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Gall midges (Diptera: Cecidomyiidae) of Malta

ABSTRACT

A study of gall midges was carried out at 17 localities (14 in Malta and 3 in Gozo) over a seven-day period in April 1999. Sites were chosen from the coast and inland up to an altitude of 240 m above sea level. The number of species in each locality ranged from 1 to 9 (average 4.5 species per locality). The greatest number (9 species) was found at Buskett, the only established semi-natural forest in Malta and at Wied Babu, Zurrieq, a well vegetated steep-sided valley leading to the south coast cliffs. The zoogeographical composition of the gall midge fauna is 67% Mediterranean, 20% European, 8% Euro-Siberian and 5% Holarctic species. *Dasineura plicatrix*, larvae of which cause galls on *Rubus ulmifolius*, *D. aparines* on *Galium aparine* and *Lasioptera carophila* on *Foeniculum vulgare* are very common species. *Dasineura* sp. causing galls on *Asparagus aphyllus* is the most abundant species in Malta. *Asphondylia gennadii* on *Ceratonia siliqua*, *Odinadiplosis amygdali* on *Prunus persica*, *Resseliella oleisuga* on *Olea europaea* and *Mayetiola avenae* on *Avena* sp. are potential pests. An annotated list of all 36 gall midge species known from Malta is given together with a list of their host plants.

Key words: Cecidomyiidae, gall midges, galls, faunistics, zoogeography, Mediterranean, Malta.

INTRODUCTION

A preliminary study of arthropods that form galls in plants in Malta, was undertaken by CARUANA GATTO (1926). He recorded 72 species of arthropods, all with their host plants. Nine species were gall midges. BORG (1922) had previously recorded one species of gall midge. The present study is restricted to the gall-forming midges of the family Cecidomyiidae and the total number of species now known from Malta is 36. Of the Cecidomyiidae recorded by Caruana Gatto, the following four species have not been found during the present study: *Contarinia nasturtii* (Kieffer, 1888), *Dasineura pyri* (Bouché, 1847), *Rabdophaga terminalis* (Loew, 1850) and *Stefaniella trinacriae* Stefani, 1900. Since that

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time, there have been no studies of gall midges in Malta. Botanists who worked in this area seem to have paid little attention to the galls that undoubtedly would have been present on some of the botanical samples that they collected.

Gall midges (Cecidomyiidae) are one of the largest families of Diptera and include about 2200 species described from the Palaearctic Region (SKUHRAVÁ, 1986). Larvae of the majority of species are phytophagous, causing galls on their host plants. Some are free-living in association with plants, some are zoophagous preying on other gall midges, aphids, mites and other invertebrates. Larvae of some species are mycophagous (SKUHRAVÁ *et al.*, 1984). Many gall midge species occur in Central Europe, the number decreasing towards the Southern Palaearctic (SKUHRAVÁ & SKUHRAVY, 1998).

The paucity of data on the family Cecidomyiidae in the Maltese Islands prompted an investigation by the authors, the results of which are the subject of this paper.

STUDY AREA

The Republic of Malta is a small archipelago in the central Mediterranean Sea. The three main islands are inhabited: Malta, Gozo and Comino. In addition, there are eight uninhabited islets large enough to sustain vegetation. The archipelago is situated about 35°50' Northern Latitude and 14°30' Eastern Longitude, nearly 100 km south of Sicily and 300 km east of Tunisia. Malta occupies an area of 316 square kilometres. The rock substrate is largely coralline limestone and the highest altitude is 245 m above sea level. The climate is characterised by hot, dry summers (April to October) and cool, rainy winters. There is an almost complete absence of frost.

The Maltese Islands are rich in species of flowering plants (circa 1200 species) in spite of their small area, absence of mountains and dry climate. The comparatively long coastline, with many inaccessible cliff areas, allows humid sea breezes to supply moisture to a large variety of isolated plant communities. Inland, the river-valley systems, although small, are able to sustain a rich plant community because their relative inaccessibility limits cultivation or building.

From the biogeographical point of view, the Maltese Islands belong to the Mediterranean Sclerophyll Province (UDVARDY, 1975). Not surprisingly, the flora is most similar to that of southeast Sicily. The four main types of plant communities are evergreen wood, maquis, garigue and steppe. All suffered significant anthropogenic effects and today there remains no original

evergreen wood. However, a few stands of isolated evergreen oak still exist. The maquis is probably the community with the highest plant diversity relevant to Cecidomyiidae. The uncultivated and non-urbanised parts of the island consist mostly of karstland on which thrives the garigue type of plant community. This consists of many small shrubs, herbaceous plants and geophytes. The coastal slopes and cliffs have their own characteristic plant communities that can best be described as mostly intermediate between maquis and garigue. These localities are important refuges for many species. Many plants are tolerant of saline conditions to a variable degree because of the proximity of the sea to all the small islands. Salt marshes exist, but they are very small.

MATERIAL AND METHODS

Gall midge galls were collected from various types of localities, viz. damp, dry, saline or freshwater habitats, on coralline, clay or sandy substrate and in several valleys covered with rich vegetation. Galls were collected by a uniform method at each locality, by slowly walking through various biotopes, over the course of several hours, searching and collecting galls on various plants, or plants inhabited by mites, aphids or coccids, rusts and fungi in which gall midge larvae may develop. All findings at each locality were recorded, including the occurrence of the most common species. On the other hand, the absence of gall midge species was also noted when the host plants were present in the locality under study. Results of such methods were used to compare gall midge faunas in other areas of Europe and thus providing useful data for zoogeographical conclusions.

A sample of the host plant with galls was placed between filter papers to make a herbarium collection. A second sample of the plant with galls was placed in small emergence cages to obtain developmental stages including adults. Larvae, pupae and adults of gall midges thus obtained from galls were placed into small glass vials with 75% alcohol for subsequent determination and morphological studies. Gall midges were mounted on microscope slides using the conventional method of preparation including processing them from 75% through 95% ethanol and xylene to Canada Balsam, or using Faure's Liquid as medium.

Determination of galls is based on HOUARD (1908-1909), BUHR (1964-1965), of larvae on MÖHN (1955) and of adults on SKUHRAVÁ (1997a). The nomenclature of gall midge species is based on SKUHRAVÁ (1986, 1989). Determination of host plant species is based on HASLAM *et al.* (1977) and

BLAMEY and GREY-WILSON (1998). Nomenclature of host plant species is mainly according to TUTIN *et al.* (1964-1980). Data on gall midges gathered during these investigations are analysed and evaluated from the zoogeographical point of view using methods described by SKUHRAVÁ (1987, 1994a, b, 1997b). Data about harmful species of gall midges may be found in BARNES (1946-1956), NIJVELDT (1969) and DARVAS *et al.* (2000).

Gall midge galls (voucher specimens) are deposited in the collection of Marcela Skuhrová in Praha, Czech Republic.

LOCALITIES EXAMINED

Specimens were collected from 14 localities in Malta and from 3 localities in Gozo. They were selected because of their natural value and because of the occurrence in them of such plant species that were considered as potential host plants for gall midges. Localities are arranged alphabetically. Data given for each locality include: the name of the locality, followed in parenthesis by the number of the locality indicating its position on the map (Fig. 1), short ecological characteristics together with the main plant community and important plant species and the date when the locality was visited.

MALTA

Bajda Ridge (14). Originally an extensive area of karstland garigue, it was planted with *Pinus*, *Olea* and *Acacia* about 25-30 years ago. It is becoming an established wood, but the undergrowth is poor especially near *Pinus* and *Acacia*. The periphery supports a good variety of shrubs, mainly Compositae and Umbelliferae; 6 April 1999.

Buskett (11). This is Malta's only semi-naturalised woodland with *Pinus halepensis* Miller dominating. Many other trees thrive in smaller communities. These include *Quercus ilex* L. and *Q. robur* L., *Ceratonia*, *Olea*, *Pistacia*, *Populus*, *Rhamnus*, *Laurus*, *Prunus*, *Cupressus*, and *Crataegus*. Much of the undergrowth consists of *Hedera*, *Rubus*, *Lonicera* and *Acanthus mollis* L., with borders and open spaces supporting a large variety of plant species including Umbelliferae and Labiatae. To the east, the valley supports *Arundo*; 1 April 1999.

Fomm ir-Rih (13). This locality is a small tree-less area above the cliffs with clay soil and a steppic type of vegetation. Some cultivation takes place in surrounding fields. Not very varied botanically, but entomologically rich, suggesting a well-established ecosystem; 2 April 1999.

Ghadira (1). This site consists of an area of sandy soil with a tendency for

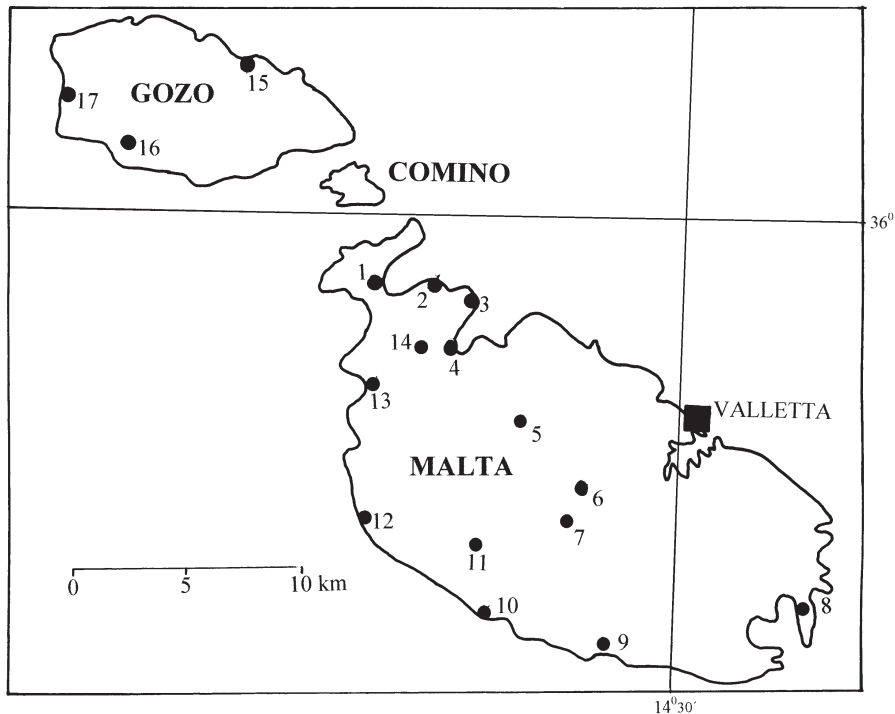


Fig. 1. Malta and Gozo with the localities visited in 1999 for investigations of the gall midge fauna. Malta: 1, Ghadira; 2, Mgiebah; 3, Mistra; 4, Is-Simar; 5, Wied il-Ghasel; 6, Lija; 7, Wied is-Sewda; 8, Marsaxlokk; 9, Wied Babu; 10, Ghar Lapsi; 11, Buskett; 12, Migra l-Ferha; 13, Fomm ir-Rih; 14, Bajda Ridge; Gozo: 15, Ramla Dunes; 16, Wied il-Lunzjata; 17, Dwejra.

dune formation and a saline marsh. There has been significant ecological change since it was physically altered about 20 years ago to accommodate a bird reserve. *Tamarix* and *Phragmites* dominate. The perimeter of the reserve has been planted with *Atriplex halimus* L. *Salicornia* and *Juncus* still occupy a larger part of the marshy area whereas the periphery supports a good variety of herbaceous plants including Gramineae, Leguminosae, Compositae, Cruciferae and Labiatae; 6 April 1999.

Ghar Lapsi (10). This is an area of well-established garigue with a gentle south-facing slope supporting healthy stands of *Periploca angustifolia* Labillardiere, *Thymra capitata* (L.) Cavanilles and *Phlomis fruticosa* L. Many other herbaceous plants grow in the area in spite of the shallow soil. In recent years there has been negligible exposure to cultivation; 3 April 1999.

Is-Simar (4). A grove of old established *Olea* has been left to go wild and behind this there is now an almost freshwater marsh with *Tamarix* and *Phragmites*. The area has been extensively and favourably managed in the last 7 years to form a bird reserve. The undergrowth is still relatively poor in terms of species composition; 6 April 1999.

Lija (6). A suburban area with gardens supporting a number of exotic plant species. Roadsides typically have the more common and hardy weed plants; 4 April 1999.

Marsaxlokk (8). This is a very small remnant of coastal saline marsh that supports a few *Tamarix* trees, bushes of *Dittrichia viscosa* (L.) Greuter and several species of Chenopodiaceae. The flat grassy area also supports patches of various Poaceae and *Melilotus messanensis* (L.) All. The combination of species in this tiny locality forms a unique plant community on the island; 2 April 1999.

Mgiebah (2). A valley with terraced cultivation of fruits and vegetables on both sides. It leads to a small area of grassland and *Phragmites* on slopes of clay with freshwater seepages above a small sandy beach. On the valley sides small areas of wild maquis still exist with a few *Quercus ilex* outnumbered by many scattered individuals of *Ceratonia siliqua* L. Higher ground supports a good garigue community with bushes of *Capparis*, *Cistus* and *Lonicera*. The whole area has a rich flora; 6 April 1999.

Migra l-Ferha (12). The steep rocky slopes above the high cliffs become dry by early April. The soil is sparse and the whole area tends to be windswept. In spite of this it supports a good variety of plant life with many typical coastal elements. No clear dominance is observed and many small plant communities are formed in scattered areas; 2 April 1999.

Mistra (3). An open valley leading to the sea with garigue slopes which, in places, tend to have a maquis type of plant community. *Ceratonia*, *Lonicera* and *Rubus* are the larger species, among which, grow many species of small herbaceous plants. *Erica* and *Capparis* bushes are very common; 6 April 1999.

Wied il-Ghasel (5). This is the island's longest inland deep river valley system. The recently abandoned terraced cultivation on the less steep sides is now replaced by scattered individuals of *Ceratonia* and *Prunus dulcis* (Miller) D.A. Webb. Large parts of the slopes also support *Euphorbia dendroides* L. and *Capparis*. Labiatae, Gramineae, Liliaceae, Umbelliferae and Ranunculaceae are well represented in all areas; 3 April 1999.

Wied is-Sewda (7). This long and narrow watercourse is a shallow river valley system that has intensively cultivated fields on both sides. Relatively devoid of trees and shrubs, most of the vegetation consists of low growing grasses with Cruciferae, Compositae and Leguminosae not forming a particularly rich plant community. The rubble walls bordering the fields

support numerous bushes of *Capparis*; 31 April 1999.

Wied Babu (9). One of the island's botanically richest areas, it consists of a deep gorge with steep slopes leading to the sea. *Ceratonia* and *Rosmarinus officinalis* L. dominate initially, but then bushes of *Rubus* and various Leguminosae take over. However, there is a large variety of herbaceous plants from many families growing on the slopes and in open spaces along the valley; 3 April 1999.

GOZO

Dwejra (17). A depression in an area of relatively barren garigue on the coast retains water for a large part of the year and a meadow type of vegetation is able to survive for longer than in the surrounding area; 6 April 1999.

Ramla Dunes (15). The dune system although partly degraded still remains the only true dune system on the islands with a rich fauna and flora. *Tamarix*, *Phragmites* and *Ononis natrix* L. dominate the plant communities. The clay slopes to the east support a tiny area of *Juncus*. Gramineae, Compositae and Leguminosae are the most commonly represented plant families; 6 April 1999.

Wied il-Lunzjata (16). This is another deep river valley system. It is extensively cultivated at the seaward end. *Arundo*, *Ceratonia* and *Laurus* are the dominant larger plants. *Rubus* forms much of the undergrowth; 6 April 1999.

RESULTS

During this brief survey 29 species of gall midges were found on the Maltese Islands and 26 of these are new records. Three species recorded by CARUANA GATTO (1926) and one recorded by BORG (1922), were not encountered during this study. Another 3 unrecorded species are added to this list. Two were found earlier by J.C. Deeming and one by M.J. Ebejer. All 36 species of Cecidomyiidae that are known from Malta are given below in an annotated list. In addition, the following data are given for each species: biology, a short description of the gall and the host plant species with its botanical family name, the site of pupation, the number of generations per year, the localities where the species was found in Malta and Gozo and its zoogeographical characteristic.

LIST OF SPECIES

Aphidoletes aphidimyza (Rondani, 1847)

Larvae are predators on various species of aphids. The species has several generations a year and pupation is in soil. It is used in biological control against aphids. Locality: Malta: Wied is-Sewda, among aphids on *Reichardia picroides* (L.) Roth (Compositae); Wied Babu, among aphids on *Cynoglossum creticum* Mill. (Boraginaceae). - Distribution: Holarctic.

Asphondylia capparidis Rübsaamen, 1893

Larvae live in swollen flower buds of *Capparis orientalis* Veillard (Capparaceae). Flower buds are malformed, hypertrophied and remain closed. Pupation is in the galls and there are several generations a year. A pest of capers. Locality: Gozo: Wied il-Lunzjata; found only the previous year's dry galls. - Distribution: Mediterranean.

Asphondylia gennadii (Marchal, 1904)

Larvae develop in dwarfed siliquas of *Ceratonia siliqua* L. (Caesalpinaceae). Attacked pods remain small and become brown in colour. Larvae pupate in pods. Several generations in a year. A pest of carob trees in the Mediterranean. GAGNÉ & ORPHANIDES (1992) considered this species to be a generalist with alternation of host species. Locality: Malta: Mgiebah; at the beginning of April small larvae (first instar) were found in very young, small pods of carob trees; adults emerged on 1st May 1999. - Distribution: Mediterranean.

Asphondylia phlomidis Trotter, 1901

Larvae develop inside the swollen leaf-buds of *Phlomis fruticosa* L. (Lamiaceae). Pupation is in galls. Several generations a year. Locality: Malta: Ghar Lapsi. - Distribution: Mediterranean.

Asphondylia stefanii Kieffer, 1898

Larvae live in swollen and deformed siliquas of *Diplotaxis tenuifolia* (L.) DC (Brassicaceae). Pupation is in galls. Several generations a year. Locality: Malta: Wied is-Sewda; CARUANA GATTO (1926) recorded it at Ta' Braxia. - Distribution: Mediterranean.

Asphondylia verbasci (Vallot, 1827)

Larvae develop in swollen flower buds of *Verbascum sinuatum* L. (Scrophulariaceae). Pupation is in galls. Several generations a year. Locality:

Malta: Mistra; found only the previous year's dry galls with openings of emerged adults; CARUANA GATTO (1926) recorded this species at Fort Manoel, Msida. - Distribution: Mediterranean and Sub-Mediterranean.

Contarinia cocciferae Tavares, 1902

Larvae cause cone-shaped galls on twigs of *Quercus ilex* L. (Fagaceae). Full-grown larvae leave the galls and fall to the soil where they hibernate. Only one generation a year. Locality: Malta: Buskett. - Distribution: Mediterranean.

Contarinia nasturtii (Kieffer, 1888)

Larvae develop in swollen flower buds of *Nasturtium officinale* R. Br., and *Brassica rapa* L., subspecies *silvestris* (L.) Clapham (Brassicaceae). The attacked flower buds remain closed. Larvae leave the gall and pupate in silken cocoons in the soil. This species has several overlapping generations a year. It is a potential pest of cultivated *Brassica*. Locality: Malta: Girgenti (on *Nasturtium*), Marsa (on *Brassica*) (CARUANA GATTO, 1926). - Distribution: European.

Contarinia sp.

Larvae live in swollen flower buds of *Cakile maritima* Scop. (Brassicaceae). Galls of this undescribed gall midge species are also known from Denmark (ROSTRUP, 1896) and France (HOUARD, 1902). Locality: Gozo: Ramla Dunes. - Distribution: Mediterranean.

Contarinia sp.

Slightly yellow larvae develop among small, deformed, young leaves on the tips of branches of *Crataegus monogyna* Jacq. (Rosaceae). Galls are similar to those caused by *Dasineura crataegi* (Winnertz, 1853) on *Crataegus oxyacantha* L. Locality: Malta: Buskett and Wied Babu. - Distribution: Mediterranean.

Contarinia sp.

Larvae develop in pod-like folded leaflets of *Medicago polymorpha* L. (Fabaceae). Galls are similar to those caused by *Jaapiella medicaginis* (Rübsaamen, 1912) on *Medicago sativa* L. Locality: Malta: Wied Babu, Wied il-Ghasel, Lija. - Distribution: Mediterranean.

Contarinia sp.

One or two larvae, pale orange-coloured, in slightly swollen pod-like folded leaflet of *Melilotus messanensis* (L.) All. (Fabaceae). Locality: Marsaxlokk, Ghadira. - Distribution:

Mediterranean.

***Contarinia* sp.**

Larvae develop in swollen flower buds of *Sinapis alba* L. (Cruciferae) and are similar to galls caused by *Contarinia nasturtii* (Kieffer, 1888) on various Cruciferae. Locality: Malta: Wied is-Sewda. - Distribution: Mediterranean.

***Cystiphora sonchi* (Bremer, 1847)**

Larvae cause pustule galls on leaves of *Sonchus oleraceus* L. (Compositae). Full-grown larvae either leave galls and pupate in soil, or pupate in the galls. Several generations a year. Localities: Malta: Buskett; Wied Babu. - Distribution: Eurosiberian, over a large area.

***Dasineura aparines* (Kieffer, 1889)**

White larvae cause large galls on vegetative tips of *Galium aparine* L. (Rubiaceae). Larvae pupate in soil. Several generations a year. Localities: Malta: Migra l-Ferha, Fomm ir-Rih, Wied Babu, Wied il-Ghasel, Lija, Is-Simar, Mistra; Gozo: Wied il-Lunzjata, Dwejra. - Distribution: Europe, over a large area and North Africa.

***Dasineura asparagi* (Tavares, 1902)**

White larvae in small galls in terminal parts of shoots of *Asparagus aphyllus* L. (Asparagaceae). Galls are about 5-7 mm long. Locality: Malta: Buskett. - Distribution: Mediterranean.

***Dasineura erodiicola* Sylvén, 1993**

Red larvae develop among seeds and seed-sheaths of *Erodium malacoides* (L.) L'Hér. (Geraniaceae). Locality: Malta: Buskett. - Distribution: Mediterranean.

***Dasineura plicatrix* (Loew, 1850)**

White larvae develop in irregularly contorted and twisted leaves of *Rubus ulmifolius* Schott (Rosaceae). Full-grown larvae leave galls and fall to the soil where they pupate. Several generations a year. Localities: Malta: Buskett, Wied Babu, Wied il-Ghasel, Mistra, Mgiebah, Bajda Ridge, Ghadira. - Distribution: Europe, over a large area and North Africa.

Dasineura pyri (Bouché, 1847)

Larvae develop inside rolled leaf margins of *Pyrus communis* L. (Rosaceae). Several overlapping generations develop in a year. Pupation takes place in soil, but some larvae pupate in rolled leaves. A potential pest of young trees in nurseries. Recorded by BORG (1922). – Distribution: Euro-Siberian, secondarily Holarctic.

***Dasineura* sp.**

Whitish larvae develop in large galls on stems of *Asparagus aphyllus* L. (Asparagaceae). Usually the whole shoot, just after budding, is changed into a gall. Leaf scales are swollen and broadened at base. The larvae are located under swollen scales. Galls are similar to those caused by *Dasineura turionum* (Kieffer et Trotter in TROTTER, 1904) developing on *Asparagus acutifolius*. Larvae of *D. turionum* are red. Localities: Malta: Wied is-Sewda, Buskett, Migra l-Ferha, Fomm ir-Rih, Wied Babu, Ghar Lapsi, Wied il-Ghasel, Lija, Mistra, Mgiebah, Bajda Ridge, Ghadira; Gozo: Ramla Dunes, Dwejra. CARUANA GATTO (1926) found galls at Marsascala, Wied il-Kbir and Msida. He determined the gall midge as *Perrisia turionum*. - Distribution: Mediterranean.

***Dasineura* sp.**

Larvae develop inside swollen and folded leaflets of *Lathyrus clymenum* L. (Fabaceae). Galls are similar to those caused by *Dasineura lathyri* (Kieffer, 1909) on *Lathyrus pratensis* L. Locality: Gozo: Dwejra. - Distribution: Mediterranean.

***Dasineura* sp.**

Larvae develop in irregular flat parenchyme galls on leaves of *Phlomis fruticosa* L. (Lamiaceae). Locality: Malta: Ghar Lapsi. Galls were found also in Greece (SKUHRVÁ & SKUHRVY 1997). - Distribution: Mediterranean.

Gephyraulus diplotaxis (Solinas, 1982)

Larvae live in flower buds of *Diplotaxis eruroides* (L.) (Brassicaceae) and change them into galls. They pupate in soil and have two generations a year. Locality: Malta: Lija. CARUANA GATTO (1926) found galls on *Diplotaxis eruroides* DC., the cause of which he determined as *Cecidomyia* sp., and on *D. tenuifolia* DC. where he determined the midge as *Contarinia* sp. - Distribution: Mediterranean.

Giraudiella inclusa (Frauenfeld, 1862)

Larvae develop in corn-like galls inside the stem of *Phragmites australis* (Cav.) Trin. (*P. communis* Trin.) (Poaceae). Pupation is in galls and there are two generations a year. Locality: Gozo: Ramla Dunes; only the previous year's galls with openings after emergence of gall midges were found. - Distribution: European.

Jaapiella reichardiae Sylvén, 1998

Red larvae develop in deformed flower heads of *Reichardia picroides* (L.) Roth. (Compositae) and pupate there. Two or more generations a year. Locality: Malta: Wied is-Sewda, Fomm ir-Rih; adults emerged 7-11.4.1999. - Distribution: Mediterranean.

Jaapiella sp.

Larvae develop inside swollen, deformed flower buds of *Asparagus officinalis* L. (Asparagaceae). Galls are similar to those caused by *Contarinia florum* Rübsaamen, 1917, on the same host plant and described from Central Europe. Larvae of *Jaapiella* sp. pupate in soil. At least two generations a year. Locality: Malta: Wied Incita, leg. M.J. Ebejer, 6.March 1994. - Distribution: Mediterranean.

Kiefferia pericarpiicola (Bremer, 1847)

Kiefferia pimpinellae (F. Löw, 1874)

Larvae develop inside swollen fruits of *Foeniculum vulgare* L. and other species and genera of Umbelliferae. Full-grown larvae leave galls and fall to the soil where they hibernate. One generation a year. Locality: Malta: Migra l-Ferha on *Foeniculum vulgare* L.; Gozo: Wied il-Lunzjata on *Smyrniolum olusatrum* L. Only the previous year's galls were found, with openings left after adults emerged. CARUANA GATTO (1926) found galls on *Daucus carota* L. in May and June, on *Foeniculum vulgare* L. and *F. piperitum* Veria, on both plants equally frequently. - Distribution: Eurosiberian over a large area.

Lasioptera arundinis Schiner, 1854

Larvae develop in swollen side shoots of *Phragmites australis* (Cavanilles) Trin. (Poaceae). Side shoots arise only when the vegetative tip is damaged by some invertebrate animal. Gall midge larvae pupate in the gall. Only one

generation a year. Locality: Malta: Is-Simar, Ghadira; Gozo: Ramla Dunes, Wied il-Lunzjata. - Distribution: European.

Lasioptera carophila F. Löw, 1874

Orange larvae develop in stem swelling at the point of insertion of umbellules of various species of Apiaceae. Pupation in galls. Two generations develop in a year. Localities: Malta: Wied is-Sewda, Migra l-Ferha, Wied Babu, Wied il-Ghasel, Is-Simar, Mistra; Gozo: Ramla Dunes, Wied il-Lunzjata, Dwejra; in all cases on *Foeniculum vulgare* L. CARUANA GATTO (1926) found galls on *Foeniculum piperitum* Veria at Wied Dalam and Msida. - Distribution: European, over a large area reaching to Africa.

Lasioptera donacis Coutin, 2001

Lasioptera donacis Coutin et Faivre-Amiot, 1981 (nomen nudum)

Larvae develop inside shoots of *Arundo donax* L. (Poaceae). Pupation in galls. One generation a year. Locality: Gozo, Mgarr ix-Xini, 16.6.1999, larvae in dead shoots, leg. J. C. Deeming and M.J. Ebejer; adults emerged on 8.7.1999. - Distribution: Mediterranean.

Mayetiola avenae (Marchal, 1895)

White larvae develop inside stems of *Avena* sp. and cause swellings just above a node. When fully grown, they form brown coloured puparia in galls. Usually two generations develop a year. Potentially a serious pest. Locality: Malta: Buskett, leg. J.C. Deeming, March 1996. - Distribution: European.

Myricomyia mediterranea (F. Löw, 1885)

Larvae develop in small galls, 2-3 mm in diameter, formed of several leaves on branches of *Erica multiflora* L. (Ericaceae). Pupation occurs in the gall. One generation a year. Locality: Malta: Mistra. - Distribution: Mediterranean.

Odinadiplosis amygdali (Anognostopoulos, 1929)

Larvae cause abnormal multiplication of buds of *Prunus dulcis* (Mill.) D.A. Webb and *P. persica* (L.) Batsh. (*Amygdalus persica* L.) (Rosaceae). Flowers and fruits fail to develop and heavy infestations may result in death of the tree (NIJWELDT & TALHOUK, 1976). A serious pest. Pupation takes place in the gall. There is only one generation a year. Locality: Malta: Buskett. - Distribution: Mediterranean.

Resseliella oleisuga (Targioni-Tozzetti, 1886)

Larvae develop under the bark of twigs of *Olea europaea* L. (Oleaceae). Two generations develop per year. Locality: Malta: Bajda Ridge. - Distribution: Mediterranean.

Rabdophaga terminalis (F. Löw, 1880)

Gregarious larvae cause spindle-shaped galls of leaf buds on branches of *Salix alba* L. (Salicaceae). There are several overlapping generations a year. Larvae of summer generations pupate either in the galls or in the soil. Larvae of overwintering generations pupate in the soil. Locality: Malta: Girgenti (CARUANA GATTO, 1926). - Distribution: Eurosiberian.

Stefaniella trinacriae De Stefani 1900

CARUANA GATTO (1926) found small lenticular galls on leaves of *Atriplex halimus* (Chenopodiaceae) which he determined as *Stefaniella* sp. DE STEFANI (1900) illustrated this gall in his paper and considered it to be caused by *S. trinacriae*. Nothing is known about the adults. Locality: Malta, probably Valletta (CARUANA GATTO, 1926). - Distribution: Mediterranean.

ECONOMIC IMPORTANCE

At present, nothing is known about the economic importance of gall midges in Malta. In the course of our investigations, four species were found which can be considered potential pests of economically important plants: *Asphondylia gennadii*, larvae of which develop inside pods of *Ceratonia siliqua*; *Odinadiplosis amygdali*, larvae of which cause multiplication of buds on *Prunus dulcis* and *P. persica*; *Resseliella oleisuga*, larvae of which damage the bark of *Olea europaea* and *Mayetiola avenae*, larvae of which develop in basal parts of oat (*Avena*).

ZOOGEOGRAPHY

The present gall midge fauna of Malta includes 36 species, which is a little more than the expected number of species given the geographical position of the island and the habitat characteristics, namely a paucity of forest. The fauna, which is known for other mediterranean islands, includes: 38 species in Crete, 35 in Sardinia, 23 in Mallorca and 21 in Cyprus (SKUHRAVÁ & SKUHRAVÝ, 1997, 1998).

A zoogeographical analysis reveals that the gall midges of Malta are comprised of 67% of species belonging to a mediterranean fauna, 20% to european, 8% to eurosiberian and 5% to holarctic species. The majority of gall midges are mediterranean species the host plants of which occur only in the mediterranean area. Six gall midges belong to european species. Their host plants have an extensive area of distribution in Europe and some of them also occur in North Africa. The following gall midges belong to european species: *Dasineura aparines*, causing galls on *Galium aparine*; *Dasineura plicatrix*, occurring in Central Europe on *Rubus caesius* and in the Mediterranean on *Rubus ulmifolius*; *Giraudiella inclusa* and *Lasioptera arundinis*, developing on *Phragmites australis*; *Lasioptera carophila*, occurring in galls on various species of Apiaceae; *Mayetiola avenae*, developing in the shoots of *Avena*. Two species have a eurosiberian distribution: *Cystiphora sonchi* on various species of *Sonchus* and *Kiefferia pericarpicola* causing galls on various species of Apiaceae. Only one gall midge species has a holarctic distribution: *Aphidoletes aphidimyza*, a predator of aphids.

LOCAL DISTRIBUTION

During investigations, one to nine gall midge species were found at individual localities, on average 4.5 species per locality. Such a low species number per locality indicates that the gall midge fauna is not rich. The highest number - 9 species - was found at Buskett, the only established woodland in Malta and at Wied Babu, in Zurrieq, where there is a rich composition of plants: herbaceous, small trees and shrubs.

The majority of Cecidomyiidae, at present known from Malta, have phytophagous larvae which cause galls or live in association with host plants. Only one species - *Aphidoletes aphidimyza* - is zoophagous and its larvae prey on various species of aphids. Maltese gall midges are associated with 32 host plant species belonging to various plant families. Most of them develop in galls on herbaceous plants. Only a few gall midge species occur in galls on trees and shrubs, namely on *Ceratonia siliqua*, *Crataegus monogyna*, *Erica multiflora*, *Olea europaea*, *Prunus persica* and *Quercus ilex*.

Nine gall midge species were determined to genus level only. All are undescribed species. In several cases we were successful in rearing adults and the description will be published in another article.

It is interesting that we did not find galls of several gall midge species even though the host plants are present in Malta, for example *Atriplex halimus*, *Phillyrea media*, *Quercus ilex*, *Rhamnus alaternus* and *Tamus communis*.

From the point of horizontal occurrence and abundance, most gall midges (21 species) were found only once (each at only one locality), 6 species twice

(each at two localities), *Contarinia* sp. on *Medicago polymorpha* at three localities and *Lasioptera arundinis* at four localities. These gall midges may be considered as uncommon species in Malta. *Dasineura plicatrix* was found at seven localities, *Dasineura aparines* and *Lasioptera carophila* at nine localities and *Dasineura* sp. on *Asparagus aphyllus* at 14 localities. *Dasineura plicatrix* on *Rubus ulmifolius*, *D. aparines* on *Galium aparine* and *Lasioptera carophila* on *Foeniculum vulgare* may be considered as abundant species. *Dasineura* sp. causing galls on *Asparagus aphyllus* seems to be the most abundant gall midge species in Malta.

LIST OF HOST PLANTS ATTACKED BY GALL MIDGES

Host plant species	Gall midge species
<i>Arundo donax</i>	<i>Lasioptera donacis</i>
<i>Asparagus aphyllus</i>	<i>Dasineura asparagi</i>
	<i>Dasineura</i> sp.
<i>Asparagus officinalis</i>	<i>Jaapiella</i> sp.
<i>Atriplex halimus</i>	<i>Stefaniella trinacriae</i>
<i>Avena</i> sp.	<i>Mayetiola avenae</i>
<i>Brassica rapa</i> ssp. <i>silvestris</i>	<i>Contarinia nasturtii</i>
<i>Cakile maritima</i>	<i>Contarinia</i> sp.
<i>Capparis orientalis</i>	<i>Asphondylia capparis</i>
<i>Cerantonia siliqua</i>	<i>Asphondylia gennadii</i>
<i>Crataegus monogyna</i>	<i>Contarinia</i> sp.
<i>Cynoglossum creticum</i>	<i>Aphidoletes aphidimyza</i>
	(zoophagous on aphids)
<i>Daucus carota</i>	<i>Kiefferia pericarpicola</i>
<i>Diplotaxis eruroides</i>	<i>Gephyraulus diplotaxis</i>
<i>Diplotaxis tenuifolia</i>	<i>Asphondylia stefanii</i>
	<i>Gephyraulus diplotaxis</i>
<i>Erica multiflora</i>	<i>Myricomyia mediterranea</i>
<i>Erodium malacoides</i>	<i>Dasineura erodii</i>
<i>Foeniculum officinale</i>	<i>Kiefferia pericarpicola</i>
<i>Foeniculum piperitum</i>	<i>Kiefferia pericarpicola</i>
	<i>Lasioptera carophila</i>
<i>Foeniculum vulgare</i>	<i>Kiefferia pericarpicola</i>
<i>Galium aparine</i>	<i>Dasineura aparines</i>
<i>Lathyrus clymenum</i>	<i>Dasineura</i> sp.
<i>Medicago polymorpha</i>	<i>Contarinia</i> sp.
<i>Melilotus messanensis</i>	<i>Contarinia</i> sp.

<i>Nasturtium officinale</i>	<i>Contarinia nasturtii</i>
<i>Olea europaea</i>	<i>Resseliella oleisuga</i>
<i>Phlomis fruticosa</i>	<i>Asphondylia phlomidis</i>
	<i>Dasineura</i> sp.
<i>Phragmites australis</i>	<i>Giraudiella inclusa</i>
	<i>Lasioptera arundinis</i>
<i>Prunus dulcis</i>	<i>Odinadiplosis amygdali</i>
<i>Prunus persica</i>	<i>Odinadiplosis amygdali</i>
<i>Quercus coccifera</i>	<i>Contarinia cocciferae</i>
<i>Reichardia picroides</i>	<i>Jaapiella reichardiae</i>
	<i>Aphidoletes aphidimyza</i> (zoophagous on aphids)
<i>Rubus ulmifolius</i>	<i>Dasineura plicatrix</i>
<i>Salix alba</i>	<i>Rabdophaga terminalis</i>
<i>Sinapis alba</i>	<i>Contarinia</i> sp.
<i>Smyrniolum olusatrum</i>	<i>Kiefferia pericarpicola</i>
<i>Sonchus oleraceus</i>	<i>Cystiphora sonchi</i>
<i>Verbascum sinuatum</i>	<i>Asphondylia verbasci</i>

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RIASSUNTO

CECIDOMIIDI (DIPTERA: CECIDOMYIIDAE) DI MALTA

Nell'aprile 1999 sono state eseguite raccolte di cecidomiidi in 17 località di cui 14 in Malta e 3 in Gozo. I siti di raccolta sono stati individuati tra la costa ed aree fino a 240 m s.l.m. Sono stati rinvenuti da 1 a 9 specie per località con una media di 4,5 specie per località. Il maggior numero di specie (9) è stato raccolto a Buskett, la sola foresta semi-naturale di Malta, e a Wied Badu, Zurrieq, una valle a pendio ripido, buona vegetazione, che conduce alla scogliera della costa a Sud dell'isola. La composizione zoogeografica della fauna cecidomiidica è formata per il 67% da specie mediterranee, 20% europee, 8% euro-siberiane 5% oloartiche. Specie molto comuni sono state *Dasineura plicatrix*, le cui larve causano galle su *Rubus ulmifolius*, *D. aparines* su *Galium asparine* e

Lasioptera carophila su *Foeniculum vulgare*. *Dasineura* sp., responsabile di galle su *Asparagus aphyllus*, è la specie più abbondante a Malta. Potenziali organismi dannosi individuati sono: *Asphondylia gennadii* su *Ceratonia siliqua*, *Odinadiplosis amygdali* su *Prunus persica*, *Resseliella oleisuga* su *Olea europea* e *Mayetiola avenae* su *Avena* sp. Viene fornita una lista comprendente le 36 specie di cecidomiidi conosciuti per Malta con un elenco delle piante ospiti.

Parole chiave: Cecidomyiidae, galle, faunistica, zoogeografia, Mediterraneo, Malta.

REFERENCES

- BARNES H.F., 1946-1956 - Gall Midges of Economic Importance. Vol. 1-7. London.
- BLAMEY M., GREY-WILSON CH., 1998 - Mediterranean Wild Flowers. Harper Collins Publishers, London, 560 pp.
- BORG J., 1922 - Cultivation and diseases of fruit trees in the Maltese Islands. Government Printing Press, Malta, 622 pp.
- BUHR H., 1964-1965 - Bestimmungstabellen der Gallen (Zoo- und Phytocecidien) an Pflanzen Mittel- und Nordeuropas. Vol. 1+2. Jena, 1572 pp.
- CARUANA GATTO A., 1926 - Primo Contributo alla conoscenza dei Zoocecidii delle Isole Maltesi. *Archiv. Melit.* Valletta, 7(3): 105-126.
- DARVAS B., SKUHRAVÁ M. & ANDERSEN A. 2000 - 1.15. Agricultural dipteran pests of the Palaearctic region, pp 565-650. In: Papp L., Darvas B. (editors): Contributions to a Manual of Palaearctic Diptera. Vol. 1. General and Applied Dipterology. Budapest, 978 pp.
- DE STEFANI T., 1900 - Zoocecidii e cecidozoi dell'*Atriplex halimus* L. in Sicilia. *Atti Accad. Gioenia Sci. nat.* 13: 1-28.
- GAGNÉ R.J., ORPHANIDES G.M., 1992 - The pupa and larva of *Asphondylia gennadii* (Diptera: Cecidomyiidae) and taxonomic implications. *Bull. Entomol. Res.*, 82: 313-316.
- HASLAM S.M., SELL P.D., WOLSELEY P.A., 1977 - A Flora of the Maltese Islands. Malta University Press, MSIDA - Malta, 560 pp.
- HOUARD C., 1902 - Sur quelques zoocécidies nouvelles ou peu connues recueillies en France. *Marcellia* 1: 35-49.
- HOUARD C., 1908-1909 - Les Zoocécidies des Plantes d'Europe et du Bassin de la Méditerranée. Vol. 1+2. Paris, 1247 pp.
- MÖHN E., 1955 - Beiträge zur Systematik der Larven der Itonididae (=Cecidomyiidae, Diptera). 1. Teil: Porricondylinae und Itonidinae Mitteleuropas. *Zoologica, Stuttgart*, 38 (105): 1-247.
- NIJVELDT W., 1969 - Gall Midges of Economic Importance. Vol. 8. London, 221 pp.
- NIJVELDT W., TALHOUK A.S., 1976 - Contribution to the knowledge of almond pests in East Mediterranean countries. IV. Notes on morphology, biology and importance of *Odinadiplosis amygdali* (Anag.) (Diptera, Cecidomyiidae). *Z. Ang. Ent.*, 80: 325-334.
- ROSTRUP S., 1896 - Danske Zoocecidier. *Vidensk. Meddel. Naturh. For.* 1896: 1-64.
- SKUHRAVÁ M., 1986 - Cecidomyiidae, pp. 72-297. In: Soós Á., Papp L. (editors): Catalogue of Palaearctic Diptera. Vol. 4. Sciaridae - Anisopodidae. Akadémiai Kiadó, Budapest, 441 pp.
- SKUHRAVÁ M., 1987 - Analysis of areas of distribution of some Palaearctic gall midge species (Cecidomyiidae, Diptera). *Cecidologia Internationale*, 8(1+2): 1-48.
- SKUHRAVÁ M., 1989 - Taxonomic changes and records in Palaearctic Cecidomyiidae (Diptera). *Acta Entomol. Bobemoslon.*, 86: 202-233.

- SKUHRAVÁ M., 1994a - The zoogeography of gall midges (Diptera: Cecidomyiidae) of the Czech Republic. I. Evaluation of faunistic researches in the 1855-1990 period. *Acta Soc. Zool. Bohem.*, 57(1993): 211-293.
- SKUHRAVÁ M., 1994b - The zoogeography of gall midges (Diptera: Cecidomyiidae) of the Czech Republic. II. Review of gall midge species including zoogeographical diagnoses. *Acta Soc. Zool. Bohem.*, 58: 79-126.
- SKUHRAVÁ M., 1997a - 2.7. Family Cecidomyiidae, pp 71-204. In: Papp L., Darvas B. (editors): Contributions to a Manual of Palaearctic Diptera. Vol. 2. Nematocera and Lower Brachycera. Budapest, 592 pp.
- SKUHRAVÁ M., 1997b - Gall midges (Diptera, Cecidomyiidae) of the Czech and Slovak Republics as members of zoogeographical units in the Palaearctic Region. *Folia Fac. Sci. Nat. Univ. Masarykianae Brunensis*, Biol. 95: 149-171.
- SKUHRAVÁ M., SKUHRAVÝ V., 1997 - Gall midges (Diptera, Cecidomyiidae) of Greece. *Entomologica*, Bari, 31: 13-75.
- SKUHRAVÁ M., SKUHRAVÝ V., 1998 - The zoogeographic significance of European and Asian gall midge faunas (Diptera: Cecidomyiidae), pp. 12-17. In: Csóka G., Mattson W.J., Stone G.N., Price P.W. (editors): The biology of gall-inducing arthropods. Gen. Tech. Rep. NC-199. St. Paul, MN: U.S. Dep. Agric., Forest Service, North Central Research Station, 329 pp.
- SKUHRAVÁ M., SKUHRAVÝ V., BREWER J.W., 1984 - Biology of gall midges, pp. 169-222. In: Ananthakrishnan T.N. (editor): Biology of Gall Insects. Oxford & IBH Publishing Co., New Delhi, Bombay, Calcutta, 362 pp.
- TROTTER A., 1904 - Nuovi Zoocecidii della Flora italiana. Seconda serie. *Marcellia*, 3: 3-13.
- TUTIN T.G., HEYWOOD V.H., BURGESS N.A., VALENTINE D.H., WALTERS S.M., WEBB A.A., 1964-1980 - Flora Europaea. Vol. 1-5. Cambridge Univ. Press.
- UDVARDY M.D.F., 1975 - A Classification of the Biogeographical Provinces of the World. IUCN Occasional Paper No. 18, Morges, Switzerland, 48 pp.