

Biological control in the Maltese Islands — past initiatives and future programmes¹

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Past records of introduced predators and parasites for biological control programmes in the Maltese Islands are reviewed. Literature on this subject is very limited, difficult to obtain and to confirm. During the last 10 years, several exotic pest species were accidentally introduced into the Maltese Islands, including *Aleurothrix floccosus*, *Bemisia tabaci*, *Liriomyza* spp., *Frankliniella occidentalis* and *Phyllocnistis citrella*. Natural enemies have been imported to control these pests. These include *Dacnusa sibirica* and *Diglyphus isaea* for the control of leafminers; *Encarsia formosa*, *Eretmocerus californicus* and *Macrolophus caliginosus* for regulation of *Bemisia tabaci*; *Cales noacki* against *Aleurothrix floccosus*; *Orius laevigatus*, *O. insidiosus* and *Neoseiulus cucumeris* against thrips; *Aphidius colemani* and *Aphidoletes aphidimyza* for the control of glasshouse aphids and *Phytoseiulus persimilis* and *Amblyseius californicus* for the control of the red spider mite. *Encarsia lutea* and *Eretmocerus mundus* have been recorded from *Bemisia tabaci* in Malta. Faunistic studies of parasitic Hymenoptera occurring in Malta are currently being carried out. The data is presented and the significance of utilizing local natural enemies is briefly discussed.

Introduction

Several floristic and faunistic works have been published on the Maltese Islands. In spite of the small size of the islands, some 1000 flowering plants are known to occur there (Haslam *et al.*, 1977). Few general works on the *Insecta* of the islands have been published. The most important of these are: Saliba (1963), on species of economic importance and in which earlier work on the subject is reviewed, the contributions by Schembri, S.P., Sammut & Valletta, and Cilia (in Schembri, P.J. & Sultana, 1989) on rare, threatened and endemic species. Very few works mention the deliberate introduction of biological control agents; most of them will be mentioned in the text that follows. An important contribution was made in 1994 when entomology consultants Drs Gillian W. Watson and John W. Ismay were engaged in a FAO plant quarantine strengthening project for Malta (TCP/MAT/2351). During this survey, insect pests were identified and reported (Watson & Ismay, 1994). More recently, Farrugia (1995) recorded 44 insect species from cauliflower in a field in Gozo (Ghasri).

Lepidopterous pests and their biological control

Saliba (1963) mentions 37 lepidopteran pests in the Maltese Islands. However, few natural enemies have been identified and on only some of these pests. Borg (1932a) recorded *Pteromalus puparum* L. from *Pieris brassicae* and *Papilio machaon* subsp. *melitensis*. The latter is not considered as an agricultural pest. Valletta (1972) recorded *Cotesia glomerata* (L.) as one of the greatest natural enemies of *Pieris brassicae*. Three different hymenopteran parasites were recently reared from larvae and pupae of *Pieris brassicae* (Farrugia, 1995). These are *Pteromalus puparum*, *Cotesia glomerata* and *Pimpla hypochondriaca* (Retzius). Some 35% parasitism was observed from *Cotesia*

¹Paper presented at the EPPO/CABI Workshop on Safety and Efficacy of Biological Control in Europe, Streatley-on-Thames (GB), 1996-03-26/28.

glomerata (Farrugia, 1995) but, as previously indicated (Borg, 1935), this braconid alone is not sufficient to control this pest effectively. *Pimpla hypochondriaca* has been observed to emerge from pupae of *Pieris brassicae*, *Pieris rapae* and *Papilio machaon* subsp. *melitensis* (Schembri, 1992).

Valletta (1973) recorded *Peltocarus dendatus* F. as parasitizing *Gastropacha quercifolia* and *Hyles euphorbiae*. The former was recorded as an occasional pest on apples (Saliba, 1963). Schembri (1992) recorded *Ctenochares bicolorus* L. from pupae of *Autographa gamma* which has been recorded as a common pest of beetroot, potato and marrow (Saliba, 1963). Farrugia (1995) reared *Cotesia ruficrus* Haliday from larvae of *A. gamma*. *Microgaster spectabilis* (Haliday) was reared from an immature larvae of *Noctua pronuba*. This noctuid was recorded as a common pest on lettuce, potato and tomato (Saliba, 1963). *Selania leplastriana* is a very common pest on cabbages and cauliflowers (Saliba, 1963). Farrugia (1995) reared *Venturia canescens* (Gravenhorst) from larvae which probably belong to this moth.

Plutella xylostella was recorded as an uncommon pest on brassicas (Saliba, 1963). Farrugia (1995) recorded *Diadegma semiclausum* (Hellen) from *P. xylostella*. *D. semiclausum* has been used extensively in biological control programmes. A species of Alysiinae (genus and species undetermined) was also collected from the Maltese Islands (Watson & Ismay, 1994). Species of Alysiinae are parasitoids of lepidopterous leafminers, many of which attack the host plant *Chrysanthemum*. Very recently (1993) *Bacillus thuringiensis* was introduced against several lepidopterous pests. Preliminary results indicate that this bacterium is quite effective in controlling large populations of lepidopterous larvae.

In 1995, infestation of the citrus leafminer *Phyllocnistis citrella* was observed in some citrus groves and within a few weeks it was found to be widespread. As opposed to other Mediterranean countries, no naturally occurring enemies have yet been found in the Maltese Islands.

Leafminers and their biological control

The first agromyzid leafminer to be introduced to the Maltese Islands was probably *Liriomyza trifolii*. This pest was discovered in the UK from plants originating from Kenya and Malta. However, the indications are that Kenyan chrysanthemum cuttings were the origin of one of the infestations in Hampshire in 1977/1978 (Bartlett & Powell, 1981). Probably, the pest entered Malta from Kenya (D. Caruana, pers. comm., 1996), from whence later outbreaks in the UK developed from Maltese cuttings (Bartlett & Powell, 1981). *L. huidobrensis* has also been recorded in Malta (according to FAO), but no material ascribable to this species was collected recently (Watson & Ismay, 1994). *L. huidobrensis* as well as other agromyzids of agricultural importance are known to occur in the Maltese Islands (Ebejer, M., pers. comm., 1996). Farrugia (1995) recorded *Chromatomyia horticola* from brassicas. More than 80% parasitism was observed mainly due to *Diglyphus minoews* Walker and less frequently by a *Stenomalina* sp.

In 1979, *Dacnusa sibirica* Telenga was introduced intentionally at Ta'Qali on open fields of melons, watermelons and cucumbers (D. Caruana, pers. comm., 1996). Results indicated that the species was quite effective against the newly arrived leafminer. In 1994, *D. sibirica* was reintroduced together with *Diglyphus isaea* (Walker). Both species were released in Wardija, Rabat, Zejtun, Zabbar, Zebbug, St Paul's Bay, Marsa (Malta) and Victoria (Gozo) (M. Grima, pers. comm., 1996). Results indicated that more than 80% parasitism was due to *D. isaea* while *D. sibirica* proved to be less effective.

Thrips and their biological control

In recent years, several species of thrips have been introduced into the Maltese Islands. *Frankliniella occidentalis* is definitely considered to be a recent introduction causing extensive damage in chrysanthemum nurseries. *Thrips tabaci* was recorded as fairly common on onion and garlic

(Saliba, 1963). This species was recently confirmed as still being present in Malta (Watson & Ismay, 1994).

In 1995, several predators were imported for the control of glasshouse thrips. *Orius laevigatus* (Fieber), *O. insidiosus* Say and *Neoseiulus cucumeris* Oudemans were introduced in Wardija, St Paul's Bay (Malta) and Xaghra (Gozo). *O. laevigatus* subsp. *laevigatus* was previously recorded by Rieger (1986) from Malta. *O. laevigatus* was observed to be an active predator of thrips, while *O. insidiosus* was found to be less effective.

Scale insects and their biological control

The scale insect fauna of the Maltese Islands was extensively studied in the early part of this century (Borg, 1919, 1922a, 1932b), recording some 60 different species. These works are in need of modern taxonomic revision, which is currently being undertaken. Probably the earliest record of the control of scale insects by natural enemies in the Maltese Islands was by Borg (1932b). He mentioned the accidental introduction of two mussel scales (*Lepidosaphes* spp.) to citrus groves in 1885. These pests were later controlled by two species of coccinellid, *Exochomus quadripustulatus* (L.) and *Chilocorus bipustulatus* (L.).

Icerya purchasi was accidentally introduced into the Maltese Islands in 1907/1908 on some ornamental plants from Sicilia (IT). It was first observed in a few gardens at St Julians from whence it spread to Sliema and Msida. In 2–3 years it was widespread (Borg, 1919, 1922a). The coccinellid beetle *Rodolia cardinalis* (Mulsant), a successful biological control agent for the control of *I. purchasi*, was introduced to Malta from Napoli-Portici (IT) in 1911 (Borg, 1922a). The beetle was released in the infested gardens of St Julians. For the first year after its introduction it was considered advisable to breed the predator artificially but, by 1922, it had become widely established in orange groves, and artificial breeding was only continued as a precaution and to secure early broods in March and April (Borg, 1932b). This author also mentions an undetermined species of *Acarus* (*Tyroglyphus*) feeding on *I. purchasi*.

Borg (1919) and Borg (1922a) mentioned seven species of coccinellid beetles preying on scale insect pests in the Maltese Islands: *Chilocorus bipustulatus*, *Exochomus quadripustulatus*, *Coccinella septempunctata* L., *Hippodamia undecimnotata* (Schneider), *Adalia decempunctata* (L.), *A. bipunctata* (L.) and *Rodolia cardinalis*. Borg (1932b) added a further three species to the list: *Scymnus haemorrhoidalis* Herbst, *S. frontalis* (F.) and *Rhyzobius litura* (F.). In a recent study (Schembri, 1993) of the coccinellid fauna of the Maltese Islands, a total of 34 species was recorded. All the species previously recorded as predators of scale insects were confirmed as still present apart from *Hippodamia undecimnotata* and *Adalia bipunctata*. However, Schembri (1993) did not mention the *Scymnus* spp. recorded by Borg (1932b).

Borg (1922b) documented the introduction of *Pseudaulacaspis pentagona* in the Maltese Islands where it was actively preyed upon by two coccinellid beetles: *Chilocorus bipustulatus* and *Exochomus quadripustulatus*. An endoparasite was also mentioned as parasitizing *A. pentagona* but no identification was provided (Borg, 1922b). In this article, Borg mentioned that Prof. Silvestri of Napoli-Portici had promised to send him a colony of *Rhyzobius lophanthae* (Blaisdell) and *Encarsia berleseii* (Howard) for the control of the new pest. Borg (1932b) mentions that *R. lophanthae*, which feeds on *P. pentagona* and other scales, had not yet been introduced to Malta. No literature records were found to confirm whether such introductions were later made, but Schembri (1993) did find *R. lophanthae* in Malta. This may indicate that the species had been actually imported and had established in the Maltese Islands.

Borg (1919) recorded *Coccophagus lycimnia* (Walker) (= *C. lecanii* and *C. cognatus*) and *Microterys flavus* (Motschulsky) as parasitizing *Lecanium* spp. [= *Coccus*, *Saissetia*, *Parthenolecanium* and *Mesolecanium* (genera of species included in the genus *Lecanium* in Borg, 1919)]. *Aphytis diaspidis* (Howard) and *Metaphycus flavus* (Howard) were also recorded as commonly attacking the purple scale *Lepidosaphes beckii* (Borg, 1919). Both species were later recorded by

Borg (1932b). Borg (1919) also reported a species of *Encyrtus* from an undetermined mealybug and a species of *Aphelinus* from the white scale *Aspidiotus nerii*. *Chrysopa* spp. and *Dakruma* spp. were also recorded (Borg, 1919) as predators on scale-insect infestations. The neuropteran fauna of the Maltese Islands is currently under study (C. Plant, pers. comm., 1995).

Borg (1922a,b) reported *Eublemma scitula* (Rambur), *Scutellista caerulea* (Boyer de Fonscolombe) and other unidentified hymenopteran parasites as occurring on *Saissetia oleae*. Borg (1922a) also reported a fungal disease which probably has an important role in keeping this scale under control. As much as 75% parasitism has been observed in late autumn on *S. oleae* and *Coccus hesperidum* (Borg, 1922a). Such scales were recorded to be parasitized by *Scutellista caerulea*, *Coccophagus lycimnia* and *Microterys nietneri* (Motschulsky).

Aphytis diaspidis and *Metaphycus flavus* were recorded as parasitizing *Lepidosaphes beckii* and *L. gloverii* by Borg (1922a). He also recorded an *Encyrtus* sp. from *Dactylopius* sp. (= *Pseudococcus* sp.) and probably *Arescon aspidiolicola* (Ashmead) from *Aspidiotus nerii*. Borg (1922a) also recorded *Thalpochares grossi* and *Laetilia coccidivora* (Comstock) as significantly reducing populations of *Ceroplastes rusci* but did not indicate whether these predators were observed in the Maltese Islands. In fact, neither species is known to form part of the Maltese fauna (P. Sammut, pers. comm., 1996). Borg (1932b) recorded three noctuids as predacious on *Ceroplastes rusci*, *Saissetia coffeae* and occasionally on *S. oleae*. These include *Eublemma ostrina* (Hübner), *E. parva* (Hübner) and *E. scitula*. All three species are known to be still present in the Maltese Islands (P. Sammut, pers. comm., 1996). *Scutellista caerulea* was also found feeding on *Saissetia oleae*, *S. coffeae*, *Coccus hesperidum* and *Ceroplastes rusci*. As much as 75% parasitism was recorded (Borg, 1932b). Other hymenopteran parasites recorded from scale insects in the Maltese Islands include *Arescon aspidiolicola* and *Signiphora flavopalliatia* Ashmead (Borg, 1932b).

In a recent survey (Watson & Ismay, 1994), internal parasitoids were found in the following pests: *Ceroplastes rusci*, *Coccus hesperidum*, *Saissetia coffeae*, *S. oleae*, *Aonidiella aurantii*, *Aspidiotus nerii*, *Lepidosaphes gloverii* and *Parlatoria pergandii*; however, no attempts have been made to identify this material.

Aphids and their biological control

Very few works have been published on the aphid fauna of the Maltese Islands. Caruana Gatto (1926) recorded some aphid species which are known to cause plant galls, while Saliba (1963) gave a list of aphid pest species found in the Maltese Islands. The taxonomy of the aphid species occurring in our islands is at present being studied and it is thought that about 100 species occur locally. Five species of braconids attacking aphids in the Maltese Islands were recorded by Farrugia (1995). *Binodoxys angelicae* Haliday was reared from *Lipaphis erysimi*. Two other were reared from *Brevicoryne brassicae*; these are *Praon volucre* Haliday and *Diaeretiella rapae* M'Intosh. The latter is known to have been introduced into many countries for biological control of this aphid pest. *Myzus persicae* is another important aphid pest in the Maltese Islands. Four braconids were reared from this species: *Aphidius matricariae* Haliday, *Lysiphlebus fabrum* (Marshall), *Praon volucre* and less frequently, *Diaeretiella rapae*.

The syrphid fauna of the Maltese Islands is well known. Forty-six species are known to occur (Ebejer, 1988, 1995). In observations made by Farrugia (1995) in Gozo, three species were identified as actively feeding on aphid populations occurring on *Brassica*, namely, *Sphaerophoria ruppelli* (Wiedemann), *Episyrphus balteatus* (Degeer) and *Eupeodes corollae* (F.). *E. balteatus* has been successfully used in Italy for the biological control of aphids.

Watson & Ismay (1994) recorded an *Allothrombium* sp. as being ectoparasitic on aphids and other arthropods. Some species of the genus have been used in biocontrol programmes. In 1995, *Aphidius colemani* Viereck and *Aphidoletes aphidimyza* Rondani were introduced for the biological control of glasshouse aphids (Grima, M., pers. comm., 1996). Prior to this introduction, *A. aphidimyza* was already known to occur locally: its larvae are very effective predators of aphid populations.

Preliminary results indicate that *A. colemani* is an effective biocontrol agent of aphids, at least in glasshouses. Both species were introduced to glasshouses at Zejtun, St Paul's Bay, Wardija (Malta) and Xaghra (Gozo).

Whiteflies and their biological control

The whitefly fauna of the Maltese Islands has been revised recently (Mifsud, 1995). Four of the 13 species, namely *Trialeurodes vaporariorum*, *Dialeurodes citri*, *Aleurothrixus floccosus* and *Bemisia tabaci*, were reported as being accidentally introduced to the Maltese Islands through human activity. The locally occurring whitefly parasitoids were also studied (Mifsud *et al.*, 1995). Borg (1935) mentioned *Encarsia tricolor* Förster as an effective parasite of *Aleurodes proletella*. This whitefly is considered as a minor pest of brassicas in the Maltese Islands. The occurrence of *E. tricolor* in Malta was recently confirmed (Mifsud *et al.*, 1995).

Encarsia formosa Gahan was first introduced to the Maltese Islands in 1980 (D. Caruana, pers. comm., 1996) at Ta' Qali on protected tomato crops. No results were published on these introductions (D. Caruana, pers. comm., 1996). *E. formosa* was subsequently introduced into several localities in Malta and Gozo in 1990 (Mifsud *et al.*, 1995) and experiments were carried out at Tal-Qroqq (University of Malta, Msida) on protected tomato crops (Mifsud, 1993). The result indicated a significant control of *T. vaporariorum*. *E. formosa* was recently re-introduced (1994) at Marsa, St Paul's Bay, Rabat (Malta) and Xaghra (Gozo) (M. Grima, pers. comm., 1996). So far, *E. formosa* has never been observed outside glasshouses. *Encarsia lutea* (Masi) was reared from *T. vaporariorum* (Mifsud *et al.*, 1995).

Cales noacki Howard was deliberately introduced to the Maltese Islands in 1986 (Anon., 1986) to control the newly arrived whitefly pest *Aleurothrixus floccosus*. It was released in several localities in Malta (Mifsud *et al.*, 1995) and observations suggest it has become well established in citrus groves where as much as 85% parasitism has been observed. However, in certain localities, *A. floccosus* is still a persistent problem on citrus, mainly due to the continuous application of insecticides for the control of this pest.

Eretmocerus mundus Mercet and *Encarsia lutea* have both been recorded from *Bemisia tabaci* on outdoor crops (Mifsud *et al.*, 1995). Large populations of *E. mundus* were observed in Gozo where it seems to be effectively controlling *B. tabaci* outdoors. In 1995, *Eretmocerus californicus* Howard and *Macrolophus caliginosus* Wagner (together with *E. formosa*) were deliberately introduced to control *B. tabaci* in protected crops at Marsa, Rabat, St Paul's Bay (Malta) and Xaghra (Gozo) (M. Grima, pers. comm., 1996). The effectiveness of these newly introduced natural enemies is still being evaluated. *Sphaerophoria ruppelli* was also observed feeding on the puparia of *B. tabaci* (Farrugia, 1995). An *Encarsia* sp. was also recorded from *Dialeurodes citri* (Mifsud *et al.*, 1995). The latter is a minor pest of citrus in Malta and Gozo (Mifsud, 1995).

In 1994, *Verticillium lecanii*, a commonly occurring fungus, was also imported for the control of glasshouse whiteflies. Results indicate that this fungus is rather effective (M. Grima, pers. comm., 1996).

Psyllids and their biological control

So far, very few psyllids have been recorded from the Maltese Islands (Caruana Gatto, 1926; Saliba, 1963). The few psyllids that occur locally are of agricultural importance and a taxonomic revision of these species is currently in preparation (Mifsud, 1997). So far only some *Tamarixia* spp. have been identified as psyllid parasites from Malta.

Spider mites and their biological control

Tetranychus urticae, the red spider mite, is one of the commonest mite pests infesting agricultural

and floricultural crops in glasshouses. In the Maltese Islands, *T. urticae* was recorded as fairly common on tomatoes under cover (Saliba, 1963). The predatory mite *Phytoseiulus persimilis* Athias-Henriot was first introduced to the Maltese Islands at Ta'Qali on protected aubergines in 1980 (D. Caruana, pers. comm., 1996). Few introductions were made and the experiment was a failure. This was probably because, as soon as the predatory mite was released on outdoor crops, it went into diapause and was always confined to the lower, more shaded parts of the plants. Thus, there was a separation of the pest from the predator (D. Caruana, pers. comm., 1996).

In 1994, further attempts were made to reintroduce *P. persimilis* on outdoor crops at Wardija and St Paul's Bay. In 1995, *Neoseiulus californicus* was also introduced at Ta'Qali and Wardija (Malta) for the control of *T. urticae* (M. Grima, pers. comm., 1996). These introductions are still being monitored. *P. persimilis* is showing some positive prospects but it is still premature to provide any information on the effectiveness of *A. californicus*.

Other insect pests

There are other insect pests, e.g. Coleoptera and Diptera, which are also of great agricultural importance in Malta but no data on their native natural enemies has ever been published.

Conclusion

Relatively little work has been carried out on native natural enemies in the Maltese Islands. Currently, in collaboration with the University of Malta, studies are being undertaken to identify native hymenopteran parasites of scale insects, aphids and psyllids. It is hoped that further attempts will be carried out on the possibility of using such natural enemies to control insect pest populations in Malta. These studies will eventually confirm, or otherwise, past records of natural enemies. This work has brought together all previously records of natural enemies, both imported and naturally occurring, in an attempt to analyse the overall situation, and it is hoped that Maltese workers will understand the increasing importance of such systems in the control of insect pests.

Acknowledgements

I express my sincere thanks to C. Farrugia for allowing me to publish material which was previously unrecorded. Special thanks also go towards M. Grima (Director — Martin Grima Limited), D. Caruana (Consultant — Cosmipharma Imports Limited), D. Dandria (Consultant — Agricultural Co-operative Limited), M. Ebejer and P. Sammut for information given. I extend my sincere thanks to G. W. Watson (International Institute of Entomology, London) for revising this manuscript and to S. Aquilina, S. Vella and R. Schembri for help in typing and arranging the manuscript.

Lutte biologique dans les îles de Malte – initiatives passées et futurs programmes

Les signalements des introductions de prédateurs et parasites dans les îles de Malte dans le cadre de programmes de lutte biologique sont examinés. La bibliographie dans ce domaine est très limitée et difficile à obtenir et à confirmer. Au cours des 10 dernières années, plusieurs organismes nuisibles exotiques, parmi lesquels *Aleurothrixus floccosus*, *Bemisia tabaci*, *Liriomyza* spp., *Frankliniella occidentalis* et *Phyllocnistis citrella*, ont été introduits accidentellement sur les îles de Malte. Des auxiliaires ont été importés pour lutter contre ces organismes. C'est le cas de *Dacnusa sibirica* et *Diglyphus isaea* pour lutter contre les mineuses, d'*Encarsia formosa*, *Eretmocerus californicus* et *Macrolophus caliginosus* contre *Bemisia tabaci*, de *Cales noacki* contre *Aleurothrixus floccosus*, d'*Orlus laevigatus*, *O. insidiosus* et *Amblyseius cucumeris* contre les thrips, d'*Aphidius colemani* et *Aphidoletes aphidimyza* contre les pucerons en serre, de *Phytoseiulus persimilis* et *Amblyseius cucumeris* contre le tétranyque commun. *Encarsia lutea* et *Eretmocerus mundus* ont été signalés sur

Bemisia tabaci à Malte. Des études sont en cours sur les hyménoptères parasites de Malte. Les informations disponibles sur ces insectes sont présentées, et l'utilité des auxiliaires indigènes est brièvement discutée.

Биологическая борьба на Мальтийских островах. Прошлые инициативы и будущие программы

В статье рассматриваются результаты внедрения хищников и паразитов в программах биологической борьбы на Мальтийских островах. Литература по этому вопросу крайне ограничена, ее трудно достать и получить подтверждение. За последние десять лет несколько видов вредителей-экзотов были случайно ввезены на Мальтийские острова, включая *Aleurothrixus floccosus*, *Bemisia tabaci*, *Liriomyza* spp., *Frankiniella occidentalis* и *Phyllocnistis citrella*. Для борьбы с этими насекомыми были импортированы естественные враги. К ним относятся: *Dacnusa sibirica* и *Diglyphus isaea* для борьбы с листовёртками, *Encarsia formosa*, *Eretmocerus californicus* и *Macrolophus caliginosus* для борьбы с *Bemisia tabaci*; *Cales noacki* против *Aleurothrixus floccosus*; *Orius laevigatus*, *O. insidiosus* и *Neoseiulus cucumeris* для борьбы с трипсом, *Aphidius colemani* и *Aphidoletes aphidimyza* с тепличными тлями и *Phytoseiulus persimilis* и *Amybyseiulus californicus* для борьбы с красным паутиным клещиком. *Encarsia lutea* и *Eretmocerus mundus* были зарегистрированы на *Bemisia tabaci* на Мальте. На Мальте проводится сегодня исследование фауны паразитной Нумелпортера. В статье дается описание данных и их значения при использовании местных естественных врагов вредителей.

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