Utilization of Natural Enemies for Controlling Fruit-Tree Pest

NOBUHIKO OHO

Chief, Entomology of Fruit-Tree, Environment Division, Horticultural Research Station

Introduction

In Japan, many studies concerning utilization of natural enemies for pest control have been carried out for past several decades, and some remarkable successes were achieved in the field of fruit-tree pest control. On the other hand, many unsuccessful cases have been recorded among such studies because of unsuitable conditions to control pests by releasing natural enemies. Accordingly, some workers became indifferent to utilization of natural enemies.

Recently, since many powerful insecticides such as DDT, BHC and many organophosphates appeared and were applied extensively in orchards, insect faunae in orchards were affected and much altered, and consequently some pests were suppressed or eliminated, but some of the other arthropods which were not economically so important formerly increased markedly instead and brought serious damage.

This difficulty is said to be caused mostly by decrease of environmental resistance in intensity and destruction of balance in nature which were caused by extinction of native natural enemies by non-selective powerful insecticides. Since then, the effect of native natural enemies was revaluated and search for beneficial native natural enemies, studies on techniques to mass-produce them and ecological studies which analyze the host-parasite or prey-predator relations within the insect community became to be promoted.

In the present paper, the author summarizes the studies on utilization of natural enemies in Japan on the two subjects, i.e., utilization of entomophagous insets and that of pathogenic microorganisms.

Utilization of entomophagous insects

All instances that pests were successfuly controlled by utilization of natural enemies in early time in Japan were the cases in which exotic natural enemies were introduced in order to control the pests which had invaded from other country (i.e., control of *Icerya purchasi* Maskell by *Rodolia cardinalis* Mulsant, *Aleurocanthus spiniferus* Quaintance by *Prospaltella smithi* Silvestri, *Eriosoma lanigerum* Hausman by *Aphelinus mali* Haldman).

Rodolia cardinaris was introduced from California to Taiwan (Formosa) by Dr. T. Shiraki in 1909. In 1911, this Coccinellid beetle was also introduced to Shizuoka Prefecture and colonized. At present, this species is distributed widely in Japan and is playing an excellent role in control of the scale insects.

Prospaltella smithi Silvestri was found in Southern China and was brought into Nagasaki Prefecture by Dr. F. Silvestri (Kuwana and Ishii, 1929). This species was mass-produced at Nagasaki, distributed to prefectures in Kyushu and marked success was attained (Sweetman, 1935). Recently, when *Aleurocanthus spiniferus* invaded Yamaguchi, Shizuoka and Kanagawa Prefectures, a successful control was attained by introducing this parasite from Nagasaki and Kochi Prefectures.

Introduction of *Aphelinus mali* Haldman also successfully controlled the woolly apple aphid, *Eriosoma lanigerum* Hausman. This parasite was introduced from Oregon, North America by Dr. A. Kamitô, reproduced at the Aomori Apple Experiment Station, and widely colonized in apple-growing districts in Japan (Yuasa, 1950). This Aphelinid wasp overwinters within the body of *Eriosoma lanigerum*, emerges from the

host body in May and spends 8-9 generation in a year. Parasitized aphids stop excreting wax, change black in color, and turn into "mummy". Since this parasite is very susceptible of organo-phosphates, it is important to make careful application of chemical control agents especially during the emerging period of this parasite (Fukuda, 1961).

Recent success in utilization of natural enemies is carried out by a series of studies on *Anicetus beneficus* Ishii et Yasumatsu originated by Yasumatsu and Tachikawa (1949). One of the serious pests of citrus, the red wax scale, *Ceroplastes rubens* Maskell invaded Japan around 1897. *Anicetus beneficus* which was found by Dr. K. Yasumatsu in Kyushu in 1946 was introduced into Honshu and Shikoku after 1948 and a remarkable success was attained. This parasite can eliminate the red wax scale within 3-4 years after introduction (Yasumatsu, 1951, 1953; Fukai, 1953; Miyake, 1960).

Utilization of the following natural enemies is being investigated at present. (Murakami and Nohara 1967.) Natural enemies of one of the most important pests of apple, pear, grape, etc., *Pseudococcus comstokii* Kuwana were searched and 12 species of parasite wasps, 16 species of predators, and one species of fungous disease were found at the Horticultural Research Station (Hiratsuka). Out of these natural enemies, five parasite wasps and one predator are effective in Japan. The most effective species, *Pseudaphycus malinus* Gahan is distributed in the southern part of Chiba and Fukuoka prefectures.

In Fukuoka, this parasite repeats nine generations per year and can repeat several generations during one generation of the mealybug. Furthermore, this parasite has many other excellent characteristics as a biological control agent, i.e., it can parasitize each stage of host other than egg and can be colonized at any time, its fecundity is high, its oviposition period is short, and parasitized mealybugs can survive only for a short time (Murakami, 1965, 1966; Murakami *et al.*, 1967). Utilization of this parasite as a "biotic insecticide" is investigated at the Research Laboratories of Takeda Chemical Industries, Ltd. (Morimoto *et al.*, 1965; Endo, 1965; Murakami *et al.*, *loc. cit.*).

Studies on bionomics, mass production and evaluation of effect of liberating natural enemies are being investigated on *Chilocorus kuwanae* Silvestri, a predator of *Unaspis yanonensis* Kuwana; *Allotropa* sp., a parasite of *Planococcus kraunhiae* Kuwana; *Stethorus japonicus* H. Kamiya, a predator of plant mites; *Aphytis cylindratus* Compere, an effective parasite wasp of *Pseudaonidia duplex* Cockerell, etc., at the Kurume Branch, Horticultural Research Station (Tanaka, 1966).

Utilization of pathogenic microorganisms

Studies on microbial diseases of insects have been greatly advanced in Japan as the studies on diseases of the silkworm (Aoki, 1959). Especially, both a cytoplasmic polyhedrosis virus of the silkworm and *Bacillus thuringiensis* var. *sotto* have been extensively investigated. On the other hand, there are few works which intend to utilize pathogenic microorganisms as pest control agents. Since serliculture is extensively carried on in Japan, it is difficult to utilize microorganisms which is virulent to the silkworm, even though they are known to be excellent for pest control in other countries (e.g. *Bacillus thuringiensis*).

Although practical microbial control is not yet established in Japanese orchards. several studies are in progress.

Morimoto *et al.* studied the utilization of *Isaria farinosa* (Dicks.) Fr. in control of *Rhizoecus kondonis*. The most virulent strain was isolated from *Sesamia inferens* Walker. This fungus can grow in the range of temperature of 10-35°C and can reproduce even in more acid soil than pH 4.0. This fungus does not infect eggs. Furthermore, the technique for mass production and application of this fungus in control and virulence to the silkworm were investigated (Morimoto, 1960).

Sekiguchi studied the methods for utilization of *Isaria fumosarosia* Wize in control of *Carpoeina niponensis*. This fungus is strongly virulent to the peach fruit moth. Infected larvae form pink-colored conidiophore on hibernation cocoons. Hibernating population of the moth is mostly perished by infection of this fungus. Infected individuals are less viable

even if they succeed in surviving and emerging. As this fungus is tolerant to copper sulphate, $CuSO_4$, it is easy to mass-culture this fungus purely with soybean cakes adding $CuSO_4$ by preventing the growth of other microorganisms (Sekiguchi, 1955, 1959).

A cytoplasmic polyhedrosis virus was isolated from fruit piercing moths and studies on utilization of this virus are carried out at the Horticultural Research Station (Hiratsuka) (Oho, 1966a). Recently, utilization of a granulosis virus infectious to *Adoxophyes orana* Fischer von Röslestamm is also being studied at the Research Station.

Fundamental studies on the methods of mass culture and application in field on *Aschersonia aleyrodis* Webber against *Dialeurodes citri* Ashmead were carried out. It was concluded that this fungus is effective under humid climatic conditions (Oho and Sato, 1966b).

Conclusion

Utilization of natural enemies for control of pests becomes one of the most important problems in fruit-pest control since it is difficult to depend solely on pesticides because we are now facing many difficulties concerning application of insecticides, i.e., appearance of resistant strain, residues of pesticides in products, reduction of production cost etc,

However, to establish practical utilizations of natural enemies for pest control, they are important not only to establish the techniques concerning mass production of natural enemies, but also to establish the method to evaluate the effect of artificial colonization of natural enemies accurately and to investigate the host-parasite or prey-predator relations within the community involving them from the ecological viewpoint.

There are many unsolved fundamental problems concerning utilization of pathogens. These problems are difficult to be solved in a short time. Still, against some pests which invaded from other countries, e.g. *Unaspis yanonensis* Kuwana, it is demanded to introduce effective natural enemies from their native districts. Concerning native natural enemies, integration of natural and chemical controls must be designed, e.g. by using selective insecticides.

References

* In Japanese

** In Japanese with English summary

1) Aoki, K. 1959 Insect Pathology Gihodo, Tokyo *
2) Endo, K. 1965. On a Liberating Experiment of Natural Enemies Against a Mealybug. Kongetsu-no-Noyaku (Monthly Review of Agricultural Chemicals) (Tokyo) (9(2) : 17-22.*
3) Fukai, K. 1953. Introduction, Conservation and Utilization of *Anicetus beneficus* Ishii et Yasumastu. Plant Prot. (Tokyo) 7(2) : 17-22.*
4) Fukuda, J. 1961. Fruit-tree Pests. Yokendo, Tokyo *
5) Kuwana, I. & Ishii, T. 1927. Reports on the Course of the Introduction of an Important Pest of Citrus, *Prospaltella smithi* Silv. and *Cryptognatha* sp. Engei-no-kenkyu (Researches on Horticulture) (Tokyo) 22 : 277-280.*
6) Miyake, T. 1960. Methods for Utilization of *Anicetus beneficus* Ishii & Yasumastu. Plant Prot. (Tokyo) 14(11) : 28-30.*
7) Morimoto, T. 1960. Pest Control by Fungi. Plant Prot. (Tokyo) 14(11) : 9-12.*
8) Murakami, Y. 1965. Studies on the Natural Enemies of the Comstock Mealybug. I. Members of the Natural Enemies and Their Geographical Distributions. Bull. Hort. Res. Sta., Japan Ser. A, 4 : 125-144.**
9) —— 1966. Studies on the Natural Enemies of the Comstok Mealybug. II. Comparative Biology on Two Species of Internal Parasites, *Clausenia purpurea* and *Pseudophycus malinus* (Hymenoptera, Encyrtidae). Bull. Hort. Res. Sta., Japan Ser. A., 5 : 139-163.**
10) ——, R. Morimoto & H. Kajita 1967. Possibility of Biological Control of *Pseudoccous comstocki* in Japan. In : Natural Enemies in the Pacific Area (Biological control), Mushi 39(Suppl.) : 85-96.
11) ——, & K. Nohara 1967. Biological Control of Scale Insects. Plant Prot. (Tokyo) 8(21) : 34-38.*
12) Oho, N. 1966a. A Study on the Cytoplasmic Polyhedrosis Virus of a Fruit Piercing moth, *Oraesia emerginata*. Bull. Hort. Res. Sta., Japan Ser. A., 5 : 165-178.**
13) —— & Y. Sato 1966b. Studies on a fungus, *Aschersonia* sp. on whitefly, *Dialeurodes citri* Ashmead. Bull. Hort. Res. Sta., Japan Ser. A., 5 : 179-192.**
14) Sekiguchi, A. 1955. Studies on the Control of Fruit Moth by Entomogenous Fungus "*Isaria fumosorosea* Wize". Part I. Identification of

the Fungus and Its Pathogenicity. Bull. Tohoku Nat. Agr. Exp. Sta. 4: 152-153.**

15) —— 1959. Studies on the Control of Peach Fruit Moth by Entomogenous Fungus "*Isaria fumosorosea* wize" II. The Inoculation Tests, Some Culture Characters of the Fungus and Its Fundamental Factors on the Large Scale Culture. Bull. Tohoku Nat. Agr. Exp. Sta. 16 (Hortic. Dev. Sep.): 89-93.**

16) Sweetman, H. L. 1935. Successful Example of Biological Control of Pest Insects and Plants. Bull. Ent. Res. 26: 373-377.

17) Tanaka, M. 1966. Fundamental Studies on the Utilization of Natural Enemies in the Citrus Grove in Japan. I. The Bionomics of Natural Enemies of the Most Serious Pests. I. *Chilocorus kuwanae* Silvestri (Coccinellidae) a Predator of an Arrow-Head Scale, *Unaspis yanonensis* Kuwana. II. *Stethorus japonicus* H. Kamiya (Coccinellidae), a Predator of the Citrus Red Mites, *Panonychus citri* McG. Bull. Hort. Res. Sta., Japan, Ser. D., 4: 1-42.**

18) Yasumatsu, K. 1951. Effectiveness of *Anicetus beneficus* Ishii & Yasumatsn. Nogyo-Gijutsu (Agricultural Techniques) (Tokyo) 6: 2-4.*

19) —— 1953. Control of *Ceroplastes rubens* Moskell by a Parasite Wasp. Nogyo-Gijutsu (Agricultural Techniques) (Tokyo) 8: 18-21.

20) Yasumatsu, K. & T. Tachikawa 1949. Investigations on the Hymenopterous Parasites of *Ceroplastes rubens* Maskell in Japan. Jour. Fac. Agr., Kyushu Univ. 9: 99-102.