

First Record of Alien Species *Craspedacusta sowerbii* Lankester 1880 in a Stream of Sardinia (Italy)

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ABSTRACT

In recent decades, the number of invasive alien species introduced outside of their natural distribution range has increased. These species can rapidly spread from the place of introduction, acting as agents of change, threatening ecosystems, habitats, and indigenous species. *Craspedacusta sowerbii* Lankester, 1880 has invaded freshwater systems all over the world. This article reports the first occurrence of this freshwater jellyfish in a stream on the island of Sardinia, Italy. There is no previous data useful to understand the development of this species in the river systems of the island where streams are usually seasonal, with a strong water reduction, and native animal species are concentrated in a few pools during critical seasons. In our study, we carried out an observation of the phenomenon in order to provide preliminary information about this new population, its characteristics, and environmental features. Endangered and extremely rare endemic species, such as *Discoglossus sardus* and *Euproctus platycephalus*, live in Sardinian streams, so this is one more reason to focus on the biological invasion processes of this organism in order to understand its role in this ecosystem's ecological functioning.

Keywords: *Craspedacusta sowerbii*, invasive species, Mediterranean seasonal stream, Sardinia.

Submitted: November 10, 2023

Published: December 23, 2023

 10.24018/ejzoology.2023.2.2.29

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1. INTRODUCTION

Some species of inland water medusae have been described in localities all over the world. However, only *Craspedacusta sowerbii* has been reported in Europe and the North and South American continent (Jankowski, 2001). It is a cryptic cosmopolitan invasive species, which occurs in all continents except Antarctica (Morpurgo *et al.*, 2020).

The freshwater jellyfish *Craspedacusta sowerbii* Lankester, 1880 is a hydrozoan species belonging to the family Olindiidae and characterized by inhabiting inland water environments (Jankowski *et al.*, 2008). The life cycle of this species includes both a benthic polyp and free-swimming medusa stages. The polyps (maximum 1 mm in height and without tentacles) live alone or in small colonies attached to stable underwater surfaces. Polyps reproduce asexually by budding, producing other polyps or jellyfish. Moreover, they can produce asexual larvae, called "frustules", which can move slowly and help to spread polyps throughout the site they live in. (Morpurgo

et al., 2020). Medusae reproduce sexually in open water and have a 10–20 mm wide umbrella and a velum with a large manubrium extending beyond the umbrella margin (Medina-Gavilán & González-Duarte, 2018).

In the case of *Craspedacusta sowerbii*, environmental factors such as temperature and food availability are the main drivers when addressing sexual (by medusae) and asexual (by polyps) reproduction. It has been documented that frustules develop into polyps between 12 °C and 20 °C and that the budding of medusae generally occurs at temperatures between 26 °C and 33 °C. During the cold winter months and under unfavourable environmental conditions, polyps encyst as dormant bodies called podocytes (Morpurgo *et al.*, 2020), which can survive up to 40 years of desiccation (Marchessaux *et al.*, 2021).

According to Jankowski (2001), the first description of the existence of *C. sowerbii* occurred in 1880, at the Royal Botanic Garden of London (Lankester, 1880), but the species originated in the Yangtze River system in China (Kramp, 1950). Eastern Asia seems to be the center of



diversity for *Craspedacusta*, showing the highest concentration of species (Jankowski, 2001; Zhang et al., 2009). In 2015, 11 species of the genus *Craspedacusta* were recognized. Although all of these freshwater jellyfish lived in similar habitats, only *C. sowerbii* became an invasive alien species (Morpurgo & Alber, 2015). *Craspedacusta sowerbii* is classified by the European Commission as an alien species of high impact in the European freshwaters (EASIN, 2017; Medina-Gavilán & González-Duarte, 2018).

C. sowerbii has invaded freshwater bodies in Europe, North America, and Australia (Boothroyd et al., 2002; Carlton, 2003; Arov, 2004; El Moussaoui & Beisner, 2017; Marchessaux & Bejean, 2020). It is important to focus on the biological invasion processes of this organism when it becomes established in order to understand its role in the ecological functioning of the plankton food web (Ricciardi, 2015a).

The predatory impact of *C. sowerbii* on the zooplankton community has been described within natural environments and in the laboratory (Boothroyd et al., 2002; Jankowski et al., 2005; Smith & Alexander, 2008). In fact, different authors point out that blooms of *C. sowerbii* can increase its negative effect on the native zooplankton community, alter the aquatic food webs and reduce the dissolved oxygen in water (Jankowski, 2000; Smith & Alexander, 2008; Gasith et al., 2011; Folino-Rorem et al., 2015; Medina-Gavilán & González-Duarte, 2018).

Despite its occasional and short-lived presence in the water column of invaded water bodies and its potentially limited impact on the ecosystem, *C. sowerbii* has been intensively studied for more than 140 years after its discovery. Even if the biology is well known, the global distribution of *C. sowerbii* remains uncertain due to its

ephemeral appearances and the general lack of information on this species in various aquatic environments. (Marchessaux et al., 2021).

According to Ciutti et al. (2017), there are 40 reports of the species in Italy. *C. sowerbii* is mainly present in the northern and central regions the country, except for one report in Sardinia. In this region the report dates back to 1970 in the Liscia artificial basin (Cotta Ramusino, 1972). There are no previous data useful to understand the development of this species in the river systems of Sardinia. Therefore, any new record in natural environments becomes important in order to estimate the future distribution areas of *C. sowerbii* on the island.

During October 2023, a medusae bloom occurred in a pool of the Fossu Frate di Ghirru stream (also known as Rio Pitrisconi) located in North-Eastern Sardinia in the Monte Nieddu Nature Reserve (LR 31/89), municipality of San Teodoro (SS). The goal of this short communication is to supply preliminary information about this new population in order to describe its characteristics and environmental features.

2. MATERIALS AND METHODS

The first observations of the presence of jellyfish in the area of the Fossu Frate di Ghirru stream were made continuously from October 8, 2023, to October 27, 2023. Following this exceptional report of the event, on October 21, 2023, an observation of the phenomenon was carried out in order to verify the reports and sampling that led to identifying the species.

2.1. Study Area

Fossu Frate di Ghirru stream originates from the springs on the eastern slope of Monte Nieddu and covers 10 km in length before flowing into Rio San Teodoro River (Fig. 1).

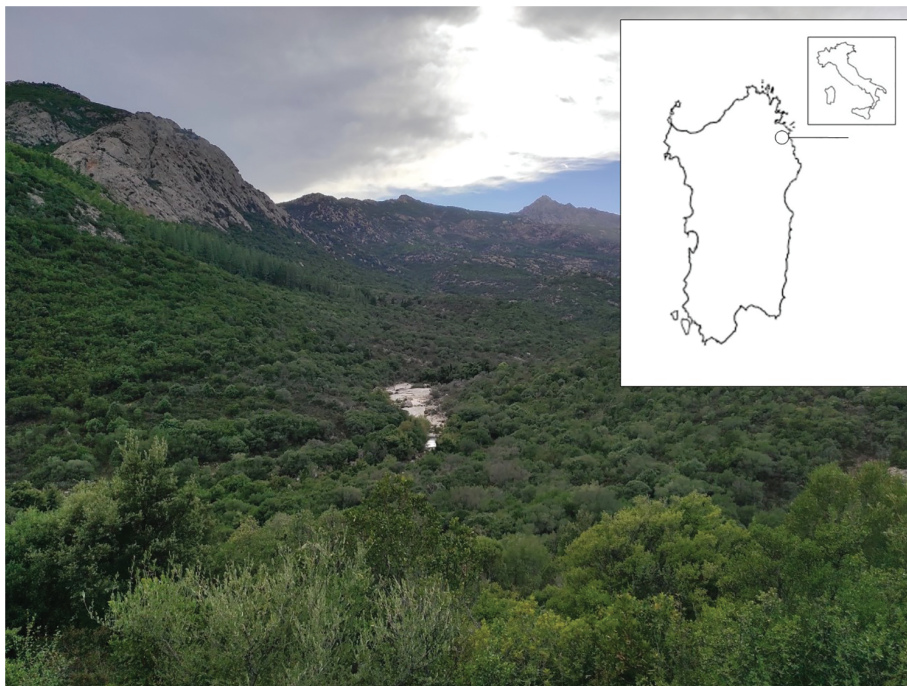


Fig. 1. Fossu Frate di Ghirru stream (Sardinia), (D-maps, 2023).



Fig. 2. Poiu Pitriolu station (Fossu Frate di Ghirru stream).

It receives several tributaries from a river basin whose highest summit is Monte Nieddu (Punta Maggiore, 970 m) and its hydrographic basin area is 16.9 km².

The stream deeply cuts the granite bedrock on which it flows, generating numerous waterfalls that reach 20 m in height and attract numerous tourists every year. Geologically, the rocky substrate is pinkish leucogranite with garnets and muscovite, belonging to the Goceano-Bittese granitoid complex (Carmignani et al., 2011). It is a seasonal stream, with a strong decrease in water from summer to the first autumn months. Inside the stream, it is possible to see different classes of vertebrates such as *Anguilla anguilla*, *Natrix maura*, *Discoglossus sardus* (Sardinian-Corsican endemism), *Euproctus platycephalus* (Sardinian newt *Euproctus*, Sardinian endemism). This latter species reproduce in the stream and is categorised as endangered in IUCN global and national Red Lists and included in Annex IV of 92/43/EEC (Andreone et al., 2013a), while *Discoglossus sardus* is categorised as vulnerable, VU, in IUCN Italian Red List and included in annexes II and IV of 92/43/EEC (Andreone et al., 2013b).

The jellyfish were spotted exclusively in the stream pool called Poiu Pitriolu, located at the base of a 10 m waterfall, about 6.7 km from the confluence with the river Rio San Teodoro.

2.2. Data Collection

Altitude and coordinates were taken by EtrexVista GPS. The width, length, and maximum depth of the pool were measured by double decametre.

To estimate the presence of other freshwater species and jellyfish density in medusae stadium, monitoring was carried out through an underwater visual census (UVC) survey by scuba (Murphy & Jenkins, 2010; Hamner et al., 1975; Berstad et al., 1995; Prato et al., 2017). Furthermore,

this allowed the detection and identification of a large number of species, as well as the quantitative descriptions of the existing set of organisms, including characteristics such as density and biomass (Prato et al., 2017).

UVCs with transects and fixed points are the most convenient for shallow areas. The UVC analysis was carried out on five random points (A, B, C, E, F, and G) along each axis, stream pool length from east to west (Ax.1) and width from north to south (Ax.2), observing within a radius of 2 m. Density was measured in the number of jellyfish m⁻³.

20 specimens were collected and observed in order to identify the species. The identification was done according to Jankowski (2001). All captured individuals were immediately placed in containers (5 l) filled with stream water. The samples were measured to estimate the umbrella diameter in millimeters.

Environmental parameters such as water and air temperature (°C), Salinity (PSU), Total Dissolved Solids (mg·L⁻¹), Dissolved Oxygen (mg·L⁻¹), and oxygen saturation (%) were recorded using a multiparameter probe (Hanna HI98494). Environmental water parameters were recorded at different depths (9 m, 5 m, 3 m, 1 m, surface) to verify the difference in the water column every 2 m from maximum depth (9 m) to the surface.

3. RESULTS

The Poiu Pitriolu sampling station (Fig. 2) is located at an altitude of 290 m a.s.l. and its coordinates are 40°45'01.9'' lat. N, 9°35'46.0'' long. E (datum WGS84) (Fig. 2). It is 20 m long × 25 m wide, with a maximum depth of -9 m and a surface of 320 m².

The sampling area is characterised by the presence of riparian vegetation (more specifically, *Osmunda regalis*, *Juncus acutus*, *Alnus glutinosa*, *Fraxinus excelsior*) and

TABLE I: SOWERBII DENSITY (N. INDIVIDUALS / M3) IN POIU PITRIOLU STATION (FOSSU FRATE DI GHIRRU STREAM)

Transect	Point					Average	Total average
	A	B	C	D	F		
Ax.1	2	3	3	1	0	1.8	2.7
Ax.2	2	3	5	4	4	3.6	

Mediterranean shrubs located along the steep and rocky slopes (characterized by *Myrtus communis*, *Juniperus sp.*, *Olea europaea sylvestris*, *Arbutus unedo*, *Lavandula stoechas*, *Genista corsica*).

The pool bed is smooth and rocky, with few sediments and rocky blocks located mostly on its southern side, and shows a concave longitudinal section.

During the survey, one specimen of *Anguilla* was identified. It is often agreed that using the UVC method to quantify the abundance of fish within an area may underestimate their presence (Thresher & Gunn, 1986). However, we considered the method to be reliable given the small size of the sampling station. Using the UVC method, an average total jellyfish density of 2.7 n. individuals m⁻³ was measured (Table I and Fig. 3).

The umbrella diameter of 20 specimens measured had a width ranging from a minimum of 7.00 mm to a maximum of 20.00 mm and the average was 14.35 mm (Figs. 4 and 5).

According to Jankowski (2001) the species was identified as *Craspedacusta sowerbii* Lankester, 1880 (Fig. 6).

Environmental water parameters did not differ with depth. The highest Temperature (17.41 °C), Total Dissolved Solids (73.00 mg·L⁻¹), and Salinity (0.07 PSU) values were recorded on the surface while the highest values of oxygen saturation (96.70%) and Dissolved Oxygen (8.56 mg·L⁻¹) were recorded at a depth of 9 m (Table II). The air temperature was 20.40 °C.

4. DISCUSSION AND CONCLUSION

While freshwater medusae have been recognized for well over a century, as evidenced by the works of Lankester (1880) and Jankowski (2001), our understanding of these organisms, particularly in terms of their taxonomy and ecology, remains notably deficient, as noted by Dumont (1994). Many ecological observations are still unexplained, the number of existing freshwater medusae species is unclear and there is only speculation concerning their phylogenetic origin (Dumont, 1994; Jankowski, 2001).

The environmental parameters observed in the Poiu Pitriolu pool were consistent with the characteristics described before for this species: salinity <0.5 PSU (Alves et al., 2009) and TDS < 1000 mg/L. However, the

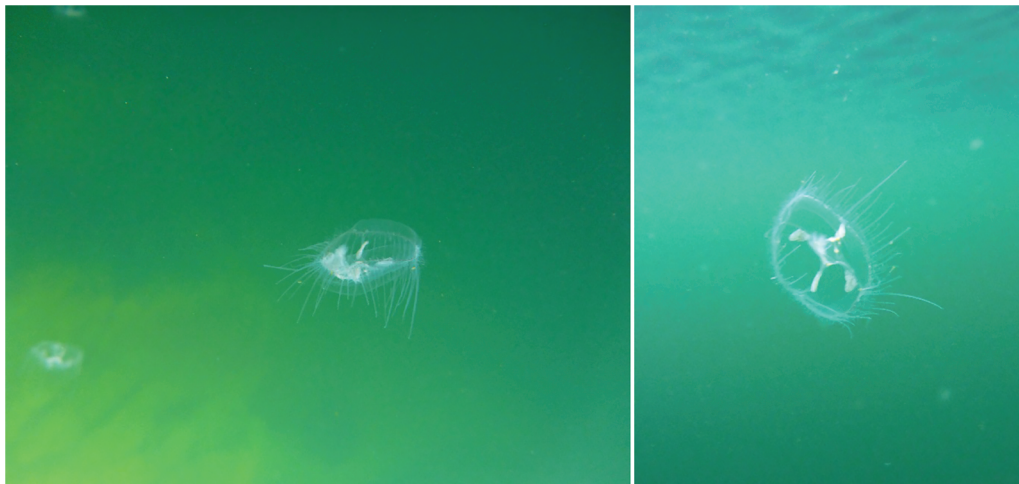


Fig. 3. (a, b). Specimen of *C. sowerbii* in Poiu Pitriolu station (Fossu Frate di Ghirru stream).



Fig. 4. Umbrella diameter measurement of *C. sowerbii* from Poiu Pitriolu station (Fossu Frate di Ghirru stream).

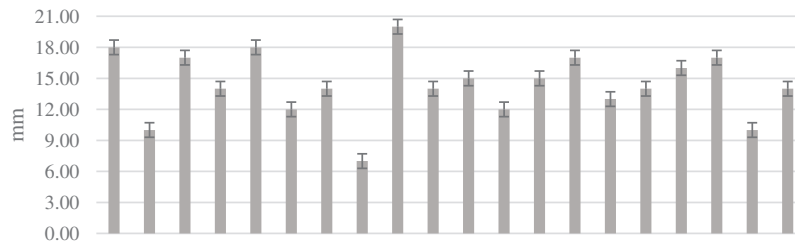


Fig. 5. Umbrella diameter of specimen recorded in Poiu Pitriolu station (Fossu Frate di Ghirru stream).

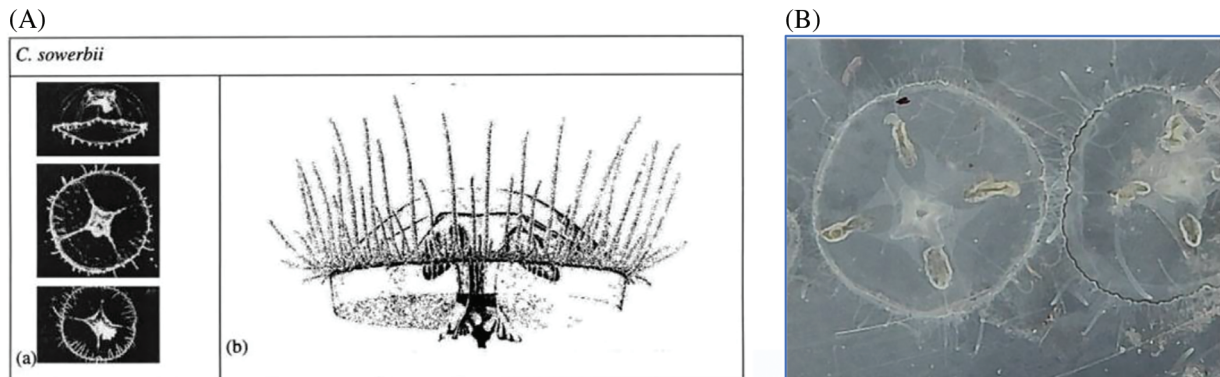


Fig. 6. A. Habitus of *Craspedacusta sowerbii* from Reisinger (1972) (Jankowski T., 2001); B. Anatomical details of the examined specimen from Poiu Pitriolu station (Fossu Frate di Ghirru stream).

TABLE II: ENVIRONMENTAL WATER PARAMETERS IN POIU PITRIOLU STATION (FOSSU FRATE DI GHIRRU STREAM)

Depth	Water temperature (°C)	Oxygen saturation (%)	Dissolved Oxygen (mg-L-1)	Total Dissolved Solids (mg-L-1)	Salinity (PSU)
Surface	17.41	94.30	8.33	73.00	0.07
-1 m	17.41	95.40	8.42	69.00	0.07
-3m	17.40	95.30	8.42	65.00	0.06
-5 m	17.38	95.05	8.40	66.00	0.06
-7 m	17.35	94.05	8.32	64.50	0.06
-9 m	17.31	96.70	8.56	62.50	0.06

water temperature was rather low (17.38 °C) compared to those indicated by other authors for the development of the medusoid form of *C. sowerbii* (Marchessaux et al., 2021).

C. sowerbii specimens were present in the Poiu Pitriolu station at an average density of 2, 7 specimens m⁻³, superior to the values of 1 specimen m⁻³ reported in the literature (Spadinger & Maier, 1999; Pérez-Bote et al., 2006; Stefani et al., 2010). The predictions showed that this species will invade high-latitude regions in both hemispheres over the next 80 years with ecological consequences in already threatened freshwater ecosystems (Marchessaux et al., 2021).

Previous results showed that another inland jellyfish species, *Odessia maeiotica*, can act as a top-predator in the planktonic food web, suppressing almost the entire trophic level of higher zooplankton and affecting phytoplankton structure by means of a trophic cascade effect (Compte et al., 2010). Experimental data (Marchessaux & Bejean, 2020) suggest that *C. sowerbii* can significantly reduce zooplankton populations. During warmer periods, medusas mainly consume small prey (0.2–2 mm) and can kill larger (>8 mm) organisms (Marchessaux & Bejean, 2020). It is reasonable to hypothesize that their impact will be greater in seasonal streams, which are subject to a strong water reduction, even desiccation, during warmer months.

In those periods, native animal species are concentrated in few pools as is their food, allowing them to survive the critical season.

This is the first time that the species is found in a Sardinian natural waterbody. Our study reinforces the knowledge of the *C. sowerbii* distribution on the island of Sardinia, which was only cited once before in 1972 (Liscia artificial basin, Ciutti et al., 2017) and it is the first to confirm the presence of the species on the island after 51 years. The Gola Fossu Frate di Ghirru/Rio Pitrisconi is an important recreational tourism destination and is very popular with tourists who visit the stream to swim or practice canyoning. Some endangered and extremely rare amphibians live in the stream, such as *Discoglossus sardus* and *Euproctus platycephalus* (Sotgiu et al., 2010), and this is one more reason to focus on the biological invasion processes of this organism in order to understand its role in the ecological functioning of the plankton food web (Ricciardi, 2015b).

Further study of this stream and its hydrographic basin is needed in order to determine the *C. sowerbii* dispersal pathways and its potential impact on ecosystem functioning.

ACKNOWLEDGMENT

We thank Yoris Palpella, for reporting his sighting of jellyfish in the Fossu Frate di Ghirru stream and Valeria Testone for the use of her equipment.

CONFLICTS OF INTEREST

Authors declare that they do not have any conflict of interest.

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