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RECENT ASPECTS OF ENTOMOLOGY IN CHINA

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Abstract: *From the viewpoint of insect taxonomy and integrated pest management the recent advance of entomology in China is dealt with.*

I. INSECT TAXONOMY

Zoogeographically, China possesses both the Oriental and Palearctic characteristics with a Palearctic portion in the north and an Oriental portion in the south. She embraces rich insect resources, especially in Qinghai-Xizang plateau, meridional Himalayas and Yunnan-Guizhou Provinces. Before the founding of People's Republic of China in 1949, there were only a few scientists working on insect taxonomy. During the last thirty years, China has made great advances in insect taxonomy, although she still lags behind the advanced level in this field.

1. Organizations and personnel

The development of insect taxonomy in China has been closely associated with the necessities for increase in production. In the early fifties, there were the problems in the naming of pests in agriculture, forestry and medicine, and in the study of their habits. A great deal of work was done on the important pests, such as cotton pests, forest pests as well as migratory locusts, army worms, mosquitoes, house flies and fleas.

With respect to organizations and personnel, the following systems may be considered:

(1) Academia Sinica: There are 4 research institutes engaged in the studies concerning insect taxonomy. The Department of Insect Taxonomy and Faunitics in the Institute of Zoology, Beijing, has a big staff of over 60 workers, 16 among whom are above the rank of associate professors, and possesses a collection of 2.5 million

insect specimens. The Shanghai Institute of Entomology ranks next, having a staff of around 20, 6 of whom are professors or associate professors. The kunming Institute of Zoology and Northwest Plateau Institute of Biology have also some workers in entomology.

(2) Educational System: It includes Department of Biology in the universities, such as Nankai Univ., Sun Zhong-shan Univ., Futan Univ., etc., and Department of plant or forest protection in the colleges of agriculture or forestry, such as Northwest College of Agriculture, Beijing Univ. of Agriculture, Fujian Univ. of Agriculture, Nanking Univ. of Agriculture, South-China Univ. of Agriculture, Chejiang Univ. of Agriculture, Shanxi Univ. of Agriculture, Jiangxi Univ. of Agriculture, Southwest College of Agricuture, Northeast College of Forestry, Nanjing College of Forestry, and Beijing College of Forestry. These departments are mainly concerned about the pests, including mites, of agriculture and forestry and their natural enemies. There are more than 100 workers in this system.

(3) System of Medical Research and Education: This system includes Academia Medica Sinica, medical universities and colleges, as well as some hygienic and epidemic preventive stations. The members of these organizations are engaged in medical entomology (including studies on mites and ticks) are over 100.

(4) System of Plant Quarantine Units, and (5) System of the Nature History Museums: There are also a few entomologists working on insect taxonomy in the above-mentioned units.

The number of scientists working on insect taxonomy may, therefore, reach a total of about 400.

2. Main achievements

(1) Solving Probelms in Agricultural Production

A correct identification of insects is a foundation of successful pest control and utilization of natural enemies. On account of the negligence in the significance of taxonomy, many workers did not make clear the correct names of the pests and the natural enemies, hence resulting in failure in the practical control work, especially during early fifties. Insect taxonomists did some splendid works in solving some confusing problems. For example, in the early fifties, there occurred an outbreak of wheat blossom midge in China. We studied the flies of 3 families, especially on their characteristics, ranges of distribution and habits of oviposition. All these fundamental studies were of great use in the control and wheat production. In our country the insects attacking

wheat culms belong to 6 different species, that is, 4 species of Chloropidae (mainly *Meromyza saltatrix* L.), *Hydrellia griseola* (Fallén) (Ephydridae) and *Cerodontha denticornis* (Panzer) (Agromyzidae). It is very important to note that *Meromyza pratorum* Meigen (very similar to *M. saltatrix*) mainly attacks grass. A clear-cut classification among these species is of great importance in their control. Another notable example refers to the noctuids that destroy jujube, an important fruit in Northern China. Its systematic position was not settled until 1979.

Rice weevil is one of the most important storage insects in China. Formerly it seemed to be belonged to a single species. After the repeated investigations, we were convinced that it was consisted of 2 species: the widely spread and the most destructive weevil, *Sitophilus zeamais* (Motschulsky), is the maize weevil, and the rice weevil, *Sitophilus oryzae* L., is mainly distributed in the region south of 26°N.,mostly in Hainan Island of Guangdong Province and southern parts of Yunnan Province. We also found that the rice weevil was resistant to zinc phosphide, while the maize weevil was susceptable. This finding proves to be very helpful to control practices.

Another storage pest, granary weevil, *Sitophilus granarius* L., is listed as an object of domestic quarantine. We found that the insect was distributed primarily in the Xinjiang Uighur Autonomous Region, and the Anxi and Dunhuang regions in Gausu Province.

The minute egg-parasitic insects, trichogrammatids, have been extensively used in the biological control. But owing to the confusion in the identification of species, great troubles arose in actual practice. We carried out a taxonomic study of 12 spp. of trichogrammatids, as well as the studies on the biological characteristics of some of the more important species. These studies exerted an important influence on the work of biological control.

For many years our authorities of agriculture and forestry got together all the organizations concerned to make a general survey of pests and beneficial insects in the different agricultural and forest regions. In every region, we have made clear all the predominant species and their ranges of distribution, and have also published catalogues and monographs. All these works have paved the way for the pest control and utilization of natural enemies.

(2) Studies on the Theories of Insect Taxonomy

The studies on the theories of taxonomy involve many difficult problems. In the early fifties, our Chinese famous biologist, Professor Sicien Chen, started to study the problem of species.

In 1956 he published a review: "About the problem of species", and subsequently a series of papers, as "Evolution and taxonomy", "The historic regulations of development in living organisms", "Some fundamental conceptions of evolution" and The species conception and the taxonomy principles". He pointed that the speices has on the one hand variability and on the other hand heredity, and the evolution has been progressing in the contradiction of variability and heredity. He divided the characteristics of taxonomy into two categories, i.e., new characteristics and ancestral characteristics. New characteristics are the products of variability, while the ancestral characteristics are the maintenance of heredity. Taxonomy is the contradictory unity of division and union. New characteristics embody discrepancies and is the source of division, while ancestral characteristics reflect continuity, which is the basis of union. All the contradictions, such as variation and heredity, new characteristics and ancestral characteristics, discrepancy and continuity, division and union, are mutually coexisting and transforming, and sum up to the dialectical principles of classification. He also put forward three supplements to the theory of natural selection: 1) Enormous production is not only the cause of struggle for existence and natural selection, but their outcome also results in over-production which in itself is a kind of adaptation; 2) Three lines of evolution formed by plants, fungi and animals, respectively, are 3 different lines of struggle for nutrition. The struggle for nutrition is the core of the struggle for existence,and determines the direction of adaptation and evolution in the living organisms; and 3) Every species presents two kinds of adaptation, i.e., the minor adaptation and major adaptation, the former being the adaptation to a particular habitat or environment, while the latter being the adaptation to the direction of the evolutionary lines.

(3) Phylogeny of Insects

While studying the taxonomy of individual groups, our insect researchers also make approaches from the angle of phylogeny.

i) Study on the Taxonomy of the Order Protura:

Untill now it was reported that there were 400 species in this order. Professor W.Y. Yin has made studies of 112 species of the Chinese Protura, and has discovered a new family (Sinentomidae), 15 new genera and 92 new species. On the basis of the characteristics in the post-embryonic stages and the ultrastructure of sperms and other pecularities, Prof. Yin proposed a new concept of phylogeny in Protura, quite different from that proposed by the former workers in that the non-tracheal groups are primitive,

while the tracheal groups are more or less specialized. This new concept has been attached great importance by insect taxonomists. On account of the rapid increase in new species, Prof. Yin on the basis of Tuxen's system (1964) studied more 54 genera of this group, and proposed a new scheme of classification of Protura consisting of 8 families and 17 subfamilies. Coupled with ultrastructural studies on the sperms, it is made clear that Protura is quite different from the other groups of insects, so it should be treated as an independent group in the phylum Arthropoda.

ii) Phylogeny and Taxonomy of Leaf Beetles (Chrysomeloidea):

Chrysomeloidea is a very large group in Insecta. More than 60,000 species are known so far but an overall classification remains to be done. Professor Sicien Chen, after a study of more than 50 years, proposed a scheme of classification of these insects (including nearly 700 new species), on the basis of analysis of ancestral and new characteristics of the adult as well as the larval stages. The new scheme comprises 6 new families (2 American subfamiles Aulacoscelinae and Magascelinae are excluded because of lack of specimens). Those are considered to evolve along two separate lines. There are 2 families along the first line: 1) Megalopodidae, comprising 3 subfamilies - Megalopodinae, Zeugophorinae and Orsodacninae and 2) Cerambycidae. The second line is composed of 4 families: 1) Crioceridae, comprising 4 subfamilies - Sagrinae, Bruchinae, Donaciinae and Criocerinae; 2) Chrysomelindae, comprising 4 subfamilies - Chrysomelinae, Galerucinae, Alticinae and Synetinae; 3) Eumolpidae, including 5 subfamilies - Clytridae, Cryptocephalinae, Chlamisinae, Lamprosomatinae and Eumolpinae; 4) Hispidae, comprising 4 subfamilies Anisoderinae, Hispinae, Callispinae and Cascidinae.

iii) Studies on the Systematics of Acridoidea:

There are many systematic studies on this superfamily. The Soviet entomologists Bei-Bienko and Michenko in 1951,and Dirsh in 1975 put forward their views, respectively, but improvements still remained to be done. Our Chinese taxonomist of locusts, Associate Professor X. C. Yin divided the family into 6 families and 32 subfamiles, and added 12 new subfamilies, on the basis of the principal characteristics of chirping organs and reproductive organs.

iv) Studies on the Group of Chinese Malaria Mosquitoes:

Chinese malaria mosquito, *Anopheles sinensis* Wiedemann, was known as a species with much variation. In the early sixties, it was referred to as a species with multiple types. After extensive investigations of the larval stages and habits of mosquitoes, our Chinese taxonomists confirmed that the Chinese malaria mosquito

was a species group, which included 16 species, 4 of whcih were new species and 2 were recorded for the first time in China. This study gives some clues in the work concerning the dissimilation and control of malaria and Malaya filariasis.

v) Studies on the biological characters (such as the habit of oviposition in parasitic flies) and developmental stages (egg, larva and pupa) have provided a great deal of scientific data for the phylogenetic studies.

3. Application of new methods in insect taxonomy

The approaches of mathematics, biochemistry and cytology to taxonomy and the application of new appliances add new vitality to this age-old branch of science - insect taxonomy. Some troublesome problems which cannot be solved by morphological studies alone are being settled satisfactorily.

Application of the sex pheromone: For many years,the corn borer in China was known as the European corn borer, *Ostrinia nubilalis* (Hübner). After the application of sex pheromone and analysis of structures, also with the help of sex isolation tests, it has been proved that the predominant corn borer in the principal corn production regions is to be the Asian corn borer, *O. furnacalis* (Guenée), and that only in a part of northwest region the European corn borer coexists with the Asian corn borer, and only in certain regions the European corn borer causes damages to corn crops. The treatment of Matsumura pine scale, *Matsucoccus matsumurae* Kuwana, and Masson pine scale, *M. massonianae* Young et Hu, with the sex pheromone showed up distinction clearly, but in these species there are obviously reciprocal activities. Because of the difference between these 2 species in their life cycles and in the date of emergency, they can not get hybridized with each other. We have also obtained satisfactory results by using the sex pheromones to identify the sugar cane borer and other insects.

It is also significant to use the sound spectrographic analysis in solving taxonomic problems. By means of the sound spectrographs of chirps, we preliminarly consider the field crickets (*Gryllus*) distributed in Beijing and those in Yinchuan belong to 2 different species or subspecies. We also make studies on the sound of flying in 8 species of mosquitoes for taxonomic purpose.

We have also studied the phylogenetic relationships among the species of Crambidae (grass moths), Aphidoidea (aphids) and Acarina (mites) with the help of numerical phenetics. Professor H. F. Chu used cladistical methods in studying the phylogenetic

relationships among the 4 genera of Hepialidae (ghost moths) and realized that there was a close relationship between *Hepialus* and *Hepialiscus*, and that *Phassus* had a same relation with the above 2 genera, while *Palpifer* was only very loosely related with the other 3 genera.

Electropherogram and karyotype analyses have long been applied in taxonomy, and have gained significant results. Rice weevil and maize weevil are very difficult to distinguish from one another, but it becomes rather feasible by using electropherogram. With the assistance of transmission electron microscopy some of the ultrastructures observed are also significant to taxonomy.

4. Studies on insect fauna

Chinese insect fauna comprises 2 portions of the Oriental and Palearctic realm, but the border-line between these 2 realms in China is a problem, which Chinese entomologists are much concerned about. Now the matter is being mainly settled, i.e., the boundary starts from the Himalayas to the meridional Himalayas. As the deep gorges in these mountain run in a north-south direction, the insects of the 2 realms are distributed in a jigsaw pattern, and thus form a very complicated fauna. Then the border-line runs northeastward to the Qinling Mountains, and and turns southeast through Jiuling Mountains, Tian-mu Mountain to the Jejiang and Fujian hilly areas. Further in the east there are no more natural barriers, so the demarcation line between 2 realms is no more clearcut, hence the region around 28 N forms a mixed zone. The boder-line in this zone has been a debating problem. In order to provide more informations about this problem we have been making investigations in Shen Nong Jia, Wu Yi Mountains, Nang Ling and other regions.

The fauna of the Xinjiang Uighur Autonomous Region in the Palearctic Realm is of great significance in economic reconstruction (development). This region is a part of the Central Asian subregion. The important pests of Palearctic Realm such as the pink bollworms, cotton aphids, armyworms, wheat blossom midge, diamond bollworms, yellow cotton moths, green leaf bugs and others have not as yet been found in this region. At present, a strict quarantine against the pink bollworm has been established to protect the Xinjiang Uighur Autonomous Region.

In recent years we have done a great deal of work in the study of the insect fauna in Xizang (Tibetan) region. As is well known, because of the upheaval of plateau and the formation of Himalayas the insect fauna in this region is very complicated; constituents

of both Palearctic and Oriental Realms are found at present. Nearly 500 new species of insects have been found here. In addition, we have discovered 2 species of *Zorotypus*: *Zorotypus sinensis* Huang and *Z. medoensis* Huang, including a winged type of the latter species. On account of the continuous upheaval and rich geothermal resources, the distribution of insect species is quite different from that in the eastern part of China as well as the other parts of the world. The insects of the same category are distributed to a higher elevation above sea level or to a higher latitude in Tibet than in the other parts of the world. We tentatively divide the insect fauna of Tibet into: the Oriental Realm, including Himalayan Rain Forest Subregion, Seasonal Rain Forest Subregion (with 2 minor regions), East Tibetan Hilly Forest Subregion (with 2 minor regions); and the Palearctic Realm, including High Elevation and Cold Grassland-Grass Marshland Subregion (with 3 minor regions), Central Asian Desert Subregion (with only 1 minor region).

5. Papers and books published

(1) Papers

Since 1950, the insect taxonomists of China have published more than 1,200 papers, described 4,000 new species (including mites and ticks) in 6 academic journals (not including articles published in Journals other than the 6 mentioned above). Of the articles, those concerning Diptera are most numerous, ticks and mites rank the next, then Lepidoptera, Homoptera, Coleoptera and so on in the oder mentioned. The number of articles may reflect the degree of importance of the different orders of insects in agriculture, forestry and medicine.

(2) Monographs

"Fauna Sinica - Insecta" and "Economic Insect Fauna of China" are edited under the Fauna Sinica Editorial Committee, the Institute of Zoology, Academia Sinica. Two volumes: "Hispidae" (with 417 species), "Siphonoptera" (with 452 species, and more than 100 new species) have been published. Thirty-one volumes of "Chinese Economic Insects" have been published (with 4,563 species) and the remaining 7 volumes are still in press.

(3) Other Works

"Insects in Tibet, I and II" (including 2,340 species, over 400 new species), "Sand Mites of China" (including 335 species, 150 new species), "Chinese Armored Scales", "Important Armored Scales in Chinese Gardens, I and II", "Chinese White Ants", etc..

Icons., Manuals, Catalogues: "Identification of Chinese

Hemiptera I" (742 species, 94 new species); "Illustrated Handbook of Chinese Moths" (4 volumes); Icon. of Chinese Moths; Icon. of Moths, and Larvae; Icon. of Insect Natural Enemies (435 species); Cotton Pests, Rice Pests, Mosquitoes, Flies, Scale Insects, Parasitic Flies,, Wasps, etc., altogether over 10 identification manuals and icons.; Catalogues of Forest Insects, Agriculture Pests, Fruit Tree Pests and Injurious Insects occurring in various local regions, over 10 volumes altogether.

II. INTEGRATED PEST MANAGEMENT

In recent years, a lot of research on the integrated pest management (IPM) have been done by the Chinese entomologists. Since the post World War II, an extensive application of pesticides has caused a lot of human and social problems. Now more emphasis has been laid on application of ecological principles and system methods to pest control. The IPM strategies are concerned with the optimum combination and use of all known pest control techniques, including biological, cultural and chemical approaches. The economic, ecological and social benefits are considered and incorporated in IPM program. The IPM in China will be described below from various aspects briefly.

1. Economic thresholds and ecosystem modeling

It is found from our studies on the economic thresholds of 10 odd major pests, such as the cotton bollworm, cotton pink bollworm, cotton aphid, armyworm, rice leafroller, rice gall fly, wheat aphid, sorgham aphid, pine caterpillar, etc., that most of the thresholds for applying chemicals in the past were too low so as to cause early and heavy application of pesticides. The results of our studies indicate that it is allowable and reasonable to have a certain density of population exist in the agroecosystem. For example, light damage to cotton at the early stage by cotton aphids has no effect on the growth and developments of the cotton plants themselves. Cotton yield increases by 8.6 % when the leaf damage by cotton leaf caterpillars reaches 40 %. Particularly, it was found from our experiments that there was a remarkable increase in cotton yield when 6 or 7 squares were removed from each cotton plant before early July because of its capability of over-compensation. In the past, heavy application of pesticides were needed to control the pink bollworm of the first generation in the cotton growing area of the Yangtze River basins in the late June, but it has now been proved that, like

the cotton bollworm, damaged parts of cotton flowers at that time produced little effect on cotton yield. Because of this changed concept of pest damage and raised economic thresholds of many major insect pests, there is a marked reduction in the application of pesticides so that not only natural enemies could be protected, but also the pollution of pesticides to environment could be alleviated. In our country, IPM program in Hubei Province amounted to more than 3 million mu*, while the amount of applied pesticides reduced by 46.5 % and the number of natural enemy increased by over 30 % in 1984. In the Guanzhong cotton growing areas, about 3.5 million mu, of Shaanxi Province, the cost of pesticide used is only 2 yuan or so per mu owing to the implementation of IPM, reduced by 5 or 6 yuan per mu as compared with before.

We have made a certain progress in seeking the optimal strategies include optimum use of biological, cultural and chemical methods. Mathematical models and computer simulations are useful tools for reaching this objective. Population dynamic models of cotton bollworm, cotton aphid, armyworm and other pests are developed for this purpose.

2. Pest forecast systems

In our country, the monitoring and forecasting of the incidence and density of pests is well mass-based. The pest surveillance data collected have been processed by means of computer, cluster analysis, stepwise regression analysis, etc., in recent years to improve the accuracy of forecasting and monitoring of pests.

We won better achievements in studying the migration of armyworm and locust. In recent years we have made some new progress in studying the migration of brown planthopper, white backed rice fulgorid, rice leafroller, lawn moth, black cutworm, wheat aphid, etc., by means of mark-recapture, alpine net trap, aeroplane catch, ship catch and radar monitoring.

3. Forest pest control

In our country, IPM tactics for forests involve the development of mixed forests and energetic encouragement of artificicial afforestation at the hillside, etc., to achieve the diversity and stability of biocommunity in the forest ecosystem. All of these measures bring the selfregulation and natural control of the ecosystem into full play. Studies on the economic threshold of

* mu = 6.6 a.

pine caterpillar (a major pest in the forest) have indicated that a dynamic economic thresholds should not merely rely on the the density of caterpillar population, but on the situation of forest forms, abundance of natural enemies, amount of needle leaf stock, ingestion of insect larvae, meteorological factors and fluctuation of insect pest population, etc.. The area using *Trichogramma*, white muscardine fungus, viruses and dimilin to control the pine catapillars is enlarged year by year. There is also a new progress in using the ichneumon wasp for control of longicornia. The attraction of beneficial birds and domestication of *Cyanopica cyana* Pallas and *Parus major* L. as predators of insect pests have received the great attention.

4. Biological control

As far as biological control in our country is concerned, more rapid progress has been made in the mass-rearing of natural enemies for recent years in addition to the yearly expanded application of *Trichogramma*, *Bacillus thuringiensis* Berliner, white muscardine and viruses. *Trichogramma* containing a small amount of insect blood lymph has been mass-reared to the extent that they can be used in larger areas. Breakthrough successes have been obtained by using artificial egg with insect materials to culture *Trichogramma*. The effectiveness of rearing seven-spotted lady-beetle with artificial diets is almost the same as with natural food (aphids). The above work on biological control has won the praise both from our colleagues and from abroad. Besides, mass-rearing of lacewings, tachinid flies and predaceous mites also has been crowned with great successes. There is a very remarkable effectiveness in controlling planthopper and leaf-hopper in the paddy field by use of various species of spiders, which covers an area of 15 million mu of paddy fields only in Hunan Province. An area of using predaceous mites to control citrus red mites reaches over 50,000 mu. *Encarsia formosa* Gahan, *Typhlodromus occidnetalis* Nesbitt, *Phyteseiulus persimilis* Athias Henriot, and *Bacillus thuringiensis* H-14 introduced from abroad have been widely used in the cropland and forest, and the use of the above natural enemies has won initial success.

5. Chemical control

Synthetic organic pesticides continue to be effective tools in pest control especially when the densities of pest population are over economic damage level, and thus they still play an important

role in IPM, but extensive use of pesticides cause a lot of serious problems,such as the rapid development of pest resistance and the destruction of natural enemies by some all-known pesticides as organophosphates, carbamates, pyrethroids, decis, fenvalerate, cypermethrin, etc.,apart from other possible adverse effects on environment, users, consumers and others. Because of the existence of these problems in our country as well, we have placed special emphasis on the sutdies (1) of the development and application of new pesticides, such as demilin, chlordimeform, and antijuvenile hormone and toosendamin (petroleum ether extract of seed kernels of melia toosendan, *Melia azedarach*, Meliaceae) abstracted from plants; (2) of application practices, such as microcapsular drug-form, ultra-low-volume sprayer, seed dressing, etc., which have been widely used in our country: (3) of the retardation of pesticide resistance and the synergy of pesticides (it has been proved that the mixed use of SV with organophosphate and decis produces obvious synergized action, so SV has been produced in large quantity in the Chinese factories at present; besides great attention has been paid to the shifting of pesticides for use.); (4) of pesticide residues, which are being made thoroughly; and (5) of resistance mechanisms, which have been undertaken for many years.

6. Application of insect sex pheromone

In the last few years, there is a rapid progress in the development and application of insect sex pheromone for forecasting and monitoring the fluctuation of pest population in the fields. These pests are pink bollworm, peach fruit moth, oriental fruit moth, peach pyralid moth, sugarcane stem borer, sugarcane spotted borer, Asiatic rice borer, rice leafroller, rice gall midge,armyworm, cottonwood crown borer, diamondback moth, cotton bollworm, etc.. Some monitored areas reach over millions mu. The area of diamondback moth control directly by mass-trapping method amounts to 400,000 mu so far. The area of peach fruit moth control is 50,000 mu per year. Sex pheromone has provided effective control of pests and has produced no effect on natural enemies and environment. We have obtained good results of our experiments on control of pink bollworm, peach fruit moth, oriental fruit moth, sugarcane stem borer, etc., by means of disturbance of their mating. It has been proved that insect sex pheromone has become a new important component of IPM.

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