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Insect Control in Mainland China

Good progress has been made through combining the knowledge and methods of scientists and farmers.

Tien-Hsi Cheng

The background of contemporary entomology in mainland China extends back only to 1948, a year before the Communist regime came to power. Before 1948, no organized research in entomology, or indeed in any field of science, existed. Insect control was practically unknown to the average farmer, who in his lifetime never saw a sprayer or a duster. For centuries, Chinese farmers had been left to the mercy of insects, which were considered one of the necessary evils. The small number of Chinese entomologists who had been trained in this country or in Europe could find little support for research. Most of them taught in universities and colleges, and only a few conducted research in insect taxonomy and morphology. Any scientific foundation they may have laid was to a large extent destroyed during World War II. Against this barren and poverty-stricken background, entomology in China got started 13 years ago.

For 3 years after the establishment of the Communist Government, in 1949, Chinese scientists and intellectuals found themselves in the midst of turmoil. Many scientists were humiliated and intimidated during the nation-wide program of "thought reform" and political indoctrination, but none, as far as we know, were tortured or executed. They were impelled to engage in political "study" in order to "reform" themselves. Among the main bases of criticism and attack were bourgeois family background, pro-Americanism, and individualism. A number of confessions were made by entomologist friends of mine, among them Chiu Shin-foon, holder of a Ph.D. degree from Cornell University. Chiu was, and still is, teaching in Sun Yat-sen University in Canton, now renamed South China Agricultural College. On several occasions he had acknowledged in his publications the assistance and encouragement given him by American entomologists, such as Roy Hansberry formerly associate professor of entomology at Cornell (*1*). In the eyes of Chinese Communists, this concrete evidence of pro-Americanism was a grave error which bespoke numerous pro-American activities. According to a news report from outside the mainland, Chiu was prodded into confessing his bourgeois family background, his American-style bourgeois education, his cooperation with Cornell in research on Chinese insecticidal plants, and his attempt to obtain a teaching position in an American university.

After the brief period of free criticism, the so-called "hundred-flower blooming" period in 1956-57, an entomologist, Fang Teh-chi, who denounced the totalitarian policies of the regime was sent to the countryside to join the "Reform by Labor" camp. His publications were scrutinized and castigated, and his "crime" in making inaccurate observations on the life history of an acorn weevil was publicized throughout the country (*2*).

Recent reports from the mainland indicate that the present regime is endeavoring to win the confidence of the nation's scientific community by appointing outstanding scientists to positions of authority. Chiu, the Cornell-educated entomologist, has been promoted to associate deanship of South China Agricultural College and publicly extolled for his distinguished service. And, since 1960, many of the so-called "rightist reactionaries" have been exonerated.

The basic policy, as decreed by Mao Tse-tung and his associates, is that all scientific research must point toward practical applications, with particular reference to conditions on the mainland. Scientists are charged with bourgeois individualism when they pursue scientific studies according to their personal interests instead of following state plans. In order that research work needed by the nation may be carried out, the Communist authorities have required some entomologists to change their lines of research. For instance, Pu Chih-lung, a coleopterist, holder of a Ph.D. from the University of Minnesota (*3*), found it expedient to change from research in taxonomy to investigation of the biological control of sugar-cane borers. Chao Hsiu-fu, author of a series of papers on the classification of Chinese dragonflies of the family Gomphidae (*4*), has been working on the control of the citrus black scale by fumigation with hydrocyanic acid.

The finding that published works on entomology in China deal, by and large, with applied research (*5*) is not surprising. However, limited basic research of commendable quality has been accomplished by senior Chinese entomologists trained in America or Europe.

After the stormy period of confes-

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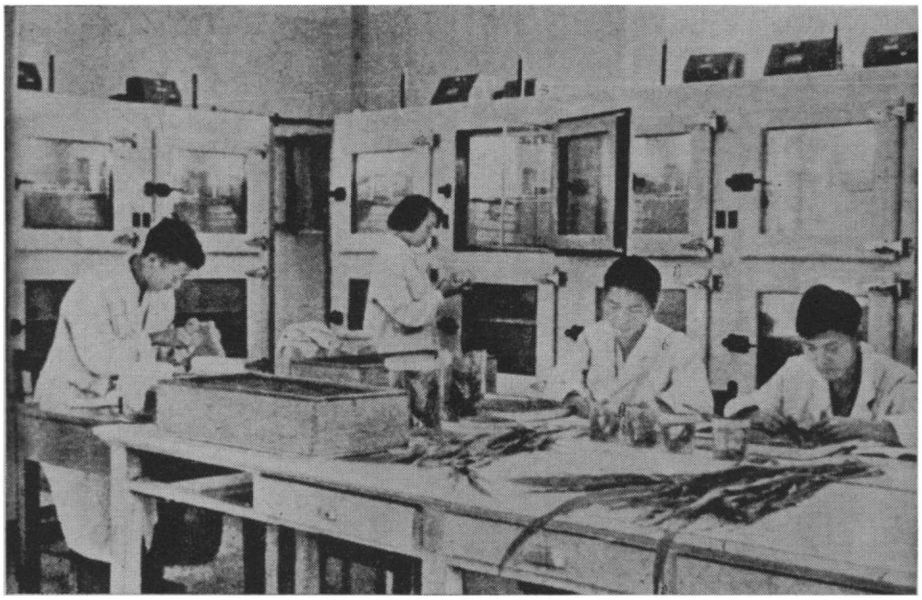


Fig. 1. Constant-temperature cabinets for studying insect growth in the laboratory.

sions, thought reform, and indoctrination, the first Five-Year Plan, covering the period 1953–57, was drafted and put into effect. At this time research in entomology and other zoological disciplines entered its initial stage of development. Most of the country's trained personnel in entomology were marshaled in the Chinese Academy of Sciences (Academia Sinica) and its affiliated research institutes and experiment stations. Under the Department of Biology, 21 research institutes were established, including the institutes of Entomology and Zoology. The Academy serves as the "brain trust" for planning and conducting research on a national scale. All first-rate scientists trained in the best scientific institutions abroad were brought together in a few centers where modern research facilities were concentrated.

The Institute of Entomology serves as the center of entomological research and coordinates programs in entomology throughout the land. The publication of research findings, dissemination of public information, and promotion of entomological activities are being carried out under the auspices of the Entomological Society of Communist China (*6*). The society has grown from 861 members in 1954 to 1068 in 1958, and has 22 branches in different provinces (*7*). The minimum requirement for membership is a college degree, or its equivalent, plus at least 2 years' experience in entomological work.

Export of most technical publications has been banned since October 1959. Several persons who attempted to smuggle publications out of the country reportedly suffered severe punishment.

Personnel and facilities for training new generations of entomologists are provided by the universities and agricultural institutes. The number of institutions of higher learning reportedly has increased from approximately 200 in 1949 to 400 in 1963, and the enrollment, from 117,000 to 819,000. In the last 13 years, over 900,000 students have graduated from universities and colleges; among the 170,000 recipients of college diplomas last summer, 31,000 had specialized in science, agriculture, and forestry, 59,000 in engineering, and 17,000 in medicine (*8*). Most of the 50-odd comprehensive universities and agricultural institutes are known to have offered both undergraduate and graduate training in entomology. In addition to doing classroom and laboratory work (Fig. 1), students make on-the-spot observations in areas of insect infestation. Steady improvements in the curriculum and facilities of instruction have been noted, although no one in the outside world knows clearly how well the young entomologists are being trained.

One of the odd slogans widely popularzied in Communist China today is that of "walking on two legs" to achieve world status. In entomology, as in other sciences, all available means are being utilized in research and development;

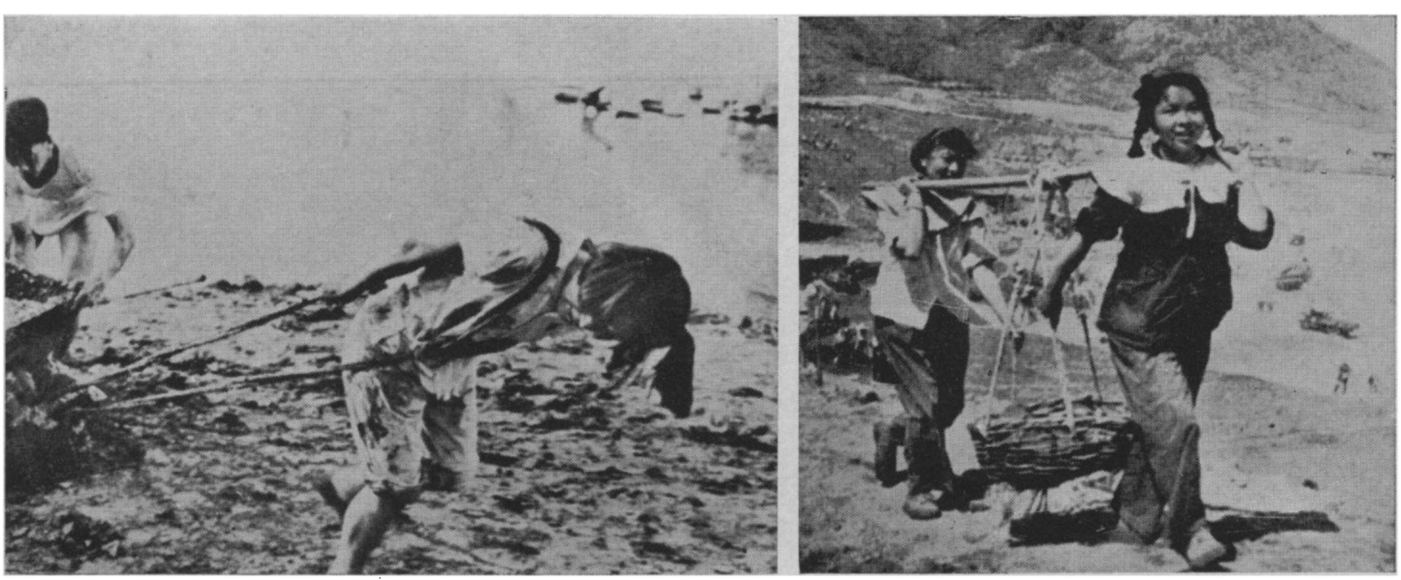


Fig. 2. Women students tugging mud (left) and transporting sand (right) for construction of a dam as part of their extracurricular requirements.

these include the old and the new, the native and the Western, the efficient and the awkward. Insecticides now being used vary from crude native materials to refined products of modern laboratories. Dusting equipment ranges from burlap sacks to airplanes. College students are required to learn from the so-called "countrified experts" (experienced farmers who have never been to school) as well as from entomologists with Ph.D. degrees from the best universities of America and Europe. Faculty members, students, public officials, and office workers live and work with peasants in order to increase agricultural production (Fig. 2). The peasants are to learn from the scientists, and the scientists are to share the practical experience of the peasants (Fig. 3).

Elementary training in entomology is offered in commune schools. Commune members, both men and women, are the backbone of insect-control operations. They are the source of China's power, and they are largely responsible for carrying out some of the seemingly impossible pest-control projects. They are farmers, soldiers, and pest-control operators all at the same time.

Major developments in entomology in Communist China follow the general outline of the Twelve-Year Plan for Scientific Development (1956–67) aimed at achieving world standards by 1967. One of the first steps taken was standardization of Chinese biological nomenclature. The published monograph on entomological nomenclature consists of a comprehensive list of the names of insects in Chinese and in Latin or Greek (*9*). In addition, a large number of simplified Chinese characters, puzzling to educated people, have appeared in all kinds of documents, scientific publications, and newspapers. According to the official explanation, this is to facilitate teaching and learning the Chinese language and to save precious time needed for national reconstruction.

Fig. 3. Lin Cheng-shang, professor of entomology at Peking University (second from right), discussing insect problems with peasants.

Chemical Control

Current entomological research in Communist China is concentrated on the biology and control of insects which for centuries have devastated field crops and inflicted heavy losses in life and property. Among these creatures are migratory locusts, rice-stem borers, wheat midges, armyworms, corn borers, sugarcane borers, cotton bollworms, red spiders, and aphids, termites, and pine caterpillars as well as mites, mosquitoes, fleas, flies, and other carriers of disease. Notable progress in the study and control of these pests has been reported. Between 1950 and 1955, insect-control measures were dependent on human labor; since 1956, insecticides of foreign and native origin have played an increasingly important role. These include benzene hexachloride (BHC), DDT, chlordane, Demeton, Dipterex, Thimet, Malathion, chloropicrin, calcium arsenate, and rotenone-bearing products. Benzene hexachloride and DDT are the mainstay in chemical control. According to reports, 65,000 tons of BHC and 4700 tons of DDT were produced in Communist China in 1958 (*10*). The total amount of insecticides produced in that year was reportedly 17,478,000 tons, of which about 70 percent was of native origin. In 1958, according to reports, 60 pounds, on the average, of indigenous insecticides were applied to every acre of cultivated land in China (*11*).

To judge from numerous articles I have read and from the importance that the present regime attaches to the production of insecticides, chemical control has a dominant role in China's struggle against insect pests. As reported by Z. Eckstein (*12*), a Polish scientist who recently visited mainland China, "progress in the field of pesticides is tremendous in China. . . . The establishment of new factories, production companies, and the variety of chemicals manufactured for plant protection attests to the unusual pace of development, which already had equaled the average world level." Exaggerated as this statement may be, the fact remains that Communist China has made considerable progress in promoting chemical control measures to achieve immediate suppression of such devastating insects as migratory locusts and rice borers. According to the same author, as of 1960 no fewer than 38 basic chemical compounds had been manufactured under the direction of the Plant Protection Institute of the Chinese Academy of Agricultural Science. From these compounds, some 97 new pesticides had been prepared and field-tested. The institute, reportedly equipped with "the most modern apparatus of foreign and domestic construction," is engaged in synthesizing organic phosphorus compounds and in testing their toxicity against insects, in isolating toxic ingredients of native insecticides, and in determining toxic residues in food. To a large extent, spectrophotometry, polarography, and chromatography are employed in these studies. Large-scale production of insecticides is being carried out both in modern factories, such as the new Shanghai Chemical Factory for Plant Protection, and in primitive production shops in rural areas (Fig. 4). Some factories have their own biological testing laboratories.

During the first Five-Year Plan (1953–57), 2,530,000 sprayers and 170,-

Fig. 4 (left). A rural insecticide-production shop. Fig. 5 (right). Dusting cotton in Hupeh with a hand-powered blower duster.

000 tons of insecticides were distributed to the farmers (*13*). Most of the sprayers were of the compressed-air type; a few were power sprayers. Hand dusters, hand-powered blower dusters (Fig. 5), and traction dusters are used. Airplanes have been used for dusting cotton, rice, and forests. Between 1954 and 1958, over 13 million acres of crops reportedly were saved from locust outbreaks by airplane dusting (see *14*).

The mass production and wide application of BHC is a milestone in the history of Chinese agriculture. This insecticide is used throughout China for controlling major pests. Chinese scientists have done relatively little research on the toxicology of BHC in relation to the native pests. However, in the course of extensive field applications of the insecticide during the last decade there were some interesting findings (*11*). (i) When used as a soil insecticide, BHC may also serve as a growth stimulant for some field crops, notably sugarcane. (ii) Under favorable conditions, BHC appears to act as a systemic insecticide for effective control of certain insects with chewing mouthparts, such as the rice-stem borer (*Chilo simplex*). Benzene hexachloride is absorbed by the roots and leaves of rice when applied as a pour-on or by irrigation. The effectiveness of BHC against rice borers is said to be comparable to that of organic phosphorus compounds. (iii) A mixture of BHC powder and an alkaline substance, such as lime and ashes, is effective if used immediately after mixing. Also, soap may be added to BHC in suspension form. The addition of these alkaline substances does not affect the toxicity of BHC but rather enhances its efficiency. (iv) Heavy applications of BHC on field crops have not significantly reduced the populations of parasites and predators, and as of 1959 no outbreaks of injurious insects had occurred as a result of such applications. It has been thought, however, that the use of BHC in sugarcane plantations may have interfered with the activities of *Trichogramma evanescens,* which parasitizes the eggs of sugarcane borers. Latest reports from China reveal outbreaks of some destructive pests in certain localities where BHC and DDT have been widely employed.

The insecticide DDT and mixtures with BHC and organic phosphorus compounds are used extensively for controlling the cotton bollworm, the overwintering pink bollworm, and other cotton insects, as well as fruit-tree pests.

The wide use of organic phosphorus compounds as systemic insecticides has had an immense impact on the nation's economy, according to reports. Chinese Communists claim that in the 18 provinces where these insecticides have been employed, yields of treated crops have increased by 30 to 40 percent (*12*).

The production of organic phosphorus insecticides is reported to have risen rapidly in recent years. For example, the amount of Dipterex produced by the Shanghai factory alone is now 1000 to 1500 tons a year. These insecticides are playing an increasingly important role in the insect eradication program, the Communists claim. Demeton has been employed as a dust in about 50 percent of the cotton-growing areas on the mainland, they say. It has solved the problem of leaf-curling caused by cotton aphids and has held red spiders under control. Moreover, Demeton has proved to be an effective weapon against apple aphids in North China, and against citrus red mite in the South.

Since 1958 a concerted search has been made throughout China for native plants and minerals with insecticidal properties, and the use of native plant and mineral products as a supplement to insecticides of "foreign" origin has been vigorously promoted. In 1958, 500 kinds of native products were made into over 10 million tons of insecticides and fungicides (*11*). Among the newly discovered insecticidal plants are two species of *Derris,* from Hainan Island and eastern Kwangtung, respectively, that contain rotenone, in concentrations of 13.5 and 10 percent. *Anabasis aphylla,* a nicotine-bearing species, was found recently in the vicinity of the Gobi Desert in Sinkiang.

Biological Control

In Communist China, biological control of insects has been promoted wherever climatic conditions have been found to favor the propagation of parasites or predators. The use of a minute wasp, *Trichogramma evanescens,* to parasitize the eggs of sugarcane borers has been an outstanding success. Under the leadership of Pu Chih-lung, the coleopterist, this program has been carried out in the sugarcane districts of Kwangtung and Kwangsi provinces (*15*).

The parasitic wasps were released from seven to nine times a year, an area of more than 1000 acres of sugarcane plantation being covered each time by 36,000 to 60,000 individuals per acre. According to Pu, as a result of these releases parasitism was increased from 18.3 to 83.0 percent and the number of borer-infested stalks in the experimental plantations averaged only one-fourth the number in the control plantations. The yield of sugarcane per acre in the former was one-third higher than in the latter. By early 1959, more than ten propagation centers of *T. evanescens* had been established in sugarcane districts in Kwangtung, and the number of wasps thus produced was sufficient to cover about 12,000 acres.

The eggs of the ricinus silkworm, *Attacus cynthia ricini*, and of the pine caterpillar, *Dendrolimus* sp., have been suggested as the best hosts for rearing *Trichogramma*. Pu and his associates report that adult wasps emerging from these eggs are generally large, active, and highly reproductive. On an average, 27.3 parasites emerge from a single egg of the pine caterpillar, 28 from an egg of the ricinus silkworm. The maximum numbers reported are 52 and 59, respectively. The female sex ratio remains unchanged in the successive generations.

In contrast, eggs of the Angoumois grain moth, *Sitotroga cerealella*, commonly used in other countries for rearing *Trichogramma*, are so small that only one adult *Trichogramma* emerges from each egg. Such adults are usually smaller in size, less active, and of lower reproductive potentiality than those raised on eggs of the pine caterpillar and ricinus silkworm. Also, the female sex ratio decreases in successive generations.

The Chinese entomologists further report that fresh eggs of the pine caterpillar and ricinus silkworm kept in cold storage at 0° to 4°C for 97 and 61 days, respectively, were still usable as host material. Also, adult wasps that were fed honey lived 8.6 times as long as those fed distilled water and had 14.7 times as many offspring.

The use of a small parasitic wasp, *Dibrachys cavus*, against pink bollworm is a recent noteworthy development in biological control. The wasp, discovered in a cotton storehouse at Wuchang, Hupeh Province, invariably kills the overwintering larva of the bollworm before laying eggs in the cocoon; after hatching, the young parasites feed on the dead larva. According to an article in Peking's *Kwang Ming Jih Pao* (dated 26 March 1962) (*16*), after 6 years of research, entomologists at Hupeh Agricultural Research Institute have perfected techniques for rearing and propagating the wasps. In cotton-storage areas where the wasps had been released, approximately 90 percent of the bollworm larvae were killed, and damage to cotton by the pink bollworm in such areas was reduced by 70 to 90 percent. On the average, 50 eggs were laid by a female, and under the conditions in Hupeh Province, 12 generations were grown a year. Preliminary observations indicate that the wasp may also be employed against the European corn borer, the diamond bollworm, and the diamond-back moth.

Biological control of rice insects is being investigated, along with chemical control. A tachinid fly, *Zenillia roseanae*, has been found to be an effective parasite of the rice leaf-roller, the rice swarming caterpillar, and the European corn borer (*17*).

Two species of predator lady beetles, *Rodolia cardinalis* and *Cryptolaemus montrouzieri*, were introduced from Soviet Russia to Kwangtung Province in 1955 to check the spread of cottony cushion scales. Another species, *R. rufopilosa*, has effectively reduced the population of the cottony cushion scale *Icerya purchasi* (*11*), a serious pest of citrus in Hupeh Province.

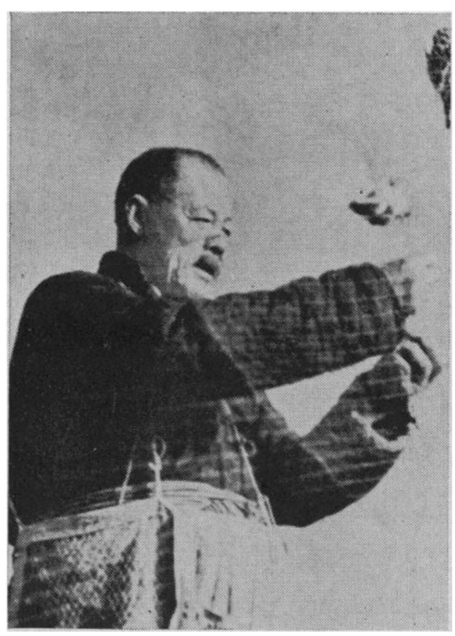


Fig. 6. An 85-year-old Chinese peasant, Chang Teh, catching sparrows in a net. By means of this and other ingenious devices he and his family caught 30,000 sparrows in the winter of 1957.

Chinese entomologists have utilized with some success the muscardine fungus *Beauveria bassiana* against the soybean pod borer, the sweet potato weevil, and the pine caterpillars (*18*). Reports indicate that hand application of a suspension of the spores of *Bacillus thuringiensis* for the control of the European corn borer might be practical under the conditions in China, although it is believed to be impractical in Western countries (*19*).

In addition to insect predators and parasites, fungi, and bacteria, biological agents such as fish and birds have been employed. An insectivorous fish, *Pseudobagrus fulvidraco*, reportedly a voracious feeder on mosquito larvae, is a new addition to the list of predators used in the malaria extermination campaign (*20*).

Many publications in ornithology from mainland China are concerned with the life histories and habits of birds and the parts they play in the biological control of locusts, pine caterpillars, and other major pests of crop plants. Those that feed primarily on destructive insects are protected and propagated; those that feed on beneficial insects and grains are destroyed. Much of the research was done by Cheng Tso-hsin, China's leading ornithologist, who holds a Ph.D. degree from the University of Michigan. In the 1930's and 1940's Cheng made numerous contributions to the study of Chinese birds, especially to study of the songs of different species. His change of interest after the Communists came to power was evidently necessitated by the realities of the situation, since the songs of birds, however fascinating, are of little practical value as far as the construction of a socialist state is concerned.

One of the groups of birds most thoroughly investigated is the European tree sparrow, of the weaver-bird family. A notoriously ravenous feeder on cereal crops, this sparrow was designated one of the "four evils" and marked for immediate extermination.

Various means were utilized to capture and destroy the birds (Figs. 6 and 7), with such effectiveness that over a billion sparrows were killed in 1959 (*21*). The captured birds were decapitated, and their heads were used as bait for rats.

In the summer of 1960, however, when I visited Hong Kong, newspapers in Communist China were launching a campaign for the protection and conservation of sparrows, which the government once had vowed to exterminate. Apparently the Chinese Communists had not realized how complex the balance of nature is; the almost complete extermination of the sparrow was soon followed by serious outbreaks of cereal insects. Since then the sparrow has been exonerated, and its place among the "four evils" has been taken by the bedbug.

Cultural Control

Recent surveys made in rice-growing areas on the mainland indicate that a solution to the borer problem can be found in the traditional cultural control practices expertly executed by Chinese peasants and further developed through modern technology. Significant developments reportedly have resulted from research on early or late sowing and transplanting of rice to avoid borer damage. Ecological studies have proved that heavy losses invariably occur when the peak of the borer population occurs at the period of spike formation in rice plants. Thus, Chinese entomologists are making intensive studies to determine safe planting dates in different rice districts from their knowledge of the life histories and breeding habits of the borers in the locality in question. According to Chiu (*11*), some initial success has been achieved in several districts. However, owing to the complexity of the problem, Communist China is not likely in the near future to put forth a well-conceived program for the cultural control of rice borers similar to that conducted in North America for the protection of wheat against damage by the Hessian fly. Reports indicate that, in southern Shansi, late sowing of wheat has drastically reduced damage by the wheat-stem maggot, *Meromyza saltatrix,* and late spring sowing has protected the crop from heavy infestation by chironomids.

Selection of insect-resistant varieties of crop plants constitutes an important phase of Communist China's projected cultural control program, although only limited progress has been achieved so far. Reports indicate that two varieties of wheat, highly resistant to the wheat-blossom midge, *Sitodiplosis mosellana,* have been selected and propagated successfully. In wheat-growing areas, use of the resistant varieties in combination with chemical control has provided effective protection against one of the eight most destructive insects on the mainland.

Neat husbandry, including the destruction of crop residues, weeds, fallen leaves, and twigs, has been strictly enforced by the regime to eliminate overwintering insects. In South China, removal from paddy fields of the weed *Leersia hexandra* is reported to have provided effective control of the rice gall-midge, *Pachydiplosis oryzae,* and other pests, such as *Nilaparvata oryzae* (*11*). In most instances, the weeding has been done manually by peasants, with or without the aid of simple tools. Success in cultural control of the European corn borer has been demonstrated in Ch'ang-ch'ih, special district of Shansi Province, where the insect has been almost completely eradicated (*11*) through a vigorous campaign to eliminate all infested corn stalks, cobs, and weeds from the area. Cotton aphids have been held under effective control in Hsin-hsiang, special district of Honan Province, through spraying of such plants as the pomegranate and prickly ash, where the aphids overwinter before migrating to cotton fields.

Mechanical and Physical Control

In addition to biological and cultural control measures, mechanical control methods are used in the insect-eradication program. Newly installed irrigation facilities have been utilized for insect control over large areas, especially for eliminating infestation centers of rice borers and locusts. An example cited by Chiu (*11*) as typical is the destruction by drowning of the paddy borer *Schoenobius incertellus.* In Kwangtung alone this practice was extended, in 1958, to more than 2.5 million acres, approximately 79 percent of the rice-growing area in that province. The roots of the rice plants were kept under water for 7 to 10 days during the period of spring plowing; this reportedly resulted in the death of all overwintering larvae. In Central China, automatic irrigation has been employed for controlling the rice-stem borer. During the rice-growing period the paddy fields were submerged under approximately 17 centimeters of water; some 70 percent of the full-grown larvae and pupae perished after 5 to 7 days of submersion.

Dams, reservoirs, and drainage systems, installed for reclamation of wastelands, have played an important part in keeping migratory locusts under control in recent years. In addition, trenches dug by farmers have served as burial places for thousands of young hoppers. In orchards and cotton fields, light traps have been used extensively to capture adults of pink bollworms, aphids, cutworms, and various pests of fruit trees.

Insect Forecasting and Reporting

The forecasting and reporting of changes in insect population was virtually unheard of in China before 1950, when an improvised system was adopted. Owing to the shortage of trained personnel and to lack of information concerning the ecology and population dynamics of most insect pests, the Communist regime had to rely upon a crash program, limited to short-range forecasting of impending insect outbreaks in major rural areas. In 1951, 3000 residents of Shantung Province were given emergency training in reporting locust populations. The program was gradually expanded, and by 1958, 678 insect-forecasting and reporting stations had been organized throughout mainland China. These were manned by 700,000 farmers working under the direction of a handful of specialists (*22*). Since the establishment of the commune system in 1959, development of this program has been accelerated.

The crash program includes a short course, offered to commune members, covering visual identification of some destructive species, their life histories and habits, and the elementary routine for checking and reporting insect populations. The farmers reportedly were so enthusiastic that they worked themselves to the point of exhaustion. Among the insect-reporting methods currently employed in Communist China are some contributed by illiterate but ingenious peasants. For instance, a peasant woman planted triangular flags in cotton fields to signify a heavy infestation of the cotton diamond bollworm and square flags to indicate an abundance of the cotton bollworm (*22*). When the worms had begun to bore into the cotton bolls she made a hole in each of the appropriate flags

Fig. 7. Commune members scaling walls to plug holes and destroy sparrow nests.

to show that insecticide should be immediately applied. The flags were removed only when effective control had been achieved. This method is used by farmers in many cotton districts.

Reporting and forecasting stations are set up in areas where outbreaks of locusts are likely to occur. Teams of trained reporters are dispatched to survey the locust populations. They are joined by herdsmen, fishermen, lumbermen, and other commune members. As stated earlier, the forecasts are limited to short-range estimates of the time and seriousness of expected outbreaks in given localities. Studies on population dynamics of migratory locusts have provided some significant information which may make long-range forecasting possible in the future.

Plant-inspection and quarantine regulations concerning imports and movement of plants within mainland China were drafted in 1951. They have since been revised and put into effect. Strict inspection procedures are carried out to prevent entry of the pink bollworm —a major pest—into the cotton-producing districts of Sinkiang, Chinghai, and western Kansu.

More than 60 quarantine offices have been set up for the inspection of agricultural products; warning and diagnostic services have been developed. Also, according to the Plant Protection Research Institute in Peking, agreements on plant quarantine have been reached with the U.S.S.R., East Germany, Czechoslovakia, Hungary, Bulgaria, and other countries east of the Iron Curtain (*23*).

Migratory Locusts

The most noteworthy contribution that Chinese entomologists have made in the last decade is their work on migratory locusts. A survey of Chinese literature reveals that the earliest record of a locust plague dates back to 707 B.C. In the past 1000 years (A.D. 957–1956), 717 outbreaks of the oriental migratory locust, *Locusta migratoria manilensis,* have occurred in various parts of China—in the basins of the Hwai-Ho, Yellow River, Hai-Ho, and Yangtze rivers and in the coastal regions to the south (*24*). The intervals between successive outbreaks in a given locality have varied from 4 to 15 years, and each outbreak has lasted from 1 to 2½ years. Often an outbreak has occurred in the year that followed a drought, or 1 or 2 years after a flood, and often the outbreak and drought have occurred in the same year. In 1929 a severe locust plague devastated more than 11 million acres of land, causing death, starvation, illness, and mass exodus from the stricken areas.

Centers of locust infestation in China are of four types: lake shore, coastal area, river-flooded area, and flooded plain (*25*). The degree of infestation in these areas has been found to be directly or indirectly affected by changes in the courses of the Yellow and other large rivers.

Ecological studies indicate that oriental migratory locusts are highly adaptive to their environment, though ecological requirements for the egg stage are relatively precise (*25*). There is no true diapause in this species (*24*), and the number of generations a year varies in different areas, or in the same area in different years.

In the past, Chinese farmers were virtually helpless in the face of locust devastation. In a desperate attempt to prevent the insects from settling on their fields they took such futile and pathetically comic measures as beating gongs, drums, and even pots and pans. Since its inception, the Communist regime has mobilized rural manpower and resources in an all-out effort to stamp out the pest. Measures intended to provide immediate protection include the use of benzene hexachloride and other chemicals; installation of mechanical devices; propagation of locust-eating birds and other natural enemies; improvement of cultural practices; and above all, manual destruction.

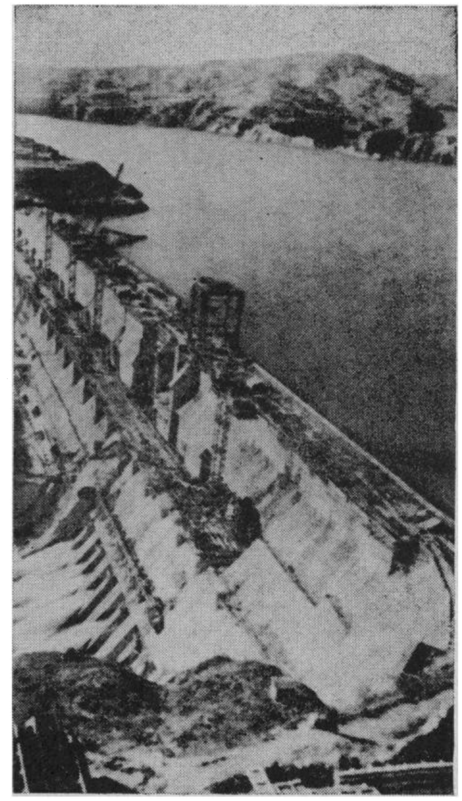
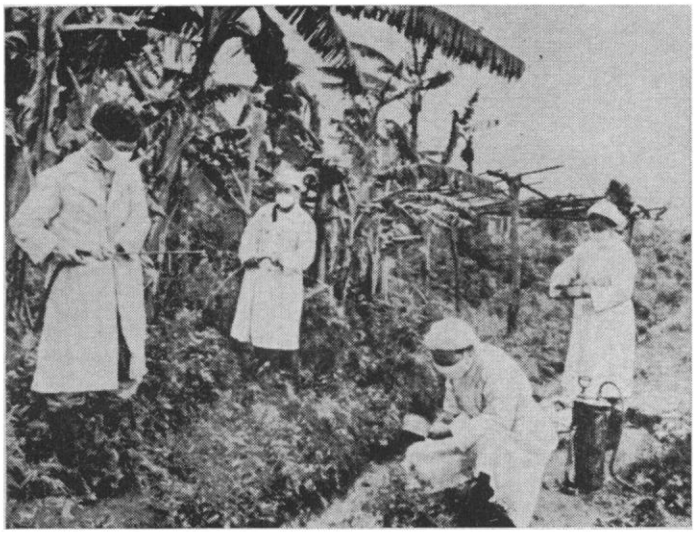


Fig. 8. The Sanmen Gorge Dam of the Yellow River, March 1962.

In the early 1950's the fight against locusts was mainly a matter of manual destruction. The farmers dug trenches 20 to 30 kilometers long, drove the young hoppers in, and buried them. Or thousands of people lined up to encircled a plot and then, inching forward, killed the hoppers with bamboo brooms or with swatters made of shoesoles nailed to wooden poles. In the winter, locust eggs were dug up and destroyed (*26*).

More recently, the use of insecticides —of benzene hexachloride in particular —has gradually replaced these less efficient methods. Dusting from airplanes was initiated in 1951, and by 1960 it was practiced in more than 70 percent of the major areas of infestation (*26*).

For permanent solution of the locust problem, Herculean efforts have been made to eliminate breeding grounds by transforming waterlogged areas, waste-



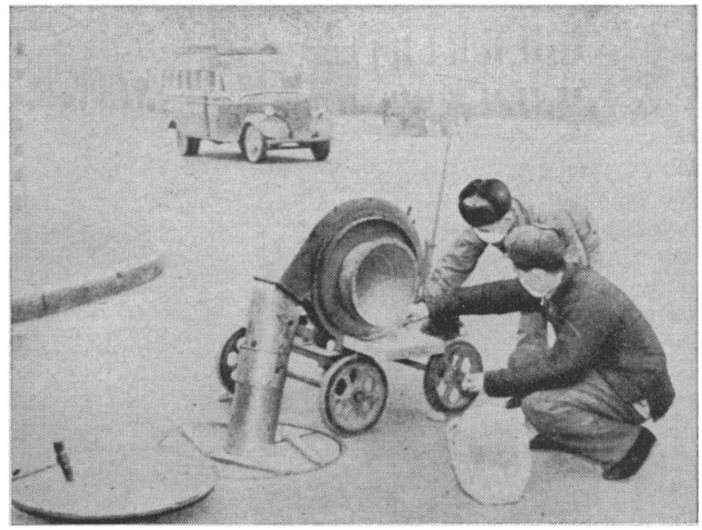


Fig. 9 (left). Members of the Malaria Prevention Station in Szemao, Yunnan Province, treating mosquito breeding grounds with insecticides. Fig. 10 (right). Workers pumping benzene hexachloride into a sewer to destroy mosquitos.

lands along the coast, and weedy riverside regions into rice paddies, forest belts, and livestock pastures. In 1959 alone, the Communists claim (*26*), 1½ million acres were thoroughly transformed. The flood-control measures and irrigation projects include construction of the Sanmen Gorge Dam to tame the Yellow River (Fig. 8) and of the Ming Tomb Dam near Peking.

None of the other major schemes which the present regime has undertaken can compare in importance and magnitude with the efforts to control "China's Sorrow," the Yellow River. According to a neutral source in Hong Kong (*27*), over 2½ million acres of sloping farmland have been turned into neatly terraced fields. Four million check dams and 27,000 small reservoirs have been built across small tributaries and gullies to hold back water and silt, and trees and grasses have been sown on 10 million acres.

The so-called "transformation and control dual approach" adopted by the Chinese Communists has significantly altered the topography of locust areas and eliminated a number of age-old centers of outbreak. The indications are that locust populations have been decreasing steadily since 1953. Despite the severe floods and droughts of the past 3 years, the pests have largely been kept under control. It is claimed (*28*) that 11 districts in the provinces of Honan, Anhwei, and Kiangsu, long noted as infestation centers, are "locust free." However, Chinese scientists have been disturbed recently by the appearance of small pockets of short-term infestation. Thus, a new problem has arisen even before the old one has been solved (*25*).

Studies of flight behavior of the Asiatic migratory locust *Locusta migratoria migratoria* (*29*) in its solitary phase have shown that the migratory flight usually takes place in moonlight, at about 7 o'clock in the evening, and reaches its peak an hour or so afterward. When the evening temperature is below 19°C, no flights occur. The locusts generally migrate in groups of three or five, often unnoticed, but there is also mass migration.

At first the flight is invariably oriented toward the moonlight, but there are changes in direction according to the speed and direction of the wind. When the wind velocity is not over 3 miles per hour, most of the locusts fly against the direction of air movement, but when the velocity exceeds 10 miles per hour, they tend to drift, with their heads partially facing the wind.

Most of the migratory locusts fly at a height of 15 to 20 meters. In tests with artificially released locusts, individuals have traveled from 1 to 25 miles, and it is believed that some individuals cover even greater distances under natural conditions.

Recent studies have shown that the speed of migratory flights varies with temperature and differs for the two sexes. In general, female locusts fly faster than males. At 19°C, females were found to fly at speeds averaging 4.7 meters per second, while males flew at 3.7 meters per second. At 29°C, the speed of flight was 7.4 meters per second for females, 5 for males.

After a long flight the locusts descend on lake shores or on river banks where weeds and gramineous plants flourish. These are favorite breeding grounds for the migrants. Examination of specimens collected in the landing areas beside lakes and rivers have revealed that females outnumber males by 10 to 37 percent. And since the females are stronger fliers, it is believed that they play the leading role in setting the course of migration.

The fact that migratory locusts descend on areas adjacent to lakes and rivers year after year, and that these insects show positive phototropism, has led Chinese entomologists to suspect that the reflection of moonlight from waters attracts and guides them to the landing grounds.

The cause of migratory flights is a subject of interest to many naturalists. It has been postulated that the flights are a response to the urge to search for food and breeding grounds. According to the Chinese entomologists, however, there is little difference, if any, in the food supply at the take-off and landing areas.

Most of the female migrants studied, the Chinese scientists report, were in the middle or late stage of sexual development, and none had laid eggs prior to flight. Approximately 85 percent of the females were found to bear eggs, and from 20 to 30 percent proceeded to copulate immediately after landing. The Chinese researchers believe (*29*) that the migratory flights are triggered by arousal of the mating instinct as a result of moonlight and other environmental conditions.

Other Extermination Programs

Other insect pests which have been intensively studied under the present regime, and to a greater or lesser extent controlled, are the rice-stem borer, the paddy borer, the European corn borer, the cotton aphid, the cotton bollworm, the pine caterpillar, the wheat-blossom midge, the wheat mite, the subterranean termite, the sand fly, the mite, the mosquito, the house fly, and the flea. The last three have been attacked by every means at the government's disposal (see Figs. 9 and 10).

Millions of people, young and old, have been mobilized to take part in the extermination programs. According to estimates, more than 11 million kilograms of mosquitoes and 100 million kilograms of flies were eliminated during 1959.

Conclusion

On the whole, one must say in all fairness that good progress has been made. So far, the regime's achievements reflect credit more on contributions from other countries, especially the United States, than on the creative work of its own entomologists. In a decade or so, Communist China may approach Western standards in applied entomology, but her contributions to basic research will be spotty at best. According to a statement made in 1956 by an Indian delegation which visited China (*30*), "There is no technical measure in the field of agriculture practiced in China which is really new. But it is the manner in which these technical measures are being implemented which is remarkable."

In large measure the methods of insect control used in Communist China could be applied profitably in many of the underdeveloped countries of Southeast Asia. Western methods, however efficient, are in many instances too costly to be practical, or too sophisticated to suit conditions in Asia. By fully utilizing local manpower and resources, as Communist China is doing, the underdeveloped countries could, through their own efforts, do much to eradicate the insect pests that have plagued their people for centuries.

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