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# INTRODUCED SAP-FEEDING INSECT PESTS OF CROP PLANTS IN THE MALTESE ISLANDS

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## ABSTRACT

Sap-feeding insects within Hemiptera and Thysanoptera are some of the most important crop pests world-wide. Apart from the loss of yield they cause by sap depletion, saliva toxicity and soiling of the leaves, some species transmit serious plant virus diseases. Important sap-feeding species that have been introduced to the Maltese Islands include the whitefly *Bemisia tabaci*; the scale insects *Pseudococcus longispinus*, *Planococcus citri* and *Icerya purchasi*; the aphids *Aphis gossypii*, *Aphis spiraecola*, *Myzus persicae* and *Viteus vitifoliae*; and the thrips *Frankliniella occidentalis* and *Heliothrips haemorrhoidalis*. For each of these pests information is provided on area of origin, present distribution, host-plant range and virus disease transmission. Control strategies undertaken in the Maltese Islands are described where relevant. Some general considerations on quarantine measures are discussed.

## INTRODUCTION

Sap-feeding insects include true bugs, cicadas, whiteflies, jumping plant-lice, scale insects, aphids and thrips. Not all members of these mentioned insect groups are sap-feeding; some exceptions include bed-bugs and assassin bugs which are either adapted to suck the blood of vertebrates or are predators of other insects.

Sap-feeders are usually small insects and reliable identification requires expert knowledge. They are also difficult to detect at quarantine points and are therefore easily introduced to new territories. Their feeding damage can be troublesome to agricultural crops in various ways:

- They pierce and injure plant tissues while feeding, and damage plants by sap depletion thus reducing productivity by direct consumption of carbohydrates and other nutrients transported in the phloem. Sometimes injected saliva may cause leaf drop, stunting or distortion of growth or even galling, debilitating the plant and making ornamental plants unsaleable;
- Adults of mobile sap-feeding insects can carry a number of important plant virus diseases from one plant to another;
- Some sap-feeding insects, particularly members of the Sternorrhyncha (i.e. aphids, scale insects, jumping plant-lice and whiteflies) excrete sugary honeydew which coats nearby surfaces and provides a substrate for growth of unsightly sooty moulds. These deposits and growths block light and air from the leaves, impairing photosynthesis and reducing produce quality and quantity. Severe fouling may make plants and produce unmarketable.

Most of these insect groups favour humid, warm and dry conditions, while excessive heat or dryness is avoided. Cold climate and heavy rainfall causes high mortality by washing the insects off the plant. Most sap-feeding insect pests are spread from one country to another through human transport of infested plant material. Inherently, small islands have fewer insect pests than continental countries, but their small agricultural industries are more vulnerable to the impact of any introduced pest. Small island states often do not have appropriate records of insects already present, so that new introductions often go unnoticed until it is too late to take control measures for eradication of the introduced pests.

There are very few published works which mention introduced insect pests in the Maltese Islands. Saliba (1963) provided a comprehensive list of insect pests on crop plants in the Maltese Islands but did not mention introduced species. Other works (Borg, 1922, 1932; Mifsud, 1995, 1997) provided brief information on some introduced insect pests. More recently, a number of introduced insects were cited (Schembri & Lanfranco, 1996) in the work edited by Baldacchino & Pizzuto (1996) on alien species of flora and fauna of the Maltese Islands.

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The following account is intended to present data on some of the most important introduced sap-feeding insect pests in the Maltese Islands.

**Thrips or Thunder-flies (Thysanoptera)**

Thrips are very small insects; both immature and adults can crawl about but the adults also fly actively. Thrips are gregarious and lacerate plant cells to feed on their contents, often causing distinctive brown or silver patches in lines on leaves and petals, disfiguring or distorting the plant and sometimes reducing productivity and fruit set. Distinctive specks of faeces are often left on leaf surfaces, but no honeydew is produced. Plant virus diseases are sometimes transmitted via the mouthparts of thrips. Predators such as ladybird beetles, anthocorid bugs, ants, spiders and predatory thrips are often effective in keeping thrips populations low. Almost nothing has been published on the thrips fauna of the Maltese Islands; however, this group is currently under study. Two economically important species known to have been introduced to the Maltese Islands are *Frankliniella occidentalis* and *Heliothrips haemorrhoidalis* (Mifsud, 1997; Watson & Ismay, 1994).

***Frankliniella occidentalis*** Pergande – Western Flower Thrips

This species originated in North America (Canada, Mexico and continental USA) (Anon., 1992a). It began spreading internationally in the early 1980s and has now reached all continents, spreading across north-western Europe (particularly on Chrysanthemums) and reaching Africa in 1989 (CIE, 1993). It is not known when it was introduced in the Maltese Islands. The Western Flower Thrips is a polyphagous species; it often attacks flowers, causing serious damage to seed crops, cut flowers, nursery stock, peaches, plums, nectarines, strawberries, sweet peppers, grapes, cotton and many other crops. In Malta it is a particular problem in flower nurseries, causing discoloration and scarring of open blooms, especially in carnations. Tomato Spotted Wilt Virus (TSWV) is one of the most important diseases of tomatoes, causing losses up to 100%. The rate of spread of TSWV greatly increased during the 1980s (Roselló *et al.*, 1996), about the same time as the arrival of the Western Flower Thrips, which is now regarded as the most important vector of this virus. TSWV has so far been recorded in greenhouses on *Dahlia* and *Gerbera* in the North-western parts of Malta (Mgarr and St. Paul's Bay) (Wheeler, 1958, 1994).

***Heliothrips haemorrhoidalis*** Bouché – Greenhouse Thrips

The Greenhouse Thrips is a native of tropical America but now has a virtually cosmopolitan distribution, occurring out of doors between 45 degrees North and 40 degrees South, and under glass in more temperate regions (CIE, 1964). Probably the species arrived in the Maltese Islands only recently. It is highly polyphagous, attacking leaves with a relatively low nitrogen content, causing bleached patches and leaving black faecal spots on the lower leaf surface (Watson *et al.*, 1995). The impact of this pest in the Maltese Islands is still being investigated. Large populations have been found on cultivated *Viburnum* sp. grown in the open in the Southern parts of Malta (Zabbar).

**Whiteflies (Hemiptera, Aleyrodoidea)**

Adult whiteflies resemble minute moths about 1 mm long, having two pairs of wings normally coated with white powder, but occasionally darkly pigmented. Adults fly very actively when disturbed. The immature stages are immobile (except for the first instar larvae commonly referred to as crawlers) and are usually found on the lower leaf surfaces, sometimes surrounded or covered by transparent or whitish waxy secretions. The last larval instar, the 'pupal case', is used for identification purposes. Most whitefly species (nymphs) excrete sugary honeydew droplets that tend to coat surrounding surfaces, encouraging sooty moulds to grow. Heavy infestations may cause leaf-drop and yellowing due to sap depletion and saliva toxicity. Adults of some species are efficient vectors of serious plant virus diseases. Populations may be successfully regulated by natural enemies such as parasitic wasps, neuropteran larvae and ladybird beetles. The whitefly fauna of the Maltese Islands totals 13 species and is well documented (Mifsud, 1995; Mifsud & Palmeri, 1996; Rapisarda *et al.*, 1996). Probably, four species are relatively recent introductions to the Maltese Islands. *Aleurothrixus floccosus* (Maskell) and *Dialeurodes citri* (Ashmead) are mainly associated with citrus trees, which are not cultivated on a large scale, so their agricultural importance locally is limited. *Trialeurodes vaporariorum* (Westwood), the greenhouse whitefly, is also of moderate importance. The most economically important pest species is *Bemisia tabaci*. Mifsud *et al.*, (1995) mentioned naturally occurring whitefly parasites found in the Maltese Islands.

***Bemisia tabaci*** Gennadius (*s.l.*) – Sweetpotato or Silverleaf Whitefly

The origin and identity of this damaging pest is uncertain and controversial. Possibly, *B. tabaci* originated in India (Fishpool & Burban, 1994), but it has been present in several parts of the world for at least 100 years and it may be indigenous in some places, e.g. the Mediterranean basin. Early damage by the insect was reported initially from India, Sudan and Israel. Two significant events are worth mentioning. During 1970-79, the insect caused outbreaks first in Sudan, then in the Middle East and later in southwestern America. Another outbreak occurred in 1986 in Florida; there has since been a worldwide epidemic. Today, the geographic range of the pest ranges from temperate countries like Japan, Canada and the Netherlands (on greenhouse crops), throughout most of the world's subtropical and tropical countries (Anon., 1992b; CIE, 1986). Recently, even Australia has reported greenhouse problems with *Bemisia*. Biochemical and biological evidence suggests that what was regarded as a single species is actually a complex of biotypes or separate species (De Barro, 1995; Brown *et al.*, 1995). A pesticide-resistant biotype, biotype B, which causes silvering of cucurbit leaves in high infestations, was first recognized in

the mid 1980s as particularly damaging, due to its high polyphagy, high fecundity and efficiency as vector of plant geminivirus diseases. Originally recorded in Israel, it soon spread to the Caribbean, Africa and India and is now present on all temperate and tropical continents. It causes crop losses globally worth hundreds of millions of dollars every year, and is extremely difficult to control. This biotype B, commonly referred to as the silverleaf whitefly or ponsietta strain, has been recently described as a separate species *B. argentifolii* (Bellows *et al.*, 1994); however, this population cannot be identified reliably except by specialist biochemical methods, and most workers are continuing to refer to it as biotype B (De Barro, 1995).

*B. tabaci* is considered as the most common and important whitefly vector of plant viruses throughout the world. It is the only known whitefly vector of geminiviruses (Brunt, 1986; Dufus, 1987; Harrison, 1985).

In the Maltese Islands, the species has been known as a pest of tomatoes since 1993 and was recorded on several crops (Anon., 1993; Mifsud, 1995; Saliba, 1993). So far, the major damage was reported in tomato crops, due to the spread of the Tomato Yellow Leaf Curl Virus (TYLCV). In addition to the use of pesticides, control of this pest in greenhouses has involved introduction of natural enemies (Mifsud, 1997) and exclusion of adults from greenhouses by covering the vents with fine mesh.

**Scale Insects (Hemiptera, Coccoidea)**

The pest scale insects discussed below are all soft-bodied insects coated with white waxy secretions, up to 12 mm long. They feed on plant sap, occurring singly or in colonies on plant stems, leaf undersides and sometimes on developing fruit. Honeydew is often excreted and sooty mould may develop on nearby plant surfaces. Plants may be damaged by sap depletion or by the effects of fouling with honeydew and sooty mould. Local dispersal is by locomotion of the smallest immature stage or by transport by wind or animals. Scale insects are not normally vectors of plant virus diseases. Populations may be regulated by parasites or through predation by ladybird beetles, birds and neuropteran larvae.

The scale insect fauna of the Maltese Islands was studied quite extensively (Borg, 1919, 1932) with some 60 species recorded. No further work was done on this economically important group until the present authors made recent surveys, and an updated list is currently being prepared (Mifsud & Watson *in prep.*). A number of scale insect pests were introduced to the Maltese Islands with citrus cultivation. These include species such as *Ceroplastes floridensis* Comstock, *Saissetia coffeae* (Walker), *Aonidiella aurantii* (Maskell), *Lepidosaphes* spp. and *Parlatoria* spp. These are not discussed further here, as they are mostly confined to citrus. More information on these pests is available in Borg (1919, 1922, 1932) and Mifsud (1997). The scale insects discussed below attack commercial crops in the Maltese Islands.

***Icerya purchasi*** Maskell – Cottony Cushion Scale

This insect originated in Australia but reached California in 1868 (Bartlett, 1978a) and has since spread around the world to become virtually cosmopolitan, occurring in greenhouses in many temperate countries (CIE, 1971). Cottony Cushion Scale is polyphagous but is noted as a pest of fruit trees including citrus. Heavy infestations can kill branches by sap depletion and sooty mould damage. *I. purchasi* entered the Maltese Islands on some ornamental plants from Sicily in 1907/8 and was first observed in a few gardens at St. Julian's from where it spread to Sliema and Msida and then throughout the islands in less than three years (Borg, 1919, 1922). The ladybird beetle *Rodolia cardinalis* (Mulsant) was introduced during this time as a biological control agent and is still a means of control against this pest (Mifsud, 1997). Cottony Cushion Scale is a common pest of fruit trees, especially citrus, in the Maltese Islands. The most common control measure used in the islands involves surface oil sprays mixed with insecticides.

***Planococcus citri*** (Risso) – Citrus Mealybug

This species is probably the most economically important and cosmopolitan species of mealybug; its origin is obscure but may possibly have been in China (Bartlett, 1978b). There are very few parts of the world where it does not occur, either in the field in warm climates or on protected crops in temperate regions (CIE, 1969a). The species is polyphagous, especially in protected cultivation, but in field conditions it shows a strong preference for citrus and is only rarely found on other hosts, e.g. grapevines in the Mediterranean region (Cox, 1989). In the Maltese Islands, *P. citri* attacks mainly citrus but is also occasionally found on vines. However, most damage observed on grapevines in the Maltese Islands is due to a probably native species, *P. ficus* (Signoret), which is also known to attack other crops. These two mealybug species are extremely difficult to separate even with the aid of microscope slide mounts (Cox, 1989). Control measures against Citrus Mealybug in Malta are similar to those for the Cottony Cushion Scale. In other countries, Citrus Mealybug in protected crops is often controlled using parasites.

***Pseudococcus longispinus*** (Targioni Tozzetti) – Long-tailed Mealybug

This species differs from the *Planococcus* species discussed above, in having the marginal white wax projections much longer at the posterior end than on the sides, hence the name. The origin of this species is unknown; it is almost cosmopolitan, occurring in the field in warm countries and in greenhouses in temperate regions (CIE, 1984). The Long-tailed Mealybug is highly polyphagous, frequently occurring on ornamentals, citrus and other fruit trees; heavy infestations of branches can cause fruit drop due to sap depletion (Bartlett, 1978b). *P. longispinus* is a virus vector on grapevines. It transmits viruses associated with leafroll symptoms (Petersen & Charles, 1997) and stem pitting (Rosciglione & Gugleri, 1986). In the Maltese Islands, large populations of this mealybug have been recorded causing extensive damage to

several crops including *Citrus* spp., *Ficus* spp., *Prunus* spp. and others. Control measures are similar to the previously mentioned species. Populations in open fields can be regulated by natural enemies.

**Aphids or Plant-lice (Hemiptera, Aphidoidea)**

Aphids are small, soft bodied insects about 1-5 mm long. They often form dense colonies on the growing points of plants, either on shoots or underground on the roots, and feed on plant sap. They excrete sugary honeydew, often causing sooty mould growth and sometimes attracting ants to attend them. Plants may be damaged by sap depletion (causing wilting), saliva toxicity (causing leaf yellowing and death or galling) or through the effects of sooty mould growth. Many aphids reproduce asexually in warm dry conditions, giving birth to live young, so minimising the time between generations. All stages are capable of walking short distances; the adults may be wingless or winged. Dispersal over long distances is by flight of winged adults assisted by winds. Aphids, particularly the mobile winged forms, are important vectors of plant virus diseases. Populations are regulated by natural enemies such as parasitic wasps and by predators such as ladybird beetles and syrphid, cecidomyiid and neuropteran larvae. Very little has been published on the aphid fauna of the Maltese Islands. Some species causing plant galling have been recorded by Caruana Gatto (1926), while Saliba (1963) gave a list of aphid pests occurring in the Maltese Islands. In recent years, the present authors have collected numerous aphids and estimate that over one hundred species occur locally.

*Aphis spiraecola* Patch – Green Citrus Aphid

The species probably originated in the Far East but has spread widely in citrus-growing parts of the world during this century, arriving in North America in the early 1900s, Australia in 1926, New Zealand in 1931, the Mediterranean region around 1939 and in Africa in 1961 (CIE, 1969b). The aphid is polyphagous but prefers woody hosts, including ornamentals and citrus. In the Maltese Islands it was collected on apple, pomegranate and citrus. Colonies on young shoots often cause curling of the leaves, which may protect the aphids from heavy rain. Green Citrus Aphid is an inefficient vector of the important citrus virus disease, Citrus Tristeza Virus, and is known to transmit at least six other virus diseases (Blackman & Eastop, 1984).

*Aphis gossypii* Glover – Melon or Cotton Aphid

There is uncertainty about the area of origin of this aphid, which is now virtually cosmopolitan (CIE, 1968). It is particularly abundant in tropical countries; in colder climates it is confined to greenhouses, where it can be a major pest. It is highly polyphagous, feeding on the leaf undersides of mostly herbaceous host-plants including vegetables and other crops; it is particularly damaging to cucurbits and cotton. The species is known to transmit over 50 plant virus diseases (Blackman & Eastop, 1984), some affecting a number of important crops. In the Maltese Islands, it is an important pest on several crops including potatoes, marrows, cut flowers, aubergines, cucumbers and citrus. Most local control measures still involve application of various insecticides.

*Myzus persicae* (Sulzer) – Green Peach or Peach-Potato Aphid

This species is probably of Asian origin but now occurs world-wide (Blackman & Eastop, 1984). In temperate climates it usually overwinters in the sexual form on its primary host, peach and related *Prunus* species and hybrids; during summer, it is highly polyphagous on secondary hosts in over forty plant families, including many important crop plants. *M. persicae* is known to transmit over one hundred plant virus diseases (Kennedy *et al.*, 1962). Persistent viruses transmitted include beet mild yellowing, pea leaf roll, potato leaf roll and others. In the Maltese Islands, it is commonly found on both outdoor and greenhouse crops such as kohlrabi, cabbage, potato and aubergines, where severe damage is often reported. Four species of braconid parasites were recorded from this aphid pest (Mifsud, 1997).

*Viteus vitifoliae* (Fitch) – Grape Phylloxera

This serious pest of grapes originated in North America, where the local vines evolved with it and are not severely damaged by its feeding. It was accidentally introduced to Europe around 1860 (when it devastated the wine industry), then to the Mediterranean region, the Middle East, Africa, Korea, Australia, New Zealand and parts of South America (CIE, 1975). Grape Phylloxera feeds on species of *Vitis* including grape vines. Foliar attack does not seem to be unduly damaging, but asexual forms attacking roots all year round can kill plants that did not originate from North America. Grafting European vines onto North American root stocks has successfully solved this problem in the past, but concern has increased in recent years because this resistance has broken down in some parts of the world as new biotypes of Grape Phylloxera have evolved (King & Rilling, 1985; Strapazzon & Girolami, 1985). *V. vitifoliae* was first introduced in Italy in 1879 and one year later was reported from Sicily. For a long time, the Maltese Islands remained free from this insect pest. However, in July 1919, a considerable infestation of the insect was found at Ramla in Gozo as well as other localities on the same island (Borg, 1922). Vines grafted on American rootstock are nowadays used in this important industry as the pest does not attack such rootstock. The pest is still occasionally met with on wild, non grafted vines in the Maltese Islands.

## DISCUSSION

Agriculture on small islands (such as the Maltese Islands) often has a restricted crop selection. Thus the accidental introduction of a harmful pest can have serious effects on the agricultural community in both economic and social terms. Sap-feeding insects are small, cryptic and can easily be imported accidentally on plant material from other countries. The examples discussed were all accidentally

introduced to the Maltese Islands, and have caused serious damage or yield reduction in a number of crops. The Maltese agricultural export sector is not very strong, the most important crop in this respect being potato. Export crops can become economically non-viable as a consequence of a serious pest or disease, because other countries will refuse to accept produce unless it is guaranteed pest-free. In the early 1970s, Malta had a strong export industry of Chrysanthemum flowers and cuttings. However, this industry came to an end because of the accidental introduction of the leafminer, *Liriomyza trifolii* (Burgess). This dipteran pest was intercepted in England and Wales on plants originating from Kenya and Malta in 1977/8 (Bartlett & Powell, 1981) and soon afterwards Chrysanthemum imports from these countries were banned.

The introduction of insect pests can have even wider implications. Many small islands rely heavily on tourism as a source of foreign exchange. Agriculture is often mainly responsible for maintenance of an aesthetically pleasing landscape and loss of a crop due to an introduced pest can result in fields being abandoned, becoming derelict and unsightly. This happened in Malta in 1993, when tomato crops were infested with the Tomato Yellow Leaf Curl Virus (TYLCV), transmitted by the whitefly *Bemisia tabaci*. Many tomato crops were devastated and for some time the landscape in these areas was degraded.

In small island states, agriculture is often afforded little importance, because it does not generate significant foreign exchange earnings. This may result in low levels of investment in the plant quarantine and agricultural extension sectors. However, when the economic and social consequences of some past introductions of insect pests are considered, it becomes apparent that these activities definitely deserve ongoing investment and development. The risk of accidental pest introduction is growing constantly, thanks to continually increasing mobility of people and growing international trade in fresh produce. The greatest plant quarantine risks are posed by importation of whole ornamental plants for the tourist and horticultural industries, and by importation of whole plants by visitors arriving by yacht or ferry. Tourists arriving by air seldom carry significant quantities of viable plant material. The best method of plant protection is to prevent pests ever entering the island in the first place. This requires appropriate legislation and effective quarantine inspection of imported living plant material at points of entry in order to enforce phytosanitary regulations. Up-to-date information is needed on which pest species are already present, as well as local expertise in crop monitoring and insect identification, so that any introduction can be quickly recognised and appropriate action taken promptly. Investment in such capability will not only benefit the agricultural and tourist industries, but is also required under the Global Biodiversity Convention.

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## REFERENCES

**Anonymous** (1992a) *Frankliniella occidentalis*. Pp. 145-150, In: Smith, I. M., McNamarra, D. G., Scott, P. R. & Harris, K. M. [Eds.]. *Quarantine pests for Europe*. 1032 pp. CAB International, Wallingford, U.K.

**Anonymous** (1992b) *Bemisia tabaci*. Pp. 71-74. In: Smith, I. M., McNamarra, D. G., Scott, P. R. & Harris, K. M. [Eds.]. *Quarantine pests for Europe*. 1032 pp. CAB International, Wallingford, U.K.

**Anonymous** (1993) Virus fit-tadam tas-serer. *Il-Biedja llum*, **1**: 3, Agricultural Co-operative Ltd., Malta.

**Baldacchino, A. E. & Pizzuto, A.** [Eds.] (1996) *Introduction of Alien Species of Flora & Fauna*. Environment Protection Department, Floriana, Malta. 77 pp.

**Bartlett, B. R.** (1978a) Margarodidae. Pp. 132-136. In: Clausen, C. P. [Ed.] *Introduced parasites and predators of arthropod pests and weeds; a world review*. 545pp. Agriculture Handbook No. 480. United States Department of Agriculture, Washington, D.C.

**Bartlett, B. R.** (1978b) Pseudococcidae. Pp. 137-170. In: Clausen, C. P. [Ed.] *Introduced parasites and predators of arthropod pests and weeds; a world review*. 545pp. Agriculture Handbook No. 480. United States Department of Agriculture, Washington, D.C.

**Bartlett, P. W. & Powell, D. F.** (1981) Introduction of American serpentine leafminer, *Liriomyza trifolii*, into England and Wales and its eradication from commercial nurseries, 1977-81. *Plant Pathology*, **30**: 185-193.

**Bellows, T. S., Perring, T. M., Gill, R. J. & Headrick, D. H.** (1994) Description of a species of *Bemisia* (Homoptera: Aleyrodidae). *Annals of the Entomological Society of America*, **87**: 195-206.

**Blackman, R. L. & Eastop, V. F.** (1984) *Aphids on the world's crops - An identification and Information Guide*. John Wiley & Sons, Chichester, New York, Brisbane, Toronto, Singapore. 466 pp.

**Borg, P.** (1919) *The Scale-Insects of the Maltese Islands*. Malta Herald Office, Malta. 67 pp.

**Borg, J.** (1922) *Cultivation and diseases of fruit trees in the Maltese Islands*. Government Printing Press, Malta. 622 pp.

**Borg, J.** (1932) *Scale insects of the Maltese Islands*. Government Printing Office, Malta. 20 pp.

**Brown, J. K., Frohlich, D. R. & Rosell, R. C.** (1995) The sweepotato or silverleaf whiteflies. Biotypes of *Bemisia tabaci* or a species complex. *Annual Review of Entomology*, **40**: 511-534.
**Brunt, A. A.** (1986) Transmission of diseases. In: Cock, M. J. W. [Ed.] *Bemisia tabaci – A literature survey on the cotton whitefly with annotated bibliography*. Pp. 43-50, Ascot, UK, FOA/International Institute of Biological Control (IIBC) of CAB International.
**Caruana Gatto, A.** (1926) Primo Contributo alla conoscenza die Zooccidii delle Isole Maltesi. *Archivum Melitensis*, 7 (3): 103-126.
**CIE** (1964) Distribution maps of pests, Series A, no. 135. CAB International, Wallingford, UK.
**CIE** (1968) Distribution maps of pests, Series A, no. 18. CAB International, Wallingford, UK.
**CIE** (1969a) Distribution maps of pests, Series A, no. 43. CAB International, Wallingford, UK.
**CIE** (1969b) Distribution maps of pests, Series A, no. 256. CAB International, Wallingford, UK.
**CIE** (1971) Distribution maps of pests, Series A, no. 51. CAB International, Wallingford, UK.
**CIE** (1975) Distribution maps of pests, Series A, no. 399. CAB International, Wallingford, UK.
**CIE** (1979) Distribution maps of pests, Series A, no. 45. CAB International, Wallingford, UK.
**CIE** (1984) Distribution maps of pests, Series A, no. 93. CAB International, Wallingford, UK.
**CIE** (1986) Distribution maps of pests, Series A, no. 284. CAB International, Wallingford, UK.
**CIE** (1993) Distribution maps of pests, Series A, no. 538. CAB International, Wallingford, UK.
**Cox, J. M.** (1989) The mealybug genus *Planococcus* (Homoptera: Pseudococcidae). *Bulletin of the British Museum (Natural History)*, **58** (1): 1-78.
**De Barro, P. J.** (1995) *Bemisia tabaci* biotype B: *a review of its biology, distribution and control*. Second Edition. Division of Entomology Technical paper No. 36. Commonwealth Scientific and Industrial Research Organisation, Canberra, Australia.
**Duffus, J. E.** (1987) Whitefly transmission of plant viruses. In: Harris, K. F. [Ed.] *Current topics in vector research*. **4**: 73-91. New York, NY, USA, Springer – Verlag.
**Fishpool, L. D. C. & Burban, C.** (1994) *Bemisia tabaci* the whitefly vector of African cassava mosaic geminivirus. *Tropical Science*, **34**: 55-72.
**Harrison, B. D.** (1985) Advances in germinivirus research. *Annu. Rev. Phytopathol.*, **23**: 55-82.
**Kennedy, J. S., Day, M. F. & Eastop, V. F.** (1962) *A Conspectus of Aphids as Vectors of Plant Viruses*. Commonwealth Institute of Entomology, London. 114 pp.
**King, P. D. & Rilling, G.** (1985) Variations in the galling reaction of grapevines: evidence of different *Phylloxera* biotypes and clonal reaction of *Phylloxera*. *Vitis*, **24**: 32-42.
**Mifsud, D.** (1995) Whiteflies (Homoptera, Aleyroididae) from the Maltese Islands. *The Central Mediterranean Naturalist*, **2** (3): 61-78.
**Mifsud, D.** (1997) Biological Control in the Maltese Islands – past initiatives and future programmes. *Bulletin OEPP/EPPO Bulletin*, **27**: 77-84
**Mifsud, D. & Palmeri, V.** (1996) A new species of *Aleurolobus* Quaintance & Baker (Homoptera, Aleyrodidae) from Southern Europe. *Boll. Lab. ent. agr. "F. Silvestri", Portici*, Napoli, **52**: 89-95.
**Mifsud, D., Viggiani, G., Dandria, D. & Lanfranco, E.** (1995) Whitefly parasitoids from the Maltese Islands. *The Central Mediterranean Naturalist*, **2** (3): 101-107.
**Petersen, C. L. & Charles, J. G.** (1997) Transmission of grapevine leafroll-associated closteroviruses by *Pseudococcus longispinus* and *P. calceolariae*. *Plant Pathology*, **46** (4): 509-515.
**Rapisarda, C., Mifsud, D. & Martin, J. H.** (1996) Current studies on the Whitefly fauna of the Mediterranean Basin (Homoptera, Aleyrodidae). *Proceedings of the XX International Congress of Entomology*, Florence, Italy. 02-090, LVI + 820 pp.
**Rosciglione, B. & Gugleri, P.** (1986) Leaf roll and stem pitting diseases of grapevine; microscopic and serological analysis. *Revue Suisse de Viticulture, d'Arboriculture at d'Horticulture*, **18** (4): 207-211.
**Roselló, S., Diez, M. J. & Nuez, F.** (1996) Viral diseases causing the greatest economic losses to tomato crop. I. The Tomato Spotted Wilt Virus - a review. *Scientia Horticulturae*, **67**: 117-150.
**Saliba, L.** (1963) *Insect pests of crop plants in the Maltese Islands*. Department of Information, Malta. 35 pp.
**Saliba, F.** (1993) TYLCV f'Ghawdex. *Biedja u Sajd*, Department of Agriculture, Malta, **32**: 1.
**Schembri, P. J. & Lanfranco, E.** (1996) Introduced species in the Maltese Islands. Pp. 29-54, In: Baldacchino, A. E. & Pizzuto, A. [Eds.] *Introduction of Alien Species of Flora & Fauna*. Environment Protection Department, Floriana, Malta. 77 pp.
**Strapazzon, A. & Girolami, V.** (1985) The *Phylloxera* on European vines. *Informatore Agrario*, **41**: 73-76.
**Watson, G. W. & Ismay, J. W.** (1994) Strengthening of plant quarantine capabilities, Malta. FAO report in TCP/MAT/2351 (unpublished).
**Watson, G. W., Ooi, P. A. C. & Girling, D. J.** (1995) *Insects on plants in the Maldives and their management*. International Institute of Biological Control, Ascot, Berks, UK. 124 pp.
**Wheeler, B. E. J.** (1958) *A Plant Disease Survey of Malta*. Central Office of Information, Malta. 30 pp.
**Wheeler, B. E. J.** (1994) Plant Pathology Consultant's Second report (4-26 June, 1994) FAO report in TCP/MAT/2351 (unpublished).