

HENRIK ENGHOFF * & PATRICK J. SCHEMBRI **

* Zoologisk Museum, København, Denmark

** University of Malta, Msida, Malta

THE MILLIPEDES OF THE MALTESE ISLANDS
(CENTRAL MEDITERRANEAN)

(*Diplopoda*)

INTRODUCTION

Previous records of millipedes from the Maltese Islands are very few. GULIA (1890) listed five species: *Glomeris marginatus* Leach, *Julus terrestris* Lin., *Julus sabulosus* Lin., *Julus modestus* Risso and *Lysiopetalum foetidissimum* Savi. None of these names is valid for any of the species found on the Islands during the present study and in the case of the "*Julus*" spp. it is even impossible to guess which of the Maltese species GULIA was referring to. In the modern literature we have only been able to find two records of millipedes from the Maltese Islands: STRASSER (1969 a) recorded *Schizophyllum oxypygium* (= *Ommatoiulus oxypygium*) and the same author (STRASSER, 1969 b) recorded *Acanthopetalum sicanum*.

The present study is based on a large collection of some 600 millipedes amassed over the period 1975-87 by systematic collecting in all Maltese habitat types and summarizes our taxonomic (HE) and ecological (PJS) knowledge of the Diplopoda of the Maltese Islands.

MALTESE HABITATS

The Maltese Islands, located in the Central Mediterranean some 93 km south of Sicily, consist of three main inhabited islands (Malta, Gozo and Comino with a total area of about 316 km²) and a number of very small islets and rocks (e.g. Filfla islet, St. Paul's Islands, Cominotto). The climate is typically Mediterranean with a seasonal pattern of precipitation that defines a wet season (October to March) during which falls approximately 70% of the total annual rainfall, and a dry season (April to September) (MITCHELL, 1961). The islands are entirely composed of Oligo - Miocene sedimentary rocks, mainly limestones, capped with minor deposits of Quaternary age (PEDLEY *et al.*, 1976; ZAMMIT MAEMPEL, 1977). Structurally the islands are eroded northeastwardly tilted blocks; there are no mountains, the highest point being some 240 m above sea - level, and neither are there lakes, rivers or streams (HOUSE *et al.*, 1961).

HENRIK ENGHOFF * & PATRICK J. SCHEMBRI **

* Zoologisk Museum, København, Denmark

** University of Malta, Msida, Malta

THE MILLIPEDES OF THE MALTESE ISLANDS
(CENTRAL MEDITERRANEAN)

(*Diplopoda*)

INTRODUCTION

Previous records of millipedes from the Maltese Islands are very few. GULIA (1890) listed five species: *Glomeris marginatus* Leach, *Julus terrestris* Lin., *Julus sabulosus* Lin., *Julus modestus* Risso and *Lysiopetalum foetidissimum* Savi. None of these names is valid for any of the species found on the Islands during the present study and in the case of the "*Julus*" spp. it is even impossible to guess which of the Maltese species GULIA was referring to. In the modern literature we have only been able to find two records of millipedes from the Maltese Islands: STRASSER (1969 a) recorded *Schizophyllum oxypygium* (= *Ommatoiulus oxypygium*) and the same author (STRASSER, 1969 b) recorded *Acanthopetalum sicanum*.

The present study is based on a large collection of some 600 millipedes amassed over the period 1975-87 by systematic collecting in all Maltese habitat types and summarizes our taxonomic (HE) and ecological (PJS) knowledge of the Diplopoda of the Maltese Islands.

MALTESE HABITATS

The Maltese Islands, located in the Central Mediterranean some 93 km south of Sicily, consist of three main inhabited islands (Malta, Gozo and Comino with a total area of about 316 km²) and a number of very small islets and rocks (e.g. Filfla islet, St. Paul's Islands, Cominotto). The climate is typically Mediterranean with a seasonal pattern of precipitation that defines a wet season (October to March) during which falls approximately 70% of the total annual rainfall, and a dry season (April to September) (MITCHELL, 1961). The islands are entirely composed of Oligo - Miocene sedimentary rocks, mainly limestones, capped with minor deposits of Quaternary age (PEDLEY *et al.*, 1976; ZAMMIT MAEMPEL, 1977). Structurally the islands are eroded northeastwardly tilted blocks; there are no mountains, the highest point being some 240 m above sea - level, and neither are there lakes, rivers or streams (HOUSE *et al.*, 1961).

were visited during the same season. Within a given locality, diplopods were collected by physically searching suitable microhabitats, by the use of pitfall traps, by removing samples of leaf-litter and soil and searching them by hand in the laboratory and/or subjecting them to Berlese-Tullgren extraction, or by a combination of these methods. Detailed field notes on the habitat and microhabitats sampled were made for most of the localities visited. Specimens collected were killed and fixed in 70% ethanol. The material upon which this paper is based is housed partly in the collections of Zoologisk Museum, København, Denmark (HE) and partly at the University of Malta (PJS).

SPECIES LIST

The species are listed according to the system of HOFFMAN (1979). Synonyms are only listed as far as previous Maltese records are concerned. For each species Maltese locality records of the material examined in this study are given and distribution outside the Maltese Islands is indicated, followed by notes on ecology.

ORDER POLYXENIDA

Family Polyxenidae

1. *Polyxenus lapidicola* Silvestri, 1903

Malta: Tal-Qroqq; Wied il-Ghasel.

Distribution outside Malta: Italy (Campania); France (southeast, Corsica).

This minute species was only collected twice in the present study, both times from leaf-litter accumulated under large shrubs. Its scarcity may be more apparent than real since its small size makes it easily overlooked and necessitates the use of special methods (e.g. Berlese-Tullgren extraction) for its collection.

Family Lophoproctidae

2. *Lophoproctus jeanneli* Brölemann, 1910

Malta: Wied il-Ghasel.

Distribution outside Malta: Italy (Campania); France (south, Corsica); Spain (Catalonia, Mallorca).

This species was collected once only, together with *P. lapidicola*. Much the same comments made for this last species apply also for *L. jeanneli*.

ORDER GLOMERIDA

Family Glomeridae

3. *Glomeris distichella* Berlese, 1884

Glomeris marginatus; GULIA, 1890: 41

Malta: Ballut tal-Imgiebah; Balluta tal-Wardija; Dingli Cliffs; Il-Maqluba (Qrendi); Naxxar Gap; Wied Bufula; Wied il-Hesri; Wied Qannotta; Wied il-Qoton; Wied Znuber.

Gozo: Fort Chambray slopes; San Blas Valley.

Distribution outside Malta: Italy (Sicily, including Egadian Islands).

A common species which occurred in leaf-litter shaded from full sunlight. It was collected from woodlands, from the maquis which develops at the base of *rdum*, and that which develops on the sides of *widien*. It was also collected from

were visited during the same season. Within a given locality, diplopods were collected by physically searching suitable microhabitats, by the use of pitfall traps, by removing samples of leaf-litter and soil and searching them by hand in the laboratory and/or subjecting them to Berlese-Tullgren extraction, or by a combination of these methods. Detailed field notes on the habitat and microhabitats sampled were made for most of the localities visited. Specimens collected were killed and fixed in 70% ethanol. The material upon which this paper is based is housed partly in the collections of Zoologisk Museum, København, Denmark (HE) and partly at the University of Malta (PJS).

SPECIES LIST

The species are listed according to the system of HOFFMAN (1979). Synonyms are only listed as far as previous Maltese records are concerned. For each species Maltese locality records of the material examined in this study are given and distribution outside the Maltese Islands is indicated, followed by notes on ecology.

ORDER POLYXENIDA

Family Polyxenidae

1. *Polyxenus lapidicola* Silvestri, 1903

Malta: Tal-Qroqq; Wied il-Ghasel.

Distribution outside Malta: Italy (Campania); France (southeast, Corsica).

This minute species was only collected twice in the present study, both times from leaf-litter accumulated under large shrubs. Its scarcity may be more apparent than real since its small size makes it easily overlooked and necessitates the use of special methods (e.g. Berlese-Tullgren extraction) for its collection.

Family Lophoproctidae

2. *Lophoproctus jeanneli* Brölemann, 1910

Malta: Wied il-Ghasel.

Distribution outside Malta: Italy (Campania); France (south, Corsica); Spain (Catalonia, Mallorca).

This species was collected once only, together with *P. lapidicola*. Much the same comments made for this last species apply also for *L. jeanneli*.

ORDER GLOMERIDA

Family Glomeridae

3. *Glomeris distichella* Berlese, 1884

Glomeris marginatus; GULIA, 1890: 41

Malta: Ballut tal-Imgiebah; Balluta tal-Wardija; Dingli Cliffs; Il-Maqluba (Qrendi); Naxxar Gap; Wied Bufula; Wied il-Hesri; Wied Qannotta; Wied il-Qoton; Wied Znuber.

Gozo: Fort Chambray slopes; San Blas Valley.

Distribution outside Malta: Italy (Sicily, including Egadian Islands).

A common species which occurred in leaf-litter shaded from full sunlight. It was collected from woodlands, from the maquis which develops at the base of *rdum*, and that which develops on the sides of *widien*. It was also collected from

This species appears to tolerate relatively arid conditions and was found on clay slopes and in garigue habitats where it occurred under stones and in the debris accumulating under vegetation; it was also found under stones and in soil cracks along the sides of *wieden*. *B. stuxbergi* also occurred in leaf-litter under trees and shrubs in woodland, maquis and in gardens.

7. *Ommatoiulus oxypygus* (Brandt, 1841)

Schizophyllum oxypygum; STRASSER, 1969 a: 127

Malta: Ballut tal-Imgiebah; Buskett; Dingli (small cave); Dingli Cliffs; Ghajn Tuffieha; Ghar Lapsi (*rdum*); Il-Maqluba (Qrendi); Ras il-Karraba; Verdala; Wied il-Faham; Wied Ghar Lapsi; Wied il-Luq (Buskett).

Gozo: Fort Chambray slopes; Ghajn Damma; Xlendi Tower (Xlendi).

Minor islands: Cominotto; Filfla; St. Paul's Islands.

Distribution outside Malta: Italy (Sicily, including Eolian and Egadian Islands; Calabria).

This is one of the commonest diplopods in the Maltese Islands and also one of the most ubiquitous. It apparently tolerates a wide variety of environments provided that they contain sheltered microhabitats. It was found under the more deeply embedded stones on clay slopes and in the debris accumulating under vegetation growing in the shelter of *rdum*. It was also found in leaf-litter in woodland, maquis and gardens. This species appears to be one of the few Maltese diplopods to tolerate maritime conditions. It was the only species which occurred on the smaller islets, all of which are subject to sea spray during winter storms, and the predominant vegetation of which is maritime garigue.

ORDER CALLIPODIDA

Family Schizopetalidae

8. *Acanthopetalum sicanum* (Berlese, 1883)

Lysiopetalum foetidissimum; GULIA, 1890: 42

Acanthopetalum sicanum; STRASSER, 1969 b: 197

Malta: Birkirkara; Buskett; Chadwick's Reservoir; Dingli Cliffs; Girgenti; Ghar Dalam Cave (Birzebbuga); Ghar il-Friefet Cave (Birzebbuga); Ghar Hasan Cave; Ghar tal-Inkwizitur (Girgenti); Rđum il-Bies; San Pawl tat-Targa; Ta'Kortin (Mistra); Tal-Qroqq (underground shelter); Wied il-Ghasel; Wied il-Luq (Buskett).

Gozo: Ghajn Damma; San Blas Valley; Xlendi Tower (Xlendi).

Distribution outside Malta: Italy (Sicily with Lipari Island; Puglia including M. Gargano; Trieste); Yugoslavia (Istra, Cres); Greece; see map in STRASSER 1969 b: 197).

As the preceding species, this is one of the commonest and most widespread species in the Maltese Islands. It was recorded from leaf-litter in woodland and *rdum* maquis habitats, from clay slopes, garigue and *widien*. It was the only diplopod encountered in the deeper caves. This affinity for caves possibly explains its occurrence in cellars and similar dark and damp environments inside houses.

ORDER POLYDESMIDA

Family Paradoxosomatidae

9. *Oxidus gracilis* C.L. Koch, 1847

Malta: Buskett.

Distribution outside Malta: cosmopolitan, in colder regions only in glasshouses.

This species appears to tolerate relatively arid conditions and was found on clay slopes and in garigue habitats where it occurred under stones and in the debris accumulating under vegetation; it was also found under stones and in soil cracks along the sides of *wieden*. *B. stuxbergi* also occurred in leaf-litter under trees and shrubs in woodland, maquis and in gardens.

7. *Ommatoiulus oxypygus* (Brandt, 1841)

Schizophyllum oxypygum; STRASSER, 1969 a: 127

Malta: Ballut tal-Imgiebah; Buskett; Dingli (small cave); Dingli Cliffs; Ghajn Tuffieha; Ghar Lapsi (*rdum*); Il-Maqluba (Qrendi); Ras il-Karraba; Verdala; Wied il-Faham; Wied Ghar Lapsi; Wied il-Luq (Buskett).

Gozo: Fort Chambray slopes; Ghajn Damma; Xlendi Tower (Xlendi).

Minor islands: Cominotto; Filfla; St. Paul's Islands.

Distribution outside Malta: Italy (Sicily, including Eolian and Egadian Islands; Calabria).

This is one of the commonest diplopods in the Maltese Islands and also one of the most ubiquitous. It apparently tolerates a wide variety of environments provided that they contain sheltered microhabitats. It was found under the more deeply embedded stones on clay slopes and in the debris accumulating under vegetation growing in the shelter of *rdum*. It was also found in leaf-litter in woodland, maquis and gardens. This species appears to be one of the few Maltese diplopods to tolerate maritime conditions. It was the only species which occurred on the smaller islets, all of which are subject to sea spray during winter storms, and the predominant vegetation of which is maritime garigue.

ORDER CALLIPODIDA

Family Schizopetalidae

8. *Acanthopetalum sicanum* (Berlese, 1883)

Lysiopetalum foetidissimum; GULIA, 1890: 42

Acanthopetalum sicanum; STRASSER, 1969 b: 197

Malta: Birkirkara; Buskett; Chadwick's Reservoir; Dingli Cliffs; Girgenti; Ghar Dalam Cave (Birzebbuga); Ghar il-Friefet Cave (Birzebbuga); Ghar Hasan Cave; Ghar tal-Inkwizitur (Girgenti); Rđum il-Bies; San Pawl tat-Targa; Ta'Kortin (Mistra); Tal-Qroqq (underground shelter); Wied il-Ghasel; Wied il-Luq (Buskett).

Gozo: Ghajn Damma; San Blas Valley; Xlendi Tower (Xlendi).

Distribution outside Malta: Italy (Sicily with Lipari Island; Puglia including M. Gargano; Trieste); Yugoslavia (Istra, Cres); Greece; see map in STRASSER 1969 b: 197).

As the preceding species, this is one of the commonest and most widespread species in the Maltese Islands. It was recorded from leaf-litter in woodland and *rdum* maquis habitats, from clay slopes, garigue and *widien*. It was the only diplopod encountered in the deeper caves. This affinity for caves possibly explains its occurrence in cellars and similar dark and damp environments inside houses.

ORDER POLYDESMIDA

Family Paradoxosomatidae

9. *Oxidus gracilis* C.L. Koch, 1847

Malta: Buskett.

Distribution outside Malta: cosmopolitan, in colder regions only in glasshouses.

14. *Brachydesmus proximus* Latzel, 1889

Malta: Ballùt tal-Wardija; Bingemma Gap; Mgiebah; Salini; San Pawl tat-Targa; Skorba (Mgarr); Wied Anglu; Wied il-Ghasel; Wied Incita.

Gozo: Ghajn Damma; Wied il-Mtelah.

Distribution outside Malta: Italy (including Sicily and surrounding islands); southeast France; Tunisia; Macaronesian Islands.

Unlike its cogener, this species was found in a variety of habitats including leaf-litter in woodland and gardens, under stones and amongst vegetation on clay slopes, garigue and *widien* sides, as well as in steppic communities. It was particularly abundant under stones in garigue habitats suggesting that it can tolerate a certain degree of aridity.

DISCUSSION

As a group, diplopods are predominantly cryptofaunal and associated with leaf-litter. Habitats rich in decomposing plant material are also rich in species. Such habitats are few in the Maltese Islands and this is reflected in the low number of species which occur: 14 as opposed to 35 in Sicily (STRASSER, 1969 b), the nearest mainland and which has much more woodland, maquis and similar habitats than do the Maltese Islands.

In terms of diplopod species richness, the Maltese habitats investigated may be grouped into three: those with high, medium or low diversity. Those habitats where relatively large amounts of leaf-litter accumulate in damp, shady situations not unexpectedly have the highest diversity. Of the 14 species found in the Maltese Islands, 11-12 occurred in woodland and *widien* habitats. In the semi-natural wooded area at Buskett alone, were found 9 of the 14 species recorded, including two (*Oxidus gracilis* and *Brachydesmus superus*) so far known only from there.

The second group of habitats are those with a medium number of species (5-8). These habitats are neither as sheltered nor is plant debris as plentiful in them as in the first group. In this category are included gardens, both public and private, which ecologically are more or less equivalent to the natural maquis communities, the patches of maquis that develop amongst the boulder screes round *rdum*, garigue, particularly that which is somewhat sheltered (e.g. on *rdum* boulder screes) and clay slopes with a heavy cover of grasses.

A third group of habitats are those with low species richness (less than 5 species). These include those habitats with little or no plant debris (e.g. deep caves), exposed habitats (e.g. maritime garigue and that developing at the edges of cliffs), arid habitats (e.g. steppic communities) and disturbed habitats (e.g. built up areas, waste ground, field and road verges).

There are no troglitic diplopods in the Maltese Islands. While three species are found in caves: *Pachyiulus flavipes*, *Ommatoiulus oxypygus*, *Acanthopetalum sicannum*, the first two are only found in shallow caves or near the entrance of deeper ones. Only *A. sicannum* is found penetrating deeply and may be regarded as trogliphilic. This may be related to the carnivorous feeding habits of this millipede, unique amongst the Maltese species, and which enable it to live in habitats devoid of vegetable matter (carnivory was reported in *A. sicannum* by STRASSER (1935); although this author did not fully identify the species involved, on purely geographical grounds it can now be assumed to have been *A. sicannum*).

14. *Brachydesmus proximus* Latzel, 1889

Malta: Ballùt tal-Wardija; Bingemma Gap; Mgiebah; Salini; San Pawl tat-Targa; Skorba (Mgarr); Wied Anglu; Wied il-Ghasel; Wied Incita.

Gozo: Ghajn Damma; Wied il-Mtelah.

Distribution outside Malta: Italy (including Sicily and surrounding islands); southeast France; Tunisia; Macaronesian Islands.

Unlike its cogener, this species was found in a variety of habitats including leaf-litter in woodland and gardens, under stones and amongst vegetation on clay slopes, garigue and *widien* sides, as well as in steppic communities. It was particularly abundant under stones in garigue habitats suggesting that it can tolerate a certain degree of aridity.

DISCUSSION

As a group, diplopods are predominantly cryptofaunal and associated with leaf-litter. Habitats rich in decomposing plant material are also rich in species. Such habitats are few in the Maltese Islands and this is reflected in the low number of species which occur: 14 as opposed to 35 in Sicily (STRASSER, 1969 b), the nearest mainland and which has much more woodland, maquis and similar habitats than do the Maltese Islands.

In terms of diplopod species richness, the Maltese habitats investigated may be grouped into three: those with high, medium or low diversity. Those habitats where relatively large amounts of leaf-litter accumulate in damp, shady situations not unexpectedly have the highest diversity. Of the 14 species found in the Maltese Islands, 11-12 occurred in woodland and *widien* habitats. In the semi-natural wooded area at Buskett alone, were found 9 of the 14 species recorded, including two (*Oxidus gracilis* and *Brachydesmus superus*) so far known only from there.

The second group of habitats are those with a medium number of species (5-8). These habitats are neither as sheltered nor is plant debris as plentiful in them as in the first group. In this category are included gardens, both public and private, which ecologically are more or less equivalent to the natural maquis communities, the patches of maquis that develop amongst the boulder screes round *rdum*, garigue, particularly that which is somewhat sheltered (e.g. on *rdum* boulder screes) and clay slopes with a heavy cover of grasses.

A third group of habitats are those with low species richness (less than 5 species). These include those habitats with little or no plant debris (e.g. deep caves), exposed habitats (e.g. maritime garigue and that developing at the edges of cliffs), arid habitats (e.g. steppic communities) and disturbed habitats (e.g. built up areas, waste ground, field and road verges).

There are no troglitic diplopods in the Maltese Islands. While three species are found in caves: *Pachyiulus flavipes*, *Ommatoiulus oxypygus*, *Acanthopetalum sicannum*, the first two are only found in shallow caves or near the entrance of deeper ones. Only *A. sicannum* is found penetrating deeply and may be regarded as trogliphilic. This may be related to the carnivorous feeding habits of this millipede, unique amongst the Maltese species, and which enable it to live in habitats devoid of vegetable matter (carnivory was reported in *A. sicannum* by STRASSER (1935); although this author did not fully identify the species involved, on purely geographical grounds it can now be assumed to have been *A. sicannum*).

two Maltese species which do not occur in Italy/Sicily (*Stosatea minima* and *Polydesmus mediterraneus*) have clear Balkan affinities. Apart from the Maltese Islands, *S. minima* is known only from Greece (Epirus, below Ligiades; STRASSER, 1976), the Maltese record being only the second one for this species. *P. mediterraneus* is known from Greece and from Bulgaria, Yugoslavia and Turkey. To these species may be added another two (*Brachyiulus stuxbergi* and *Acanthopetalum sicanum*) which, although occurring also in Italy/Sicily are also of eastern Mediterranean affinity (STRASSER, 1965). A link between the Maltese Islands and the northeastern Mediterranean lands clearly exists. STRASSER (1965) has hypothesised that Balkan diplopods invaded Italy and Sicily when these became connected to the Balkan lands during the Pleistocene glacials when the sea level fell considerably, exposing large tracts of what is now the Adriatic seabed. If these eustatic sea level changes were sufficiently low, a link with the Maltese Islands may also have been established.

As required by THAKE's hypothesis, the link with North Africa is tenuous. Four Maltese diplopods are found also in North Africa, however, all four occur in Sicily and Italy. For at least two of these species (the *Brachydesmus* spp.), it is thought that they might have invaded North Africa from Sicily (STRASSER, 1965). Both are widespread in southern Europe but in North Africa occur only in Tunisia which is the North African land closest to Sicily. *Stosatea italica* is also widespread in Europe and in North Africa occurs only in Tunisia and Algeria, so it too probably invaded North Africa via Sicily. The remaining species, *Brachyiulus stuxbergi*, has closer affinities to southern European and eastern Mediterranean forms than to any North African ones (STRASSER, 1965). There is therefore no clear North African element in the Maltese diplopod fauna.

It is interesting to note the absence of any endemic millipedes in the Maltese Islands. The Maltese Islands are remarkable for the relatively large number of endemic animals they contain in comparison with other circumsicilian islands (FRANCINI CORTI & LANZA, 1973) so there can be no doubt that the islands have been isolated for sufficiently long periods for endemisms to evolve. Therefore, either there have never been any endemic diplopods on the islands or else they have been competitively displaced by European species arriving on the islands during the Pleistocene connections as has happened in other groups (THAKE, 1985). Another possibility is that endemic millipedes have not been able to adapt fast enough to the degradation of the original vegetation of the Maltese Islands and/or to increasing dryness.

ACKNOWLEDGEMENTS: We gratefully acknowledge the assistance of A.E. Baldacchino, M. Borg, M. Galdes Giappone, M. Gauci, C. Hili, D.M. Johnson, E. Lanfranco, J.L. Schembri, S. Schembri and J. Sultana in collecting specimens. We thank Professor A. Minelli of the University of Padova for reading and criticizing the draft manuscript of this paper.

REFERENCES

- ATTEMS C., 1927 - Über palaearktische Diplopoden - *Arch. Naturgesch.*, 92 A: 1-256.
 BLOUET B., 1984 - *The story of Malta* - Progress Press, Malta, 1-239.
 BORG J., 1979 - *The public gardens and groves of Malta and Gozo* - Men of the Trees (Malta), Malta, 1-147.
 FRANCINI CORTI E. & LANZA B., 1973 - XVIII congresso della Società Italiana di Biogeografia: note conclusive sulla storia del popolamento animale e vegetale delle isole circumsiciliane - *Lav. Soc. Ital. Biogeogr.*, 3: 911-918.

two Maltese species which do not occur in Italy/Sicily (*Stosatea minima* and *Polydesmus mediterraneus*) have clear Balkan affinities. Apart from the Maltese Islands, *S. minima* is known only from Greece (Epirus, below Ligiades; STRASSER, 1976), the Maltese record being only the second one for this species. *P. mediterraneus* is known from Greece and from Bulgaria, Yugoslavia and Turkey. To these species may be added another two (*Brachyiulus stuxbergi* and *Acanthopetalum sicanum*) which, although occurring also in Italy/Sicily are also of eastern Mediterranean affinity (STRASSER, 1965). A link between the Maltese Islands and the northeastern Mediterranean lands clearly exists. STRASSER (1965) has hypothesised that Balkan diplopods invaded Italy and Sicily when these became connected to the Balkan lands during the Pleistocene glacials when the sea level fell considerably, exposing large tracts of what is now the Adriatic seabed. If these eustatic sea level changes were sufficiently low, a link with the Maltese Islands may also have been established.

As required by THAKE's hypothesis, the link with North Africa is tenuous. Four Maltese diplopods are found also in North Africa, however, all four occur in Sicily and Italy. For at least two of these species (the *Brachydesmus* spp.), it is thought that they might have invaded North Africa from Sicily (STRASSER, 1965). Both are widespread in southern Europe but in North Africa occur only in Tunisia which is the North African land closest to Sicily. *Stosatea italica* is also widespread in Europe and in North Africa occurs only in Tunisia and Algeria, so it too probably invaded North Africa via Sicily. The remaining species, *Brachyiulus stuxbergi*, has closer affinities to southern European and eastern Mediterranean forms than to any North African ones (STRASSER, 1965). There is therefore no clear North African element in the Maltese diplopod fauna.

It is interesting to note the absence of any endemic millipedes in the Maltese Islands. The Maltese Islands are remarkable for the relatively large number of endemic animals they contain in comparison with other circumsicilian islands (FRANCINI CORTI & LANZA, 1973) so there can be no doubt that the islands have been isolated for sufficiently long periods for endemisms to evolve. Therefore, either there have never been any endemic diplopods on the islands or else they have been competitively displaced by European species arriving on the islands during the Pleistocene connections as has happened in other groups (THAKE, 1985). Another possibility is that endemic millipedes have not been able to adapt fast enough to the degradation of the original vegetation of the Maltese Islands and/or to increasing dryness.

ACKNOWLEDGEMENTS: We gratefully acknowledge the assistance of A.E. Baldacchino, M. Borg, M. Galdes Giappone, M. Gauci, C. Hili, D.M. Johnson, E. Lanfranco, J.L. Schembri, S. Schembri and J. Sultana in collecting specimens. We thank Professor A. Minelli of the University of Padova for reading and criticizing the draft manuscript of this paper.

REFERENCES

- ATTEMS C., 1927 - Über palaearktische Diplopoden - *Arch. Naturgesch.*, 92 A: 1-256.
 BLOUET B., 1984 - *The story of Malta* - Progress Press, Malta, 1-239.
 BORG J., 1979 - *The public gardens and groves of Malta and Gozo* - Men of the Trees (Malta), Malta, 1-147.
 FRANCINI CORTI E. & LANZA B., 1973 - XVIII congresso della Società Italiana di Biogeografia: note conclusive sulla storia del popolamento animale e vegetale delle isole circumsiciliane - *Lav. Soc. Ital. Biogeogr.*, 3: 911-918.