# Integrated Pest Management in Italian Citriculture

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## Abstract

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Several indigenous species belonging to different zoological groups, mostly arthropods, are injurious to citrus-groves in Italy. In addition, the introduction of exotic species, insects and mites, has frequently occurred in the last thirty years changing the composition of the naturall pre-existing citrus pests fauna. Investigations carried out by pubblic scientific institutions, followed by demonstration trials, have showed the efficacy both of the supervised and of integrated management measures. Some biological control practices have also revealed an economic validity against numerous key insects attacking citrus-groves.

According to the recent available data, the Italian Citriculture acreage distribution is summarized in Table 1.

**Table 1.** The Italian citriculture acreage distribution (in hecteres)

| | ITALY | | SICILY | |
|---|---|---|---|---|
| Variety | Young Plantings | Productive Orchards | Young Plantings | Productive Orchards |
| Orange | 3,675 | 107,402 | 606 | 65,090 |
| Tangerine | 221 | 12,029 | 15 | 7,893 |
| Lemon | 333 | 37,767 | 62 | 34,007 |
| Clementine | 1,635 | 19,183 | 62 | 4,806 |
| Grapefruit | 29 | 222 | --- | 70 |
| Total | 5,893 | 176,603 | 745 | 111,866 |
| Grad Total | 182,496 | | 112,611 | |

Data from Statistiche dell'agricoltura (ISTAT), 1994

The control measures against citrus pests in Italy, similar to other countries of the Mediterranean Basin where such cultivations is of economic importance, is an important component of the cultural practices applied by farmers.

The main reasons are due to: 1) the pests' biodiversities; 2) the frequent "accidental introduction" of exotic pests that change the composition of the previous existing pests' fauna. Usually they spread without their natural antagonists, rapidly multiply and disperse in the new areas. Consequently in a short time, new control measures are needed involving the previous equilibrium pest management; 3) the correct selection and application of pesticides; 4) the side effects on the citrus biocenosis, derived from the simplification of the agroecosystem, mostly caused by those chemical practices which eradicate all the synantropic vegetation, seen only as a competitor for the soil nutrients.

**Phytophagous biocenosis of *Citrus* spp. in Italy**. Other than pathogens, the number of all other organisms related to citrus cultivations covers a complex of 95 species belonging to different zoological groups, only 15 may reach the level of economically important species. Among them, insects play the major role followed by mites. Few are of secondary importance and often they have only a local interest. Some nematodes, molluscs and rodents also occur, but their importance is rather marginal.

**Nematodes**. Few species have been recorded in Italy (20) of which the most common is *Tylenchulus semipenetrans* Cobb. Nevertheless no particular control measures are usually applied on infested trees.

**Rodents.** The wild rabbit, field mice and rats may occasionally be noxious, mostly in some citrus orchards where farmers remain absent for long time (personal observations). Particular control measures are in some cases required (13, 37).

**Snails and slugs.** Occasionally damaging either leaves or fruits, snails and slugs are controlled by using acetic methaldeid pellets (13).

**Mites**. Among the several species recorded (34), few require particular attention and often they are only of local interest, e.g. *Panonychus citri* (Mc.Gr.) and *Tetranychus urticae* Koch. The citrus bud mite *Eriophyes sheldoni* Ew., however, provokes severe damages, particularly on lemon trees, but it is well controlled by oil spray. The former two species may reach sometimes high population levels on all citrus species and their hybrids, mostly during end of summer and early autumn, due to favourable climatic conditions. On the other hand, Ragusa (33), through a study carried out for 5 years on an unsprayed lemon orchard in Sicily had found that *T.urticae* was naturally maintained for 5 years under economic threshold level by the trophic activities of the indigenous Phytoseiid mites, represented by a complex of 18 species. *E. sheldoni* had reached in some years high levels (Fig. 1 and 2). These results support the authors' view (48, 49) to avoid the use of non-selective pesticides, especially those provoking trophobiosis effect on phytophagous mites, or adversely affect Phytoseiid and other mites predators. On the other hand the study of Hmimina *et al.* (16) have also stressed the role played by some elements of the synantropic vegetation as pasture of *T. urticae* on which the predators develop naturally and control the mite populations infesting citrus trees.

**Beetles**. Numerous species have been recorded, but their economic value is negligible. Local infestation in young plantings, due to *Otiorrhynchus cribricollis* Gyll., or other similar species, sometimes occur during May-June. In such cases, sticky rings on citrus tree trunk is suggested to avoid the use of pesticides.

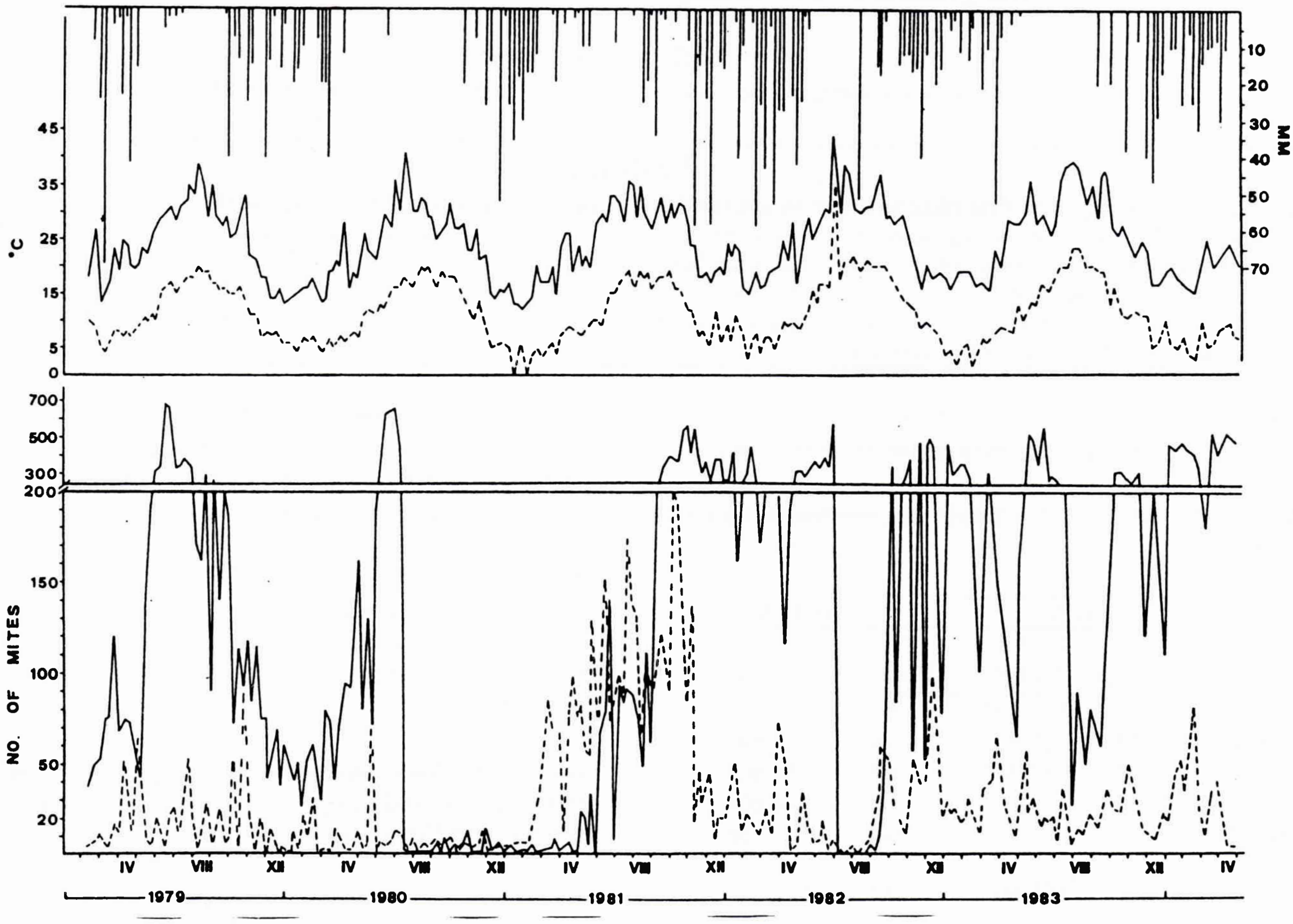


**Figure 1.** Weekly fluctuations in the population of *Amblyseius stipulatus* Athias-Henriot during February 1979 -March 1984. Reproduced from Ragusa (33).

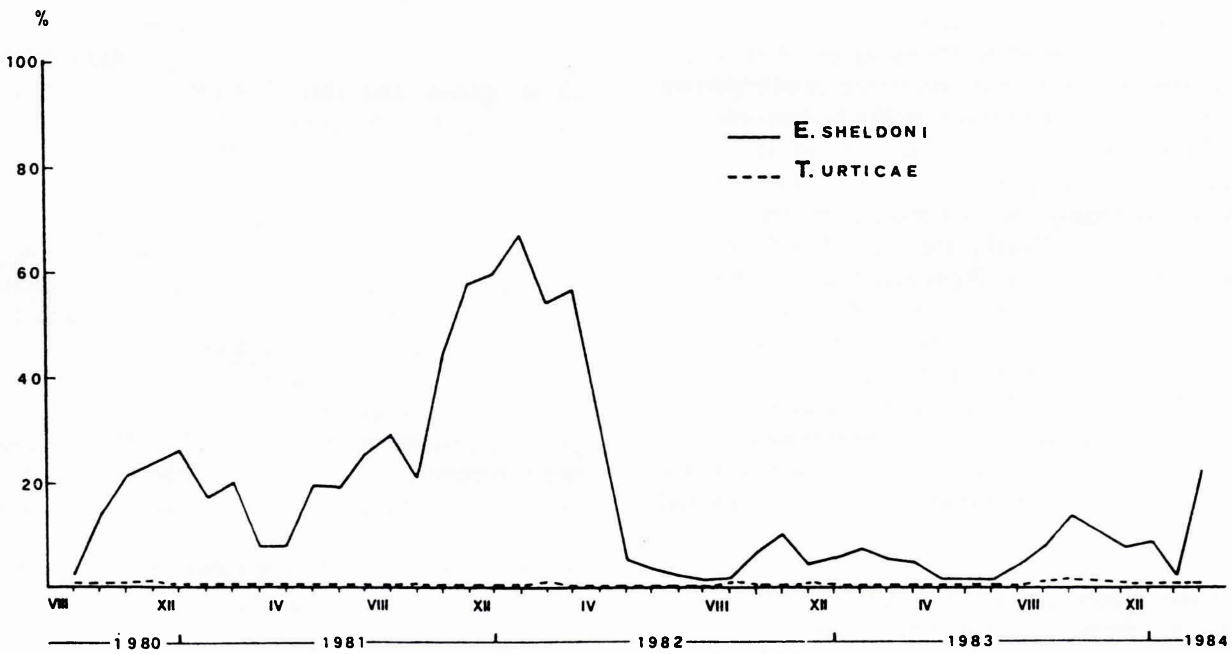


**Figure 2.** Fluctuations in populations of the two-spotted spider (*Tetranychus urticae* Koch) and of the citrus bud mite (*Eriophyes sheldoni* Ewing). From reproduced Ragusa (33).

**Bugs and leafhoppers.** The flower bug, *Calocoris trivialis* (Costa), damages both orange new sprouts and flower buds while the cotton leafhopper, *Asymmetrasca decedens* (Paoli) attacks the orange and tangerine fruits producing "oleocellosis" spots on their epicarp. Both insects have a local interest only in Western Sicily. *Tetrastichus miridivorus* Dom. and *Telenomus lopicida* Silv. may naturally parasitisize up to 70% of the flower bug eggs.

**Thrips.** Few species of thrips were recorded as living on citrus groves (21) and the greenhouse thrips *Heliothrips* *haemorroidalis* Bouchè and *Thrips tabaci* Lind. are the most common. No specific control measure is required.

**Whiteflies.** Three species were "accidentally" introduced in the past thirty years: *Dialeurodes citri* (Ashm.), *Aleurothrixus floccosus* (Mask.) and *Parabemisia myricae* (Kuw.). At the present time they are of negligible economic importance due to the control achieved by the introduction and release of some exotic hymenopterous wasps, namely: *Encarsia lahorensis* (How.) *vs.* the citrus whitefly (50); *Cales noacki* (How.) and *Amitus spiniferus* Brethés *vs.* the whoolly whitefly, *Eretmocerus debachi* Rose et Rosen *vs.* the japanese bayberry whitefly (38).

**Flies**. The Mediterranean fruit fly, *Ceratitis capitata* Wied. still remains a pest affecting orange, tangerine and clementine groves. Its adults population is controlled by using poisoned bait-sprays of protein-hydrolysate, supported by population monitoring by using chromotropic or pheromonic traps (12, 31). Lately, strong cryticism has been made against these methods due to the evidence of catching a rather large number of natural antagonists (52, 53).

**Aphids**. Of a dozen of species known as infesting *Citrus* spp. in Italy (2), *Aphis gossypii* Glov., *A. spiraecola* Patch (= *citricola* auct., nec V.d.G.) and *Toxoptera aurantii* (B.d.F.) may reach economic importance. The former two species are very rare on lemon. Furthermore, of all three, the green citrus aphid undoubtly is the most dangerous because its indigenous complex of antagonists are poor natural biological control agents. Consequently, both in old and young tree plantings, chemical control measures are sometimes required. On the contrary, usually no chemical sprays are used against *A. gossypii* and *T. aurantii*, being well controlled by their natural antagonists. It is worth mentioning that with regard to the cotton aphid there is some evidence that there have apparently been selective aphicide resistent strains.

Concerning aphids natural antagonists complex, the most significant in the Mediterranean Basin, is the presence of numerous Aphidiid wasps (either indigenous or exotic). It is also known that citrus cultivation is elsewhere accompanied by a synantropic vegetation regularly looked at as competitive elements which are eliminated through the year by the cultural practices used by farmers. In the Sicilian citrus groves the composition of such a flora and its occurrence through the year have been studied by botanists (6, 32, 35, 45) who listed more than 200 subgeneric taxa.

In our institution some researchers since 1996 are involved in the development of a program that look at the eventual existing relationships between the arthropode fauna of such a synantropic cover and that of the citrus groves. Due to the short time since this program has started, only *Parietaria* spp. (Urticaceae) and other few botanical species have been partially explored.

Mineo *et al.* (26, 27) have found that *Aphis parietariae* Theob., monophagous and then indifferent to other target plants, should represent a "chronic polyspecific reservoir" (*sensu* 42) of the mentioned braconids (Fig 3), and most probably such a list of species in future observations could be enriched by other species. In fact for the same aphid, Stary (43) quotes other aphidiid wasps not so far intercepted during our work. It could be of interest to outline other three natural reservoirs of Aphidiids whose hosts infest plants that in some way could be related to citrus agroecosystems. The first is *Aphis nerii* B. d. F. on *Nerium oleander* L. from which *Lysiphlebus ambiguus* (Haliday), *L. fabarum* (Marsh.) and *Trioxy angelicae* (Haliday) (42) were bred; the second is *Aphis hederae* Kaltenbach on *Hedera helix* L. from which Ippolito and Parenzan (17) have bred *L. testaceipes; the* third is *Aphis solanella* Theobald on *Solanum nigra* from which Ben Halima-Kamel (4) has found more than 70% of parasitism due to *L. confusus*. It must be pointed out that all the above wasps are known to parasitisize the main aphid pests in Italy (46).

**Scales**. Of the about 20 species infesting citrus groves, only the coccid *Planococcus citri* (Risso) is frequently a severe pest. Nevertheless, if the indigeneous complex of natural antagonists is fortified by the action of *Leptomastix dactylopii* How., mass-reared in insectary, then the citrus mealybug becomes efficiently controlled below the economic threshold level. Such a wasp, being however unable to overwinter, annual inoculative releases, in early spring, are needed in citrus groves.

Several species of Aphelinid wasps, *Aphytis* spp. and *Encarsia* spp., some of which are of exotic origin, such as *A. melinus* De Bach, ensure a satisfactory natural control against armoured scales (*Cornuaspis beekii* New.; *Aonidiella aurantii* Mask.; *Aspidiotus nerii* Bouchè, *Insulaspis gloverii* Pack., etc.) infesting citrus trees; however in the event that some of them could become dangerous, oil sprays are prefered for their chemical control. As already mentioned, a selective insecticide is used whenever the black scale (*Saissetia oleae* Oliv.) population requires to be controlled.

**Moths**. Only two Lepidoptera species actually are harmful: the citrus flower moth (*Prays citri* Mill.) and the citrus leaf miner (*CLM*) (*Phyllocnistis citrella* St.), both have a high number of generations per year. *Pr. citri* known as having only *Citrus* spp. as host, recently has also been observed attacking flowers and young fruits both of *Casimiroa edulis* Llave et Lez (Rutaceae) and of *Ligustrum lucidum* Ait. f. (Oleaceae) (39). Its infestation reaches an intervention threshold only in lemon orchards during late summer vegetative flush, derived after irrigation to break the water-stress to which the plants were previously submitted to, when flowers give rise to the so called "verdelli" fruits. To control the pest, it is recommended to the farmers to use cultural practices, whenever possible, in a way to have the mass of flowers produced not later than the last ten days of July. In fact it has been ascertained (25) that during the previous long water stress period, the *Pr. citri* population cannot increase because of the lack of susceptible tissue (e.g. bottoms or buds) for egg laying. Due to this and to the high temperatures that strongly reduce the life span of adults (23), a population knock-down occurs. Consequently, most flowers developing during this lack of adult population escape infestation with citrus flower moth.

The synthetic sexual pheromone, either for mass-trapping or male disruption, has been also tested in some trials by Sternlicht (44) and by Mineo (unpublished data). Nevertheless, satisfactory economic results are not yet available. Inoculative releases trial of *Ageniaspis fuscicollis* Dalm. var. *praysincola* Silv. whose strain was bred on the olive flower moth (*Prays oleae* Bern.) and later multiplied on *Acrolepia assectella* Zeller in laboratory, in a lemon orchard infested by the citrus flower moth, reached in less than 3 weeks from the Encyrtid wasps release, a high level of parasitism (more than 90%) (24).

*Phyllocnistis citrella* has been "accidentally" introduced in 1995 and rapidly dispersed elsewhere. The damage concerns mainly nursery production, top-grafted plants and young plantings. The phenology of infestation and relative sites of different preimmaginal stages has been studied by Caleca et *al.* (8) in an unsprayed lemon grove in a lemon area regularly submitted to "forzatura" (water stress to get, as mentioned above, vegetative flush that gives rise to summer fruits "verdelli"), in order to evaluate the level of *CLM* attacks both on spring and on summer flushes. Figure 4 shows the trend of flushing from 2$^{nd}$ ten days of March to the last ten days of October 1996. The spring and summer flushes are estimated at 44 and 53% of the total amount of the annual vegetative growth, respectively.

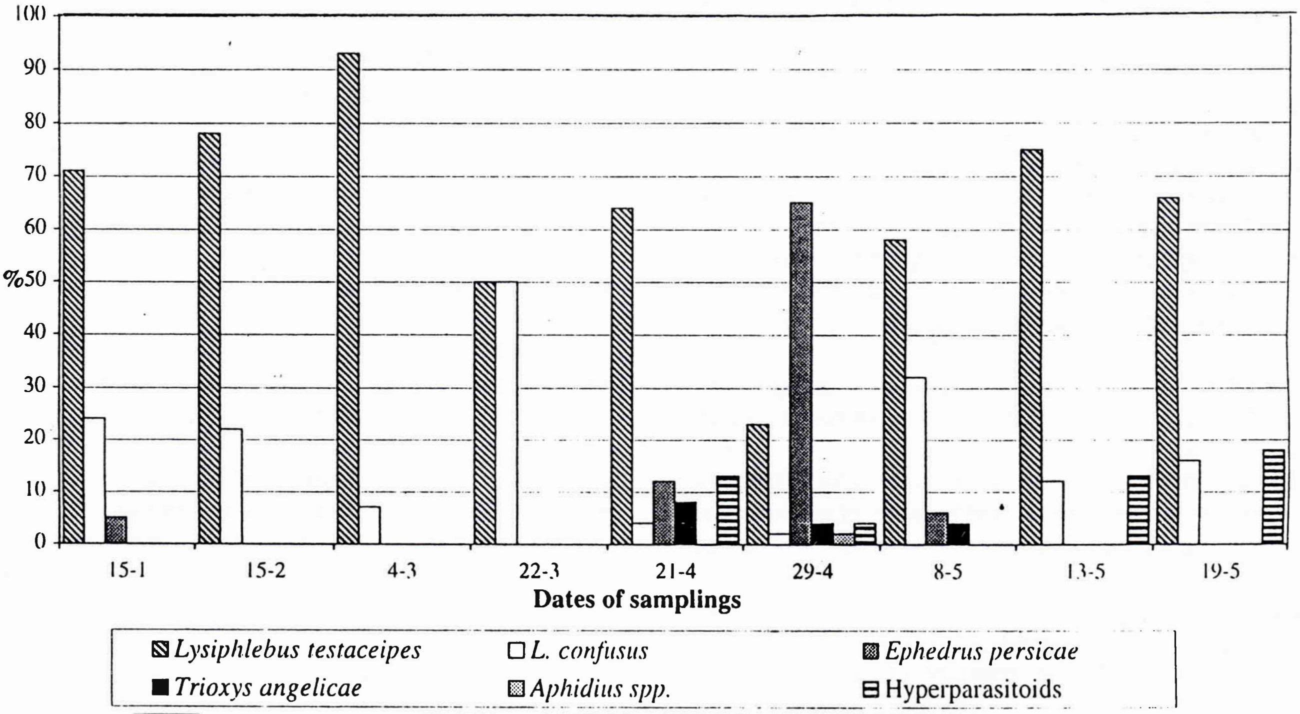


**Figure 3.** Relative abundance of Aphidiid species emerged from *Aphis parietariae* and of their hyperparasitoids represented on the whole. Reproduced from Mineo *et al.*, (27).

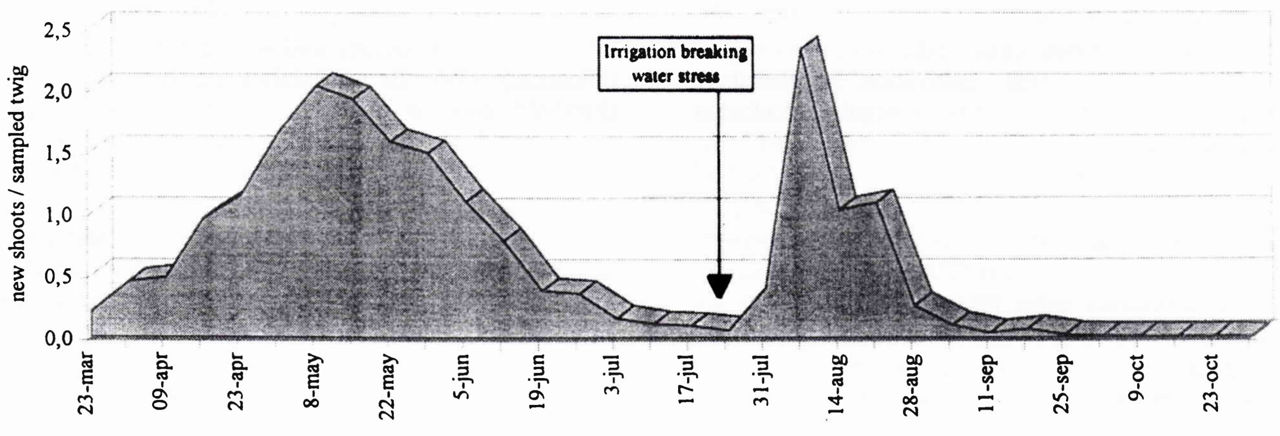


**Figure 4.** Trend of flushes in a lemon grove in which water stress to produce summer fruits is applied. Reproduced from Caleca *et al.* (8).

Taking into account the different levels of development of leaves constituing the same shoot, 4 arbitrary length categories have been considered at the time of their examination under the microscope i.e.: 1$^{st}$ = 0,5-1 cm; 2$^{nd}$ = 1-3 cm; 3$^{rd}$= 3.5 cm; 4$^{th}$= 5 cm. The results obtained are summarized in Figure 5. They show that 87% of eggs were laid on 1$^{st}$ + 2$^{nd}$ leaves, whereas 13% of the eggs were laid on leaves of the 3$^{rd}$ category. Such results are in agreement with those observed by Garrido Vivas and Gascon Lopez (15) on the shoots of *cvs.* Navel, Fortune and Clementine, or by Santana et *al.* (36). The highest percentage of pupae was found on leaves of 4$^{th}$ category (78%); and the remaining

22% was distributed on the of 2nd (3%) and 3rd (19%) leaf categoies, respectively.

The natural antagonists of the *CLM* is not more than a dozen of indigenous Eulophid wasps (5, 8, 19, 51). In addition, some predators (*Orius* sp. and *Chrysopa* sp.) have also been intercepted. Nevertheless their cumulative efficacy remains far from satisfactory as biological control agents.

The phenology of adult population obtained, by using unbaited traps is compared with that of new vegetation and preimaginal stages per leaf (Fig. 6) (7). The number of preimaginal stages reached a maximum in the periods in which the availability of the susceptible biomass for the egg laying of *CLM* becomes rather rare. Between the two vegetative flushes, the one which was subjected more to *CLM* attack was the summer flush. In fact while spring flushes suffered 14% infestation, the shoots emerged after irrigation to break water stress suffered 70% infestation with *CLM*. The infestation level reported in Sicily on spring flush (8) is similar to what has been reported by several authors from other citrus areas of the world (1, 14, 18, 47). Applying the method of Knapp et *al.* (18), based on the number of *CLM* larvae per infested leaf, Caleca et *al.* (8) estimated the percentage of damaged leaf surface of 6 and 41% on spring and summer shoots, respectively (Fig. 7). It is of interest to note that the effect of water stress on *CLM* population on summer shoots seems very similar to that described for citrus flower moth.

**Citrus pest management: present status.** From the time the negative side effects caused by spraying synthetic compounds in citrus groves, alternative joint research programmes were promoted by different scientific institutions in citrus growing areas. With the aim of outlining economic thresholds as well as sampling methodologies for estimation of pest population densities, the C.E.C. supported in the past several Working Groups to collaborate in this field of research (11).

The guideline represented in Table 2 summarized the data to be acquired before establishing the intervention thresholds for the main citrus pests. To achieve this, different sampling methodologies are recommended; visual, laboratory and biothecnic methods. The use of the first and second methods is recommended on 5-10% of trees and according to the periods of the year when plant parts susceptible to attack(s) by target pest(s) are available.

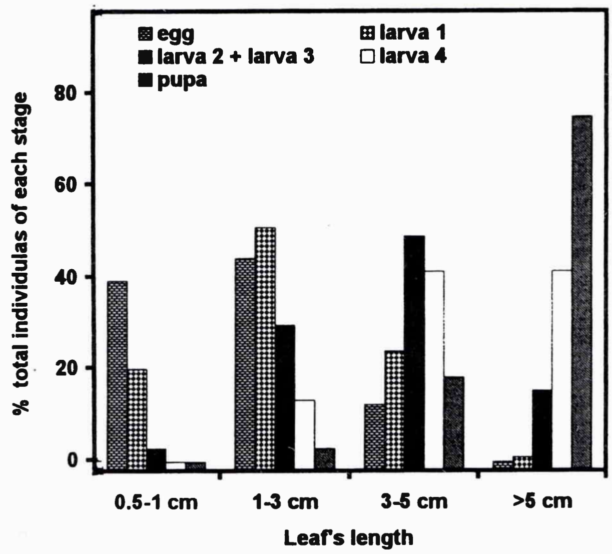


**Figure 5.** Frequenc of preimmaginal stages of *Ph. citrella* on lemon leaves of various sizes. Reproduced from Caleca et *al.* (8).

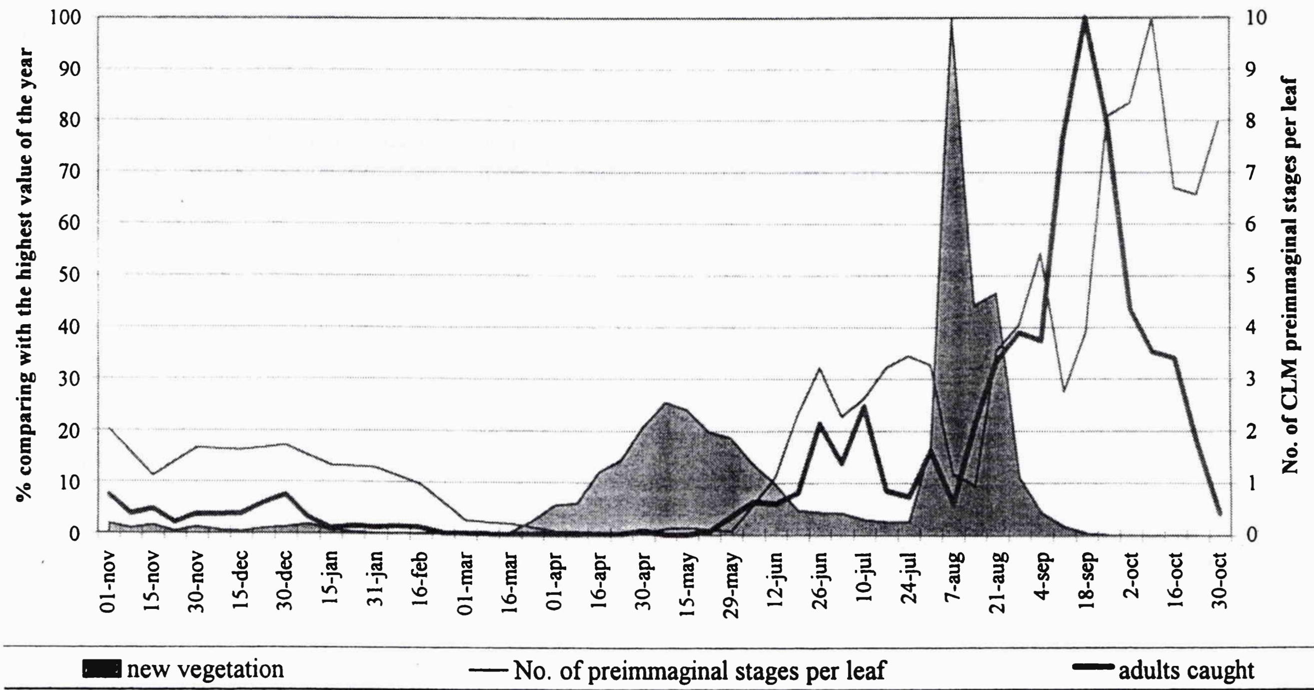


**Figure 6.** Comparison among new vegetative growth, number of individuals of preimmaginal stages of *Ph. citrella* per leaf, and captures of adults by unbaited sticky traps, in a water stressed lemon grove to produce summer fruits. Modified after Caleca et *al.*, (8).

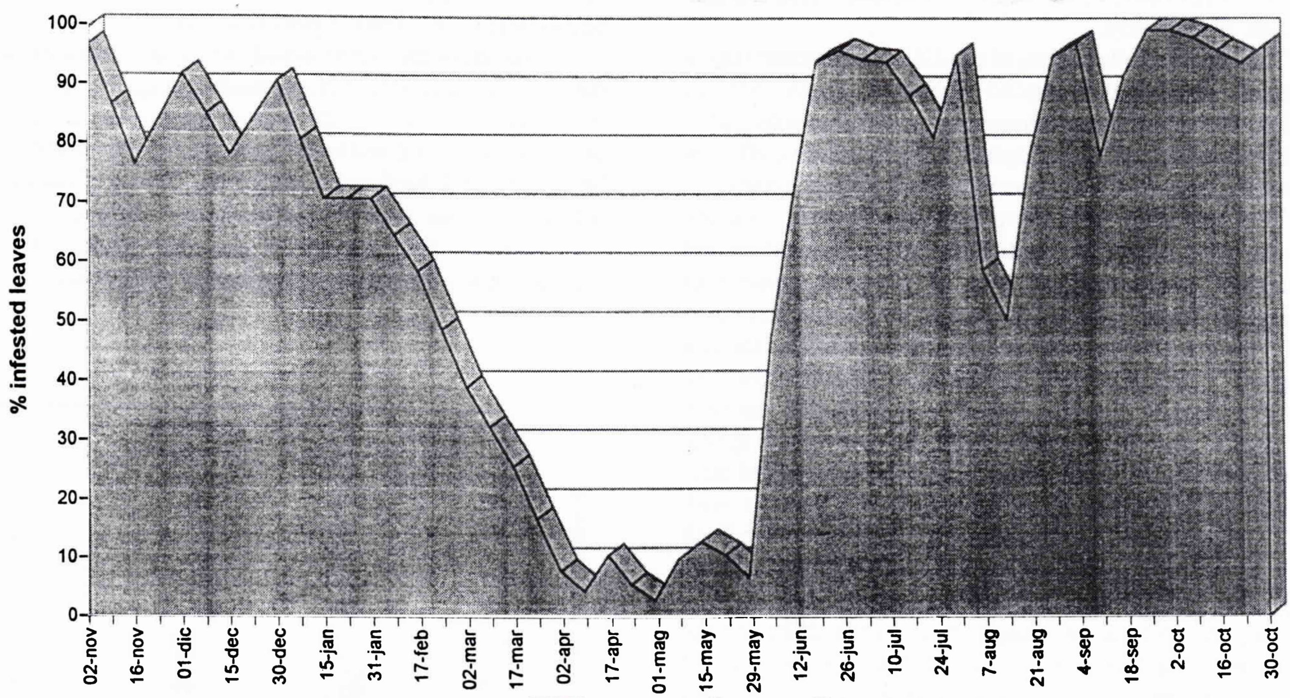


**Figure 7.** Trend of percentage of tender leaves infested by citrus leaf miner in a lemon grove of Western Sicily (samples consisting of leaves of four different size). Reproduced from Caleca *et al.* (8).

From the time when the supervised control is applied according to the guidelines presented in Table 2, citrus pest management was oriented by both researchers and technicians to mostly reduce the noxious effects of traditional chemical control. On the other hand, such operative management was also encouraged and stressed from the increasing number of consumers that requested "biologically" or "organically" produced food products.

To promote high quality food, the C.E.C. established regulations in 1991 to encourage farmers to produce "biological" products. Such regulations provide farmers with a bonus of 1400 US$ per hectare for biologically produced products and 700 US$ when farmers follow the option of supervised control. It is important to note that the check of such pest control management is made by the regional public administrative institutions close to where farmer's option must formerly be communicated and which also certifies the final sanitary status of the food product.

According to the data, courtesey of the Environment Service Section of the Assessorato all'Agricoltura e Foreste of the Sicilian Region, in 1995 the C.E.C. bonus covered 15285.89 hectares of which 11960.31 hectares followed the supervised control option.

Before 1995, citrus pest management had reached a certain degree of stability. In fact, except from specific interventions against some pests like *Ceratitis capitata*, mostly to protect early *cvs.* productions of orange and clementine groves, or local measures for other species (e.g. *Prays citri* and some red mite), stability of all the other pests was generally ensured through the natural control by pest antagonists (indigenous or exotic) integrated with the use of oils, whenever necessary. In some other cases (e.g. *Planococcus citri*) the pest population below the economic threshold level was obtained by the inoculative release of the termitophilous Encyrtid *L. dactylopii* (Table 3).

Shortly after the accidental introduction of *Phyllocnistis citrella*, the strategy shown on Table 3 has reached a critical point, mostly because of the negative effects caused by the use of long lasting synthetic compounds. Intensive studies on the biology of *CLM* (8) as well as field trials concerning the efficacy of unregistered and registered pesticides, was carried out by several workers (5, 22, 30). In 1997, field trials was carried out on a young lemon orchard, submitted to water-stress, looking at both the efficacy and side effects against natural indigenous antagonists. The experiment lasted 35 days (30/7 - 5/9/97) and some results were obtained (26).

The data presented in Table 4 show that no significant difference in efficacy of different compunds to control *CLM* was obtained. As for their side effects against the natural antagonists, no significant difference between the control and the used insecticides was observed (Table 5).

Antagonists were mostly Eulophid wasps, being the other known entomophagous species of parasitoids and predators of *CLM*, occasionally intercepted at all their stages. Some larvae of Chrysopids as well as some preimmaginal and adult stages of *Orius* sp. were also present. It could be of interest to point out that in all the blocs, the emerged parasitoids from *CLM* infested shoots almost always belonged to *Cirrospilus pictus* (Nees), followed by a very few number of both *Cirrospilus diallus* (Walk.) and *Pnigalio agraules* (Walk.). Furthermore, *Cirrospilus vittatus* Walk., was intercepted in few individuals during spring flush at the end of June, but never found later.

Based on the above results it can be concluded that only one spray was not sufficient to reduced *CLM* larval trophic activity to preserve almost all the photosynthetic activity of the leaves.

Data presented in Table 6 confirm the authors' criticism derived from the use of monitoring traps. *C. diallus*, *C. pictus* and *P. agraules*, as already mentioned, belong to the natural complex of *CLM*' antagonists.

**Some considerations.** With the aim to maintain the previous picture of IPM in citrus groves where such system was consolidated, the interventions against *CLM* should only be considered when damage to the leaf's surface might reduce the yield of productive trees. At the present time, attention should be focused to protect young plantings and reduce the negative effects on the previous consolidated equilibrium of the arthropod fauna. Studies concerning the biology of this leaf-miner suggested that, such control measures should only involve summer flush. Since females of *Ph. citrella* prefer to lay eggs on 0.5-3.5 cm long leaves and that during July-August it takes about one month for a newly developed leaf to reach 5-5.5 cm long, not more than two well timed highly selective sprays (at least one with oil) are needed to ensure an acceptable leafs surface protection.

Similar to other citrus producing countries, research programs in Italy are looking at the biological control against *CLM*, by introducing exotic, mostly Hymenoptera, entomophagous insects: *Ageniaspis citricola* Logvinovskaya and *Quadrastichus* sp. are the first two candidates for this purpose (40, 41).

**Table 2.** Economic thresholds and sampling methods proposed for the main citrus pests, modified after Barbagallo et *al.*, (3).

| Group and Species | Intervention threshold | Sampling methodology | Monitoring survey period |
|---|---|---|---|
| **Aphids** | | | |
| *Aphis spiraecola* | 5-10 % infested shoots | Visual weekly examination | Flushing period |
| *Aphis gossypii* | 25 % infested shoots | Visual weekly exam. | Flushing period |
| *Toxoptera aurantii* | 25 % infested shoots | Visual weekly exam. | Flushing period |
| **Whiteflies** | | | |
| *Dialeurodes citri* | 5-10 nymphs/leaf on mandarine-like<br>20-30 nymphs/leaf on orange and lemon | Laboratory exam. on samples of 5-10 leaves/plant | Late spring, summer and winter |
| *Aleurothrixus floccosus* | first colonies occurrence | Visual survey of sprouts | From late spring to autumn |
| *Parabemisia myricae* | first colonies occurrence | Visual survey of sprouts | Flushing period |
| **Mealybugs** | | | |
| *Planococcus citri* | 5-10 % inf. fruits (summer)<br>15 % inf. Fruits (autumn) | Visual exam. Every 20 days of 10 fruits/plants | From late summer to autumn (every 20 days) |
| **Soft scales** | | | |
| *Saissetia oleae* | 1 Female/10 cm twig or 3-5 nymphs/leaf | Exam. Of 4 twigs (10 cm long)/ plant | Summer and winter |
| **Armored scales** | | | |
| *Aonidiella aurantii* | 1 Female/10 cm twig or 3-5 nymphs/leaf | Exam. Of 4 twigs (10 cm long)/ plant and 20 fruits/plants | Every months from summer to winter |
| **Moths** | | | |
| *Prays citri* | 50 % infested flowers | Weekly exam. of 50 flowers/plant | Summer bloom period |
| **Flies** | | | |
| *Ceratitis capitata* | 20 adults/trap/week (clementine)<br>40-50 adults/trap/week (orange) | Weekly counting adults/10 white trimedlure traps/ha | From late summer to autumn |
| **Mites** | | | |
| *Eriophyes sheldoni* | 50-70 % infested buds | Laborat. buds exam. Of 4 shoots/ plant | Summer and winter |
| *Panonychus citri* | 3 individuals/leaf or 50% inf. Leaves | Laborat. count mobile forms on 4 leaves/plant | Every two weeks |
| *Tetranychus urticae* | 2 % inf. fruits or 10 % inf. Leaves | Laborat. exam. on 4 shoots/plant and visual exam. 20 fruits/plant | Every two weeks (from spring to autumn) |
| *Aculops pelekassi* | 2-3 % infested fruits | Visual exam. 10 fruits/plant | Every two weeks from June to December |

**Table 3.** IPM against the main citrus pests recommended in Italy.

| Pest | Methods of Control: Biological agents | Chemical | Cultural | Biothecnic or others | Estimated[a] level of efficacy |
|---|---|---|---|---|---|
| **Aphids** | | | | | |
| *A. spiraecola* | Aphidiid spp. + Others | Aphicides | -------- | -------- | U↔S[b] |
| *A. gossypii* | Aphidiid spp. + Others | Aphicides | -------- | -------- | E↔S |
| *T. aurantii* | Aphidiid spp. + Others | Aphicides | -------- | -------- | E↔S |
| **Flies** | | | | | |
| *C. capitata* | -------- | Poisoned yeast hydrolizated Spray, at stripes | -------- | Chromotropic traps + attractant | S |
| **Moths** | | | | | |
| *Pr. citri* | | -------- | Water-stress practice | | S |
| **Mites** | | | | | |
| *E. sheldoni* | -------- | White, or other oils only on lemon orchards | -------- | -------- | S |
| *Pa. citri* | Phytoseiid spp. + Others | Acaricides | -------- | -------- | E S |
| *T. urticae* | Phytoseiid spp. + Others | Acaricides | -------- | -------- | E S |
| **Scales** | | | | | |
| *Pl. citri* | *L. dactylopii* (inoculative releases) + Others | -------- | -------- | | S |
| *A. aurantii* | *A. melinus* + Others | White - (or other oils on local infestation) | -------- | -------- | S S |
| *S. oleae* | *Metaphycus* spp. + Others | White - (or other oils on local infestation) | -------- | -------- | S S |
| **Whiteflies** | | | | | |
| *Aleurothrixus floccosus* | *C. noacki* + *A. spiniferus* + Others | -------- | -------- | -------- | C |
| *Dialeurodes citri* | *E. lahorensis* + Others | -------- | -------- | -------- | C |
| *Parabemisia myricae* | *E. meritoria* + *E. debachi* + Others | -------- | -------- | -------- | C |

[a] Symbols used are as follows: U= Unsatisfactory, E= Efficient, S= Satisfactory, C=Complete

[b] When two letters are connected (e.g. U↔S), it means that while natural control methods alone cannot produce a satisfactory level of control, it is satisfactory when integrated with chemical control.

**Table 4.** Percent of necrotized leaf surface (n.l.s.) due to the *CLM* larval trophic activity. Data calculated on 3 leaves per shoot selected at basal, median and apical level of the axis (60 leaves per bloc on the whole); the leaf's surface measured by a leaf-gauge, the necrotized spots by a square millimiter tracing paper.

| Blocs | Cc or gr x hl of c.p. | % n. l. s. |
|---|---|---|
| Biolid | 1000 | 49.02 |
| Methomyl | 250 | 62.54 * |
| W. oil | 1000 | 47.17 |
| W. oil | 500 | 35.91 * |
| Rufast | 20 + 500 w. o. | 52.99 |
| Control | Water sprayed | 43.31 |

Data marked with asterisk are significantly different at $P = 0.05$ (*Tukey* – test (10)). Data from G. Mineo *et al.* (29).

In the above mentioned research, concerning the existing relationships between the biocenosis of citrus groves and that of the associated synantropic vegetation, the role of the latter with regard to the indigenous factors of the natural control of *CLM*, has been demonstrated. From this latter mychrolepidopteran 12 hymenopteran parasitoids were reared, and among them are *Cirrospilus diallus* and *C. pictus*. Mineo et *al.* (27, 28) have bred the two species from *Cosmopteryx parietariae* Hering (Lep. Cosmopterygidae) infesting *Parietaria diffusa* M. et K. and *P. lusitanica* L. growing either inside or in the neighbouring of citrus plantations.

The former Eulophid has also been emerged from *Euleia heraclei* (L.), living on *Smyrnium olusatrum* L. (Umbrelliferae) (28) that is a very common species of a such synantropic cover and develops during autumn-winter. From *Stigmella aurella* F. (Lep. Nepticulidae), living on *Rubus ulmifolius* Schott., an arbust generally developping in the neighbouring of citrus groves, Caleca et *al.* (9) have bred three other known parasites of *CLM* namely: *Apotetrastichus postmarginalis* (Boucek), *Neochrysocharis formosa* (West.), and *Pnigalio agraules*.

Furthermore, either from the above hosts, or from others living on other plants such as *Sonchus* spp., *Chenopodium* spp., associated with citrus groves, a large number of Eulophids, mostly belonging to the genera *Chrysocharis* Foerster, *Sympiesis* Foerster and *Pnigalio* Schrank were intercepted. Some of these species are known parasites of *CLM* which could be intercepted in the near future, and require further identification.

In conclusion waiting for an ecological definitive solution to the *CLM* problem, at the present time, the integrated control continues to be, based on the reconsideration of synantropic vegetation associated with citrus groves, as pasture of alternative hosts of *CLM* autoctonous antagonists which plays the role of natural reservoir during winter and spring, in addition to the well timed use of selective sprays.

**Table 5.** Percent of parasitized larvae after spray (30/07/1997). Data from G. Mineo *et al.* (29).

| Dates of sampling | Biolid | Methomyl | W. O. (1) | W. O. (2) | Rufast | Control |
|---|---|---|---|---|---|---|
| 06/08/97 | * | * | * | * | * | * |
| 13/08/97 | 23.04 b** | 11.77 bc | 33.58 b | 15.17 bc | 7.85 bc | 18.14 bc |
| 21/08/97 | 24.38 c | 37.24 c | 32.23 ce | 43.75 cd | 32.43 c | 20.00 cd |
| Mean value | 15.81 d | 16.34 d | 21.94 d | 19.64 d | 13.43 d | 12.71 d |

* = no parasitized larvae observed

** Numbers in the horizontal colomns followed by different letters are significantly different at $P = 0.05$ (*Tukey* – test (10))

(1), (2) = 1000 and 500 gr/hl white oil, respectively.

**Table 6.** Number of adults of citrus leaf miner and Hymenopteran captures observed on 10 yellow and 10 white pan unbaited sticky traps, randomly located into the lemon orchard during the time of experiment (30/7 - 21/8/97). Data from Mineo G. *et al.*, (29)

| | Unbaited sticky traps | |
|---|---|---|
| | Yellow | White |
| **Pest** | | |
| Citrus leaf miner | 59 | 41 |
| **Hymenopteran captures** | | |
| *Aphidiidae* | 1 | 0 |
| Ceraphronoids | 4 | 4 |
| Cynipoids | 5 | 0 |
| Chalcidoids, *Eulophidae* | | |
| Cirrospilus diallus | 6 | 4 |
| Cirrospilus pictus | 14 | 4 |
| Pnigalio agraules | 5 | 5 |
| *Mymaridae* | 10 | 4 |
| Proctotrupoids, *Platygastridae* | 166 | 3 |
| *Scelionidae* | | |
| Anteromorpha sp. | 1 | 0 |
| Idris spp. | 7 | 8 |
| Gryon sp. | 4 | 0 |
| Telenomus spp. | 12 | 18 |
| Trissolcus sp. | 1 | 0 |
| *Trichogrammatidae* | 0 | 3 |
| Unidentified | 28 | 17 |
| Total | 264 | 70 |


## الملخص

**مينيو، ج. 1998. الإدارة المتكاملة للآفات في بيارات الحمضيات الإيطالية. مجلة وقاية النبات العربية. 16(1): 38-48.**

يحدث عدد من الأنواع المحلية، تنتمي لمجموعات حيوانية مختلفة، معظمها من مفصليات الأرجل، أضرارا لبيارات الحمضيات في إيطاليا. كما دخلت بعض الأنواع الغريبة من الحشرات والحلم في العقود الثلاثة الماضية وأحدثت تغييرا في "فونا" آفات الحمضيات. وقد أظهرت البحوث المنفذة من قبل المعاهد العلمية الحكومية، والتي أتبعت بتجارب مشاهدة فعالية المكافحة المراقبة والمتكاملة، بما في ذلك بعض ممارسات المكافحة الأحيائية، وأظهرت ايضا الجدوى الإقتصادية لتلك الإجراءات في مكافحة عديد من الحشرات الرئيسية التي تهاجم بيارات الحمضيات.

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