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The contribution of Italian entomological Schools to applications of biological control of insects harmful to agriculture and forests in southern Italy and Sardinia

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Abstract

The first episodes of biological control in Italy started formally in the first half of the 1800's when Agostino Bassi demonstrated, in 1835, the activity of the entomopathogenic fungus *Beauveria bassiana* (Balsamo) Vuillemin against the silkworm, *Bombyx mori* (L.). In the same period, Antonio Villa managed to control, specifically in 1844, some insect pests by using predatory beetles (carabids and stafilinids). The first substantial studies, however, were carried out starting in the early 1900's at the University of Portici (Naples). From 1890 to 1903, Antonio Berlese introduced the afelinid *Encarsia berlesei* (Howard) from the USA and Japan to biologically control the white peach scale, *Pseudaulacaspis pentagona* (Targioni Tozzetti). Filippo Silvestri, who introduced, over the span of about 50 years, dozens of beneficial insects from different regions of the world for biological control, worked at the Naples University from 1903 to 1949. Furthermore, the role of the entomological Neapolitan School in the training of full professors and researchers in the Universities of southern Italy (and not) was highly significant. The work of Silvestri has been central to the development of agriculture in southern Italy and these entomological Schools belong to the Universities of Catania, Palermo, Bari, Sassari and Reggio Calabria. Among the assistants of Silvestri, we can find Vincenzo Lupo and Domenico Roberti, respectively founders of the entomological Schools of Catania and Bari Universities. In Sardinia, Francesco B. Boselli worked in the field of biological control. At Portici, Giuseppe Russo succeeded Silvestri, followed over the years by indirect heirs to the work and teaching of Filippo Silvestri. Guido Grandi, another prestigious entomologist working at Bologna University, was assistant of Silvestri as well. We can simply consider that in 1970 over 50 species of entomophagous were introduced into our country from different regions of the world; of these, however, only ten were actually acclimatized. The most significant events of biological control carried out in the time are listed in tables and regard citrus, olive, and protected crops. They clearly indicate that applications of biological control are crucial for economic development in those areas. Several entomological problems, such as attacks of the cottony cushion scale, *Icerya purchasi* Maskell, the wooly whitefly, *Aleurothrixus floccosus* (Maskell), *Liriomyza* spp. and other pests, have found in the biological control a more convincing solution than that offered by other technical means, including that of chemical agents.

Key words: history, biological control, pests, southern Italy, Mediterranean crops.

Origin and development of biological control of harmful insects in Italy

The biological control of harmful insects starts formally in Italy in the first half of the nineteenth century. In 1835, Agostino Bassi demonstrated the activity of the entomopathogenic fungus *Beauveria bassiana* (Balsamo) Vuillemin against the silkworm, *Bombyx mori* (Linnaeus) (Bassi, 1835-36). A few years later, in 1844, Antonio Villa controlled some insect pests by using predatory beetles (carabids and stafilinids) (Villa, 1845). Almost simultaneously, in 1856, the American Asa Fitch proposed the importation of European entomophagous insects to the U.S. to combat the wheat midge, *Sitodiplosis mosellana* (Géhin) (Fitch, 1854), emulated a decade later by Benjamin Walsh, who suggested the introduction from Europe of the entomophages needed to contain insect pests imported from the Old Continent (Walsh, 1866).

The implications of the industrial revolution at the end of the century stimulated this turmoil, and its influence began to be felt also in agriculture. In the second half of 1800's, the symptoms of a gradual and unexpected development of agriculture could already be felt, encouraged by the policy that the Kingdom of Italy was given. The improvement of the production process involved, in Italy as elsewhere, thereby increasing of the eco-resistance of crops (i.e. the pressure exerted by the harmful organisms against, unfortunately, an arsenal of technical means that were not adequate for real needs). The increased possibility of trade between the continents and the risk of the accidental introduction of pests and diseases of crops and forests aggravated the problem, as shown by the infestation of grape phylloxera [*Viteus vitifoliae* (Fitch)] in Europe (Flint and van den Bosch, 1981). To deal with the emergency, the entomological culture at that time encouraged awareness of the irreplaceable role of the various natural enemies (parasitoids, predators, pathogens) in the containment of pest populations and called for their practical application (Wilson and Huffaker, 1976).

During the same period, between 1888 and 1889, the first intervention of biological control of the modern era was created in California against the cottony cushion scale, *Icerya purchasi* Maskell, an insect that was harmful to citrus and other crops, where its natural antagonist, the Vedalia beetle, *Rodolia cardinalis* (Mulsant) was introduced from Australia. The operation was crowned with bona fide success, albeit two years later. In 1890, it allowed for the near total reduction of infestations of scale in California citrus groves. The entire

project cost approximately $5,000, compared to a positive effect on the citrus industry estimated at millions of dollars per year. Since then, the use of *R. cardinalis* registered a similar measure of success in over 50 countries around the world (DeBach and Rosen, 1991) and introduced a new way to control harmful insects (pests and other types). This last episode has a positive affect on the development of the biological control in Italy. The success in California was a starting block for numerous actions that were and are carried out in biological control in Italy, and this study acts as a summary of what happened from this point on in southern Italy and Sardinia. The main works and actions of the entomological Schools involved are clearly listed in tables. Southern Italy, in this study, is the territory including the regions of Campania, Puglia, Basilicata, Calabria and Sicily. Sardinia was also included for the analogy of its socio-economic conditions.

The contributions of the entomological Schools of southern Italy and Sardinia

The entomological Neapolitan School plays a key role in the development of the main strategy in Italy. Antonio Berlese, 1890-1903, and Filippo Silvestri later, from 1903 to 1949, would be the first to apply their work on an international scale and inaugurate the start of the applications of biological controls in Italy. Both of these specialists had a deep naturalistic culture, capable of examining entomological problems from an ecological viewpoint – a characteristic that was innovative for their time. Silvestri had, moreover, a good knowledge of languages, which allowed for an easy relationship with the most reliable scientific communities worldwide. The international scene at the time was focused on the successful conclusion of biological control projects of the Division of Biological Control of Department of Entomology of the University of California at Riverside, as previously described. Drawing on the North American experience, Berlese introduced *R. cardinalis* to Italy in 1901, achieving a success similar to that obtained in America (Ribaga, 1904). The same specialist achieved, between 1905 and 1906, the introduction of the afelinid *Encarsia berlesei* (Howard) from the USA and Japan to biologically control the white peach scale, *Pseudaulacaspis pentagona* (Targioni Tozzetti), a pest that is harmful to mulberry (but also of peach and various other fruit trees) of oriental origin, found for the first time in Lombardy in 1885 and whose infections put the silkworm culture in Italy at great risk (Berlese, 1909-1925).

However, the most significant studies and actions were carried out by Silvestri, who introduced dozens of useful species from different regions of the world for biological control over the span of 50 years. Among the species introduced, we should take note of the mealybug destroyer, *Cryptolaemus montrouzieri* (Mulsant), the black lady beetles, *Chilochorus kuwanae* Silvestri and *Rhizobius lophantae* (Blaisdell), or the braconid *Opius concolor* Szepligeti (Silvestri, 1934-51). He also took great interest in the application of the biological control of scale insects and tephritids (olive fly, Mediterranean fruit fly). Silvestri died in 1949 after having laid the foundations of modern biological control in Italy. His scientific activity is documented by 470 publications, including the famous "Compendio di Entomologia applicata" (Applied Entomology Handbook) (1934-1951), which was unfortunately never completed. A salient aspect of his life was his active involvement in the foundation of the IOBC (International Organization for Biological Control of Noxious Animals and Plants), an international association that brings together over 3,000 specialists worldwide. This organization is still very active and a leader in the development of biological control in all parts of the world (Boller, 2005).

The work of this famous entomologist has been central to the development of agriculture in southern Italy – consider the fact that in 1970 over 50 species of useful insects were introduced into our country from different regions of the world; of these, however, only ten were actually acclimatized (table 1). Furthermore, the entomological Neapolitan School trained full professors and researchers in various Universities. The most important entomologists were called to work in the second half of the twentieth century in universities, research institutes and phytopathological observatories operating in southern Italy, as well as academic institutions of the Centre and North Italy. Among the assistants of Silvestri, we can find Vincenzo Lupo and Domenico Roberti, respectively founders of the entomological Schools of Catania and Bari Universities. In Sardinia Francesco B. Boselli worked in the field of biological control. At Portici,

Table 1. Main entomophagous species introduced in Italy by the entomological Neapolitan School.

Entomophagous	Pest	Reference
Rodolia cardinalis (Mulsant)	*Icerya purchasi* Maskell	Ribaga, 1904
Encarsia berlesei (Howard)	*Pseudaulacaspis pentagòna* (Targioni Tozzetti)	Berlese, 1909-1925
Cryptolaemus montrouzieri (Mulsant)	Pseudococcidae	Silvestri, 1934-1951
Rhizobius lophanthae (Blaisdell)	Diaspididae	Silvestri, 1934-1951
Chilocorus kuwanae Silvestri	Diaspididae	Silvestri, 1934-1951
Opius concolor Szepligeti	*Bactrocera oleae* (Rossi)	Silvestri, 1934-1951
Leptomastix dactylopii Howard	*Planococcus citri* (Risso)	Zinna, 1959
Metaphycus helvolus (Compere)	*Saissetia oleae* (Olivier)	Viggiani, 1978
Encarsia lahorensis (Howard)	*Dialeurodes citri* (Ashmead)	Viggiani and Mazzone, 1978
Metaphycus bartletti Annecke *et* Mynhardt	*Saissetia oleae*	Viggiani and Mazzone, 1980a
Encarsia pergandiella Howard	*Trialeurodes vaporariorum* (Westwood)	Viggiani and Mazzone, 1980b

Giuseppe Russo succeeded Silvestri, followed over the years by indirect heirs of the work and teaching of Filippo Silvestri. Guido Grandi, another great Italian entomologist who worked for and extended period of time at Bologna University, studied in Portici (Naples) and was an assistant of Filippo Silvestri.

Silvestri's death, however, did not interrupt the movement he had founded, as shown by the numerous introductions of entomophages subsequently made by Neapolitan entomologists, including several encyrtids such as *Leptomastix dactylopii* Howard (Zinna, 1959), *Metaphychus helvolus* (Compere) (Viggiani, 1978) and *M. bartletti* Annecke *et* Mynhardt (Viggiani and Mazzone, 1980a) and aphelinids as *Encarsia lahorensis* (Howard) (Viggiani and Mazzone, 1978) and *E. pergandiella* Howard (Viggiani and Mazzone, 1980b).

The entomological School of Catania University was founded in the 1950's thanks to Vincenzo Lupo, extending the work of Silvestri to Sicilian agriculture. Over time, various natural enemies of scales, whiteflies and leaf miners have been introduced to citrus crops in Sicily, such as the aphelinids *Aphytis lingnanensis* Compere, *A. melinus* DeBach (Inserra, 1966), *E. lahorensis* (Barbagallo *et al*., 1981), *Cales noacki* Howard (Longo *et al*., 1985), and *Eretmocerus debachi* Rose *et* Rosen (Longo *et al*., 1992), the encyrtids *L. dactylopii* (Longo and Benfatto, 1982) and *Ageniapsis citricola* Logvinovskaya (Conti *et al*., 2001), the coccinellids *C. montrouzieri* (Longo, 2002) and the eulophid *Citrostichus phyllocnistoides* (Narayanan) (Conti *et al*., 2001) (table 2). The results of the scientific experience gained with regard to citrus through *C. montrouzieri*, *L. dactylopii* and *Aphytis* spp. have encouraged the ESA (Ente di Sviluppo Agricolo, Agricultural Development Board) of the Sicilian Region to implement a mass production of the three beneficials, which can currently serve about 1,500 ha of citrus surface.

The scientific activity of the Catania entomological School has also been accompanied by international awards, including the role of convenor for the Working Group "Integrated Control in Citrus Fruit Control" of the Western Palaearctic Regional Section of IOBC, held by the writer for nearly a decade. Since the early 1980's, a new approach to biological control of pests on protected crops has been taken; this has mainly been focused on the study of indigenous biodiversity and is aimed at understanding the bio-ecology of different species involved and their practical use (table 3).

Table 2. Entomophagous species introduced on citrus crops by the Catania entomological School.

Entomophagous	Pest	Reference
Aphytis lingnanensis Compere *Aphytis melinus* DeBach	*Aonidiella aurantii* (Maskell)	Inserra, 1966
Encarsia lahorensis (Howard)	*Dialeurodes citri* (Ashmead)	Barbagallo *et al*., 1981
Leptomastix dactylopii Howard	*Planococcus citri* (Risso)	Longo and Benfatto, 1982
Cales noacki Howard	*Aleurothrixus floccosus* (Maskell)	Longo *et al*., 1985
Eretmocerus debachi Rose *et* Rosen	*Parabemisia myricae* (Kuwana)	Longo *et al*., 1992
Ageniapsis citricola Logvinovskaya *Citrostichus phyllocnistoides* (Narayanan)	*Phyllocnistis citrella* Stainton	Conti *et al*., 2001
Cryptolaemus montrouzieri (Mulsant)	*Planoccoccus citri*	Longo, 2002

Table 3. Indigenous and introduced natural enemies investigated in protected crops of the Ragusa province.

Natural enemy	Pest	Reference
Therodiplosis persicae Kieffer	*Tetranychus urticae* Koch	Vacante, 1981
Phytoseiulus persimilis Athias Henriot	*Tetranychus urticae*	Vacante and Firullo, 1983
Dyglyphus isaea (Walker)	*Liriomyza* spp.	Vacante *et al*., 1988
Beauveria bassiana (Balsamo) Vuillemin	*Otiorhynchus* spp.	Magnano di San Lio and Vacante, 1989
Orius laevigatus (Fieber)	*Frankliniella occidentalis* (Pergande)	Vacante and Tropea Garzia, 1993a, b
Amblyseius cucumeris (Oudemans)	*Frankliniella occidentalis*	Vacante and Tropea Garzia, 1993c
Nesidiocoris tenuis (Reuter)	*Bemisia tabaci* Gennadius *Trialeurodes vaporariorum* (Westwood)	Vacante and Tropea Garzia, 1994a, b
Neozygites parvispora (McLeod et Carl)	*Frankliniella occidentalis*	Vacante *et al*., 1994
Verticillium lecanii (Zimmerman)	*Bemisia tabaci* *Trialeurodes vaporariorum*	Cacciola *et al*., 1995
Eretmocerus mundus Mercet	*Bemisia tabaci*	Vacante *et al*., 1995
Podisus maculiventris (Say) *Podisus nigrispinus* (Dallas)	*Chrysodeixis chalcites* (Esper)	Vacante *et al*., 1996
Coenosia attenuata Stein	*Bemisia tabaci* *Trialeurodes vaporariorum*	Vacante, 2000
Aphidius matricariae Haliday	*Myzus persicae* Sulzer	Vacante, 2000
Beauveria bassiana	*Bemisia tabaci* *Frankliniella occidentalis*	Vacante *et al*., 2001a, b
Bacillus thuringiensis Berliner	*Chrysodeixis chalcites*	Vacante *et al*., 2001c

The natural enemies that were investigated include, in chronological order, the cecidomyiid *Therodiplosis persicae* Kieffer [= *Feltiella acarisuga* (Vallot)] (Vacante, 1981), the phytoseiid mite *Phytoseiulus persimilis* Athias Henriot (Vacante and Firullo, 1983), the eulophid *Dyglyphus isaea* (Walker) (Vacante *et al*., 1988), the antocorid *Orius laevigatus* (Fieber) (Vacante and Tropea Garzia 1993a, 1993b), the phytoseiid mite *Amblyseius cucumeris* (Oudemans) (Vacante and Tropea Garzia, 1993c), the mirid *Nesidiocoris tenuis* (Reuter) (Vacante and Tropea Grazia, 1994a, 1994b), the aphelinid *E. mundus* Mercet (Vacante *et al*., 1995), the muscid *Coenosia attenuata* Stein, and the aphidiid *Aphidius matricariae* Haliday (Vacante, 2000). Moreover, there has been a clear assessment of role of different entomopathogenic fungi, such as *Beauveria bassiana* (Balsamo) Vuillemin against *Otiorhynchus* spp. (Magnano di San Lio and Vacante, 1989), tobacco whitefly (Vacante *et al*., 2001a) and western flower thrips (Vacante *et al*., 2001b), *Neozygites parvispora* (McLeod *et* Carl) against the western flower thrips (Vacante *et al*., 1994) and *Verticillium lecanii* (Zimmerman) against the tobacco whitefly (Cacciola *et al*., 1995). *Bacillus thuringiengis* Berliner (Vacante *et al*., 2001c), the spined soldier bug, *Podisus maculiventris* (Say), and the stink bug, *P. nigrispinus* (Dallas) (Vacante *et al*., 1996) have been assessed against the tomato looper, *Chrysodeixis chalcites* (Esper).

The results of studies carried out on the protected crops allowed for the development of protocols that were alternatives with respect to those applied in greenhouses in Central and Northern Europe (Hussey and Scopes, 1985), which are largely ineffective in the Mediterranean cold glasshouses. The study of indigenous biodiversity has offered numerous ideas, some of which now have a practical application in other Mediterranean regions, such as the mirid bug *N. tenuis*, positively assessed in the defence of tomatoes in protected crops in the Ragusa province (Sicily) and currently used on over 2,500 ha of tomato greenhouses in Almeria in Spain and over the same area in Morocco. Even in protected crops, methods of mass production of some beneficial insects were defined (*Ph. persimilis*) (Vacante *et al*., 1989).

The first programs of the entomological School at Palermo University date back to the 1960's. The most famous program was created by Salvatore Monastero, who arranged a mass rearing of the braconid *Opius concolor*, employed against the olive fruit fly, *Bactrocera oleae* (Rossi), in collaboration with Pietro Genduso and with the help of IOBC, producing a series of inundating interventions (Monastero and Delanoue, 1966; Monastero and Genduso, 1963). During the same period, tests of biological control of the citrus mealybug, *Planococcus citri* (Risso) were carried out, using the Australian lady beetle, *C. montrouzieri* (Liotta and Mineo, 1964). Some time afterwards, with successful results in Sicily, the aphelinid *Encarsia lahorensis* (Howard) was introduced against the citrus whitefly, *Dialeurodes citri* (Ashmead), which had infested citrus orchards of the Palermo countryside since 1968 (Liotta, 1978). In 1980, following the appearance of the wooly whitefly, *Aleurothrixus floccosus* (Maskell) in Sicily, the aphelinid *C. noacki* and the platigastrid *Amitus spiniferus* (Brèthes) were introduced – the first species had an immediate effect (Liotta and Maniglia, 1983), whereas the response of the latter had mid-term positive effects. In 1988, the encyrtid *Comperiella bifasciata* Howard (Liotta *et al*., 1990) was introduced to control the California red scale, *Aonidiella aurantii* (Maskel) and the aphelinid *Encarsia herndoni* (Girault) (Viggiani and Liotta, 1990) against the Glover scale, *Lepidosaphes gloveri* (Packard). *Encarsia herndoni* gave the most striking result, controlling a pest that for about 50 years was considered the citrus trees' greatest threat. Today *L. gloveri* is simply an entomological curiosity (Liotta *et al*., 2003).

The entomological School of Bari University was founded in 1965 by Domenico Roberti, another assistant of the legendary Silvestri. In the field of biological control, Roberti acquired basic knowledge on taxonomy, morphology and bio-ecology of natural enemies of important pests of the Mediterranean agro-ecosystems, including olive groves. Its contributions in the biological control include the study of two cecidomiids, *Phaenobremia aphidimyza* (Rondani), predator of *Aphis* (*Doralis*) *frangulae* Koch (Roberti, 1946), and *T. persicae* (Roberti, 1955), natural enemy of the two-spotted spider mite *Tetranychus urticae* Koch, and of the coccinellid *Scymnus* (*Nephus*) *kiesenwetteri* Mulsant (Roberti, 1977). He studied the entomophagous organisms of the olive fruit fly, *Bactrocera oleae* (Roberti and Monaco, 1967; Roberti, 1969), the parasitoids of Mediterranean black scale, *Saissetia oleae* (Olivier) (Roberti, 1980-1981a) and the hosts of braconid parasitoids of *Prays* (Roberti, 1980-1981b). Recently, it has been evaluated the action of entomopathogenic nematodes in the biological control of the pests of the forest environment (Tarasco, 2005) and of the peach flatheaded rootborer, *Capnodis tenebrionis* (L.) (Marannino and De Lillo, 2007).

The entomological School at the Mediterranean University of Reggio Calabria has a relatively recent history, established in the 1980's. During almost three decades it has changed its structure, present in a composite matrix, partly deriving from Portici and Catania Universities, or related, as in the case of the writer, to other extended visit or studies connected to work elsewhere. Since the University's foundation, there have been many interesting achievements – such as a mass production of entomophages, developed by ENEA in Lamezia Terme (Catanzaro) with funds from the MIUR (Vacante and Benuzzi, 2004), as well as the study of important parasitoids and predators of pests of protected crops and pinewood, and testing the effectiveness on pests of natural substances.

A summary of the contribution of the entomological School of Sassari University, in Sardinia, is not easy – be it for the skilled interventions recorded over time as well as the amount of scientific contributions on the most important agro-ecosystems, such as citrus, olive grove, horticultural, greenhouse and open field, and the Mediterranean forest. Among the first biological control measures, we should highlight the introductions of meloid *Zonabris variabilis* Pallas and bombiliids *Cytherea obscura* Fabricius and *Systoechus ctenopterus* (Mikan) for containment of invasions of the Moroccan lo-

cust, *Dociostaurus maroccanus* (Thunberg), made by "Osservatorio per le malattie delle piante" (Observation group for plant disease) of Cagliari since the time of Francesco B. Boselli (Paoli and Boselli, 1947). Over the past 40 years, the Sassari School has been among the most active in the study of biological control of crops and forests from pest attack. Romolo Prota had supported, thanks to encouragement from his friend Raffaele Cavalloro, a renowned entomologist at the EU Joint Research Centre in Ispra (Varese), the transfer of modern strategies for the control of pests, giving priority to the achievement of scientific objectives closely linked to the unique characteristics of the environment in Sardinia and its preservation. The promotion and implementation of the CNR Institute on Biological Control of the Environment within the Sassari research area, which he directed from 1989, fall within this context. The focus on the biological equilibria that govern the agro-ecological systems involving all of the Sassari School has led over the years to a series of studies aimed at understanding the role of antagonists of insect pests on crops and forests (Prota *et al*., 1991, 1996), with a canny use of modern methods on ecological and statistical analysis. Numerous studies have focused on the biological and integrated pest management (IPM) of citrus and olive groves, as well as horticultural crops and the forest environment (Ortu and Prota, 1986; Delrio *et al*., 1991, 2005). In the operational context, we must highlight the importance of protocols regarding the control of different crops and the development, in the 1990's, of mass production of *L. dactylopii*, *O. concolor* and the mirid bug, *Macrolophus caliginosus* Wagner, at the CRAS (Centro Regionale Agrario Sperimentale) in Cagliari and used in biological control projects for citrus and olive tress, as well as vegetable cultivation.

Conclusions

In the past century, the results of experience in key agricultural sectors in southern Italy and their practical implications clearly indicate that applications of biological control are crucial for economic development. Several entomological problems, such as attacks of *Icerya purchasi*, *Aleurothrixus floccosus*, *Liriomyza* spp. and other pests, have found in the biological control a more convincing solution than that offered by other technical means, including that of chemical treatment. The high and unusual infestations of *I. purchasi* that have occurred in the latter period on citrus trees as a result of the irrational use of neonicotinoids and deltamethrin or other pyretroids, notoriously non-selective for *Rodolia cardinalis* and other beneficial organisms, indirectly confirm this aspect. The same consideration can be applied to vast infestations of leaf miners and whiteflies in protected crops as a result of treatments with broad-spectrum pesticides, which are not selective for natural populations of *Diglyphus isaea*, parasitoid of leaf miners, nor of *Nesidiocoris tenuis*, predator of whiteflies and other small arthropods.

Among the entomological Schools of southern Italy, that of Naples has played a leading role, especially in the first half of the last century, and has led to a highly-innovative change of direction, with serious implications of a technical, scientific and social nature. The entomologists involved, directly or indirectly as heirs of Silvestri's assistants, collected and developed the theoretical formulation and application of the Master, planning solutions for the problems of biological control in a radical way. The economic and ecological results have been crucial for both individual farms and for farming communities. The application of biological control has had positive repercussions not only for the agricultural environment, but also for the social context in which it took place. We should note, however, that the assessment of environmental impact and the results of biological control are not always possible in the short to medium term.

Along general lines, southern Italy gives priority to citrus and olive groves. It should be clear, however, that the fortuity of interventions on citrus was due in part to two specific contingencies, wisely used from the outset – the particular ecology of the citrus grove and the considerable amount of beneficial organisms that were made available by the scientific world, such as the aforementioned Division of Biological Control University of California.

The lower number of projects on olive trees is explained by the limited extension of areas dedicated to olive cultivation, the agro-ecosystem ecology, characterized by a framework of insect species poorer than citrus, and with lower risk of introduction of new pests from other areas of the world. In short, the relative lack of the populations of olive-harming insects has not requested a sufficient *corpus* of specific research, with respect to citrus, aside from that of the olive fly.

The case of protected crops is drastically different, where studies have been carried out mainly by researchers working at the University of Catania, although referring in part to other cultural matrices. The method adopted has opened a new path for managing relationships of operators with the pests of protected crops. The validity of the results has finally been recognized, not without some difficulty, by other Mediterranean researchers, initially more inclined to pander to the protocols implemented in the greenhouses of Central and Northern Europe, sometimes conditioned by the interests of producers of natural enemies. Today, the technique tested in Sicily is applied with success on large areas of greenhouses in southern Italy and in other agricultural areas of the Mediterranean countries.

With regard to forests, setting aside the use of *Bacillus thuringiensis* against insect defoliators, other practical programs have not been implemented in the southern regions. The studies on the entomopathogenic nematodes can be considered as an academic approach.

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