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TABATADZE, E.S.; YASNOSH, V.A.
Kanchaveli Plant Protection Research Institute, Tbilisi - 380062, Georgia

POPULATION DYNAMICS AND BIOCONTROL OF THE JAPANESE SCALE, *LOPHOLEUCASPIS JAPONICA* (COCKERELL) IN GEORGIA.

ABSTRACT

POPULATION DYNAMICS AND BIOCONTROL OF THE JAPANESE SCALE, *LOPHOLEUCASPIS JAPONICA* (COCKERELL) IN GEORGIA.

The Japanese scale, *Lopholeucaspis japonica* (Cockerell) was discovered in Georgia in the Batumi Botanical Garden in 1931, where it was probably introduced from Japan. During the 1950's, it was widespread and became a major pest of citrus, other fruits, tea, tung and ornamental plants. Japanese scale differs greatly from many other diaspidid species because it is pupiparial, the adult female being enclosed in a chitinous "puparium" which makes the use of contact pesticides to control this insect difficult. The scale has 2 generations a year (sometimes 3) and development of some stages is prolonged. Recently, the populations of Japanese scale have been significantly reduced due to effective control by its natural enemies, which include some chalcid parasitoids and coccinellid predators, but which is mainly due to an undescribed species of the fungus genus *Aschersonia*, hitherto not found in the Caucasus.

Key words: Black Sea, insecticides, biology, Aphelinidae, Acarina, *Chilocorus bipustulatus*, *Aspidiotiphagus citrinus*, deuteromycete fungi, entomopathogenic fungi.

INTRODUCTION

The Japanese scale, *Lopholeucaspis japonica* Cockerell (Coccinea: Diaspididae) was apparently accidentally introduced into Georgia from Japan and was first discovered on a *Magnolia* plant in the Botanical garden near Batumi in 1931. Since 1951, it has become as serious pest of many crops along the Black Sea coast, including citrus, many types of fruit trees, tea, tung and ornamental and wild plants. Heavy infestations were observed prior to the end of the 1980's. During this period, its distribution, biology, and biological and chemical control were studied in detail (for reviews, see Borchsenius (1966), Hadzibeyli (1983) and Konstantinova & Kozárzhevskaya (1990)).

Prior to the present time, pesticides were the only means of controlling *L. japonica*. However, insecticides are effective only against nymphs which are only covered by a thin scale-like test, whereas the adult females are enclosed in a chitinous "puparium" which completely covers them with a thick sclerotised sheath, impenetrable to insecticides. Since the end of the 1980's, the importance of *L. japonica* has been significantly reduced, mainly due to:

(a) the decreasing use of broad-spectrum pesticides against pests in orchards, which has led to an increase in the biodiversity and efficiency of natural enemies, and (b) the appearance of a new and effective biocontrol agent, an entomophathogenic fungus in the genus *Aschersonia*, previously unknown in Georgia and throughout the Caucasus.

This paper gives information on the population fluctuations and natural enemies of *L. japonica* during the period 1983 to 1997.

MATERIAL AND METHODS

The investigations were conducted at Adjaria (Batumi region) on the Black Sea coast. The population fluctuations of *L. japonica* and the efficiency of its natural enemies were determined by monitoring the populations in two mandarin (*Citrus nobilis*) orchards, namely:

I. Akhalsheni farm plus some of the surrounding area (total about 1000ha) during 1986-88. Here a new integrated management program (IPM) for citrus pests was being used. This programme had been designed by specialists at the Georgian Plant Protection Institute (Recommendation, 1986; Yasnosh, 1995; Yasnosh *et al.*, 1996) and it significantly reduced input of chemicals, especially the organophosphorous insecticides, which are dangerous to the beneficial fauna.

II. Angisa (Makvilauri) farm. Here no insecticides were applied to the experimental plots between 1989 and 1991, the period during which the study was undertaken. In addition, data on the population densities of *L. japonica* were available for the period 1983-88.

In each orchard, three trees infested with *L. japonica* were selected and the number of scales on four areas of the trunk and main branches, each $1cm^2$, were counted on each tree. The efficiency of natural enemies was determined in the same sites by counting the number of scales which had been parasitised or destroyed by predators. The beneficial insects were identified by the second author and the entomophathogenic fungus, *Aschersonia* sp., by Prof. E.S. Koval (Microbiological and Virological Institute of the Ukraine, Kiev).

RESULTS AND DISCUSSION

L. japonica infests nearly all parts of the plant but mainly the trunk and main branches and, in the case of heavy infestations, can cause death of the host. It is a polyphagous species, with an extensive host list and attacks more then 20 plants from different botanical families in Georgia (Hadzibeyli, 1983).

Table 1. List of the natural enemies of the Japanese scale in Georgia.

PARASITOIDS	PREDATORS
HYMENOPTERA, Aphelinidae	**COLEOPTERA**, Coccinellidae
Aspidiotiphagus citrinus Craw. *Aphytis hispanicus* Mercet *Encarsia fasciata* Malenotti *E. intermedia* Ferrière	*Chilocorus bipustulatus* L. *Ch. renipustulatus* Scriba *Exochomus quadripustulatus* L. *E. flavipes* Thunb. *Lindorus lophanthae* Blaisd.
	ACARI *Hemisarcoptes dzhashii* Dzibladze *Hemisarcoptes sp.*

It has two generations per year in Georgia, although sometimes there is a distinct 3rd generation. It overwinters as the 2nd-instar nymph, giving rise to adult males and females at the end of March (Tabatadze, 1994). Each female generally lays between 11 and 28 eggs (range 4-50). The 1st (Spring) generation develops between the end of May and the beginning of June, while the 2nd (Summer) generation develops between the end of July and the beginning of August. However, the development of all stages of the scale in the summer is prolonged and there is no clear separation of the generations, so that during the later periods in the year, all development stages of the scale may be present.

Figs 1 & 2 show the population densities and percentage parasitism of *L. japonica* at Akhalsheni farm since 1983, when the new IPM program against a complex of pests (coccids, aphids, citrus whitefly and mites) was introduced and, since when, the use of broad-spectrum pesticides (mainly organophosphorous) has been rare.

Fig. 3 shows similar data for Angisa farm between 1989 and 1991, where no insecticides were applied during this period. There are no significant differences in the population density of *L. japonica* between the two experimental orchards, where the fluctuations in scale density were always below the economic threshold of 20-25 scales/cm^2 on the trunk and main branches (Tabatadze, 1994) and where the peaks of percentage parasitism were at similar times in both orchards. The efficiency of the natural enemies was sometimes high, when about 50% of the scale population were destroyed by the parasitoids, predators and fungi.

The complex of natural enemies (Table 1) also includes such non-specialized (oligophagous) predators as mites and spiders. The main controlling agent of this complex of natural enemies of *L. japonica* is the new pathogenic

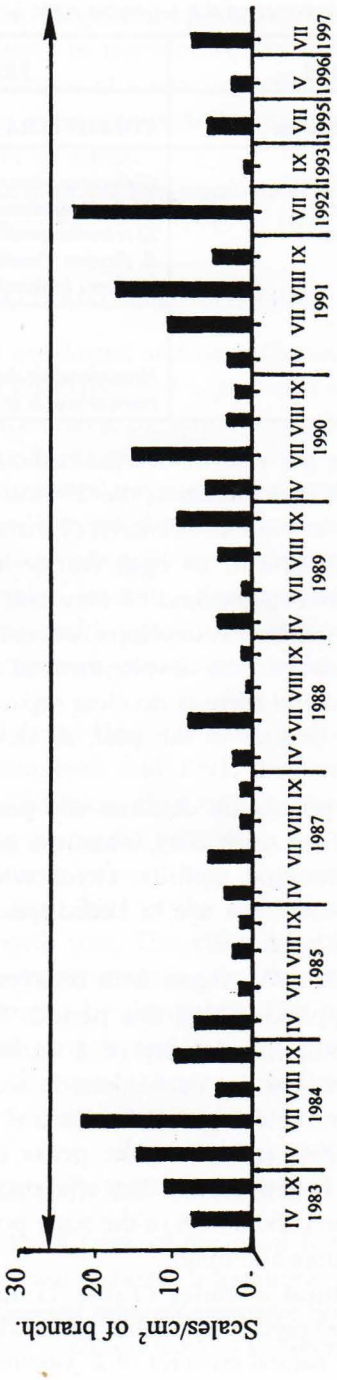

Fig. 1. Population fluctuations of the Japanese scale in citrus orchards, Akhalsheni farm, 1983-1997. Where ■ = coccid populations and <—> = economic threshold (25 scales $10cm^{-1}$).

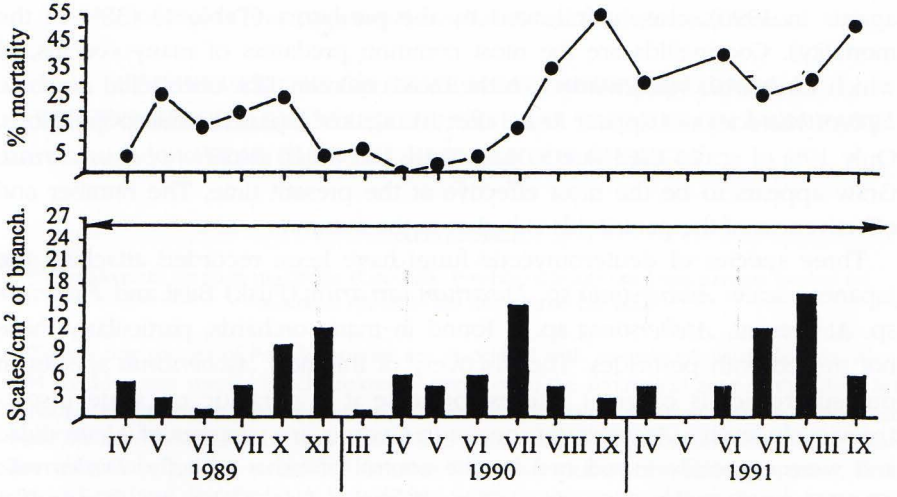

Fig. 2. Population fluctuations of the Japanese scale and percentage mortality due to natural enemies in citrus orchards, Akhalsheni farm, 1989-1991. Where ■ = coccid populations and <—> = economic threshold (25 scales $10cm^{-1}$).

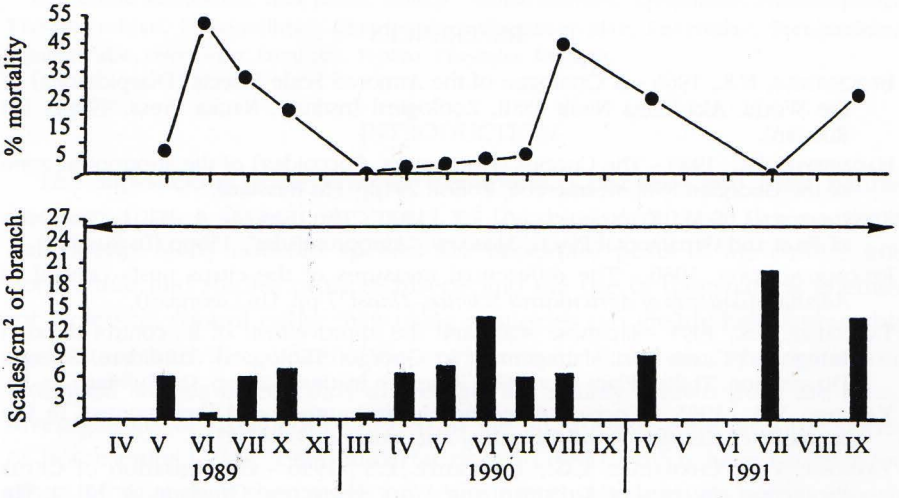

Fig. 3. Population fluctuations of the Japanese scale and percentage mortality due to natural enemies in citrus orchards, Angisa farm, 1989-1991. Where ■ = coccid populations and <—> = economic threshold (25 scales $10cm^{-1}$).

fungus *Aschersonia* sp. (which caused 43% of the mortality due to biocontrol agents in 1990), closely followed by the predators (Table 1) (38% of the mortality). Coccinellids are the most common predators of many coccids, of which *Chilocorus bipustulatus* L. is the most common. The coccinellid *Lindorus lophanthae* does not appear to be effective against Japanese scale populations. Only 19% of scales died due to parasitoids, of which *Aspidiotiphagus citrinus* Graw appears to be the most effective at the present time. The number and effectiveness of the parasitoids is higher in the autumn.

Three species of deuteromycetic fungi have been recorded attacking the Japanese scale: *Aschersonia* sp, *Fusarium larvarum* (Fusk) Bilai and *Fusarium* sp. At present, *Aschersonia* sp. is found in many orchards, particularly those not treated with pesticides. The discovery of this new *Aschersonia* species in our subtropics is of great interest because it is parasitic on scale insects (previously known *Aschersonia* species in Georgia are parasites of Aleurodidae and were especially introduced for the control of citrus whitefly, *Dialeurodes citri* Ashmead, in the sixties from China, Vietnam, USA, Cuba, etc. (Yasnosh & Tabatadze, 1997)).

The results of this investigation show that the population density of *L. japonica* has been significantly reduced by its natural enemies, particularly the new pathogenic fungus *Aschersonia* sp., which is now its most important biocontrol agent.

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