

The Occurrence of *Panonychus citri* (McGregor) (Acari: Tetranychidae) in Northern Italy: Distribution, Host Range and Phenology

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In the late 80s, symptoms linked to spider mite feeding were observed on ornamental plants, in particular *Prunus laurocerasus*, in Padua (Venetia, Northern Italy). Surprisingly, symptoms were caused by *Panonychus citri* (McGregor) a tetranychid well-known as one of the major pests of citrus in the world. Previously, *P. citri* had been recorded in southern Italy, especially on citrus. In subsequent years the species has been recorded on different ornamental plants.

In the laboratory, mites collected on *P. laurocerasus* in Padua developed successfully on *Citrus aurantium*, *Prunus laurocerasus*, *Poncirus trifoliata* and *Pyrus serotina*.

Field observations, carried out in different sites and on *P. laurocerasus*, showed that *P. citri* populations reached the highest densities in spring-early summer in correspondence with the development of the new vegetation. Some weeks later population densities dramatically decreased. The impact of predators did not appear to be important. A new population increase in late summer was seldom observed.

In northern Italy, climatic conditions are quite different from those recorded in the Mediterranean area, especially as regards winter temperatures. However, *P. citri* infestations on ornamentals have been recorded for a number of years both in urban and non-urban areas, typically on hedges along roads. The factors involved in this phenomenon and the implications are discussed.

Symptoms apparently caused by spider mites, i.e. leaf bronzing and stunted shoot growth, were observed in July of 1988 on hedges of *Prunus laurocerasus* L., an ornamental evergreen, in some towns of northern Italy. Surprisingly, the symptoms were associated with the occurrence of *Panonychus citri* (McGregor), a tetranychid mite well known as a serious pest of citrus in southern Italy and in several citrus growing areas of the world. In subsequent years *P. citri* was found in several sites of northern Italy not exclusively on *P. laurocerasus* but also on other evergreen ornamentals (e.g. *Jasminum officinale* L.).

Prior to these records, the geographic distribution of *P. citri* in Italy was consistent with that of citrus, including Campania, Apulia, Calabria, Sicily and Sardinia with Latium as the northern limit (Ciampolini and Rota, 1973; Barbagallo and Perrotta, 1977; Ciampolini and Foti, 1979; Lanza et al., 1980; Russo, 1991). The biology and ecology of *P. citri* and the role of natural enemies on citrus in Italy were also studied (Ciampolini and Rota, 1973; Vacante et al., 1980; Ragusa et al., 1983; Delrio and Monagheddu, 1986; Benfatto and Vacante, 1986).

The occurrence of *P. citri* on *P. laurocerasus* has been reported in southern France where citrus is also cultivated (Fauvel and Cotton, 1986). Severe bronzing was

observed in late summer but the interactions between *P. citri* and this host were not analyzed. Southern France represented the northern limit of the species' distribution in western Europe until the presentation of the present work.

Detailed studies on *P. citri* have been carried out in Japan. In particular, a number of publications have dealt with two strains, called diapausing and non-diapausing, characterized by different morphology, geographic distribution, biology and behaviour (e.g. Shinkaji, 1979; Takafuji and Morimoto, 1983; Takafuji and Fujimoto, 1985; Osakabe, 1987; Uchida and Shinkaji, 1989; Kunimoto et al., 1991).

Initially, the strain found on *P. laurocerasus* in Padua was suspected to belong to the diapausing strain due to its geographic distribution and overwintering. More recently, the rank of species was assigned to the diapausing strain, i.e. *P. mori* Yokoyama (Ehara and Goth, 1992). Some mites were reexamined in accordance with this description and their identity as *P. citri* was confirmed.

Research carried out in Japan emphasizes the importance of studying the characteristics (e.g. host range and esterase isozymes) of *P. citri* populations occurring on different plants, including ornamentals. A new species living on *Osmanthus* spp. has recently been distinguished from *P. citri* and described as *Panonychus osmanthi* Ehara and Gotoh (Kitashima and Gotoh, 1995; Ehara and Gotoh, 1996; Osakabe and Komazaki, 1996a, 1996b). The different hosts of *P. citri* in northern Italy and southern Italy (mainly citrus) and the differences in climatic conditions between the former region and citrus growing areas, have promoted this study on the behaviour of the strain found on *P. laurocerasus*.

Materials and Methods

Laboratory studies

A study on the developmental success on various host plants of the mites belonging to the strain found on the cherry laurel in Padua was conducted in the laboratory. Adult females were reared on detached leaves placed in so-called arenas on a water-saturated cotton panel. A N-P-K solution (7-5-6) was used in order to improve leaf maintenance. The eggs obtained were used in experiments aiming to evaluate the development on four hosts: *P. laurocerasus*, *Pyrus serotina* Rehder var. *culta* Rehder, *Citrus aurantium* L., *Poncirus trifoliata* Raf. The eggs were placed on detached leaves of these plants at 27 ± 2 °C, $70 \pm 10\%$ R. H., 16:8 L:D. Observations were made every 24-48 h. A number of females that had developed on the different hosts were placed on fresh leaves for 14 days, at the same experimental conditions, to obtain preliminary data on oviposition. Data on development was analyzed by using analysis of variance and the means were separated using Duncan's test.

Field studies

Observations on the population dynamics of *P. citri* were carried out on *P. laurocerasus* hedges during 1992 and 1993. Three sites gave the most interesting data. The first two sites considered were situated along streets in two nearby squares in Padua (P. Salvemini, P. Stazione). In the latter, potted plants were considered. The third site was along the main road of a village (P. S. Nicolò), 10 kilometers from Padua. During 1992, samplings were carried out in two sites (P. Salvemini and P. S. Nicolò) while they were made on the three sites in 1993.

Observations were performed every week, usually from May to September, by collecting 50 leaves from each site. In the first sampling, 25 leaves that had developed in the previous year and 25 current-year leaves were collected. When the current-year leaves were fully developed, only the latter were sampled. The leaves were immediately transported to the laboratory in order to evaluate the densities of spider mites and of their potential predators. The different developmental stages of *P. citri* were divided into four classes (eggs, juveniles, males, females). Records of mites occurring on the two different leaf surfaces were also considered separately. The data was analyzed by using analysis of variance and the means were separated using Duncan's test.

Results

Geographic distribution

Records on the geographic distribution of *P. citri* were taken from 1988 to 1996. The species was recorded on *P. laurocerasus* in Piedmont (Turin and nearby areas), Lombardy (Milan), Venetia (several towns and small localities), Trent province (Borgo Valsugana, above the 46th parallel, is the northern limit), Friuli-Venezia Giulia (Udine, Pordenone), Emilia-Romagna (Bologna). The mite was frequently found in touristic seaside localities (e.g. Jesolo, Lignano, Bibione). In some sites *P. citri* occurred on other evergreen ornamentals such as *Jasminum officinale* L., *Elaeagnus pungens* Thunb. var. *maculata* Hort., *Elaeagnus ebbingei* Thunb. The symptoms varied from more or less severe leaf bronzing to stunted shoot growth, to leaf fall (especially on potted plants). In some cases, infestations were observed in several successive years.

Laboratory studies

Development was successfully completed on the four host plants. The data indirectly confirmed that this strain belonged to *P. citri* since *P. mori* is not able to develop on citrus (Shinkaji, 1961; Morimoto and Takafuji, 1983) with the exception of *P. trifoliata* (Osakabe, 1987). Developmental success varied from 51.59% (*P. trifoliata*) to 78.86% (*P. laurocerasus*). Values obtained on *C. aurantium* and *P. serotina* were intermediate (respectively 70.89% and 69.94%). Females developed faster ($P < 0.01$) on *P.*

laurocerasus and *P. serotina* (respectively 11.81 and 11.78 days) than on *C. aurantium* and *P. trifoliata* (respectively 13.06 and 13.23 days). The development of males was also significantly faster ($P < 0.01$) on *P. laurocerasus* and *P. serotina* (respectively 11.44 and 11.60 days) than on *P. trifoliata* (12.16 days) and *C. aurantium* (12.81 days). Preliminary data on oviposition showed values of 1–2 eggs/female/day on all plants during the period considered.

Field studies

P. Salvemini

Four different hedges were monitored but *P. citri* was constantly found on only one of them. During 1992 *P. citri* densities peaked in July reaching moderate levels. Females were much more abundant than males (Fig. 1). Predators (coccinellids, chrysopids and phytoseiids) were seldom collected, suggesting that the tetranychid decline observed in late July was related to other factors (e.g. leaf quality). Observations on leaves of different ages showed that tetranychids were more abundant on the current-year leaves (Figs 2, 3). Concerning eggs, means were significantly different ($P < 0.05$, on several dates (27 May, 4, 15, 25 June, 3 July) while differences in motile forms were found in the last four samplings. A higher number of eggs was layed on the leaf upper surface (Fig. 4), especially along the midrib, while juveniles and adult stages were some-

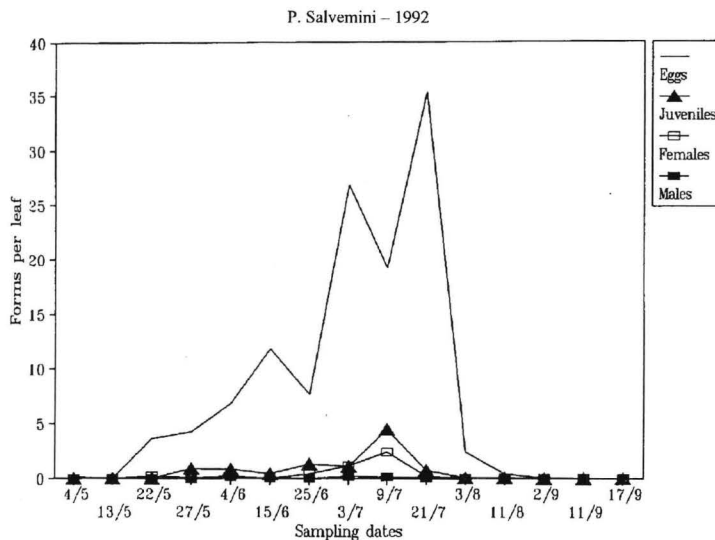


Fig. 1. Population dynamics of *P. citri* at *P. Salvemini* during 1992

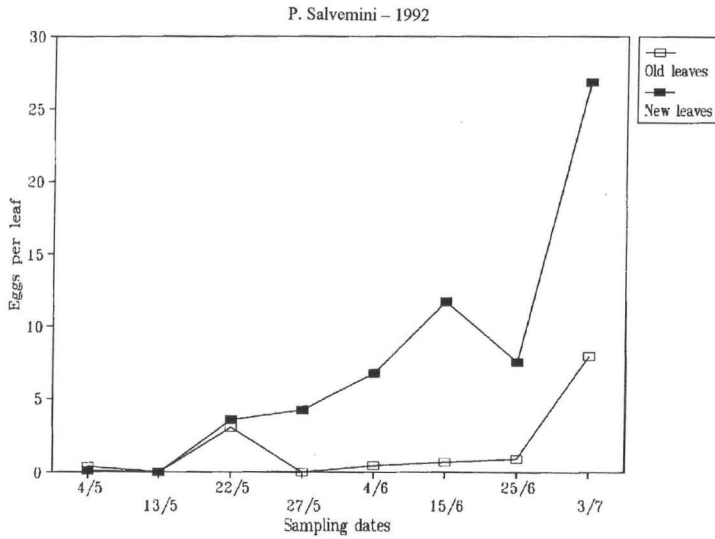


Fig. 2. *P. citri* eggs recorded on current-year (new) leaves or on old leaves at P. Salvemini during May–July 1992

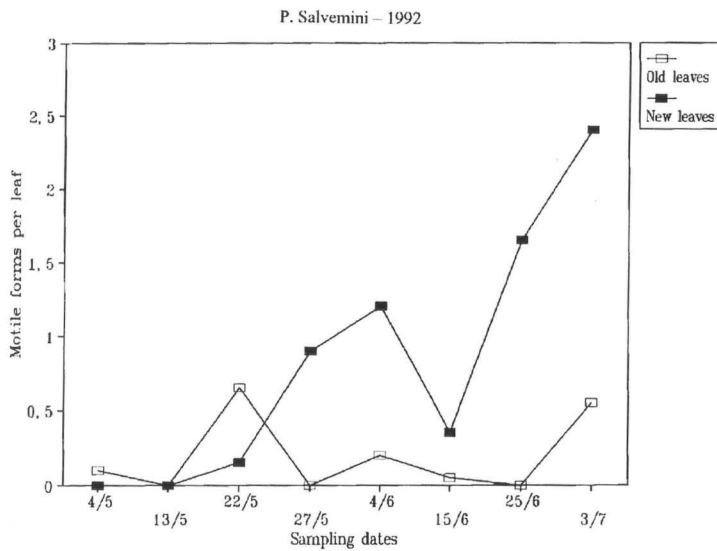


Fig. 3. *P. citri* motile forms recorded on current-year (new) leaves or on old leaves at P. Salvemini during May–July 1992

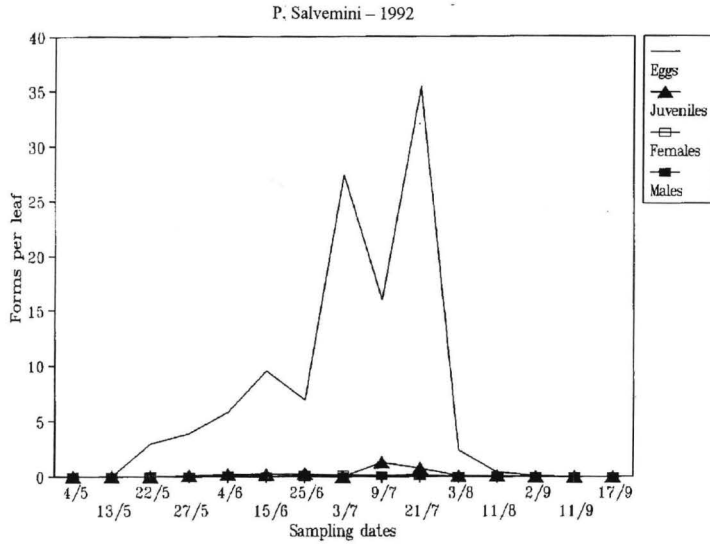


Fig. 4. Population dynamics of *P. citri* on the upper leaf surface at P. Salvemini during 1992

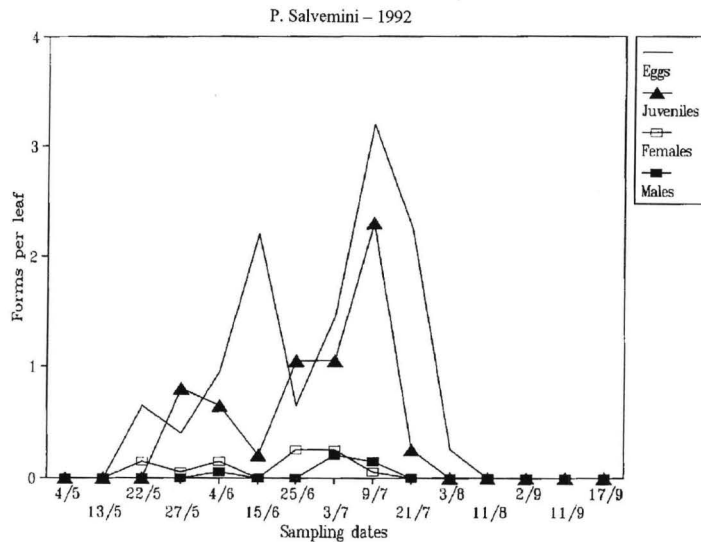


Fig. 5. Population dynamics of *P. citri* on the leaf undersurface at P. Salvemini during 1992

times more abundant on the leaf undersurface (Fig. 5). Concerning eggs, differences were significant ($P < 0.05$) on several dates (25 June, 3, 9, 21 July and 3 August) while, among motile forms, differences were recorded on 3 July. Low numbers of mites overwintered, and mostly in the egg stage.

One year later, *P. citri* populations increased in late May, reaching a peak during the first few days of June (Fig. 6). Some weeks later, mite densities dramatically declined but this phenomenon did not appear to be associated with predator activity. Sex-ratio was seen to be different than in the previous year, males being more abundant. A higher number of spider mites was recorded on the current-year leaves (Fig. 7). Differences in eggs or motile forms were significant ($P < 0.01$) on several occasions (18 and 25 May, 1, 8, 15 and 22 June). The higher abundance of eggs in the upper leaf surface and of juveniles and adults on the leaf undersurface was confirmed (Figs 8, 9). Concerning eggs and motile forms, means were significantly different ($P < 0.01$) on 25 May, 1, 8, 15 June. Egg values were also different on 29 June.

P. Stazione

Observations were carried out on potted plants during 1993. *P. citri* densities increased during the second half of May, peaking at the beginning of June (Fig. 10). Populations dramatically decreased, soon reaching low levels. The role of predators in controlling spider mites appeared to be negligible. In August a new increase of *P. citri* densities was observed but spider mites reached lower densities than in spring. Sex-ratio

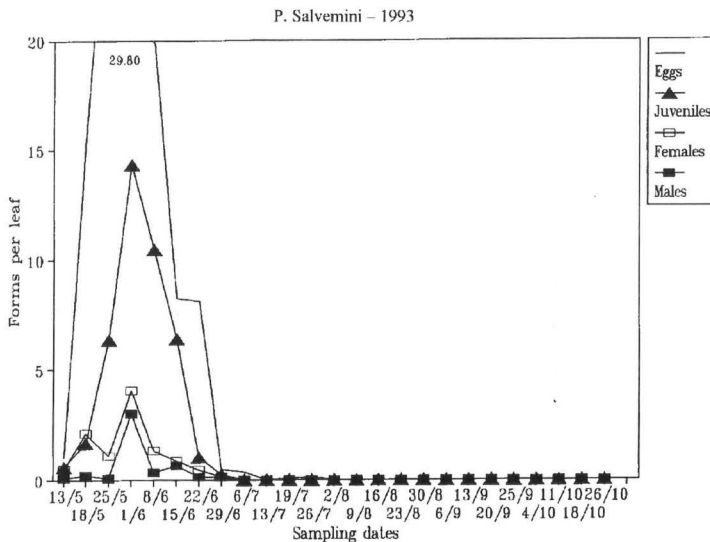


Fig. 6. Population dynamics of *P. citri* at P. Salvemini during 1993

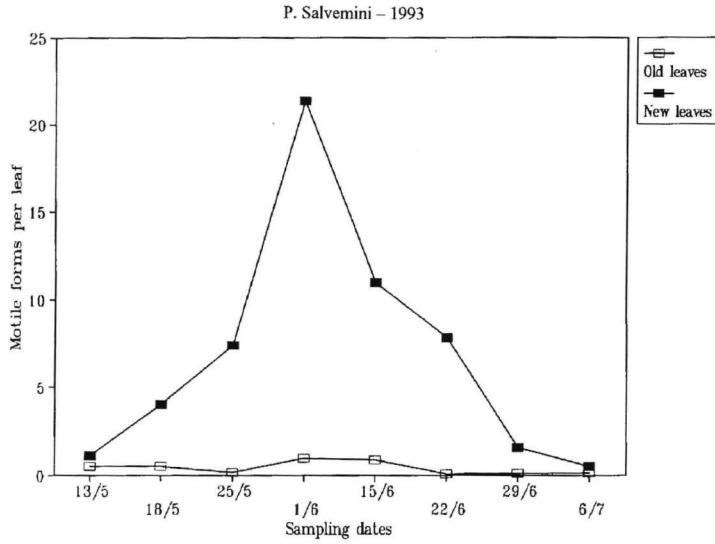


Fig. 7. *P. citri* motile forms recorded on current-year (new) leaves or on old leaves at P. Salvemini during May–July 1993

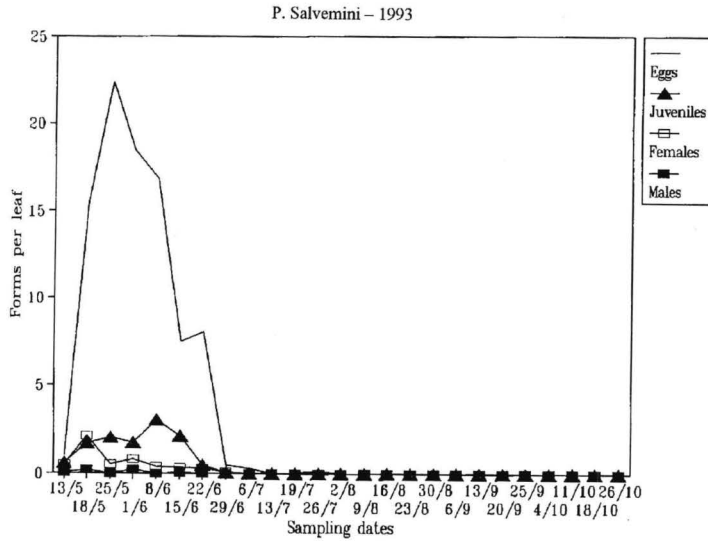


Fig. 8. Population dynamics of *P. citri* on the upper leaf surface at P. Salvemini during 1993

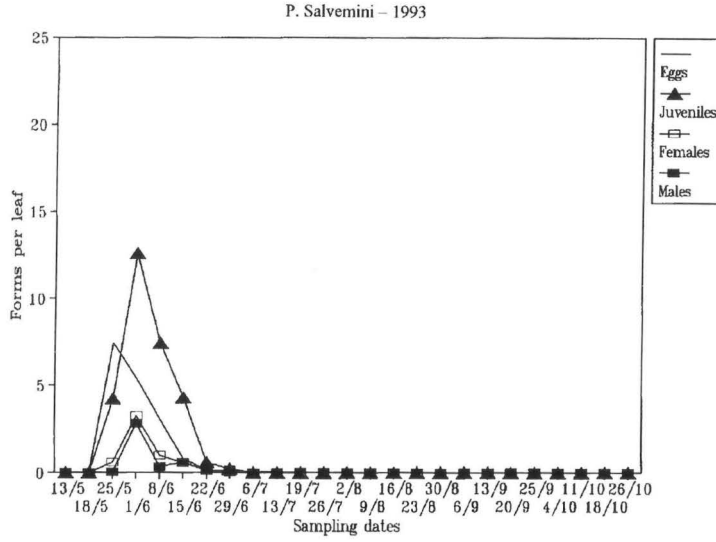


Fig. 9. Population dynamics of *P. citri* on the leaf undersurface at P. Salvemini during 1993

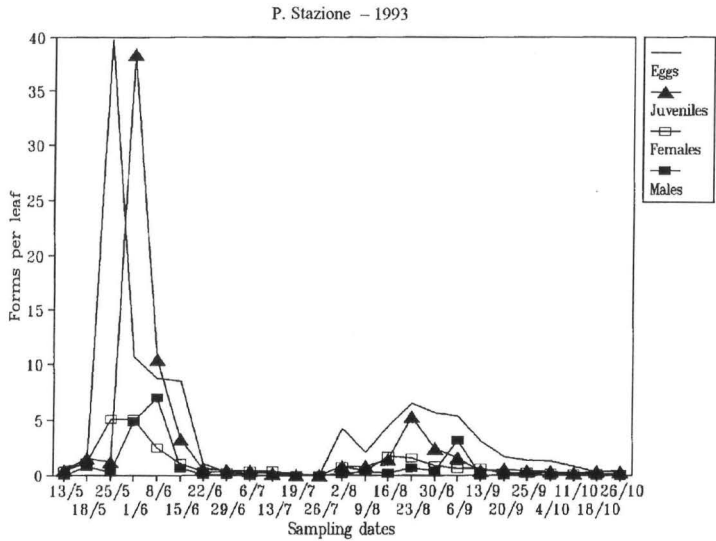


Fig. 10. Population dynamics of *P. citri* at P. Stazione during 1993

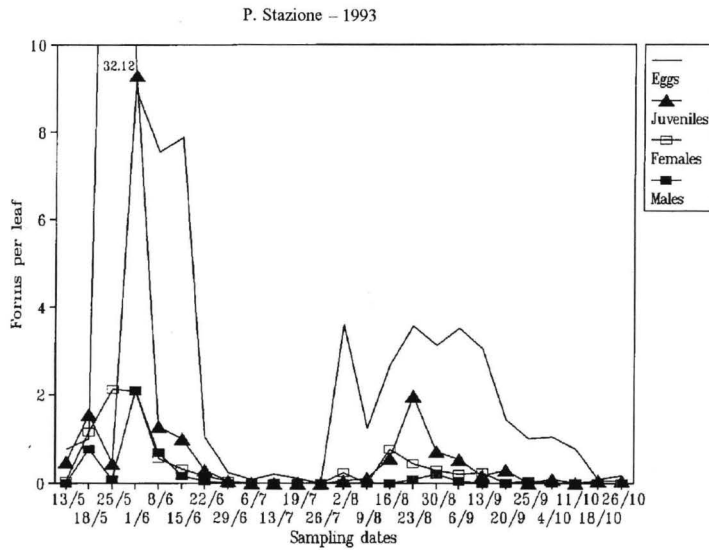


Fig. 11. Population dynamics of *P. citri* on the upper leaf surface at P. Stazione during 1993

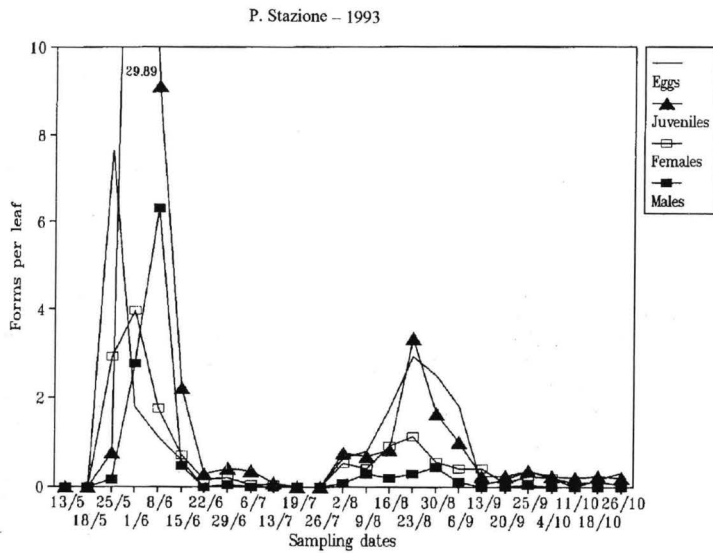


Fig. 12. Population dynamics of *P. citri* on the leaf undersurface at P. Stazione during 1993

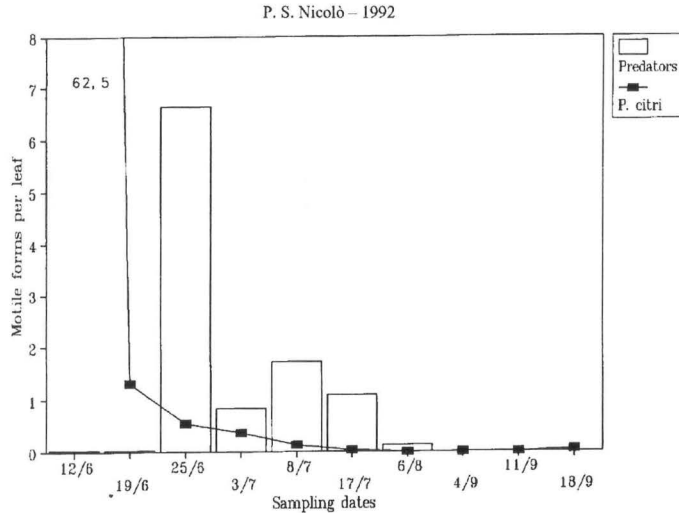


Fig. 13. Population dynamics of *P. citri* and of its predators at P. S. Nicolò during 1992

was higher than in other sites. A higher amount of eggs was laid on the upper leaf surface while motile forms were more abundant on the leaf undersurface (Figs 11, 12). Concerning eggs, means were significantly different ($P < 0.05$) on several dates (from 25 May to 22 June, 13 September, 4 and 11 October). Differences in the number of motile forms were frequently found (1 and 8 June, 6 July, 2 and 9 August).

P. S. Nicolò

In 1992 observations began in June, in correspondence with a high spider mite density on the leaves of one of the two hedges monitored (Fig. 13). Mites were rarely found in the second hedge, situated close to the first one. Some weeks later *P. citri* populations declined. The occurrence of a relevant number of predators was recorded during this phase, suggesting their potential role. The most frequent predators were a thrips, i.e. *Aelothrips* sp., and a phytoseiid, i.e. *Amblyseius finlandicus* (Oudemans). Some chrysopids and coccinellids were also observed preying upon spider mites. In the subsequent year *P. citri* populations reached negligible levels on both hedges.

Discussion

The developmental success of mites on *P. laurocerasus* was comparable with that recorded on *C. aurantium*. Preliminary data also showed that developmental times on cherry laurel were better than those observed on sour orange. These results could be

affected by strain history. However, the data supports the suitability of *P. laurocerasus* as a host and partly explain the widespread distribution of the pest in northern Italy where this plant is very frequent, while *C. aurantium* (and other citrus) cannot be cultivated, except in a few mild areas (e.g. Liguria), because of low winter temperatures.

The phenology of *P. citri* on *P. laurocerasus* showed a typical increase in late spring–early summer during the first vegetation growth while a second population increase was observed on potted plants only during mid-summer. The role of leaf quality (i.e. new vegetation) on population increases appeared to be clear. Field studies also indicated that *P. citri* densities decreased rapidly after peaks. The impact of natural enemies did not explain the population decline, except in one case. In contrast, in southern Italy as well as in various citrus growing areas, the complex of natural enemies is very effective in controlling *P. citri* especially when non-selective pesticides are not used (Viggiani, 1982; McMurtry, 1985; Benfatto and Vacante, 1986; Delrio, 1986).

Among factors affecting population dynamics on cherry laurel, the increase of summer temperatures, and probably the deterioration of leaf quality due to mite overcrowding, appeared to be more relevant than the impact of natural enemies.

On citrus, mite densities increase in spring, late summer and fall (Boyce, 1936; Ciampolini and Rota, 1973; Keetch, 1971a; Jeppson et al., 1975; Garcia-Mari et al., 1984). Climatic conditions play a significant role on the seasonal dynamics (Jeppson et al., 1957; Keetch, 1971b; Yasuda, 1980). In the laboratory, high mortality of immature stages occurs at temperatures above 30 °C (Delrio and Monagheddu, 1986). The pest prefers newly developed leaves to old ones and lay more eggs on uninfested leaves (Henderson and Holloway, 1942; Mijuskovic, 1974). Mite persistence is strongly affected by the degree of infestation as females disperse rapidly from severely infested leaves (Jeppson et al., 1957, 1961; Munger, 1963).

Therefore, the mite's seasonal dynamics on citrus and on cherry laurel shows common traits as regard its relation with leaf quality and vegetation growth phases.

The different ratio between eggs and motile forms on the two leaf undersurfaces, as observed on *P. laurocerasus*, might be explained by a different impact on the juveniles' survival by some environmental factors (e.g. temperature and R. H.). However, mite migration from one leaf surface to another should be monitored in order to understand this phenomenon.

Sex-ratio attained different values in the two first sites monitored and in particular the female proportion was higher for populations occurring in a garden (*P. Salvemini*) than for those living on isolated potted plants (*P. Stazione*). A detailed study carried out in Japan on citrus reported a higher sex-ratio in field populations than in those growing in a greenhouse. These differences may be attributed to environmental factors, plant physiology or mite population density (Yasuda, 1980). Results showed that, within a garden, certain plants were infested during successive years while the pest was virtually absent in others. Potted plants are frequently infested, probably because the impact of limiting factors is lower.

Prior to this contribution, the northern limit of *P. citri* in Italy was the Latina area, situated between the 41st and the 42nd parallels (Ciampolini and Rota, 1973) and in

western Europe it appeared to be the Montpellier area, below the 44th parallel (Fauvel and Cotton, 1986). Therefore, the records obtained in the present study (in particular Borgo Valsugana, above the 46th parallel) represent the northern limit of the species in western Europe. In eastern European countries, the pest distribution is not well documented (Anonymous, 1965).

The widespread distribution of *P. citri* in northern Italy is currently restricted to evergreen ornamentals but the species is well known as a polyphagous pest (Ashihara, 1987; Osakabe, 1987). In Japan, *P. citri* populations can survive on *Ilex crenata* Thunb. and migrate on pears where mite densities peak in late summer (Kunimoto et al., 1993). The occurrence of *P. citri* in northern Italy should be carefully monitored as the cultivation of some of preferred hosts of *P. citri*, e.g. Japanese pear, is increasing in some areas.

Among the different factors affecting the spread of the pest in northern Italy, climate – *P. citri* interactions should be investigated more thoroughly. Mite occurrence in the towns would be allowed by higher winter temperatures in urban areas but severe infestations were also recorded in the country, especially along the main roads. Apparently, the winter temperatures occurring in the last decade in northern Italy did not affect pest survival. It is well known that *P. citri* motile forms can tolerate sudden temperature drops (Simanton, 1965). In southern France, infestations on *P. laurocerasus* were observed in a season following very low winter temperatures, i.e. minimal values attained -9°C (Fauvel and Cotton, 1986). In January 1997 a number of juveniles, males and females was found to be still active on *J. officinale* potted plants despite the fact that the temperatures had reached minimal values of -7°C for some days, three weeks before.

Pollution appears to be a common trait giving an advantage to the pest in urban areas and in the country, as infestations are commonly observed on plants with dusty leaves.

Recently, *Dialeurodes citri* (Ashm.), a pest of citrus in southern Italy and in various growing areas, has been commonly found on some evergreen ornamentals (e.g. *Ligustrum* spp.) in northern Italy (Arzone and Vidano, 1990; Duso, unpublished data). The increasing winter temperatures of the last decades may be considered one of the most important factors to allow the establishment of *P. citri* and *D. citri* in northern Italy. However, their spreading is certainly favoured by the fact that they feed on evergreen ornamentals that are more resistant to cold conditions than citrus.

The repeated infestations recorded in several sites and the wide pest distribution suggest that the spread of *P. citri* (and probably *D. citri*) to northern Italy is not recent. In accordance with Fauvel and Cotton (1986), nurseries may have an important role in pest dispersion.

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