

# Temporary rainwater rockpools as repositories of biological diversity in the Maltese Islands

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RENCONTRES  
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## Summary

Ephemeral freshwater rockpools in solution pockets on karstland are subject to regular cycles of alternate flooding and desiccation that are correlated with patterns of precipitation. The aquatic phase of the pools extends from September/October to February/March and the dry phase from April to September. The biseasonal extremes of abiotic habitat variation result in a species assemblage characterised by adaptations for survival of the drought period. The resident biota of the pools is dominated by small crustaceans and chlorophytic algae. These habitats are not widespread and the biota of these pools are similarly limited in extent of distribution throughout the Maltese Islands. A number of species characteristic of these habitats are of local or regional ecological significance. These include *Branchipus schaefferi* and *B. visnyai* (Crustacea: Anostraca), *Cyzicus tetracerus* (Crustacea: Conchostraca), *Triops cancriformis* (Crustacea: Notostraca) from the fauna and *Riella helicophylla* (Bryophyta: Hepaticae), *Damasonium bourgei* (Angiospermae: Alismataceae), *Elatine gussonei* (Angiospermae: Elatinaceae) and *Crypsis aculeata* (Angiospermae: Poaceae) from the flora.

Additionally, an unrecorded epizoid association involving *Branchipus schaefferi* Fischer (Anostraca) and *Lyngbya* sp. (Cyanobacteria) has been observed in a single pool. The pool biota also includes several podocopid ostracods, two cyclopoid copepods and at least five cladocerans representing the Daphniidae, Moinidae, Macrothricidae and Chydoridae.

Localities where such pools are situated are subject to severe anthropogenic pressure deriving mainly from encroachment of constructions. Eradication of such habitats results in loss of the characteristic pool biota that represents a very spe-

cific and localised portion of the biodiversity of the Maltese Islands.

There is no specific legislation for the protection of temporary rainwater pools although these habitats may be used in conjunction with other features to determine the Ecological Protection Rating of an locality. Present legislation does not specifically protect any of the resident biota of temporary freshwater pools.

## Introduction: environment of the Maltese Islands

The Maltese Archipelago consists of a group of small, low-lying islands located in the central Mediterranean, approximately 96km South of Sicily and 290km east of Cape Bon. The islands outcrop from the shallow shelf seas of the Malta-Hyblean Platform which forms the foreland margin of the African Plate. The archipelago extends for 45km in a NW-SE direction and covers a total land area of 316km<sup>2</sup>. The largest islands are Malta (length 27km; area 245.7km<sup>2</sup>) and Gozo (14.5km; 67.1km<sup>2</sup>). The other islands of the archipelago are much smaller and comprise Comino (area 2.8km<sup>2</sup>), St Paul's Islands (10.134 ha.), Cominotto (9.864 ha.), Filfla (2.024 ha.) and General's Rock (0.687 ha.).

The geological structure of the islands represents a simple layer-cake succession of shallow water marine carbonates deposited during the late Oligocene and the Miocene. No rocks of Pliocene age have as yet been conclusively identified, indicating that the archipelago was exposed during this period. The stratigraphic sequence of the islands is in places overlain by unconformably bedded Quaternary deposits of lacustrine, alluvial or terrestrial origin laid down following emergence of the archipelago above sea level.

Local climatic patterns are biseasonal, characterised by a wet season and a dry

season. The wet season normally extends from October to March and approximately 86% of total annual precipitation is recorded during this period. The dry season extends from April to September and is unfavourable for plant growth due to high temperatures and low precipitation.

Annual precipitation is low, of the order of 585.3mm annually. October is the wettest month (mean 110.0mm; s.d. 83.0mm) and July the driest (mean 1.3mm; s.d. 3.7mm). Much variation occurs from year to year, with some years being excessively wet and others excessively dry. During the wet season, much of the rainfall occurs as brief, heavy showers with intervening dry periods that may last for several weeks. The number of rain days is highest in January (mean 14.0d; s.d. 4.4d) and lowest in July (mean 0.4d; s.d. 0.57d). Individual showers may contribute as much as 10% of the total annual rainfall in a single day. Thunderstorms occur most frequently in October (mean 5.8 storms; s.d. 2.7 storms).

Temperatures are generally stable from year to year (mean 18.7°C; s.d. 0.4°C). August is the hottest month (mean 26.4°C; s.d. 1.0°C) and February the coldest (mean 12.4°C; s.d. 1.0°C). Continuous cloud cover is very rare and extended periods of sunshine in winter tend to raise soil and air temperatures. Relative humidity is high, ranging from 51%-85% with little seasonal variation.

## Ephemeral regime freshwater rockpools in the Maltese Islands

Temporary freshwater pools occur in hollows (kamenitzas) on karstified limestone substrata which form through solution erosion of rock by percolation of acidified groundwater. Freshwater derived from precipitation and runoff accumu-

## Angiospermae: Poaceae (1 species)

*Crypsis aculeata* (L.) Aiton [ R D B : endangered with a restricted distribution]

Recorded from Ghadira s-Safra.

## Ecological context of temporary pools

Ephemeral-regime freshwater pools represent impermanent aquatic islets in a terrestrial habitat and the pool biota is essentially restricted to highly localised patches of suitable habitat situated throughout the Maltese Islands. These patches are characterised by varying physico-chemical conditions but are all underlined by the common factor of ephemerality which sets the behavioural and physiological limits required of potential colonisers. A subset of these colonisers (most typically the non-cladoceran branchiopods) are almost exclusively restricted to such ephemeral waters, although exceptions have been recorded (VILLA-CLARA et al., 1990).

Any major disturbance of this highly-localised, and therefore highly vulnerable, point habitat results in a loss of diversity by compressing the virtual physico-temporal hypervolume within which these species can operate in an active state.

## Threats to the pool environment

The most significant disturbances of the pool environment are directly or indirectly derived from anthropogenic activity. Isolated climatic events (e.g. flash-flooding following heavy storms) may also exert considerable disruption on temporary pools, although the effects of such phenomena are generally far less persistent than those deriving from human interference. The following are the principal sources of disturbance for pools in the Maltese Islands:

## Encroachment of human constructions

Growth of the human population in the Maltese Islands has been particularly rapid in the last forty years resulting in an increase in the area occupied by buildings. Several karstified outcrops that harboured temporary rockpools have been converted into residential areas with consequent obliteration of these habitats.

The sharply-enhanced volume of tourism since 1978 has necessitated upgrading of infrastructural facilities resulting in construction of several new hotels and upgrading of existing ones. Several of these have been built over coastal karstland. A recently-approved extension to a major coastal hotel includes development of the area in which the il-Qaliet pool is situated.

## Reclamation of land

Several attempts at converting areas of

natural landscape into agricultural or forested land have been made. Such ventures invariably involve the covering of land perceived as 'barren' (actually karstland with typical garigue vegetation) with soil resulting in the eradication of pool habitats (SCHEMBRI & LANFRANCO, 1993).

## Quarrying

The rapid growth of the construction industry has led to an increase in the number and size of quarries. A total of 96 licensed quarries were operative in 1992, 26 of which exploit karstland (MALTA STRUCTURE PLAN, 1991). There is also a sizeable number of inoperative and illegal quarries.

## Runoff

Flash-flooding during and following heavy rains has occasionally been observed to flush out smaller rockpools almost completely with the resultant loss of all sediment and biota (LANFRANCO, 1990). Infilling of kamenitzas with water-borne soil has also been noted, although the effects are generally transient, as the soil is redistributed by successive floods.

A more persistent threat is the accumulation of leachate from agricultural and industrial land in the pool sediment. Biocides derived from agriculture may inhibit the development of pool vegetation with a consequent reduction in faunal diversity. Leachate from waste dumps may also interfere with the establishment and maintenance of pool communities.

## Illegal dumping

Dumping of organic waste in pool hollows is a frequent occurrence. Consequent rapid growth of bacterial populations leads to a decline in oxygen content of poolwater and results in impoverishment of the biota.

## Protective legislation

Although there is no specific legislation for the conservation of temporary freshwater rockpools in the Maltese Islands, these habitats and some of their resident species may be used in conjunction with other features in order to determine the Ecological Protection Rating of a locality (MALTA STRUCTURE PLAN 1992a, b). A small number of temporary pools (e.g. Ghadira s-Safra) have been indirectly protected through designation of the area within which they occur as a nature reserve. This measure is however mainly cosmetic since only one site is regularly wardened (STEVENS et al., in press).

Only two of the species which occur in temporary pools are formally protected by legislation. The Painted Frog

(*Discoglossus pictus pictus* Otth) and *Riella helicophylla* (Bory & Mont.) have been protected since 1993 (Government of Malta Legal Notice 49, 1993). Present legislation does not specifically cover any of the resident fauna of temporary pools.

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## Long Abstract

Ephemeral freshwater rockpools in solution pockets on karstland are subject to regular cycles of alternate flooding and desiccation that are correlated with patterns of precipitation. The aquatic phase of the pools extends from September/October to February/March and the dry phase from April to September. The biseasonal extremes of abiotic habitat variation result in a species assemblage characterised by adaptations for survival of the drought period. The resident biota of the pools is dominated by small crustaceans and chlorophytic algae. These habitats are not widespread and the biota of these pools are similarly limited in extent of distribution throughout the Maltese Islands.

A number of species characteristic of these habitats are of local or regional ecological significance. The designation RDB refers to the status of the species as listed in the Red Data Book for the Maltese Islands:

*Branchipus schaefferi* Fischer (Crustacea: Branchiopoda: Anostraca) [RDB: restricted distribution]. Occurrence in the Maltese Islands limited to temporary rainpools.

*Branchipus visnyai* Kertész (Crustacea:

Branchiopoda: Anostraca) [RDB: very rare with a restricted distribution]. Recorded from three localities in the Maltese Islands.

*Cyzicus tetracerus* Krynicki (Crustacea: Branchiopoda: Conchostraca) [RDB: restricted distribution]. Occurrence in the Maltese Islands limited to temporary rainpools.

*Triops cancriformis* (Bosc); (Crustacea: Branchiopoda: Notostraca) [RDB: rare, with a restricted distribution]. Occurrence in the Maltese Islands limited to temporary rainpools.

*Riella helicophylla* (Bory & Mont); (Bryophyta: Hepaticae); a very rare and endangered liverwort. Listed in Appendix 1 of the Berne Convention as a "Species to be Strictly Protected". Recorded from a single pool.

*Damasonium bourgei* Cosson; (Angiospermae: Alismataceae); [RDB: Vulnerable with a restricted distribution in the Mediterranean and in the Maltese Islands]. Confined to temporary rainwater pools. This species is of very restricted Mediterranean distribution.

*Elatine gussonei* (Sommier) Brullo, Lanfranco, Pavone & Ronsisvalle; (Angiospermae: Elatinaceae); [RDB: Rare with a restricted distribution in the Mediterranean and in the Maltese Islands]. A Pelago-Maltese endemic confined to the Maltese Islands and Lampedusa.

*Crypsis aculeata* (L.) Aiton; (Angiospermae: Poaceae) [RDB: endangered with a restricted distribution]. Restricted to a single temporary pool.

Additionally, an unrecorded epizoic association involving *Branchipus schaefferi* Fischer (Anostraca) and *Lyngbya* sp. (Cyanobacteria) has been observed in a single pool. The pool biota also includes several podocopid ostracods, two cyclopoid copepods and at least five cladocerans representing the Daphniidae, Moinidae, Macrothriciidae and Chydoridae.

Localities where such pools are situated

are subject to severe anthropogenic pressure deriving mainly from encroachment of constructions. Eradication of such habitats results in loss of the characteristic pool biota that represents a very specific and localised portion of the biodiversity of the Maltese Islands.

There is no specific legislation for the protection of temporary rainwater pools although these habitats may be used in conjunction with other features to determine the Ecological Protection Rating of an locality. Present legislation does not specifically protect any of the resident biota of temporary freshwater pools.

## Résumé

Les mares transitoires créées dans des poches de dissolution en milieu karstique présentent une alternance régulière de mise en eau et d'assèchement, qui est corrélée avec le régime des précipitations.

La phase aquatique s'étend de septembre/octobre jusqu'à février/mars ; et la phase sèche d'avril à septembre. Les variations bi-annuelles drastiques des conditions abiotiques ont conduit à la présence d'un assemblage d'espèces présentant des adaptations particulières à la survie en période sèche.

Les biocénoses permanentes de ces mares sont dominées par de petits crustacés et par des algues chlorophylliennes.

De tels habitats étant peu répandus, les espèces animales et végétales qui y sont associées ont une répartition très limitée dans l'archipel Maltais. De ce fait, de nombreuses espèces caractéristiques de ces milieux présentent une forte valeur biogéographique et écologique locale ou régionale.

C'est en particulier le cas de *Branchipus schaefferi* et *B. visnyai* (Crustacea : Anostraca), *Cyzicus tetracerus*.

En outre, une association unique entre *Branchipus schaefferi* Fisher (Anostraca), et *Lyngbya* sp. (Cyanobactérie) a été mentionnée dans une seule mare.

Les biocénoses de ces mares comprennent également plusieurs ostracodes podocopides, 2 copépodes cyclopoïdes et au moins 5 cladocères appartenant au Daphniidae, Moinidae, macrothriciidae et chidoïdae.

Les zones où se rencontrent de tels biotopes sont actuellement soumises à une forte pression anthropique et en particulier au développement de l'urbanisation.

La disparition de tels milieux entraîne la perte d'une part très spécifique et localisée de la biodiversité des Iles maltaises.

Il n'existe pour l'instant aucune législation assurant la protection de ces mares temporaires.

Bien que la prise en compte de ces biotopes puisse participer à la mise en place de mesures de protection écologique sur certaines zones, il n'existe actuellement aucune mesure particulière assurant spécifiquement la conservation de ces milieux et de leur biocénose.

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lates in such solution hollows forming the pool environment. Pools supplied exclusively by these freshwater inputs are characterised by a typically autumnal cycle with the alternation of an aquatic phase with a desiccated phase. These cyclic changes are related with the biseasonal climate of the Maltese Islands.

When the pools are filled with water a diverse macro and microplanktonic resident biota is present and as they dry a flora of terrestrial macrophytes may colonise the substratum.

## Pool biota

The ephemeral nature of the pool habitat restricts colonisation and several groups that are generally regarded as being typical freshwaters (as by WILLIAMS, 1975) have not been recorded from local pools. These include gastropods, bivalves, oligochaetes and malacostracans (LANFRANCO, in prep.)

The absence of these groups is a consequence of their inability to survive the inherent instability of the habitat which places a constraint of a prolonged period of desiccation on the biota.

The resident biota therefore comprises highly-fecund organisms with short life-cycles and rapid attainment of reproductive capability. These features have been listed by WILLIAMS (1985) as biotic adaptations of organisms colonising lentic waters in arid and semi-arid regions.

The fauna of the study pools is depauperate relative to the pool of potential regional colonists. Lowered species richness is a consequence of two principal factors:

. The generally small size of pools on karstic terrain in the Maltese Islands, limiting habitat heterogeneity and hence placing an upper limit to the number of available niches.

. The insular nature of the Maltese superhabitat, representing a small target for potential sources of colonisation (such as windborne propagules).

Diversity of the pool biota in terms of species richness is furthermore dependent on the duration of hydroperiod and on the diversity of vegetation colonising the substratum during the aquatic ecophase. In general, longer hydroperiods promote the accumulation of a larger subset of the pool of colonising species, while vegetational diversity increases habitat heterogeneity and hence faunal diversity (LANFRANCO, in prep.)

The resident biota of pools in the Maltese Islands is dominated by microcrustaceans (Branchiopoda, podocopid Ostracoda, cyclopoid Copepoda) and chlorophytic algae (Chlorophyceae, Zygnemataceae, Characeae). Semi-transient biota that occupy the pool environment as larval stages include insects (Chironomidae, Culicidae, Ephemeroptera, Odonata) and tadpoles. Several adult insects visit the pools for brief periods.

All microcrustaceans recorded from local pools belong to Group I of WIGGINS et al. (1980) and are widely distributed throughout the Mediterranean littoral. All locally-occurring branchiopods that have been identified to species are also present in Italy and Algeria (LANFRANCO et al. 1991) although some of these have a wider distribution.

## Species of local or regional ecological significance

Species that occur exclusively in temporary waters are limited in their occurrence and distribution in the Maltese Islands by a paucity of colonisation sites which is

a consequence of the scarcity of karstified terrain. Several temporary-pool species are therefore of considerable ecological significance in a local context. The designation RDB refers to the status of the species as listed in the Red Data Book for the Maltese Islands (SCHEMBRI & SULTANA, 1989)

**Crustacea: Branchiopoda: Anostraca (2 species)**

*Branchipus schaefferi* Fischer [RDB: restricted distribution]

This anostracan is euryhaline (LANFRANCO et al., 1991), and has been recorded from inland pools as well as mesohaline coast-fringing habitats. Occurrence is however sporadic. A previously unrecorded epizoaic association between *B.schaefferi* and *Lyngbya* sp. (Cyanophyta) was observed at Ghadira s-Safra in 1990.

*Branchipus visnyai* Kertész [RDB: very rare with a restricted distribution]

This species has only been recorded from three pools situated in different localities: Wied ir-Raheb in Gozo (1984), Ghadira s-Safra (1989) and il-Qaliet (1995). *B.visnyai* was syntopic with *B.schaefferi* at Ghadira s-Safra and il-Qaliet and sympatric with the same species at Wied ir-Raheb. For the purposes of the present work, *B.visnyai* has been determined according to the scheme of COTTARELLI (1969), in line with previous records from the Maltese Islands.

**Crustacea: Branchiopoda: Conchostraca (1 species)**

*Cyzicus tetracerus* Krynicki [RDB: res-

tricted distribution]

Although recorded in low abundance from several pools throughout the Maltese Islands, this species is nevertheless absent from many other habitats and could be considered potential sites for colonisation.

**Crustacea: Branchiopoda: Notostomatidae (1 species)**

*Triops cancriformis* (Bosc) [RDB: with a restricted distribution]

The only records of this species in the Maltese Islands are from the main island of Malta. The last records of this species are of one live individual and a single specimen from Tal-Wej in December 1994. Prior to that, the only verified sightings in recent years were two individuals from Ghadira s-Safra in December 1994 and a single individual from Mosta in December 1990.

**Crustacea: Branchiopoda: Cladocera (at least five genera)**

The Cladocera are not featured in the lists of the Maltese Islands since records of this group are scant. This is mainly a consequence of the insufficient attention paid to this order. Following a recent survey, a number of species from different families were collected and being identified by Prof. F.G. Margalef in Rome.

**Chydoridae (2 species):** Occur in low abundances in the benthos of temporary pools.

**Daphniidae (1 species; postembryonic Ceriodaphnia):** Frequently occur in open-water form.

inidae (1 species): only recorded in a single pool in Gozo. The carapace of all specimens collected was covered with *Colacium* sp. (Euglenophyta).

Microthriciidae (1 species): recorded in very low abundance from a single pool in Gozo.

**Phytophyta: Hepaticae (1 species)**

*Ranunculus helicophylla* (Bory & Mont.)

Very rare and endangered liverwort recorded on a single occasion from Għadira s-Safra in 1990 (LANFRANCO & LANFRANCO S., in prep.). This

species is listed in Appendix 1 of the Berne Convention as a "Species to be strictly protected" but is not included in local Red lists since its discovery post-dates the compilation of the only published edition of the Red Data Book. *R. helicophylla* has recently been included in a list of local flora covered by protective legislation (Government of Malta Legal Notice 49, 1993).

**Angiospermae: Alismataceae**

*Damasonium bourgei* Cosson [ R D B : Vulnerable with a restricted distribution in the Mediterranean and in the Maltese

Islands]

Confined to temporary rainwater pools. This species is of very restricted Mediterranean distribution.

**Angiospermae: Elatinaceae**

*Elatine gussonei* (Sommier) Brullo, Lanfranco, Pavone & Ronsisvalle [RDB: Rare with a restricted distribution in the Mediterranean and in the Maltese Islands]

A Pelago-Maltese endemic confined to the Maltese Islands and Lampedusa.