himself so as to make his very survival possible.

Man, then, exists because of his ability to "outsmart" insects. Actually, in terms of geological time, man is a late arrival who has attempted to displace a well adjusted and highly versatile original population, which bars no holds in its attempt to regain its position of supremacy.

In the words of the scholarly, immortal S. A. Forbes:

"The struggle between man and insects began long before the dawn of civilization, has continued without cessation to the present time, and will continue, no doubt, as long as the human race endures. We commonly think of ourselves as the lords and conquerors of nature, but insects had thoroughly mastered the world and taken full possession of it long before man began the attempt. They had, consequently, all the advantage of a possession of the field when the contest began, and they have disputed every step of our invasion of their original domain so persistently and so successfully that we can even yet scarcely flatter ourselves that we have gained any very important advantage over them. . . . If they want our crops they still help themselves to them. If they wish the blood of our domestic animals, they pump it out of the veins of our cattle and our horses at their leisure and under our very eyes. If they choose to take up their abode with us we cannot wholly keep them out of the houses we live in. We cannot even protect our very persons from their annoying and pestiferous attacks, and since the world began we have never yet exterminated—we probably never shall exterminate—so much as a single insect species."

To those who hold that the idea of dominance by insects is absurd, let us recall that the outcome of most of the

Some entomologists deplore the fact that pesticide testing dominates the work of entomology, although they recognize pesticides as the foremost practical weapon

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great wars of history was decided not by armies, but by insects, through the spreading of insect-borne diseases. Even in World War II, in the South Pacific the Allies had to defeat the insects before they could advance to attack the Japanese forces. The great plagues of history were insect-borne diseases. Insects twice halted and nearly prevented the building of the Panama Canal. The tsetse fly still rules supreme in a large section of Africa, and the release of millions of human derelicts from the scourges of malaria and other equally devitalizing diseases has come to pass only in the last decade. As a matter of fact, this latter battle has not yet been decisively concluded.

Tropical Agriculture Undeveloped Because of Insects

Turning to the agricultural field, the vast agricultural potentialities of the tropics and many subtropical areas remain undeveloped largely because of the intolerable conditions imposed by insects. Development of a major livestock enterprise in our own southeastern states was delayed 200 years by uncontrolled insects, notably ticks and screwworms. Even today, insects are a dominant factor retarding the large scale production of corn in the Gulf Coast area.

It may be argued that these conditions do not apply to this nation's bread-basket, the great Midwest, and this area has been lucky, in a sense; but let us not forget that less than a century has passed since many hardy and courageous pioneers gave up in despair and returned to the East when invading hordes of grasshoppers denuded the whole countryside in Missouri, Illinois, Iowa, and other Midwest states, and that many others were driven out by the disastrous chinch bug losses in the 1880's and 1890's, particularly in 1887 and 1896.

There are those who will claim, "Insects are getting worse each year," or "My father and grandfather were not bothered by insects." But history belies such testimony. By 1850 farmers, and orchardists in particular, had become so distressed by insect plagues which they were unable to combat successfully that they began to demand the appointment of state and federal entomologists to study their problems and develop much needed insect control measures. Thus Townend Glover was appointed as entomologist in the U. S. Patent Office in 1854, eight years before the federal department of agriculture was created. Also in 1854, Asa Fitch was appointed state entomologist of New York. Both of these appointments preceded by eight years the passage of the "Morrill Act" of 1862, which in effect authorized the creation of the "land-grant" colleges.

In the Midwest where ravages of chinch bugs, grasshoppers, armyworms, potato beetles, and a host of other pests were creating havoc and causing many farmers to sacrifice or in some cases abandon their farms in favor of some less hazardous and more profitable occupation, Benjamin D. Walsh was appointed state entomologist of Illinois in 1867, and Charles V. Riley was appointed in the state of Missouri in 1868. These appointments were independent of, but almost simultaneous with, the creation of the land-grant colleges in these states, which in itself shows the importance and significance the farmers, agricultural leaders, and legislators attached to insects and insect control problems.

Since entomologists are quite generally accused of exaggeration, it may be useful here to quote the distinguished Horace Greeley, who in 1870 said: "If I were to estimate the average loss per annum of the farmers of this country from insects at $100,000,000, I should doubtless be far below the mark. The loss of fruit alone by the devastations of insects, within a radius of fifty miles from this city, must amount in value to millions. . . . We must fight our paltry adversaries more efficiently, or allow them to drive us wholly from the field."

Perhaps it is a tribute to the entomological and chemical professions that insect pests (bad as the situation may seem today) have been brought under control to the extent that, utilizing currently available control measures, man is able to live where he chooses and to produce crops in abundance wherever the soil and climate are suitable for their production. At the same time we must recognize that the conflict goes on eternally.

Insects, in the course of their evolution, have acquired an enviable degree of fitness that permits at least some representatives to survive, if not, indeed, thrive, in almost every earthly environment. They have likewise retained in their gene complex a multitude of little used or unused factors that permit them to make necessary adjustments to changes in their environment. Furthermore, their tremendous reproductive potential and rapid rate of development enables insects to make these adjustments in relatively short periods of time. Thus we find that insects temporarily controlled by some recommended practice may soon get out of hand. Sometimes a change of habit is involved, sometimes it is a switch of host preference, resistance to some insecticide, or the acceptance of some previously resistant variety or crop.

Insects Nullify Work Of Over a Million Men

Agriculture is generally recognized as the basic industry in our national economy, and yet we annually permit insects to nullify the productive effort of over a million men, or well over 10% of our agricultural labor force. The average citizen takes our American standard of living, including a bountiful food supply, more or less for granted. Rarely does he stop to reflect that if insects were not controlled by cultural, chemical, or other means, they would practically eliminate the production of many crops.

Orchardists and gardeners on the other hand, know full well that successful commercial production of fruits and vegetables would be impossible without the use of chemical sprays and other measures applied to control insects and plant diseases. Thus, pest control is not new, but rather is a sizable operation of long standing. Ag-

ricultural statistics reveal that American farmers now spend hundreds of millions of dollars annually for chemicals to be used in their war against insects, and an equal or even greater cost is involved in their application.

Insect Control Should Be Largely Ecological

Fundamentally insect control is or should be largely biological and ecological in nature. It is well known that pests, whether they be weeds, plant diseases, insects, or even rodents, have tremendous—sometimes almost inconceivable—reproductive powers, and that for each species nature has arrayed against it a variety of dynamic forces which tend to inhibit or nullify its reproductive powers. Thus we have a sort of natural balance wherein natural forces of environmental resistance opposing reproductive potentials tend to keep plant and animal populations in a state of near equilibrium. For every organism there is an optimum environment in which it can come closest to attaining or exerting its full reproductive potential. Outside this area of optimum, natural forces make reproduction and survival progressively more difficult until at last the point is reached where survival becomes impossible.

Since nature can and does do such an excellent job of establishing and maintaining balances between species and establishing limitations on species, it would seem logical that man, to be most successful in influencing plant or animal populations, should thoroughly study and then attempt to emulate nature. This he can do and has done successfully in many instances. Basically, all organisms, whether they be plant or animal, have three fundamental requirements: an adequate food supply, protection from their enemies or from intolerable competition, and the adequate fulfillment of their other ecological requirements.

Our highly successful agriculture of today reflects and is a tribute to man's success in controlling the forces of nature to provide a suitable environment for the production of his crops and livestock. Likewise, in the field of game management biologists are attaining considerable success by making rather minor changes in an established environment to provide additional food and cover favoring the reproduction and survival of selected species such as pheasant, quail, and game fish. Entomologists and plant pathologists have similarly, through manipulation of the environment, attained considerable success in controlling a number of agricultural pests. On the other hand, modern farm management practices have provided an abundant food supply and other environmental conditions highly favorable to many species of insects and other pests; thus agriculture has inadvertently created some of its most important insect problems.

In considering insect control from the long-time point of view, population management is or should be our ultimate objective, and to this end biological and ecological studies should dominate our research programs. In general, biological and ecological control measures, when developed and properly applied, have a long-lasting and in some cases perhaps a permanent effect on pest populations. Thus they are not only practical but exceedingly economical and sound. The observance of fly-free or optimum seeding dates for wheat to control the Hessian fly, clean cultivation before seeding to control the pale western cutworm, and the planting of resistant varieties of crops to control a number of insects and plant diseases are classic examples. In many instances chemical control of pests will find a suitable and proper place in a long-time population management program, but in most instances biologists are prone to regard the use of chemicals—insecticides, fungicides, acaricides—as emergency or fire-fighting methods to be used largely where appropriate ecological methods have not been developed or have not been properly applied.

Pesticide Testing Dominates Research Work in Entomology

In years gone by, biologists quite generally devoted most of their research time to biological and ecological studies, and at one time biological, ecological, cultural, and mechanical control measures dominated all pest control activities. Such methods alone proved to be inadequate, and research workers sought more practical measures. Then, as chemical control came into the picture, more and more time was devoted to the testing and evaluation of pesticides. With the advent of DDT and the many new insecticides, fungicides, and herbicides that followed in quick succession, laboratory and field testing of new pesticides increased to a point where it dominated all other activity. Many research institutions soon found that the major portion of their research effort was being devoted to the testing of new materials.

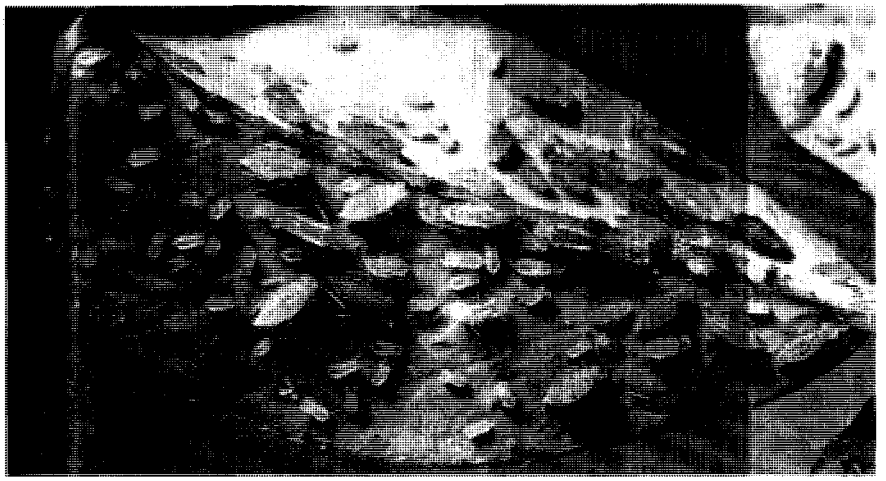
Many entomologists and plant pathologists came to deplore the excessive emphasis being placed on chemical control measures. Some actually deeply resented this turn of events, and thus about four years ago a number of department heads, experiment

Imported fire ants feed eagerly on the unopened flower bud of okra

station directors, and other administrators asked the National Research Council Committee on Agricultural Pests to consider ways and means of reducing the time and funds being devoted to the routine testing of new chemicals.

While biologists generally regard the development and proper utilization of appropriate biological and ecological control measures as the fundamental and only sound method of approaching our long-time pest control problems, most of them recognize also that attaining the ultimate goal of population management would require the adoption of approved practices by most, if not, indeed, all residents in a community or area, be it large or small. Universal adoption of such practices on a voluntary basis is always difficult, and frequently impossible to attain. Thus we often find that potentially valuable ecological control measures are ineffective and impractical because they cannot attract or demand universal acceptance.

For example, there are many who feel that the universal acceptance of good sanitation practices and the observance of appropriate planting dates would hold European corn borer populations to such a low level that this pest would not constitute a serious threat to corn production; yet there is no indication that Midwest farmers will accept such a program. To be successful such a program would require universal compliance, and a few abstainers would largely nullify the efforts of the faithful. In the absence of community action, individuals or small groups of farmers cannot hope to manage corn borer populations on their own farms, and



they have no choice but to resort to the use of insecticides to protect crops in individual fields on an annual basis.

Then, too, there are many pests for which no suitable biological or ecological control measures have been developed, and for the time being, at least, pesticides constitute our only defense weapon. Furthermore, we must acknowledge that the chance or experimental application of pesticides on a variety of crops has revealed important pest losses previously unknown or grossly underestimated. At any rate, the use of insecticides is the only established protective practice available for combatting the majority of our injurious insect species and, like matrimony, it is here to stay.

Chemical pest control is a multimillion dollar enterprise and one that is growing rapidly. Our present know-how was obtained through research, but we have only scratched the surface of this great field, and its research potentialities and requirements for the future are so large as to be inestimable.

Much progress has been made in the agricultural field, but with current insect losses estimated to be in excess of $4 billion annually, there is obviously much room for improvement. It would appear safe to estimate that insect damage to crops and animals could and can be reduced by 50%, which would be equivalent to increasing agricultural production by about $2 billion annually. Then, too, there is a very great possibility that crop losses attributable to insects may be grossly underestimated.

To obtain a vague idea of the possible extent of unrecognized insect damage, one need only consider the magnitude of insect populations. It has been stated that the total mass of protoplasm produced by insects each year exceeds that produced by all other terrestrial animal life put together. If we recall that much of this entomological protoplasm represents lost plant and animal production that might have been more profitably converted into products for human consumption, we can arrive at only one conclusion: insect losses are of enormous proportions.

Not only do we fail to recognize and evaluate hidden or obscure losses, but all too often conspicuous crop losses are misidentified and attributed to drouth, excess rain, poor seed, or just plain hard luck. For example, sod webworm larvae, well hidden in the turf mat and unobserved, frequently cut and consume practically all of the green foliage in parts of a lawn or pasture, thereby exposing dead brown leaves of the turf mat, and the owners scream "drouth," even though there may be more than adequate moisture in the soil.

Then, too, we have been prone to consider only one or two species that attracted considerable attention, guess at the acreage involved, guess at the degree of damage, and then guess that perhaps 5, 10, or 15 per cent of the total crop had been damaged or lost. It is conceivable that some smart politician long ago learned from insects that it is possible to collect more revenue with less public resentment through a 2% sales tax than can be extracted with a much higher income tax.

Rarely do we stop to consider all of the pests that may appear in a corn field between May and October. Insects may attack the seed before it germinates, a dozen species individually or collectively may damage the root system, still others attack the juvenile plants, and last but not least a wide variety of species may attack the mature foliage, tassels, main stalks, and ears. True, all species are not abundant every year, and it would probably be unusual to find all species represented in any one field in any given season. But at the same time a dozen or more species may be encountered in varying numbers and at varying times during the season in practically any corn field. Damage attributable to any one insect may be low, but the combined effects of all the insect activity in any given field from spring until fall, if accurately measured, might be appalling.

It is a matter of history that over a period of years entomologists developed what they regarded as reasonably satisfactory control measures for most of the important insect pests attacking potatoes. If pressed, they might have pointed with pride to their accomplishments in this field. If inclined to be boastful, they might even have asserted that they had about reached the pinnacle of success. And yet, what happened? When DDT, which showed promise of controlling several of the insects attacking potatoes, became available for limited use in the agricultural field in 1945, it began to replace more complicated mixtures of materials required to control a variety of pests. Reports from various sources indicated that the use of DDT resulted in phenomenal increases in the per-acre yield of potatoes. Within five years national per-acre potato yields rose to 160% of the five-year pre-DDT average.

A study of USDA statistics showed similar increases for a number of other crops on which DDT and other more recently developed materials were used extensively: onions 140%, sweet corn 160%, tobacco 125%, beet seed 180%, alfalfa seed 160% (in the state of Washington, where DDT was used most extensively, alfalfa seed production jumped to 420% of the pre-DDT level). Even milk production per animal jumped 15%. This was viewed with considerable skepticism, but more recent studies on the value of livestock sprays strongly indicate much of the gain might well be attributed to better insect control.

With All Pests Controlled Yields Might Be Doubled

At this point it should be noted that loss estimates by biologists are often severely criticized by statisticians and laymen alike. They point out that at times, according to reports, insects have taken 10%, diseases 10%, weeds 10%, nematodes 10%, frost 10%, hail 10%, drouth 10%—a total of 70%—and still the grower got a near normal crop. In the case of most fruit and vegetable crops the values are not additive. The crop may have been rendered unsalable by both insects and diseases and the control of both was essential. More important, however, is the fact that for most crops potential production is rarely attained and is often unknown. Thus, we are prone to think of average annual yields as normal, and totally ignore the fact that with all pests adequately controlled yields might be doubled, or at least greatly increased.

One other problem looms large in the development of new pesticides. A considerable portion of the American

public has become concerned over the possible public health hazard problems that might be associated with the use of insecticides and pesticides in general. Despite the assurances of the U. S. Department of Agriculture, the Food and Drug Administration, the U. S. Public Health Service, and the National Research Council that these hazards are potential, not real, and that there is no cause for alarm, there are individuals who insist that the use of pesticides is wholly unjustifiable. Skeptics may do well to recall that in 1948 Dr. Paul Miller was awarded the Nobel Prize for Physiology and Medicine in recognition of his work in demonstrating the importance and value of DDT insecticides in the field of hygiene and preventive medicine.

Commissioner Paul B. Dunbar, in the annual report of the Food and Drug Administration for 1947 (page 502), said: "The wastage of food consumed or defiled by rodents and insects during the period when millions of people throughout the world are hungry is tragic and inexcusable."

Some point to the surplus corn, wheat, dairy products, and other commodities held by USDA as evidence of overproduction. But we need only to point out that modern technology has doubled or trebled production in the last 100 years, whereas the current surpluses represent a small fraction of our annual production. The more fanatical of our critics go so far as to say that all use of chemicals is wrong and that we should let nature take its course. The American Indian followed such a course for centuries, and found that under this policy the North American continent supported a population of about 1,000,000 souls. We now have a population in excess of 170,000,000 in the United States alone.

There seems to be little question but that insects will continue to demand tribute of enormous proportions which will have to be paid in terms of insect damage, pain, and suffering, or expenditures for insect control. Man may, through judicious expenditures for research and practical insect control measures, reduce or minimize the tribute to be paid, but he can never eliminate it entirely.

In this connection, it should again be noted that entomology is not static. Insects, as highly versatile living organisms, are constantly changing to meet each change in the environment, whether it be biological, physical, or chemical. Therefore, if we are to hold our own in this continuing battle, research must continue undiminished; and if we are to make progress, research must be expanded.

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PESTICIDES

PLANT NUTRIENTS AND REGULATORS

FERMENTATION/FOOD PROCESSING

FOOD PROCESSING