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MONOGRAPH

Qanat, gebbie and water sources: the last refuge for the malacological freshwater fauna in Palermo (Sicily, Italy)

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ABSTRACT The surroundings of Palermo were characterized, over the centuries, by the presence of many natural environments of great ecological and faunal importance. These environments were placed in a context characterized by minimal and sustainable urban development and large agriculture areas, dedicated to the development of tree crops such as citrus and orchards. These crops were supported by an imposing irrigation system that, using natural resources such as watercourses, wells and springs, collected and distributed water in soils through tanks, gebbie, qanat, irrigation channels (saje), etc. Fresh water mollusks, like many other animal and vegetable organisms, spread from the natural freshwater environments in this artificial water system, thus creating a unique and varied ecosystem. The subsequent urban development of the city of Palermo and the destruction of many of those natural environments has further enhanced the ecological role of the artificial freshwater systems as an important refuge for the native fauna and flora. In the present study, we report on freshwater molluscs observed in the territory of Micciulla, a large relict area occupied almost entirely by an old citrus, now located inside the city of Palermo. In this area there are some springs, an extensive array of artificial freshwater to irrigate the crops, and the qanat Savagnone located in the "Camera dello Scirocco". The results obtained by census of different populations of freshwater mollusks confirm the importance of these environments and the growing role they play as the last refuges for fauna and flora originally linked to natural humid environments.

KEY WORDS Palermo Plain; agroecology; orchards; ecology; freshwater mollusks.

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INTRODUCTION

The Palermo Plain is about 130 sqkm wide, with NW-SE direction and an average slope of 10–15%. It is bordered to the West by the mountains of Palermo, to SE by the Eleuterio river, to NE by the Tyrrhenian Sea. The mountains of Palermo reach an average height of 900 m a.s.l., with very steep slopes and consist of limestones and dolomites with high degree of fracturing and permeability. The main peaks are Mount Gallo, Mount Pellegrino, Belmonte-Pizzo Mirabella, Mount

Grifone, Orecchiuta, Pizzo Valle Fico, Costa Lunga, Gibilmesi, Busilmeri, Mount Caputo, Mount Cuccio, Cozzo Di Lupo, Mount Gibilforni, Mount Castellaccio.

The Palermo Plain consists of Pleistocene deposits (Calcarenites and sandy clays of Ficarazzi) that lie on waterproof soils of clay and marne of the Numidic Flysch (Oligo-Miocene), beneath these latters there are meso-cenozoic limestones (Abate et al., 1978; Catalano et al., 1979).

Two aquifers are recognized, the superficial one into Pleistocene sandy-clay and calcarenites, and the deep one (below 100 m deep) into Mesozoic limestones. The two aquifers are discontinuously separated by the waterproof Flysch (Calvi et al., 1998).

The waters that leak in carbonate rocks of Palermo Mountains supply the deep aquifer and in part the superficial one. Where they encounter waterproof soils emerge suppling superficial springs. The waters of Mount Cuccio and Mount Gibilmesi, for example, emerge in the Gabriele spring group and are employed, ever since, for irrigation or drinking-water use.

The waterways and main canals were (and still partly are) part of the Oreto River, including the Papireto River, the Kemonia Stream and the Passo di Rigano Canal (cfr. Cusimano et al., 1989). The Oreto River originates from Portella di Renda, south of Palermo, at 786 m a.s.l. and flows toward the sea, always on the eastern side of the Palermo Plain. It was and is, despite centuries of deep alterations by Man, an important natural environment. At its mounths there were coastal wetlands called the Pantani dell'Oreto or Pantani di Cascino, finally dried up around 1750. The Papireto (or Conceria) River flowed northwest of the ancient Palermo town and originated from the Danisinni Depression; it was about 3 km long and was transformed into an underground sewer in 1591.The Kemonia torrent (also known as “river of bad weather”) flowed southwest of the old city of Palermo, forming the mid-terminal stretch of Sambucia-Cannizzaro, below Monreale and, after receiving several tributaries, continued its path through the Fossa della Garofala, Ballarò and Albergheria; it was transformed into a sewerage system around 1700. In 1560 part of its waters (i.e. Cannizzaro’s ones) were diverted to the Oreto River through the so-called Badami canal. The Passo di Rigano canal, built in 1856, collects the streams of water upstream of the city, but also streams such as the Bellolampo watercourse which until the 1800s crossed the city up to the S. Lucia pier.

Numerous wetlands surrounded the Palermo Plain thanks to some favorable ecological and topographic conditions. At the base of Mount Grifone, locality San Ciro, there was a large water reservoir, so-called “Favara”, Arabic name bearing witness of abundant waters. This “Favara” received the water from a spring at the base of the mountain and it is so large to be deserved the name “Maredolce” (= Fresh Sea). On the shores of this lake was the Castle of Jafar, the summer residence of the regal emirs during the Arab domination (see Barbera et al., 2015; Pasta, 2015). Another import-ant coastal wetland was the “Pantano of Mondello”, inserted into a natural coastal dune system, which throughout the 1800s was gradually dried up to the definitive disappearance around 1890. Even the surrounding dune system was, in the same period, profoundly altered and completely destroyed in the early 1900s.

There are numerous reports on the presence in these places of plant and animal species of particular naturalistic value (see Calcara, 1841; 1845; Doderlein, 1869; Ragusa, 1874, 1883, 1892–1893, 1896–1897, 1919; De Stefani Perez & Riggio, 1882; Lapiana & Sparacio, 2008).

This freshwater abundance, but also the need to census them for use, determined a huge and detailed amount of information on the item since the Arab period (Gaetani, 1777–1789; cfr. La Duca, 1986; Lo Piccolo, 1994).

The history of Palermo is intimately linked to the spread of irrigation techniques (Bresc, 1972) which, initially introduced by the Arabs, have for centuries had a development that has conditioned the choice of crops and ultimately the landscape of the Palermo Plain, and, especially, that part of citrus groves closest to Palermo, called Conca d’Oro (La Mantia, 2006, 2007).

The superficial acquifer of the Palermo Plain has was so pick up with vertical shafts and horizontal tunnels, called “qanat”, where the water flows through gravity on a slight slope; this system has a persian origin (Laureano, 1995; Biancone & Tusa, 1997; Todaro, 2002). The water was estracted by means of water wheels (“senie” or “norie”) driven by mules or horses (See Pizzuto Antinoro, 2003), then replaced in the second half of the nineteenth century by steam engines. The freshwater was accumulated in artificial basins (“gebbie”), finally distributed by means of irrigation canals (“saje”) or with castles-water it was divided and distributed in pottery pipes (“catusi”) to private house. Almost all of these terms used in water processing are of Arab origin.

This system works for simple gravity providing water without pauperizing the acquifer, without causing evaporation losses and with low pollution risks. During the 1800s, the city had at least 70 castles-water and the water flowed into three canals of sources: Gesuitico, Campofranco and Gabriele.

The oldest qanats were built during the Arab domination of Sicily, but they had the greatest development between the 16th and the 19th centuries. Their length ranges from a few hundred meters to about two kilometers. Once the aquifer was identified, the tunnel was dug starting from its outlet in the direction of the aquifer. The gallery could reach 20 meters deep; connecting wells with the outer surface were made to allow the extraction of the debris and the air entry. When the acquifer was reached, lateral drainage tunnels were dug.

The system, synthetically described, included the presence of other artefacts related to water, mills, watering canines. It began in Roman times and developed especially during the Arab domination. This system has also ecologically shaped the environment as masterly explained by the ecologist Riggio (1976) and many of these structures have carried water for many thousand years. Throughout this long period, the natural-freshwater/artificial-freshwater system represented, therefore, a unique and well structured ecosystem where most living organisms developed in the direct presence of water, or in any wetlands of the whole Palermo plain.

Moreover, especially in the last two centuries, the progressive alteration and destruction of almost all the main natural wetlands of this territory and progressive abandonment and reduction of agrarian environments has make this system the last refuge for the existence and preservation of the igrophilous and freshwater fauna.

For example, the presence of small arthropods is documented in the groundwater and in the network of qanat (Lofrano et al., 2013).

The freshwater molluscs living in the Palermo Plain are among the animal groups those that have most benefited from this context. Throughout the 1800s numerous malachologists and naturalists documented the wealth and peculiarities of these populations around Palermo that lived and developed in a harmonious system of natural and artificial freshwater (Power, 1842 but see also Sparacio, 2012, 2015; Calcara, 1841, 1845; Benoit, 1875, 1882; De Gregorio, 1895). From 1900 onwards, in conjunction with the almost complete destruction of many natural environments, the bibliographic sources on the freshwater molluscs living in the Palermo Plain drastically reduced; nevertheless we can obtain useful indications, at least until 1950, from the works of Cassarà (1948, 1951, 1958). In recent times updated knowledge is contained in the works of Riggio (1976), in the check map of the species of Italian fauna (Bodon et al., 2005), in Lo Brano & Sparacio (2006), Lapiana & Sparacio (2010) and Liberto et al. (2010).

MATERIAL AND METHODS

Study area

The study area is located in the western outskirts of Palermo, enclosed in the city streets Corso Calatafimi, Viale Regione Siciliana, Via G. Pitrè, and Via Altarello di Baida. At the base of Monte Caputo there is the complex of Gabriele’s springs, whose waters once reached the Favorita Park (La Mantia, 2004). The complex of Gabriele’s springs consists of many sources (see Lo Piccolo, 1993, 1994), some of which were sampled during this survey. The spring water is now partly employed for civil uses; on the other hand, irrigation is made up by using also the waters from the basin of Piana degli Albanesi (15 km south of Palermo), which through surface pipes (saje) or underground canals (catusi) flow to the study area.

Fondo Micciulla is an agricoltural territory which develops around the homonymous Baglio and, at present, is still entirely surrounded by walls. In Sicily the “baglio” is a fortified farm with a large courtyard. Historical information dates back to the end of the 1900s and the use of water for irrigation is a constant in the history of this ground. Next to it is the Santacolomba estate with, in the center, the Villa Belvedere, since 1300. Within the original walls of the Santacolomba estate lies the socalled "room of the sirocco" belonging to Villa Savagnone. This area and in particular Fondo Micciulla is one of the few still cultivated in the western portion of the Conca D'Oro and where water plays an important role in the conservation of the agroecosystem; there are citrus trees (*Citrus* spp.), mixed with loquat trees, *Eriobotrya japonica* (Thunb.) Lindl., but also there are numerous walnut trees, *Juglans regia* L., honeyberry trees, *Celtis australis* L., and other fruit trees (La Mantia, 2007, 2016). At the same time, unfortunately, in other areas of the Palermo Plain can be observed obvious phenomena of abandonment with serious repercussions on the agroecosystem not least of which the spread of invasive alien species (La Mantia, 2006; Badalamenti & La Mantia, 2013).

Gabriele's springs. Altarello di Baida District. Oreto hydrographic basin.

Resource Code: 19PA00 G2001 S0004

Aqueduct Complex "Agro Palermitano", Intercomunal Aqueducts

Average capacity l/s: 180

Annual volume used for civil use [m^3]: 5.676.480 n.d.

Water features: temperature 16.5 °C, calcareous, average capacity estimated at 180 liters per second.

Gabriele's springs, located at the base of Monte Caputo, originate from the cracked mesozoic limestone; they are the sources for which there are the oldest references and a rich iconography available (see Lo Piccolo, 1993). The sources despite the presence of ancient channels aimed at their exploitation since a very long time, have maintained a high level of naturalness with luxuriant vegetation (see Carapelle, 1914; Lo Piccolo, 1993). In particular, Carapelle (1923) writes about the sources that were "*covered with lush vegetation*".

Gabriele's springs have been closed and covered by some concrete structures today, losing their naturalness. The fauna and flora that lived here are found in the nearby **Source of Fontane**, destined for irrigation of the Fontane Consortium (Lo Piccolo, 1994), and in other small and similar neighboring springs. The Source of Fontane shows the most natural features as fully covered by vegetation, particularly *Arundo donax L.*, that reduces the brightness, which in some periods is lightly photic. The substrate of the bottom is sandy, fine, with many decomposing plant debris. Other vegetation that grows at the edges of the spring includes: *Equisetum ramosissimum* Desf., *Adiantum capillus-veneris* L., *Rubus ulmifolius* Schott.

Qanat Gesuitico Alto. The Qanat under investigation, located at Fondo Micciulla, was built at the beginning of the 16th century (Lo Piccolo, 1994). Sampling took place in a Qanat airship shaft, a few hundred meters from where water flows in the direction of the city center.

This qanat is aphotic.

Water features: temperature 12 °C, calcarenite, average capacity estimated at 40 liters per second.

Qanat Scibene. The source of Uscibene or Scibene is born from an underground cave in the Altarello Baida district and feeds a system of qanat; this source has been used for the water supply and irrigation of the fields of Palermo since the 15th century (Todaro et al., 2006). It is so called because it is thought to be used to bring water to the renowned Scibene building, dating back to the Norman period, located a few hundred meters from Villa Savagnone (Lo Piccolo, 1993; Biancone & Tusa, 1997; Todaro, 2002).

In its middle course, the qanat crosses the Villa Savagnone's "Camera dello Scirocco" (Room of Sirocco), another sampling site. The name "Camera dello Scirocco" is used to indicate the environments that guaranteed, thanks to its freshness, shelter in the warm days of the sirocco. Although of earlier origin, spread mainly in the seventeenth century particularly in the villas that, at that time, developed on the plain of Palermo (Todaro, 2002). These were "*underground environments capable of producing fresh ... through the presence of three fundamental elements: an artificial cave, a spring or stream of water and a ventilation well*" (Todaro, 2002). The peculiarity of the room of sirocco at Villa Savagnone is that it was obtained within a quarry of limestone and then cooled by a licking "Qanat" (Todaro, 2002). The vegetation includes *Adiantum capillus-veneris* L., *Hedera helix* L., *Reichardia picroides* (L.) Roth, and *Acanthus mol-*

lis L. that grow above the walls; there are also *Parietaria judaica* L., *Rubus ulmifolius* Schott and *Ulmus minor* Mill., and, in the water, there is the green alga *Pithophora* sp.

The **Villa Savagnone's Qanat** is fed also by the source of Scibene, which originates just upstream of the Camera dello Scirocco.

The Scibene and Villa Savagnone Qanat are lightly photic in the beginning to become aphotics.

Water features: temperature 12 °C, calcarenite, average capacity estimated at 4 liters per second.

Gebbie. Several gebbie were sampled: Gebbia Fratelli La Mantia into Fondo Micciulla, and other three in Fondo Santacolomba; the first is the smollest under the walls of Villa Belvedere, the second at the boundary wall of the Fondo Santacolomba, the third called "Ru gebbi" (two gebbie) as formed by two intercommunicating tanks.

Almost always the gebbie are placed in full light, covered only in part by the surrounding fruit trees. They are surrounded by a rich vegetation that the presence of water contributes to increasing: *Arundo donax* L., *Adiantum capillus-veneris* L., *Plantago major* L., *Marchantia* sp., *Hedera helix* L., *Parietaria judaica* L., *Tradescantia fluminensis* L., *Rubus ulmifolius* Schott. The waters, rich in filamentous algae and *Pithophora* sp., are subject to severe overheating during the summertime days.

Saja.The Saja sampled is located in Fondo Micciulla and it is the main saja from where the water from Gabriele's springs flows to Micciulla. The water is distributed also in the lands contiguous to the Sicilian region road (Chiusa Uscibene) and this determined the almost continuous presence of the water in the summer and partly even in the winter period.

The sources, compared to the gebbies from which saje originate, exhibit greater diversification both in brightness and in water temperature. In fact, in relation to their path, they can slide almost into the darkness between the vegetation or in full light. The waters are cooler and running, but there are also long periods of stagnation with drying.

The vegetation is the same of the gebbie but the saje can also cross natural areas where there are other tree and herbaceous species such as *Ulmus minor* Mill., *Fraxinus*, *Smilax aspera* L., *Rubia peregrina* L., etc.

Water tanks. Various small tanks are present throughout the territory of Micciulla, used for ornamental purposes, one of which had a populations of freshwater mollusks (Table 1).

Sampling methods

The samples have been collected by I. Sparacio and T. La Mantia from 2009 to 2016 during several excursions carried out in the study area every three months (see Figs. 1, 2; Table 1). Live specimens for taxonomic studies were collected only in 29.X.2009, 9.XII.2009, 18.IV.2012 and 20.VIII.2014. The other samplings were of empty shells and with the direct observation for census of living populations in order not to harm these environments. All the lots are kept in the authors collections and, some samples, in M. Bodon collection (Genova, Italy) and R. Viviano collection (Palermo, Italy).

Freshwater snails, shells and live specimens, were sampled on sight in the natural and artificial waters of the study area and by using little nets and sorting variable amount of sediment.

Unrelaxed material preserved in 75% ethanol, was studied by Optika light microscope. Soft parts were isolated and dissected using very fine, pointed watchmaker's forceps. Images of the body and the genitalia were drawn using a camera lucida. Habitat, shells and live specimens were photographed by using a Canon EOS 100D.

The main morphological and anatomical characters have been described to document these populations living in a relict and threatened area.

Taxonomical references are based on the checklist of the fauna europea (Bank, 2011) and other cited papers.

Anatomical acronyms: BC: bursa copulatrix; DBC: duct of the bursa copulatrix; MP: muscle plica; P: penis; PA: penial apex; PAD: penial accessory duct; PG: preputial gland; PL: penial lobe; PR: prostate; PRM: penial retractor muscle; PRP: preputium; PS: penial sheath; SLS: sucker-like structure; SM: supporting muscles; VD: vas deferent.

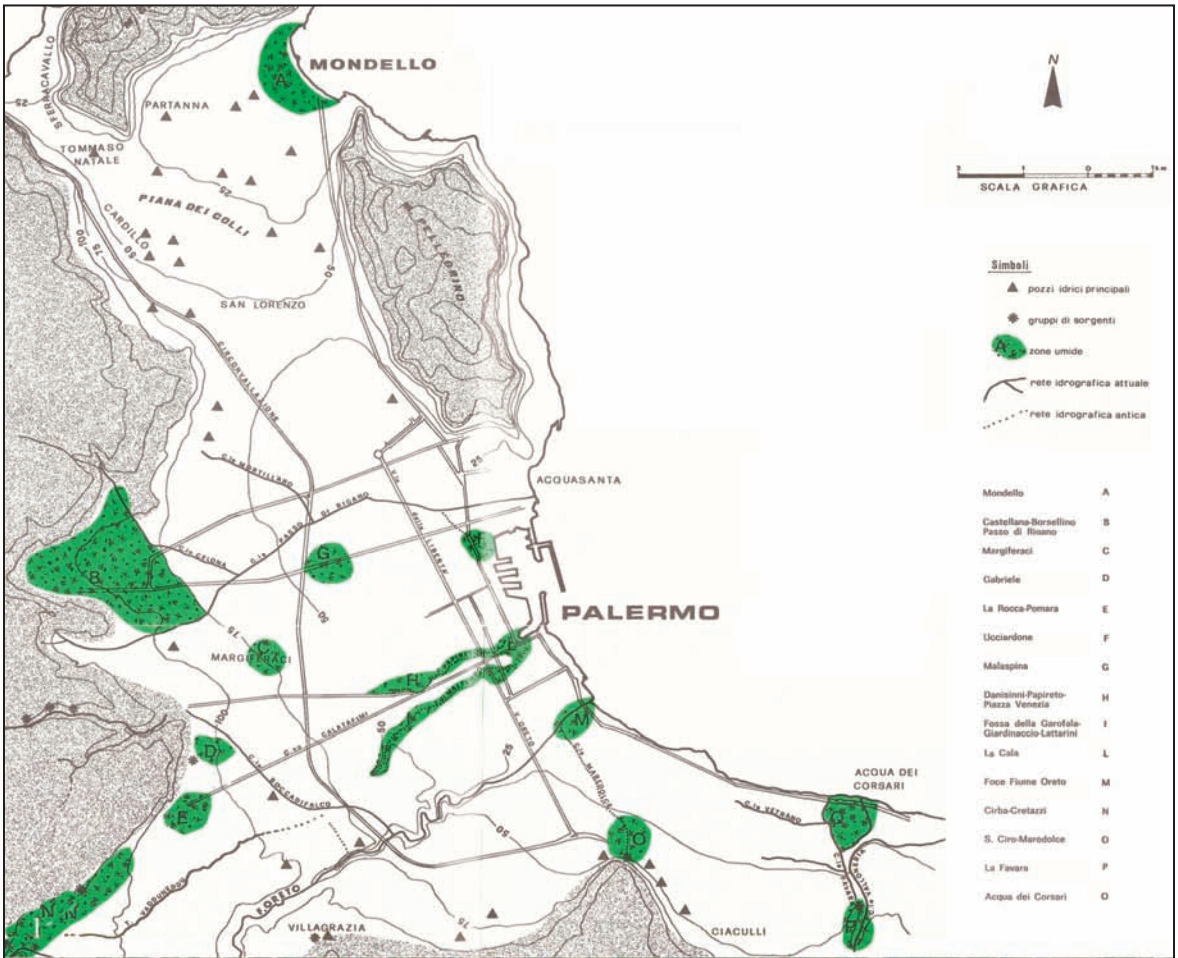
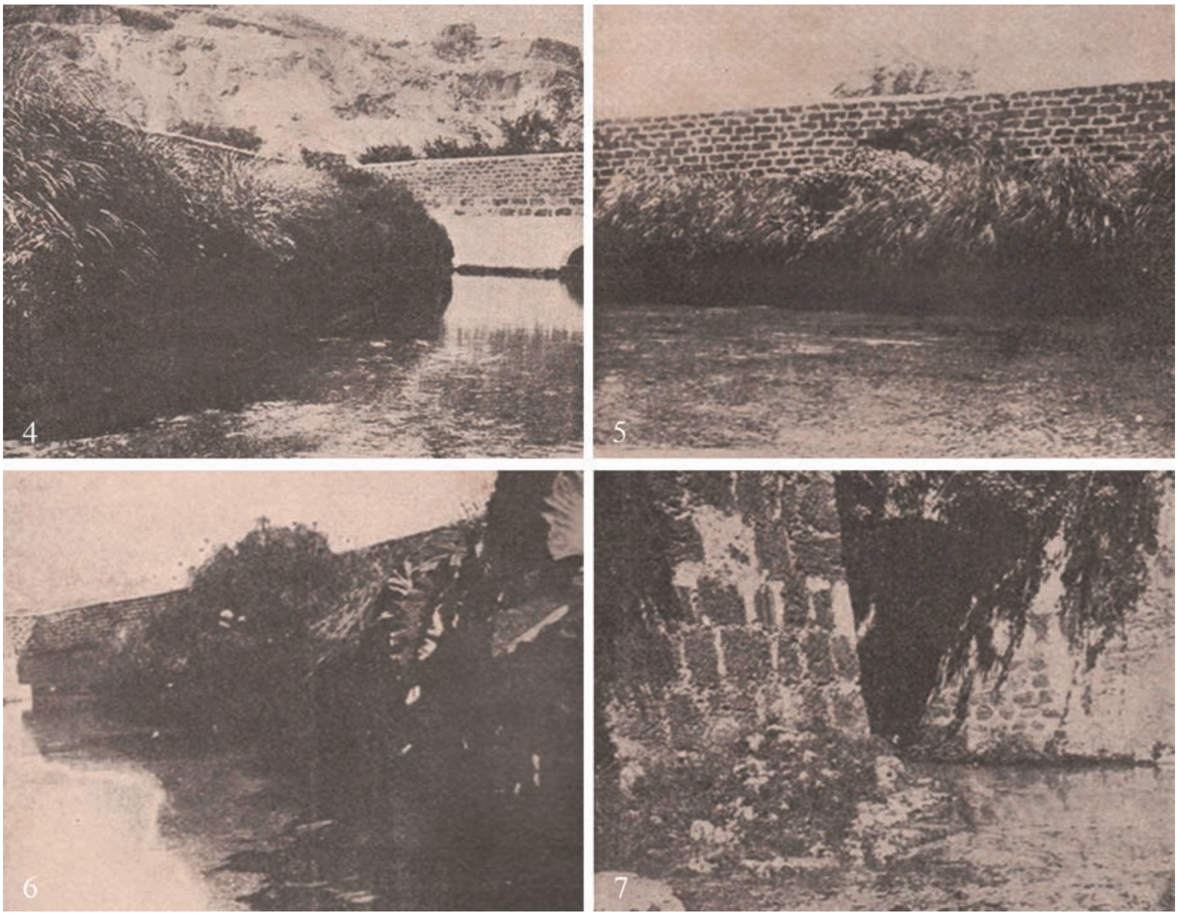


Figure 1. Freshwater environment in the Palermo surrondings (by Cusimano et al., 1989 modified). Figure 2. Study area. 1: Gabriele's springs; 2: Gebbia Fratelli La Mantia; 3: Saje Fondo Micciulla; 4: Gebbia under the walls of Villa Belvedere; 5: Gebbia at the boundary wall of the Santacolomba fund; 6: "Due gebbie" the Santacolomba fund; 7: Camera dello Scirocco (Room of Sirocco): Qanat Scibene e Qanat Savagnone; 8: Qanat Gesuitico Alto.

Figure 3. Oreto River near Palermo (by Lojacono, 1931 modified).



Figures 4-7 (by Carapelle, 1914). Gabriele's springs around 1900. Figs. 4, 5: Nixio springs. Fig. 6: the aqueduct for the Palermo city (Nixio springs). Fig. 7: Connection of the freshwaters of Cuba spring with those of Gabriele spring.

Figure 8. Gabriele's springs, to our day (2015).

Figure 9. Detail of the Gabriele springs, now covered by an ancient structure.

Figure 10. Detail of the Gabriele springs, now covered by an ancient structure.

Figures 11-15. Villa Savagnone's "Camera dello Scirocco" (Room of Sirocco). In figure 13 it can be seen the entrance of the Qanat Scibene to the right (see also Fig. 14) and the entrance of the Qanat Villa Savagnone (Fig. 15).

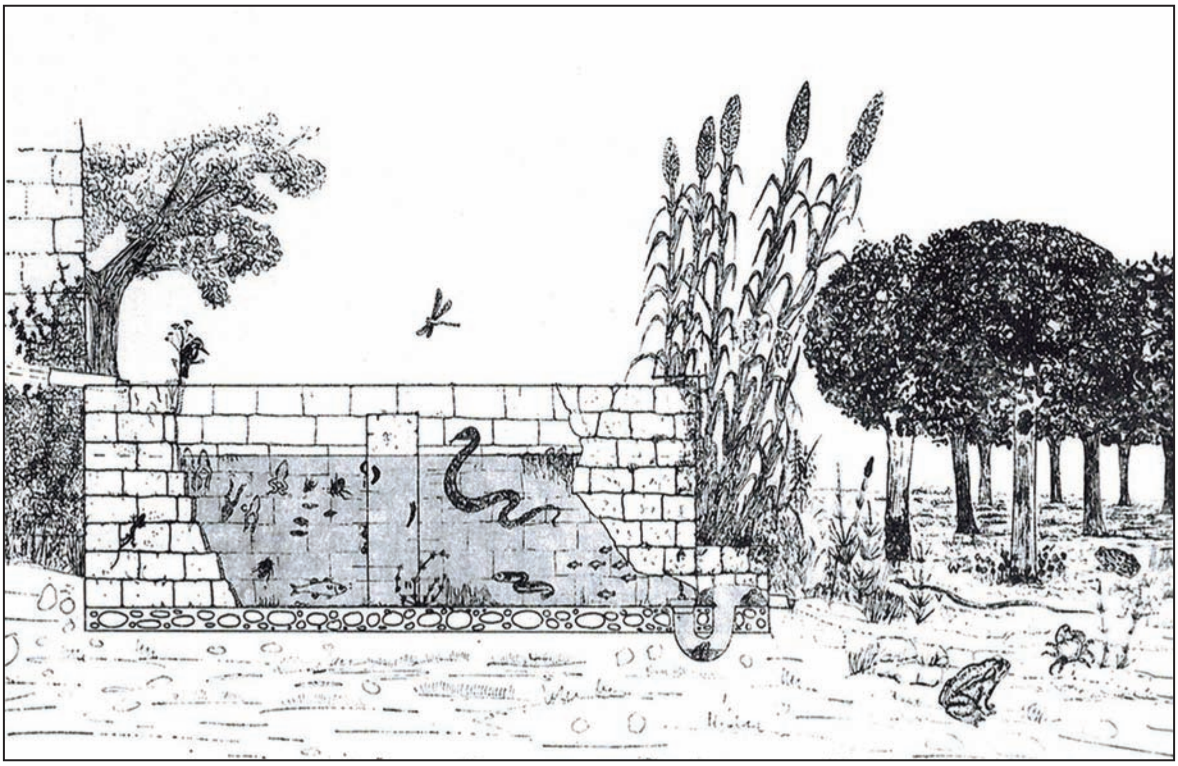


Figure 16. Ecological scheme of a Gebbia in the Palermo Plain (by Riggio, 1976 modified).

Figure 17. “Ru gebbi” (two gebbie) at Fondo Santacolomba formed by two intercommunicating water tanks.

Figure 18. Gebbia under the walls of Villa Belvedere (Fondo Santacolomba).

Figure 19. Gebbia at the boundary wall of the Fondo Santacolomba.

Figure 20. Saja located in Fondo Micciulla.

Figure 21. Detail of the saja located in Fondo Micciulla with the continuous presence of water.

Figure 22.The Source of “Fontane” overgrown by *Arundo donax*.

RESULTS

Systematics

Class GASTROPODA Cuvier, 1795
Subclass ORTHOGASTROPODA Ponder et Lindberg, 1995
Superordo CAENOGASTROPODA Cox, 1960
Ordo NEOTAENIOGLOSSA Haller, 1882
Superfamilia RISSOOIDEA Gray, 1847
Familia BITHYNIIDAE Gray, 1857
Genus *Bithynia* Leach, 1818

Bithynia* cf. *leachii (Sheppard, 1823)

Description. Shell dextral (Fig. 35), conical, elongated, moderatly robust, gray-blackish-gray in colour; height 4.9–5.7 mm, maximum diameter 3.5–4.2 mm, aperture height 2.4–3.2 mm, aperture diameter 2.2–2.9 mm; external surface with thin growth lines, spire formed by 4–5 convex whorls with a deep sutures; apex rounded; aperture subcircular, little elongated; peristome simple and continuous; operculum with thin growth lines and nucleus eccentric.

Distribution and Biology. Paleartic. *Bithynia leachii* is widespread through Italy (Girod et al., 1980; Bodon et al., 1995, 2005) and lives in different habitats, such as rivers, streams, etc.

Status and Conservation. *Bithynia leachii* is classified Least Concern (LC) by Cuttelod et al. (2011) and in IUCN Red List (Vavrova et al., 2010).

Remarks. This species was reported for this study area by Calcara (1845 sub *Paludina rubens*: "*alle sorgive del Gabriele*"), see also Bodon et al. (2005).

Sicilian populations need a systematic reassessment (Bodon et al., 1995) but in sampling for this work we did not find live specimens. Some preliminary data for a population from south-eastern Sicily (Irminio River) seem to show a morphological and anatomical difference (flagellum very short) by comparition with other Italian populations (Bodon *in litteris*).

Many taxa have been described for the populations of Sicilian *Bithynia*, that, currently, are considered synonyms of *B. leachii* (Alzona, 1971).

Familia HYDROBIIDAE Stimpson, 1865
Subfamilia BELGRANDIINAE De Stefani, 1877
Tribus ISLAMIINI Radoman, 1983
Genus *Islamia* Radoman, 1973

Islamia pusilla (Piersanti, 1952)

Description. Shell dextral (Fig. 23), valvatoid, not depressed, transparent and whitish-waxen when fresh, sometimes encrusted; height 0.8–1.5 mm, maximum diameter 0.9–1.2 mm, aperture height 0.57–0.7 mm, aperture diameter 0.6–0.8 mm; external surface of shell with thin growth lines; spire little pointed, raised, with 2.5–3 1/4 convex and rapidly expanding whorls; last whorl very wide, little descending near aperture; suture deep; umbilicus open, wide 1/7–1/8 of maximum shell diameter; aperture large and sub-circular; peristome continuous, juxtaposed to the last whorl wall, slightly thickened, slightly reflected at its inferior margin, not sinuous at its external margin. Operculum paucispiral, thin, yellow-orange pale.

Body (Fig. 24): mantle more or less pigmented, blackish; the head is little pigmented; penis non pigmented.

Genitalia. *Islamia pusilla* investigated are characterized by: apical portion of penis more or less markledy bilobate (Fig. 25); right portion, more slender, obtuse and projecting further forward, constituting tip of penis; left portion forms the so-called penial lobe; penial lobe slightly protruding to apical portion of penis; muscle plica on the ventral surface of the penis well developed but not projecting on the left side. Female genitalia with two seminal receptacles.

Distribution and Biology. *Islamia pusilla* is endemic to Italy, specifically found in the appenninic regions (Tuscany, Lazio, Campania, Puglia, Molise, Abruzzo) and in Sicily, but localised (Giusti & Pezzoli, 1980; Bodon et al., 2005; Bodon & Cianfanelli, 2012).

This species lives in springs.

Status and Conservation. *Islamia pusilla* is classified as "Least Concern" in IUCN Red List (Cianfanelli et al., 2010a) and by Cuttelod et al. (2011).

Remarks. The two populations of *I. pusilla* found in the study area (Table 1) do not show substantial morphological differences between them, except for a darker pigmentation of the body and shell more encrusted than those living in a more open environment such as the water tank at the Gabriele Spring.

Subfamilia HYDROBIINAE Stimpson, 1865
Genus *Pseudamnicola* Paulucci, 1878

Pseudamnicola* (*Pseudamnicola*) *moussonii moussonii (Calcara, 1841)

DESCRIPTION. Shell dextral, conical-ovoidal but very variable in height and roundness, brownish or black-greyish in colour, often encrusted and corroded; height 3–5.1 mm, maximum diameter 2.5–3.2 mm, aperture height 1.8-2.6 mm, aperture diameter 1.4–2.1 mm; external surface smooth with thin growth lines; spire formed by 3.5–4 convex whorls; last whorl 3/4–4/5 of shell height; sutures deep; umbiculus open; aperture oval; peristome continuous, non thickened, slightly reflected at lower and columellar margins. Operculum with thin growth lines and nucleus eccentric.

Body (Fig. 26) well pigmented in black; pallial cavity open, gill present; lobes present.

Male genitalia with penis cilindrical, elongated (Fig. 27), black pigmented; penis tip blunt with a few wide folds on side and vas deferens opening at apex. Female genitalia with renal oviduct pigmented black; gonopericardial duct present; seminal receptacle variably elongated; bursa copulatrix duct long and slender and straight to twisted; bursa copulatrix large, triangular; pallial oviduct with albumen gland runned ventrally by sperm channel and capsule gland.

DISTRIBUTION AND BIOLOGY. The genus *Pseudamnicola* has a Mediterranean distribution. To *P. moussonii* refer different and distinct populations widespread on the Western Mediterranean (see also Giusti & Pezzoli, 1980; Bodon et al., 1995; Giusti et al., 1995). This freshwater snail is found in springs, water trough, rivers and running freshwater, on rocky and sandy substrata, often aggregating on plants.

STATUS AND CONSERVATION. This species is classified as “Least Concern” in IUCN Red List (Cianfanelli et al., 2010b) and by Cuttelod et al. (2011).

REMARKS. *Pseudamnicola moussonii* is very frequent in Sicily, and it varies in the shape and size of the shell (Fig. 28, 29) and in some anatomical characters such as the length of the seminal receptacle.

In the study area the population of the tank near the Gabriele Spring has the seminal receptacle longer than that of the population from the spring of the Room of Sirocco.

Pseudamnicola moussonii was described by Calcara (1841) from Sicily (locus typicus: “*Trovasi nelle vicinanze della Piana dei Greci ... Lago di Dingoli*”); for the proper placement of the locus typicus see Liberto et al. (2010).

Other species of Sicilian *Pseudamnicola* are *P. sciaccaensis* Glöer et Beckmann, 2007, which is at the time endemic (Glöer & Beckmann, 2007, locus typycus: “*Brunnentrog an der Straße von Menfi nach Sciacca, Sizilien, Italien*”) and *P. orsinii* (Küster, 1852) probably endemic to Italy (Bodon et al., 2005).

Subfamilia TATEINAE Thiele, 1925
Genus *Potamopyrgus* Stimpson, 1865

Potamopyrgus antipodarum (J.E. Gray, 1843)

DESCRIPTION. Shell dextral (Fig. 36), elongated, grayish, yellowish, dark-brownish in colour, often encrusted; height 4.2–5.3 mm, maximum diameter 2.2–3 mm, aperture height 2.1–2.5 mm, aperture diameter 1.8–2 mm; external surface with thin growth lines; spire formed by 5–7 convex whorls; last whorl 2/3 of shell height, a specimen with a thin and interrupted keel; sutures little deep; umbilicus closed; aperture oval; peristome continuous, non thickened, detached from the last whorl; operculum paucispiral, thin and corneus.

Body black in colour, particularly head, tentacles, and mantle; pallial cavity open, gill present; operculigerous lobes present.

Female genitalia with bursa copulatrix small and oval; seminal receptacle small with long and slender duct; pallial oviduct with albumen gland, sperm channel and capsule gland.

DISTRIBUTION AND BIOLOGY. *Potamopyrgus antipodarum* (New Zealand mud snail, Jenkins’ Spire Snail) is native to New Zealand and adjacent islands and it has been introduced to Europe, Iraq, Turkey, Japan, the Americas and Australia (Ponder, 1988; Kerans et al., 2005). It is present also in Italy, including Sicily (Berner, 1963; Favilli et al., 1998; Cianfanelli et al., 2007; Colomba et al., 2013).

It is a species with great ecological value, which lives in both sweet and brackish waters, lotic and lentic environments, on rocks, gravel, mud, organic debris and vegetation. This allochthonous species has a fast spread, tolerates discrete pollution and is often present with numerous populations. In Europe, *P. antipodarum* causes declines in species richness and abundance of native snails in constructed ponds (Strzelec, 2005).

Status and Conservation. This species is classified as "Not Applicable" by Cuttelod et al. (2011) and as "Least Concern" in I.U.C.N. Red List (Van Damme, 2013).

Remarks. *Potamopyrgus antipodarum* is variable in the shell morphology, with a keel in the middle of each whorl that may be completely absent, periostracal ornamentation, umbilicus sometimes little open, etc. (Favilli et al., 1998; Hosea & Finlayson, 2005).

Normally, both sexual and asexual reproduction coexists but non-native populations of this species are parthenogenetic and consist almost exclusively of females (Jokela et al., 1997; Alonso & Castro-Díez, 2008). *Potamopyrgus antipodarum* is ovoviviparous, and females brood their offspring in a brood pouch until they reach the "crawl-away" developmental stage (Jokela et al., 1997).

Only two living females and eight shells were observed; they were found in the Qanat "Gesuitico Alto" completely underground and aphotic (Table 1).

This allochthonous and invasive species is rapidly increasing in sicilian natural waters and is already present with numerous populations in several natural localities such as the Belice River and Ciane River.

Superordo HETEROBRANCHIA J.E. Gray, 1840
Ordo PULMONATA Cuvier in Blainville, 1814
Subordo BASOMMATOPHORA Keferstein in Bronn, 1864
Superfamilia LYMNAEOIDEA Rafinesque, 1815
Familia LYMNAEIDAE Rafinesque, 1815
Subfamilia LYMNAEINAE Rafinesque, 1815
Genus *Galba* Schrank, 1803

Galba truncatula (O.F. Müller, 1774)

Description. Shell dextral (Figs. 42, 43), conical, oblong, rounded apex; brown or reddish-brown in colour, often encrusted and corroded; height 6.5–8.3 mm, maximum diameter 4–5.8 mm, aperture height 4.4–6.2 mm, aperture diameter 3–4.6 mm; external surface with thin growth lines, spire with 4–6 convex and regular whorls; last whorl large, 3/3 of shell height; sutures deep; umbilicus little open partially covered by columellar margin of peristome; aperture oval and oblique; peristome simple, interrupted.

Body yellow-greyish, tentacles triangular with eyes on internal basal vertex, mantle surface with very little light spots.

Genitalia characterized by preputium 3 times as long as penis sheath; penis short and slender; long and slender bursa copulatrix duct; seminal vesicles consisting of many long, slender, digit-like diverticula on both sides of first hermaphrodite duct.

Distribution and Biology. Holarctic. This species is reported throughout Italy (Girod et al., 1980; Manganelli et al., 1995).

Galba truncatula is found in stagnant or slow-moving freshwaters, natural and artificial. It is also tolerant of poor water quality, polluted or muddy waters, and it is able to colonize temporary ponds. It is common in Sicily.

Status and Conservation. It is classified as "Least Concern" by Cuttelod et al. (2011) and in I.U.C.N. Red List (Seddon et al., 2015).

Remarks. *Galba truncatula* is not common in the examined territory, and it is found with several living specimens in some Micciulla irrigation canals and in the Gebbia Santacolomba

Genus *Radix* Montfort, 1810

Radix auricularia (Linnaeus, 1758)

Description. Shell dextral (Figs. 37, 38), inflated, subtransparent, yellowish-brown in colour with sometimes encrusted; height 16–23.2 mm, maximum diameter 11.5–17.5 mm, aperture height

12–18 mm, aperture diameter 8–13 mm; external surface with thin growth lines; apex pointed; spire with 4 convex whorls, the last very large and convex, inflated, equal to 5/6 of shell height; sutures are shallow, only in the last whorl deep; aperture very large, ear-shaped; peristome thin, reflected; columellar margin folded on the umbilicus which is little visible.

DISTRIBUTION AND BIOLOGY. This species is a widespread palearctic species present through much of Europe and into north Asia, introduced throughout the United States. *Radix auricularia* is reported throughout Italy by Girod et al. (1980) but not in Sicily (Cossignani & Cossignani, 1995; Manganelli et al.,1995).

It is found in stagnant or slow-moving freshwaters, even artificial, as reservoirs, fountains, irrigation canals, "gebbie".

STATUS AND CONSERVATION. This species is considered "Least Concern" by Cuttelod et al. (2011) and in IUCN Red List (Seddon et al., 2014).

REMARKS. Only a few shells referred to *R. auricularia* have been found in the territory of Micciulla, near "Ru gebbie" and Gebbia Villa Belvedere (Table 1).

Genus *Stagnicola* Jeffreys, 1830

Stagnicola fuscus (C. Pfeiffer, 1821)

Description. Shell dextral (Figs. 40, 41), elongated, relatively robust, with pointed apex; brown-reddish in colour; height 11.8–17.8 mm, maximum diameter 6–9.8 mm, aperture height 7–10 mm, aperture diameter 4.5–7 mm; external surface with spiral striae which cross-cut the radial growth striae that form a square ornamentation, whorls 6–7 not very convex, sutures little deep, umbilicus closed, aperture oval, elongated, height about 1/3 of shell height.

Body grey-dark in colour with very little and yellowish spots (Fig. 39); tentacles short and sub-triangular, wide at the base and rounded to the apex, and with eyes at base; foot long, rounded anteriorly and pointed posteriorly.

Genitalia characterized by a short praeputium (slightly shorter than the penis) and two prostate folds (in the internal lume of the prostate) (Fig. 30).

DISTRIBUTION AND BIOLOGY. Distribution to be reviewed, because many reports for *S. fuscus* were attributed to *S. palustris* (O.F. Muller, 1774) (Girod et al., 1980; Manganelli et al., 1995). In Sicily *S. fuscus* is reported by Beckmann & Falkner (2003) on anatomically determined specimens from Palermo, Anapo River at Floridia and Siracusa. This species is also reported in the British Isles by Carr & Killeen (2003) and Glöer & Yıldırım (2006) assume that all Southern European *Stagnicola* probably belong to *S. fuscus*; on this wiev, see also Pavon & Bertrand (2005) for southern France and Soriano et al. (2006) for Catalonia.

Stagnicola fuscus is common in Sicily in running and slow-moving waters, even artificial, usually with rich vegetation.

STATUS AND CONSERVATION. It is considered "Least Concern" by Cuttelod et al. (2011) and in IUCN Red List (Seddon, 2011).

REMARKS. *Stagnicola fuscus* is found at Micciulla in some irrigation canals rich in vegetation fed by a "gebbia" inside an old citrus grove. Calcara (1845) reports "*Limnaeus palustris*" from Boccadifalco, a neighboring area at Micciulla.

Correa et al. (2010) proposed that species of clade C2 of their paper, including *S. fuscus*, *S. palustris* (type species of *Stagnicola)* and *L. stagnalis* Linnaeus, 1758 (type species of *Lymnaea*) should all be called *Lymnaea*, according to the principle of priority of the International Code of Zoological Nomenclature (ICZN). *Stagnicola fuscus* would be named *Lymnaea fusca* C. Pfeiffer, 1821.

Superfamilia PLANORBOIDEA Rafinesque, 1815
Familia Physidae Fitzinger, 1833
Genus *Physella* Haldeman, 1842

Physella acuta (Draparnaud, 1805)

DESCRIPTION. Shell sinistral, ovoidal-fusiform, glossy, sub-transparent, with pointed apex, pale yellowish-brown or reddish-brown in colour; height 8.2–11 mm, maximum diameter 5–10 mm, aperture height 6.7–7.6 mm, aperture diameter 3.8–4.8 mm; external surface with very thin growth lines; spire with 5–6 regularly growing whorls; last whorl large, about 2/3 of shell height; the sutures are shallow, olly in the last whorl deep; umbilicus closed; aperture ovoidal-elongated, slightly oblique, angled above and rounded below; peristome slightly thickened, sometimes with internal whitish or pinkish lip, lower and columellar margins of which are reflected, columellar margin twisted, upper and lower vertices joined by parietal callosity.

Body (Figs. 44, 45) yellowish-grey in colour with irregular and pale-yellowish spots; tentacles long and slender with little eyes at base; mantle margin with 7–11 long, tentacle-like appendages on right side and 4–6 similar ones on left side, folded on the shell; foot long, rounded anteriorly and pointed posteriorly.

Genitalia: general scheme of diaulic ditrematic type (see Giusti et al., 1995 and cited references); distal male genitalia (Figs. 31, 32) with two retractor muscles, one at base of penial sheath and one at base of preputium; penial sheath slender and long, containing penis and long and wide preputium, inside preputium is located a large sucker-like structure; the penial sheath is about half the preputium long.

Distribution and Biology. Allochthonous species, it was introduced into Europe from North America (Taylor, 2003) and it is diffused throughout Italy (Girod et al., 1980; Manganelli et al., 1995; Cianfanelli et al., 2007). Its first report in Italy dates back to Issel (1866, sub *Physa pisana*); the spread of *P. acuta* was one of the causes of the gradual rarefaction of the indigenous *P. fontinalis* (Linnaeus, 1758) (Manganelli et al., 2000).

Physella acuta lives in all freshwater systems, lotic and lentic, on rocks, water weeds and other vegetation in rivers, streams, ponds, swamps, drains, water tanks, fountains and similar habitats. Species of great ecological value, it also resists in urbanized and polluted environments and at short periods of drying.

Status and Conservation. This species is classified as “Least Concern” by Cuttelod et al. (2011) and in IUCN Red List (Van Damme et al., 2012).

Remarks. *Physella acuta* is common in the study area (Table 1), living with stable and numerous populations in natural and artificial waters of the Palermo surroundings, where it is found mainly in the gardens water tanks of the city center and in the “gebbie”, still remaining, in the citrus groves of the plain of Palermo and the valley of the Oreto River.

Familia PLANORBIDAE Rafinesque, 1815
Subfamilia PLANORBINAE Rafinesque, 1815
Genus *Ancylus* O.F. Müller, 1773

Ancylus prope ***fluviatilis*** O.F. Müller, 1774

Description. Shell conical (aperture oval) (Figs. 46, 47), convex anteriorly and concave posteriorly in section, slight blackish in colour when fresh because it is almost always incrusted, really it is yellow-whitish, sub-transparent; height 4–5.1 mm, maximum diameter 6.6–7.8 mm, some specimens are encrusted; external surface with distinct longitudinal ridges starting from apex and crossed by thin concentric growth lines; apex subobtuse curving backwards; aperture oval.

Body: mantle, head and foot blackish irregularly pigmented; tentacles short and triangular with obtuse apex and little eyes at base; foot smaller than shell opening.

Genitalia not examined in this population; for general features see Girod et al. (1980) and Giusti et al. (1995).

Distribution and Biology. Pfenninger et al. (2003) and Albrecht et al. (2006, 2007), with molecular genetic studies, subdivide the populations of *Ancylus fluviatilis*, which were attributed to almost all the Euro-Mediterranean populations including Italy and Sicily, in four clades (Albrecht et al., 2007): *A. fluviatilis* mainly in Northern Europe, but reaching southern limits in Spain, France, Northern Italy and Slovenia, *Ancylus* sp. A from S-Portugal, *Ancylus* sp. B mainly found in the Mediterranean region, from the Canary Islands, Morocco, Italy, through to Greece and Turkey, *Ancylus* sp. C mainly found in the western Mediterranean region, from Portugal and Spain to Italy. *Ancylus* sp. B and *Ancylus* sp. C are also known from Sicily.

The *Ancylus* live in well oxygenated and running freshwater, natural and artificial as springs, lake margins, river, fountains, and irrigation canals, crawling on rocks, stones, and plants; they feed on vegetal debris, algae and periphyton.

STATUS AND CONSERVATION. *Ancylus fluviatilis* sensu lato is classified Least Concern (LC) by Cuttelod et al. (2011). In IUCN Red List the four species referable to *A. fluviatilis* have been assessed as Least Concern (LC) except *Ancylus* sp. A wich is considerable as Data Deficient (DD) (Seddon et al., 2012).

The sicilian populations of *Ancylus*, widespread throughout the region, have been steadily declining in the last few years.

REMARKS. The specific attribution of the different populations of *Ancylus* is currently problematic, considering the many taxa described in the past years in almost all distribution areas. In particular, Benoit (1875) cites for Sicily ten different species, including *A. tinei* Bivona, 1839 described for Palermo surrondings (Bivona, 1839: "*… Le strie longitudinali, di cui è munita, sono più o meno notevoli… maggiore spessezza … maggiore incavamento della conchiglia medesima*"). This description refers to the samples from Micciulla, where few live specimens were found in the Source of Fontane, in the Micciulla irrigation canals and other shells were found in almost all the sampled sites (Table 1). For areas very close to our study area are reported populations of *Ancylus* by Bivona (1839 sub *A. tinei*: "*Trovasi comunissimo nel beveratojo sopra il convento di Baida*"), Calcara (1845 sub *A. fluviatilis*: "*beveratojo sopra il convento di Baida*"), and by Benoit (1875, sub *A. tinei*: "*nelle sorgive delle montagne di Boida* [Baida]").

Genus *Planorbis* O.F. Müller, 1774

Planorbis planorbis (Linnaeus, 1758)

Description. Shell sinistral, planispiral, discoidal (Figs. 48–50), with upper border flattened and lower border slightly concave; brown or reddish-brown, often encrusted, height 1.6–2.8 mm, maximum diameter 5.5–9 mm; external surface with thin growth lines; spire 5–6, last whorl slightly dilatated toward the end with rounded upper keel; sutures deep; aperture oval, transverse, angled in corrispondence with upper keel, peristome simple.

Body is black in colour; foot elongated posteriorly; tentacles long and slender with small eyes at base; the mantle pigmentation and foot are dark-grey.

Genitalia characterized by the prostate whit 35–57 digit-like diverticula; preputium moderatly elongate (1.6 to 2.2 mm).

DISTRIBUTION AND BIOLOGY. Holopalaearctic. It is present and diffused throughout Italy (Girod et al., 1980; Manganelli et al., 1995).

Planorbis planorbis lives between the aquatic vegetation of natural or artificial freshwaters, stagnant or slow-moving.

STATUS AND CONSERVATION. This species is classified as "Least Concern" by Cuttelod et al. (2011) and in I.U.C.N. Red List (Seddon & Van Damme, 2014).

REMARKS. In the Micciulla territory there are some small living populations of *P. planorbis*: in the spring of the Scirocco House, in the Source of Fontane, in the irrigation canals and "gebbie" of the citrus grove (Table 1).

It is diffused but localized in Sicily. This species was common in the artificial water system of Palermo surrondings (Lo Brano & Sparacio, 2006) but now is in decline.

Planorbis moquini Requien, 1848

Description. Shell sinistral, planispiral, concave on both sides (with upper side more concave than lower) (Figs. 51–53), subtransparent, finely striated, widely umbilicated; height 1.2–1.6 mm; maximum diameter 2.8–3.4 mm; reddish-brown in colour, with some specimens encrusted and corroded; spire with 3–4 regularly growing whorls, which are convex above and below; last whorl dilatated; sutures deep; aperture oval and transverse; peristome simple, interrupted.

Body is black in colour; foot elongated, anteriorly rounded, posteriorly pointed; tentacles very long and slender with small eyes at base; the mantle pigmentation is dark-grey.

Genitalia (Fig. 33). The preputium is on the dorsal side darkly pigmentated, 3 times penial sheath lenght, from the penis sheath starts a longer and slender vas deferens The prostate gland bears 10–12 diverticules. The bursa is oval with a short and thin bursa duct.

STATUS AND CONSERVATION. This species is classified as "Least Concern" by Cuttelod et al. (2011) and in I.U.C.N. Red List (Prié, 2010).

Distribution and Biology. *Planorbis moquini* is reported in various regions of central-southern Italy, Sicily, Sardinia (Girod et al., 1980; Manganelli et al., 1995) and Maltese Islands (Giusti et al., 1995).

However, *P. moquini* has uncertain distribution because has been confused for a long time with other Planorbid species, requiring new anatomical data for confirmed records.

Particularly, anatomical study of the small planorbids from Tuscan Archipelago, Sardinia, Corsica, Sicily and Maltese Islands showed similar structure of genitalia and was determined as *P. moquini* (Giusti, 1976; Giusti & Castagnolo, 1983; Sparacio, 1992; Giusti et al., 1995).

Glöer & Zettler (2009) redescribe the conchological and anatomical characters of the topotypes of *P. moquini* from Corsica and they confirmed that it is a valid species. Glöer & Zettler (2009) report, also, that *P. moquini* and *P. agraulus* Bourguignat, 1864, redescribed by Glöer & Bouzid (2008) locus typicus: Algeria, are two distinct species and they are distinct from *Planorbis* sp. of Sardinia and from *P.* cf. *atticus* Bourguignat, 1852 of Crete. They conclude that "*... the Planorbidae of the Mediterranean are poorly known and more diverse than is currently understood and their remains a number of taxonomic problems to be resolved*".

Planorbis moquini is found in stagnant or slow-moving freshwaters, natural and artificial, usually oxygenated and with rich vegetation.

Remarks. *Planorbis moquini* is a rare species in the study area; it found only in a few living samples at Qanat Savagnone (Table 1).

They showed similar structure of genitalia of *P. moquini* (Giusti, 1976; Giusti et al., 1995; Glöer & Zettler, 2009) but this samples have the conchological difference from other populations, well described, of Corsica (see Glöer & Zettler, 2009) and of Maltese Islands (see Giusti et al., 1995).

Particularly, *P. moquini* from Micciulla shows more robust shell, the most oval aperture and the last whorl higher than in *P. moquini* from Corsica; from the specimens of Malta they differ for smaller size and higher and convex whorls.

Also from these short observations, and from what Glöer & Zettler (2009) reported above, it appears clear that the true identity of the different populations currently attributed to *P. moquini* has not yet been clarified.

Genus *Planorbella* Haldeman, 1843

Planorbella duryi (Wetherby, 1879)

Description. Shell sinistral, planispiral, robust, concave on both side (lower side more concave than upper) (Figs. 54–57), reddish or yellowish-brown in colour; height 7.2–11.8 mm; maximum diameter 15.1–2.1 mm; external surface with thin and irregular striae; spire with 4–5 regularly and rapidly growing convex whorls; last whorl dilated slightly angled above; sutures deep; aperture oval, peristome simple.

Body reddish-brown in colour with multiple and very small white-yellowish spots; tentacles moderately elongated, robust, with eyes at base; foot wide anteriorly and pointed posteriorly.

Male genitalia consisting of penial sheath, preputium, lateral accessory duct and vas deferent (Fig. 34). Penial sheath, inserted laterally and inferiorly of preputium, is narrower to the base and larger and rounded to apex where an elongated vas deferent is inserted; preputium is wide and rounded with a penial accessory duct. Proximal internal cavity of penial sheath with the penis well developed, conical, corrugated; a muscular ring separates this cavity from distal cavity which coincides with the preputium lumen where there is an elongated preputial organ.

Distribution and Biology. Originally from Florida, USA (Wetherby, 1879), *P. duryi* was introduced to different parts of the world, including Europe (see also Welter-Schultes, 2012: range map Europe). In Italy it was reported by Giusti et al. (1995) and Manganelli et al. (1995) from Latium and Sicily, Alexandrowicz (2003) and Mienis (2004) from Albano Lake, Cianfanelli et al. (2007) from Liguria, Tuscany, Puglia and Sicily, Reitano et al. (2007) from Sicily.

Another similar North American planorbid, *P. anceps* (Menke, 1830), has been reported in Italy (Tuscany, River Frigido) by Henrard (1968 sub *Helisoma anceps*). *Planorbella anceps* reported by Zettler & Richard (2003) from Sicily (Siracusa) is actually *P. duryi* (see Cianfanelli et al., 2007).

Planorbella duryi is sold for aquaria in Europe and its presence is caused by the release of aquarium specimens or introduction of fish (see quoted bibliography). It feed on plants, detritus, dead animals, algae and vegetables. Animals can survive short periods of drought staying deeply inside the shell.

STATUS AND CONSERVATION. Classified as “Least Concern” by Cuttelod et al. (2011) and in I.U.C.N. Red List (Seddon & Van Damme, 2014).

REMARKS. Allochthonous species, widespread in Sicily and in the Palermo surroundings (Reitano et al., 2007), where it is now present in water tanks and fountains of the city gardens (Orto Botanico, Parco della Favorita, Villa Tasca, University Polyclinic, Giardino Rosa Balistreri).

In Micciulla, some living specimens were found in a small water tank.

Superordo NERITAEMORPHI Koken, 1896
Ordo NERITOPSINA Cox et Knight, 1960
Superfamilia NERITOIDEA Lamarck, 1809
Familia Neritidae Lamarck, 1809
Subfamilia Neritinae Lamarck, 1809
Genus *Theodoxus* Montfort, 1810

Theodoxus meridionalis (Philippi, 1836)

DESCRIPTION. Shell semi-globose (Figs. 58–60), robust, with 2½–3 spires separated by shallow sutures, often encrusted and corroded specially at apex; height 3–4.2 mm; maximum shell diameter 3.8–5.8 mm; aperture height 2.9–4.0 mm; aperture diameter 3–4.5 mm; it is almost always completely black in colour with irregular lines yellowish-brown almost always broken in small spots; the operculum is yellow-orange on the outside face, whitish inside; the last whorl is very developed and represents almost all the shell; the aperture is large, semi-elliptical, with an extensive, white and shiny columellar callus, obliterating the umbilicus; apex rounded; operculum with a large knob at the base of the opercular ridge, connected to the callosity underlying it, and with the absence of the lamella (Vitturi & Catalano, 1988; Bodon & Giovannelli, 1995; Bandel, 2001).

Body blackish-gray in colour, tentacles short and thin; eyes pedunculated; foot oval, yellowish, with small black spots.

Genitalia with penis located on the right side of the head; females have two genital orifices: an oviduct and a vaginal orifice; the escretor apparatus has only one functional nerve (the left).

DISTRIBUTION AND BIOLOGY. Sicily and Tunisia (Girod et al., 1980; Kristensen, 1986; Bodon et al., 1995; Zettler & Richard, 2003; Bodon et al., 2005). *Theodoxus meridionalis* in Sicily is found in cold and oxygenated waters of rivers, streams and springs and close canals and water tanks.

STATUS AND CONSERVATION. This species is classified as “Least Concern” in IUCN Red List (Zettler & Van Damme, 2010) and by Cuttelod et al. (2011). In Tunisia it was considered “Not Evaluated” (Van Damme et al., 2010).

Theodoxus species are in decline due to human alteration of natural habitat.

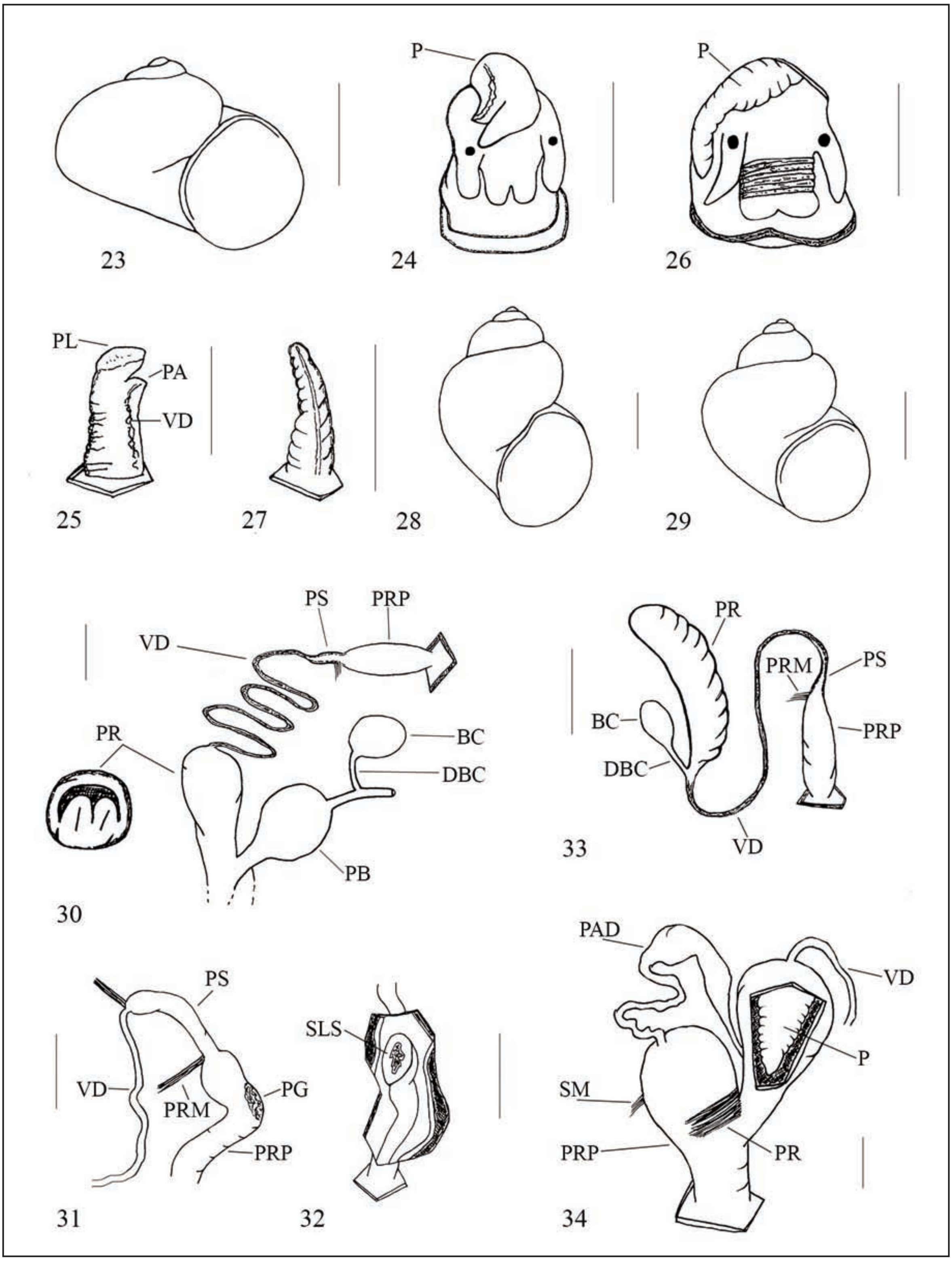
REMARKS. In the study area there are two populations: one, small, living in the spring of the Room of Sirocco and another, more numerous, living in the Source of Fontana. Also reported by Pirajno (1840 sub *Nerita fluviatilis* var. *nigra*) from “*Boccadifalco*” very close to Micciulla and by Calcara (1845: sub *Nerita baetica*) from the “*sorgive del Gabriele*”.

It is uncommon throughout the Sicilian territory, disappeared from many localities also in the surroundings of Palermo (Pirajno, 1840; Benoit, 1875, 1882; De Gregorio, 1895; Cassarà, 1951; Bodon et al., 2005).

Populations of this species from Siracusa province (Anapo, Asinaro and Lato rivers) were examined with a cariological study by Vitturi & Catalano (1988) who demonstrated the haploid number of chromosomes n=12+h and the diploid values 2n=25 in males (X0) and 2n=26 (XX) in females.

Bunje & Lindenberg (2007) studied by molecular genetics numerous *Theodoxus* populations identifying six major clades. The clade D, where *T. meridionalis* falls, is distributed throughout the Mediterranean area. According to these authors, the current specific differentiation seems to be related to the Pliocene’s geo-climatic events.

Classis BIVALVIA Linnaeus, 1758
Subclassis Eulamellibranchia Blainville, 1824
Superordo Heterodonta Neumayr, 1884
Ordo Veneroidea Rafinesque, 1815
Superfamilia Sphaerioidea Deshayes, 1855 (1820)
Familia Sphaeriidae
Genus *Pisidium* Pfeiffer, 1821



Figures 23–25. *Islamia pusilla*. Fig. 23: shell. Fig. 24: body. Fig. 25: dorsal surface of penis. Figures 26–29. *Pseudamnicola moussonii*. Fig. 26: body; Fig. 27: penis; Figs. 28, 29: shells. Figure 30. *Stagnicola fuscus*, penial complex. Figures 31, 32. *Physella acuta*: penis with open preputium. Figure 33. *Planorbis moquini*, penial complex. Figure 34. *Planorbella duryi*, penial complex. All scale bars equal 1 mm except for the bars in figures 23–25 which equals 0.5 mm.

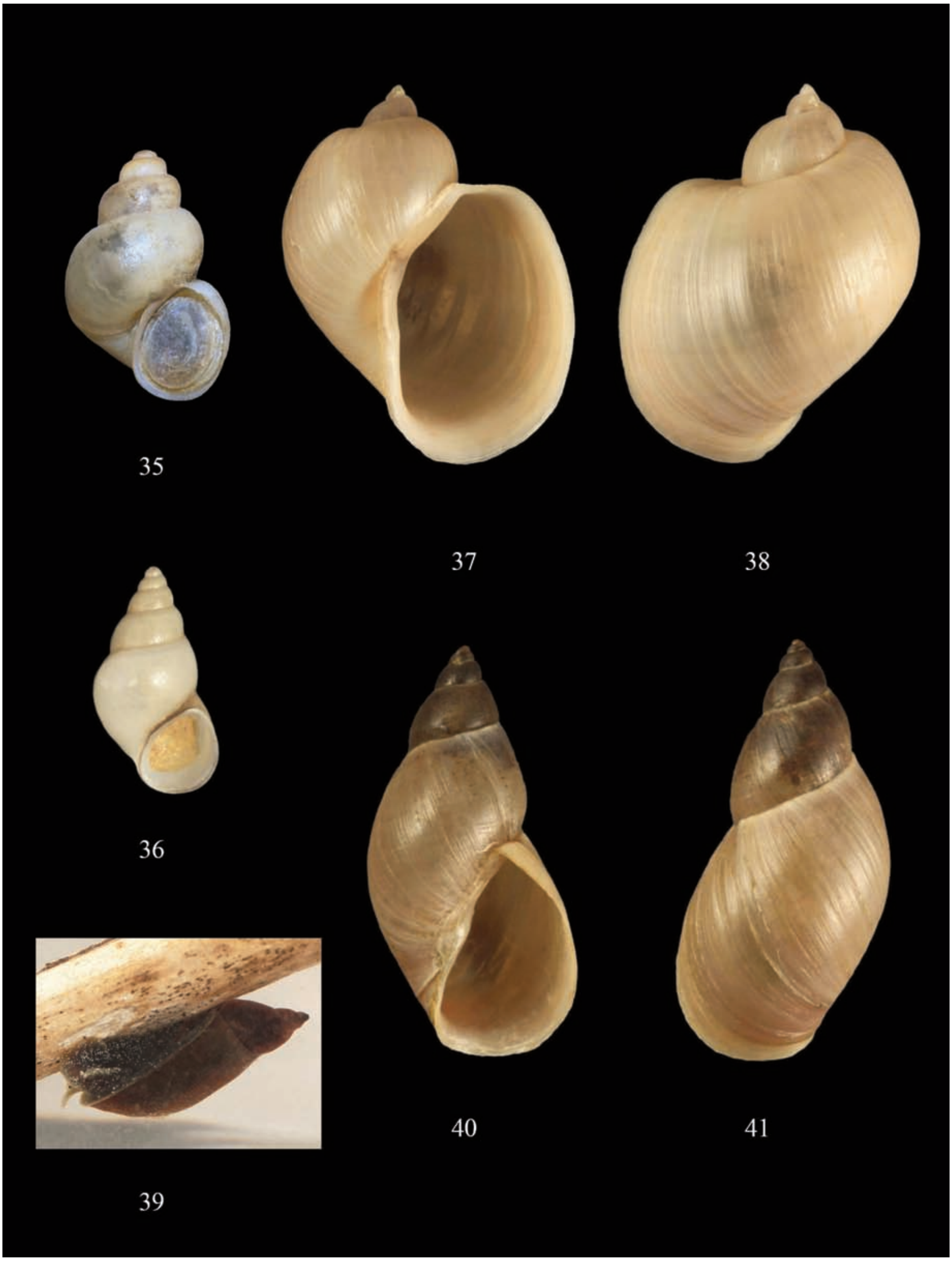
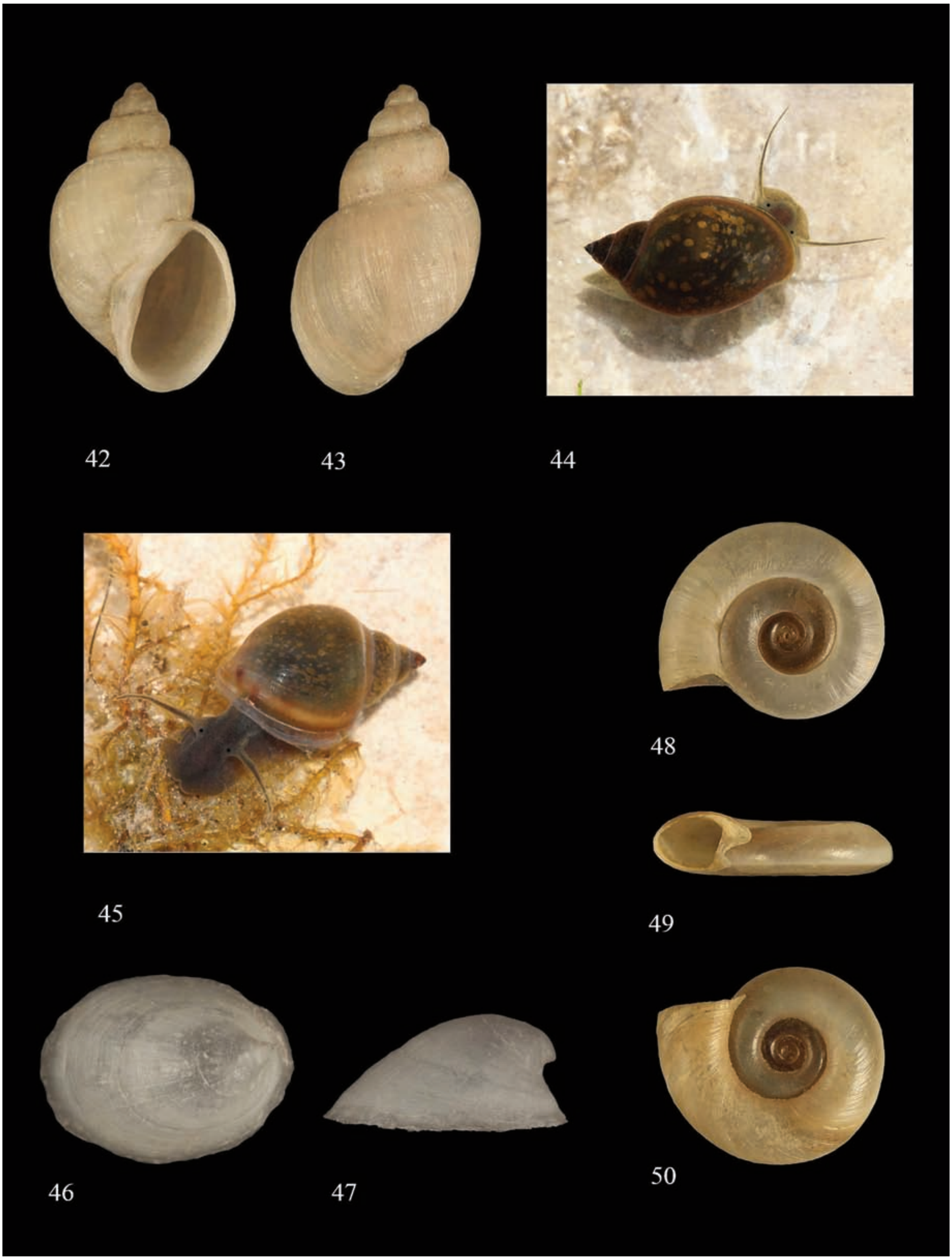
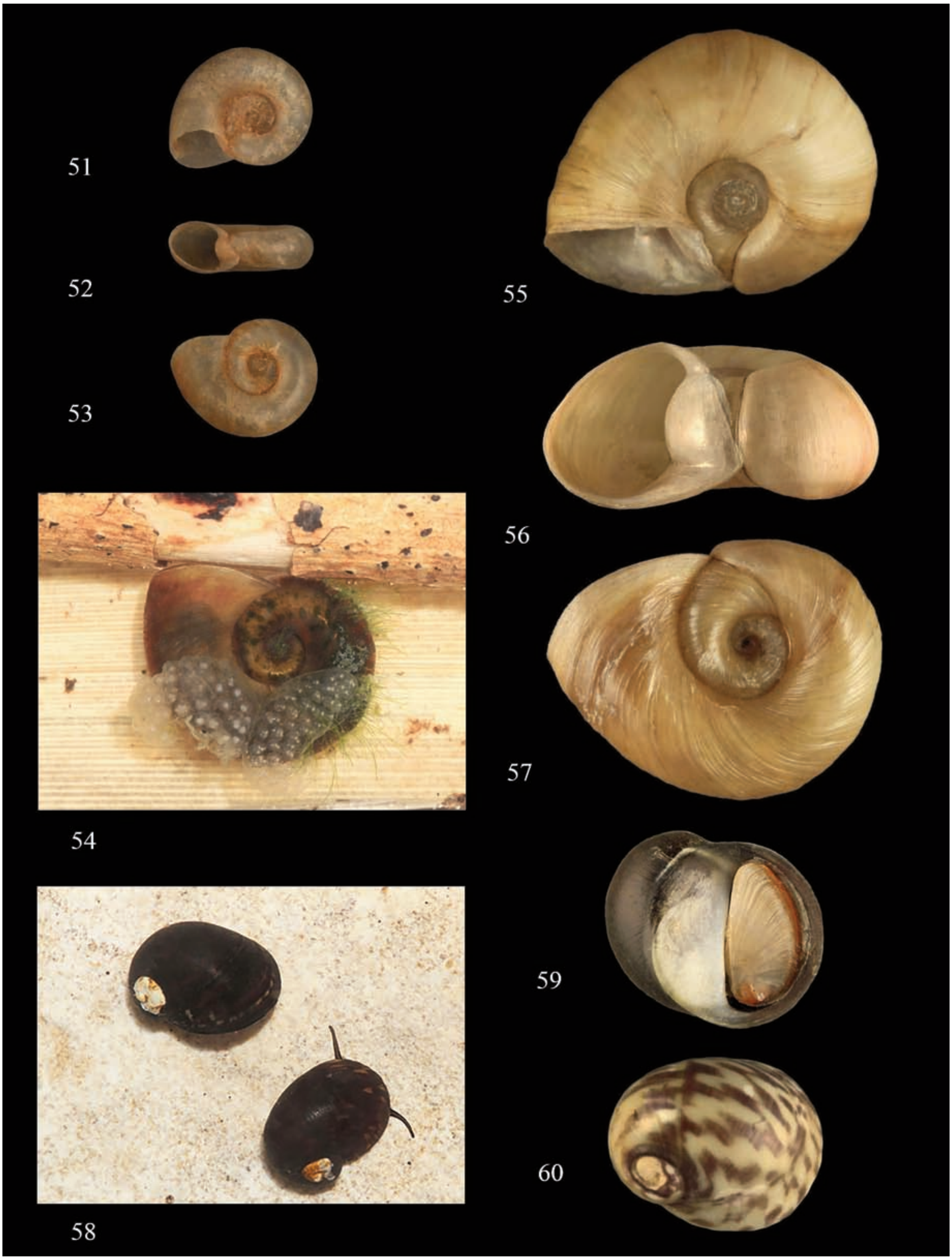


Figure 35. *Bythinia leachii*, Qanat Scibene, shell, height 5.4 mm. Figure 36. *Potamopyrgus antipodarum*, Qanat Gesuitico Alto, shell, height 5 mm. Figures 37, 38. *Radix auricularia*, Ru Gebbi, shells, height 20.1 mm. Figures 39–41. *Stagnicola fuscus*, Gebbia Villa Belvedere, live specimen and shells, height 16.3 mm.



Figures 42, 43. *Galba truncatula*, Gebbia Santacolomba, shells, height 8 mm. Figures 44, 45. *Physella acuta*, Micciulla, live specimens, shells, height 10 mm. Figures 46, 47. *Ancylus* prope *fluviatilis*, Source of Fontane, shells, height 5 mm. Figures 48–50. *Planorbis planorbis*, Gebbia La Mantia, shells, maximum diameter 8.4 mm.



Figures 51–53. *Planorbis moquini*, Qanat Savagnone, shells, maximum diameter 3 mm. Figures 54–57. *Planorbella duryi*, Micciulla, shells and live specimen, height 10.2 mm. Figures 58–60. *Theodoxus meridionalis*, Source of Fontane, live specimens (Fig. 58), shell with operculum, height 3.8 mm (Fig. 59) and honed shell, height 3.5 mm (Fig. 60).

Pisidium personatum Malm, 1855

DESCRIPTION. Shell bivalve, oval in outline, little convex, lower edge well arched, pale yellow in colour, white or grayish post mortem, subtransparent; length 2.2–4.4 mm, height 1.9–3.3 mm, width 1.7–3.2 mm; external surface with thin and irregular striae, anterior half slightly longer than posterior, umbones only just posterior, broad, but not prominent; hinge plate of both valves robust characterized by the presence of a "callus" between the ligament pit and the base of 1 and 3 posterior lateral teeth (P1 and P3), more evident on the right valve close to or fused to the base of P3. Three anterior lateral teeth (A3) and P3 moved at the margin of the shell.

Animal with small and pointed foot, yellowish in colour.

DISTRIBUTION AND BIOLOGY. Holopalaearctic-Ethiopian, including all Italy (Kuiper, 1964; Castagnolo et al., 1980; Castagnolo, 1995; Bodon et al., 2005; Pezzoli & Giusti, 2006).

Pisidium personatum lives in all stagnant and slow moving waters, also in subterranean waters. It is frequent in low and medium altitudes but it occurs at higher altitudes in the Alps (Nardi & Castagnolo, 2009).

STATUS AND CONSERVATION. Classified as "Least Concern" by Cuttelod et al. (2011).

REMARKS. *Pisidium personatum* is present in this study area with several small but stable populations (Table 1). It is a common species in Sicily, where it is found in different environments, including canals, drinking water, wells or small cavities even with little light or almost darkness.

CONCLUSIONS

The Palermo Plain is now almost completely urbanized as includes, in addition to the city of Palermo, many other neighboring towns with a total of about 1,000,000 people. Particularly in the second half of 1900, there was an uncontrolled development of buildings, without the construction of adequate networks and aqueducts, causing the spread of cesspools and the transformation into sewers of many streams and artificial canals, including the Oreto River.

All these waterways are in communication with the underground aquifers of the Plain and even the old sewerage system of Palermo's urban center is subject to frequent sewers breakage and discharge of slurry. In addition, numerous wells for drawing water from the aquifer were made without proper controls. All this resulted in over-exploitation of the underground water with consequent drainage of some springs and increased intrusion of sea water into the aquifer itself.

At the same time, occurred the disappearance of almost all the natural freshwater environments of the Palermo Plain and the strong reduction of agricultural land including its complex water-catching and distribution systems (gebbie, saje, etc.) which contributed to the creation of a complex ecosystem with articulated trophic networks (Riggio, 1976; La Mantia, 2004).

In this environmental degradation the territory of Micciulla, now completely inside the city of Palermo, witnesses a perfect integration of natural environments and agro-systems of the Palermo Plain, representing the perfect metaphor for sustainable development.

In the Palermo Plain, it is already documented for various other groups of animals a passage from the original natural habitats to the agrarian ones with biodiversity conservation.

This is the case of the loquat, *Eryobothria japonica* (Thumb.), an allochthonous species long cultivated in Sicily and, in particular, in the Conca d'Oro. Many loquat orchards contribute to creating new ecological niches for different bird species (see La Mantia, 2016) and insects xylophages, in particular Coleoptera Cerambycidae (Bellavista et al., 2015).

Fourteen (14) species of freshwater molluscs have been surveyed (Table 1). Of particular importance are the populations of *Islamia pusilla*, species bound to water springs and *Theodoxus meridionalis*, Sicilian endemism restricted to well-oxygenated waters, which has disappeared from numerous places in the Palermo area. The consistency of the *Pseudamnicola moussoni* and *Pisidium personatum* populations is good, both species linked to clean and oxygenated waters, with wide diffusion and great ecological value. *Stagnicola fuscus*, *Radix auricularia*, *Galba truncatula*, and *Planorbis planorbis* are present with small populations but still found in Palermo area, while no data is available on the consistency of the populations of *Bythinia leachii*, *Planorbis moquini* and *Ancylus* prope *fluviatilis*.

It is worth noting the presence of three allochthonous species: *Physella acuta*, widespread and common since 1900 throughout Sicily, *Potamopyrgus antipodarum* and *Planorbella duryi*, species introduced recently but continually expanding.

The largest number of living populations are found in the Fontane Spring (6) thanks also to the good natural conditions of these environments. This is also the case of the Qanat Scibene (5) and Qanat Savagnone (4), which receives clean and oxygenated waters from the Scibene Spring, despite the small area useful for malacological researchs, restricted to the qanat entrance from the "Camera dello Scirocco" (scirocco room) (see Fig 15).

The Qanat "Gesuitico Alto", however, flows completely underground and is aphotic (i.e. having no sunlight): we found empty shells and some living specimens of *Potamopyrgus antipodarum*, an allochthonous species which, throughout the entire territory studied, at the moment, was found only in this particular environment.

Within the gebbie examined we found, in the whole, a few living species, probably due to either the fast water supply they are characterized by, as being used for irrigation, and the homogeneous eco-

Species	Source of Fontane	Qanat Scibene	Qanat Savagnone	Qanat Gesuitico Alto	Gebbia La Mantia	Gebbia Villa Belvedere	Gebbia Santacolomba	Ru Gebbi	Saje Fondo Micciulla	Water tank Micciulla
Bithynia leachii		S							S	
Islamia pusilla	L	L	L							
Pseudamnicola m. moussonii	L	L	L	S				S		
Potamopyrgus antipodarum				L						
Physella acuta	L	L		S	L	L	L		S	L
Galba truncatula					S	S	L		L	
Radix auricularia						S		S		
Stagnicola fuscus	S	S			S	S	S		L	
Ancylus prope *fluviatilis*	L	S	S	S					L	
Planorbis moquini	S	S	L	S						
Planorbis planorbis	L	S			S	L	S		L	
Planorbella duryi										L
Theodoxus meridionalis	L	L	S	S					S	
Pisidium personatum	L	L	L	S	S				L	

Table 1. Freshwater snails found in Micciulla territory (2009–2016). L: live specimens, S: shell/s.

logical conditions typical of this environment; in addition, periodically, gebbies are emptied and cleaned.

Many more species can be found, on the other hand, in the saje of Fondo Micciulla, which have a considerable territorial extension, a good diversification of ecological niches and are nearly always fed by running waters.

Quite predictable was the presence of *Planorbella duryi* within an ornamental tank.

The multiple connections between all these natural and artificial systems allow to find, almost everywhere, empty shells transported remotely from the original places.

Some species have high colonization capacity and ecological adaptability to moving easily within the study area as *Stagnicola fuscus*, *Galba truncatula*, *Radix auricularia*, *Physella acuta*.

It is essential to plan conservation, recovery and enhancement programs for both natural environments and farmlands occurring within the Palermo Plain (see La Mantia, 2006, 2007). It would be necessary, therefore, to re-evaluate the role played by water throughout this entire system and to ensure its constant availability to farmers in order to slow down the processes of land abandonment (La Mantia & Rotondo, 2014).

The ecological value of these agro-ecosystems is mostly linked to the permanence of water in the irrigation system and soil and its absence for many months in the distribution channels results in disappearance of entire communities of plants and animals, not least that of freshwater molluscs object of this work.

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