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Monitoring and Control of *Quadraspidiotus perniciosus* (Comstock) Hemiptera: Diaspididae on Apple Trees in the Prefecture of Florina, Greece

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Abstract: The aim of this study was monitoring and control of *Quadraspidiotus perniciosus* on apple trees, in the prefecture of Florina, Greece. Half of the experimental area was used as a check field (no application) and in the rest a chemical insecticide was used. Sticky and pheromone traps of the same type were used for monitoring *Q. perniciosus* in both fields. Samples were taken every 10 days and pheromone application was renewed every month until 17 of October for year 2004 and 22 of October for year 2005. Sticky traps were used for monitoring insects of immature stages. For controlling *Q. perniciosus* two applications were made using insecticide chlorpyrifos (Dursban) in the application field, at 19 of June and 19 of July for year 2004 and 14 of June and 14 of July for year 2005. Results showed that, populations of adult insects and of immature stages of *Q. perniciosus* were considerably increased in the check field during the two years of this study. In the application field insect populations were considerably decreased due to the effectiveness of the insecticide used applied. Year conditions influenced statistically significantly population fluctuations of insects (in adult and immature stages). There was not found any relation between trapped male population and larvae population and this was considered the most important finding for monitoring purposes.

Key words: Insecticide, *Quadraspidiotus perniciosus*, population fluctuation, monitoring

INTRODUCTION

Northern Greece (Macedonia) is a territory with high development of agriculture production and many dynamic cultivations such as apple trees, peaches, pears, tobacco, cotton and corn fields. Many enemies of these cultivations are known (Chryssochoou, 1991; Paloukis, 1969, 1979; Zervas, 1997; Stavridis and Savopoulou-Soultani, 1998; Navrozidis *et al*., 1999; Deligeorgidis *et al*., 2007). *Quadraspidiotus perniciosus* (Comstock) Hemiptera: Diaspididae, is a widespread insect on many cultivations, mainly on apple trees (Paloukis, 1968, 1969; Kyparissoudas, 1987; Tzanakakis and Katsoyannos, 1998; English, 2006), where it may cause damages that can reduce the vigor and productivity of plants. Sometimes these damages are very serious because of the economic importance of the lost production (Paloukis, 1969, 1979). San José scale is the common name for *Q. perniciosus* and it was first described in Greece by Paloukis (1968) and later on almond trees in Northern Greece (with references on its natural enemies) by Katsoyannos and Argyriou (1985). In Greece, three generations were found in peach and almond trees (Paloukis, 1979; Katsoyannos and Argyriou, 1985; Tzanakakis and Katsoyannos, 1998) and sometimes four generations (Kyparissoudas, 1987). Two to four generations are referred by Hogmire and Beavers (1998) for the presence of the insect in USA. The

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insects overwinter as 1st or 2nd stage larvae, or even as adult females (Tzanakakis and Katsoyannos, 1998). The biology of San José scale on peach trees with references to the behaviour of adult males and juveniles was extensively reported by Gentile and Summers (1958).

Temperatures below 25°C are reported to induce extended diapause. In general, in the field, high temperatures and low humidity may lead to high mortality, while light rainfall and warm weather (25-30°C) favour population increase; heavy rainfall washes very young larvae off the leaves (Beardsley and Gonzalez, 1975; OEPP/EPPO, 1981). More extensive information, for the bio-ecological behaviour of the San José scale was reported by Freitas (1966, 1975). Furthermore, the influence of climatic factors on the development possibilities of the San José scale was reported by Huba (1969). In general, heavy rainfall, low temperatures and low humidity may decrease insect population.

To avoid economic important damages, monitoring of insect population and insecticide applications (usually with the addition of oils) are indispensable. Insecticides used in combination to monitoring, mainly applications of fenoxycarb, buprofezin and especially diofenolan, gave successful control (Paloukis and Navrozidis, 1995; Tzanakakis and Katsoyannos, 1998; Navrozidis *et al*., 1999). Pre-bloom use of oil is an important component of an apple IPM program and proved very effective on San José scale (Tree Fruit Research and Extension Center, 2008). Biological control of San José scale by natural enemies was also proposed by Gulmahamad and Debach (1978), Argyriou (1981), Katsoyannos and Argyriou (1985) and Trandafirescu *et al*. (2004). Protective films were found ineffective for reducing *Q. perniciosus* populations (Knight *et al*., 2000, 2001).

The purpose of this study was the monitoring of population fluctuations and the control of total insect population of *Q. perniciosus* by insecticide application.

MATERIALS AND METHODS

During 2004 and 2005, a study was conducted for monitoring and control of *Quadraspidiotus perniciosus* (Comstock) on apple trees (cv. Red Chief, on MM106, pollinator: Golden Delicious), a dynamic cultivation in the Prefecture of Florina in Northern Greece. The total experimental area was 0.50 ha, where 0.25 ha were used as a check field (no application) and in the rest 0.25 ha a chemical insecticide was used. The two fields were 200 m apart. Sticky and pheromone traps of the same type were used for monitoring *Q. perniciosus* in both fields (Badenes-Perez *et al*., 2002). In pheromone traps the type of pheromone used was SLS314540200684 for monitoring male adults and they were hung on the apple trees (every 15 trees), one trap on each branch (8 branches for every tree), 88 traps in total, at 20 April 2004 and 25 April 2005. Samples were taken every 10 days and pheromone application was renewed every month until 17 October 2004 and 22 October 2005. Sticky traps were used for monitoring insects of immature stages. Traps were hung on the apple trees (every 15 trees), one trap on each branch (8 branches for every tree), 88 traps in total. Monitoring was made in the same way and at the same dates, as for pheromone traps. For controlling *Q. perniciosus*, two applications were made using insecticide chlorpyrifos (Dursban 48EC, DOW Agrosciences) in the application field, at a dosage of 1.2 L ton^{-1} of water using TIFONE spraying equipment (81 L min^{-1}, 40 bar, high pressure turbo ventilator 28"), at 19 June and 19 July for year 2004 and 14 June and 14 July for year 2005. Transformation of data and ANOVA were based on Snedecor and Cochran (1980) and factors analyzed were: year of experimentation, insect stage (adult males or immature stages), period of recording and insecticide application.

RESULTS AND DISCUSSION

Table 1 presents total number of insects (adult males or larvae) measured in traps, in check field and after application of insecticide, for years 2004 and 2005. All factor (year of experimentation, insect

Table 1: Total number of insects (adult males or larvae) measured in traps, in check field and after application of insecticide, for years 2004 and 2005

Year	Insect stage	Check field	Application
2004	Adult males	8.92	3.65
	Larvae	84.93	53.07
2005	Adult males	9.84	4.11
	Larvae	87.86	50.47

All factor interactions found statistically significant at $p<0.01$

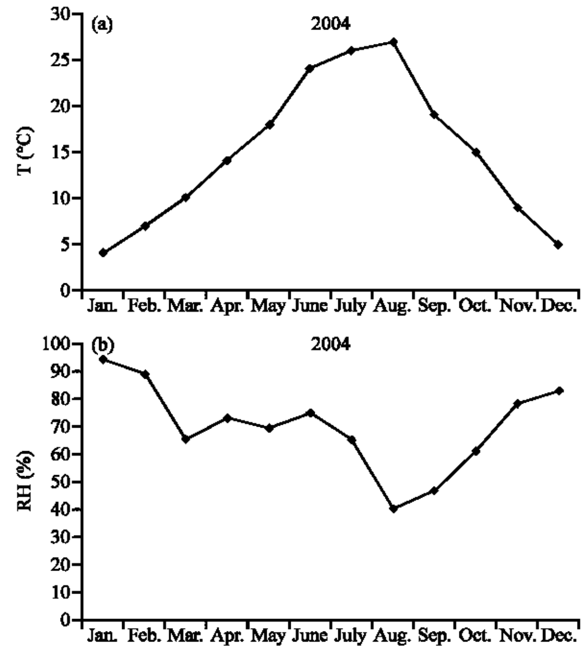

Fig. 1: Environmental conditions (a: Mean temperature T (°C), b: Relative humidity RH%) for year 2004

stage: adult males or immature stages, period of recording and insecticide application) interactions were found statistically significant at $p<0.01$. Results showed that, populations of adult insects and of immature stages of *Q. perniciosus* were considerably increased in the check field during the two years of this study. In the application field insect populations were considerably decreased due to the effectiveness of the insecticide applied, especially for the adult males (60% decrease). This maybe due to timing of application, or even the behavior of the immature stages, that can hide better than adults (Franklin Howell and George, 1984; Reissing *et al*., 1985).

Year conditions influenced statistically significantly population fluctuation of insects (in adult and immature stages). Figure 1 and 2 present environmental data in Florina (mean temperature, relative humidity), for years 2004 and 2005. As it is clearly seen, there were differences between the two years: year 2005 was found wet and without too high temperatures in comparison to 2004, resulting in a slight increase of insect population (9.84 male adults and 87.86 larvae trapped). This was in agreement to the findings of Huba (1969) and Beardsley and Gonzalez (1975).

Figure 3-6 present fluctuation of population of *Q. perniciosus* across the periods of recordings (total number of trapped larvae and total number of adult males trapped), with or without the application of insecticide for both years 2004 and 2005. As it can be clearly seen, after the two applications of insecticide, the population of *Q. perniciosus* (for both adult and immature stages) was considerably reduced in comparison to the check field (without application). In check field the

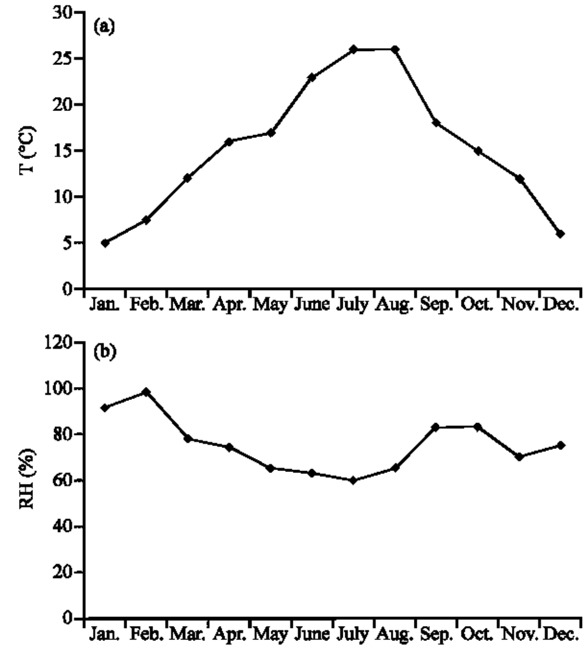

Fig. 2: Environmental conditions (a: Mean temperature T (°C), b: Relative humidity RH%) for year 2005

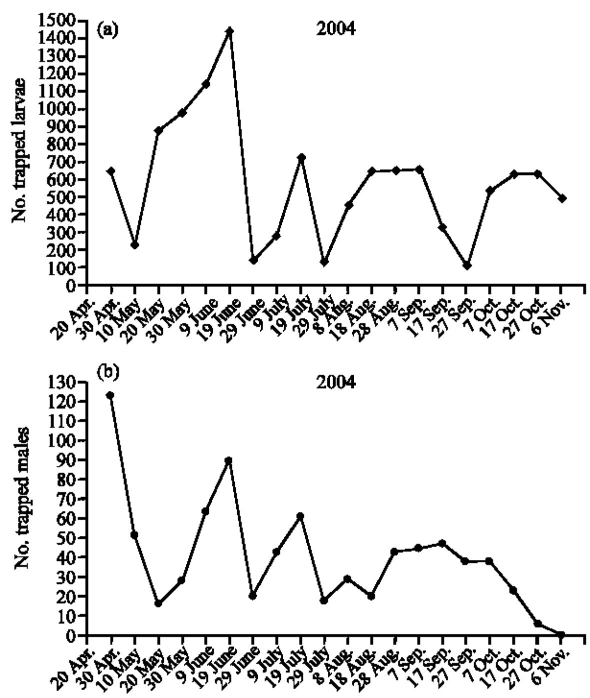

Fig. 3: Fluctuation of population of *Q. perniciosus* (a: Total number of trapped larvae, b: Total number of adult males trapped), with application of insecticide for year 2004

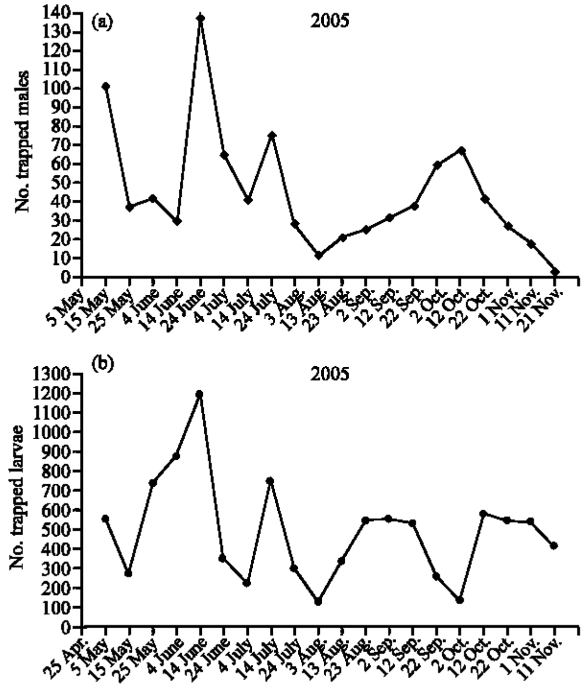

Fig. 4: Fluctuation of population of *Q. perniciosus* (a: Total number of trapped larvae, b: Total number of adult males trapped), with application of insecticide for year 2005

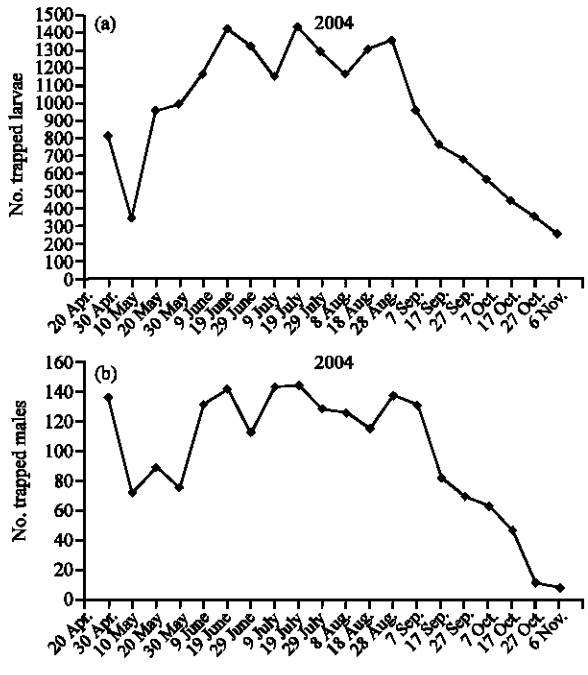

Fig. 5: Fluctuation of population of *Q. perniciosus* (a: Total number of trapped larvae, b: Total number of adult males trapped), without application of insecticide for year 2004 (check field)

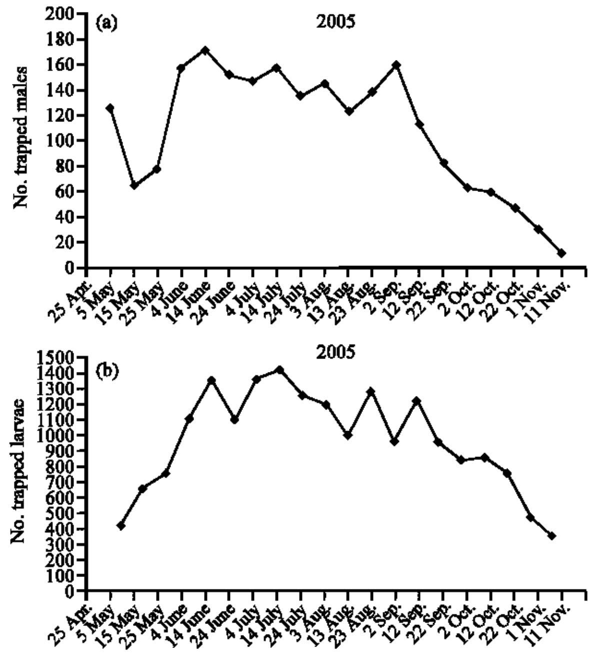

Fig. 6: Fluctuation of population of *Q. perniciosus* (a: Total number of trapped larvae, b: Total number of adult males trapped), without application of insecticide for year 2005 (check field)

population remained in high levels across all the periods of recordings until September, when started a decreasing period due to the harvest and consequently, lack of apples. Factor interactions were found significant, since fluctuation of population across recording dates was completely different, especially between years, but also between adults and larvae and of course in check field and application field.

Most important for monitoring procedure was considered the fact that population fluctuations were different from year to year (for both adult males and larvae) and between insect stages (adults and larvae). This might be due to different environmental conditions from year to year (Freitas, 1966, 1975; Huba, 1969). Deligeorgidis *et al.* (2007), also reported differences in population fluctuations between years and this seems to be a common biological phenomenon in insects. Population of insects was depended on the date of recording due to the development of insects (from one stage to another) and mainly to the new generations that appear during recording period (Paloukis, 1979; Katsoyannos and Argyriou, 1985; Tzanakakis and Katsoyannos, 1998). Population fluctuations of adult males and larvae were independent to each other, since there was not found any relation between trapped male population and larvae population and this was considered the most important finding for monitoring purposes. Results reported by Badenes-Perez *et al.* (2002) suggest that relative densities of San José scale crawlers on sticky tapes can be estimated using male trap captures mainly for the first generation. Adult males are moving freely because they can fly and they might have different enemies from those that predate larvae (Gulmahamad and Debach, 1978; Argyriou, 1981; Katsoyannos and Argyriou, 1985; Tzanakakis and Katsoyannos, 1998) resulting in independent population fluctuations recorded in traps. In general, there is no apparent relation between adults and larvae. Another factor that researchers must keep in mind when monitoring *Q. perniciosus*, is that the insect lays young larvae and not eggs (Tzanakakis and Katsoyannos, 1998) and this might resulted in different numbers of larvae between generations that influence total population.

Concluding, in the application field insect populations (trapped males) were considerably decreased due to the effectiveness of the insecticide used, although present data showed that insecticide effectiveness might be different from year to year (especially for larvae that can hide on the trees). In Greece, biological control of San José scale may be used instead of insecticide applications, since it was found satisfactory for reducing insect populations (Argyriou, 1981). There was not found any relation between trapped male population and larvae population and this was considered the most important finding for monitoring purposes.

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