

## On the Biology of some rice-field weeds in Sardinia: *Cotula* and *Heteranthera*

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### ABSTRACT

The biology and ecology of *Cotula coronopifolia* L. (*Compositae*), *Heteranthera rotundifolia* (Kunth) Griseb. and *Heteranthera reniformis* Ruiz & Pavon (*Pontederiaceae*), three new weeds naturalized in rice-fields of central-southern Sardinia, are described. Attention is focussed on the degree of propagation of these "taxa", as a consequence of their suitability for the environmental conditions of Sardinian rice-fields, where it seems that marked convergences exist with regard to the original habitat of these species.

### Introduction

Rice growing is not a tradition in the island of Sardinia, and has only been introduced recently to exploit the salty soils reclaimed from vast coastal marshlands (Aru & Baldaccini, 1961).

Rice is cultivated in the Oristano region (central-western Sardinia) and in the Sarraabus (Muravera, in the SE), covering an area of some 1,600 ha. In contrast to the rice-growing areas of northern Italy where numerous studies on the flora and vegetation have been conducted, including those by Pignatti, 1957; Pirola, 1964; Pruneddu, 1969; Piccoli, 1979; Piccoli & Gerdol, 1981, Sardinian rice-fields have been little studied, apart from a few observations on floristics and distribution of adventitious rice-field weeds in the Oristano region and at Muravera (Marchioni, 1967; De Martis & Marchioni, 1975; Marchioni & De Martis, 1982).

Since a floristic, and especially biological, knowledge of rice-field weeds is essential if exploitation of soils suited to rice-growing is to be improved, we have focussed our attention on three species in particular, acquired only recently and presently rapidly spreading in Sardinian rice-fields: *Cotula coronopifolia* L., *Heteranthera rotundifolia* (Kunth) Griseb. and *H. reniformis* Ruiz & Pavon.

### Materials and Methods for Germination Tests

*Cotula coronopifolia*, *Heteranthera rotundifolia* and *Heteranthera reniformis* seeds were collected from dry capitula and capsules in September 1985 and stored dry in parchment bags at laboratory temperatures (18-23°C). These were used in monthly germination assays of seeds which were performed all year round. Only the data for April, May and June are reported here, firstly because these months coincide with the preparation and growing periods in Sardinian rice-fields and secondly because the results are more significant. In the three species examined, first germinations were observed between February and March: *H. rotundifolia* 28% in February; *H. reniformis* and *C. coronopifolia* respectively 33% and 20% in March, after 15 days culture.

The seeds were examined under a microscope and were found to be intact and homogeneous in size and colour. Each monthly assay consisted of four replicates of 50 seeds each for each species. Seeds were placed to germinate in glass petri dishes ( $\emptyset$  6 cm) on Whatman No. 2 paper wetted with 5 ml of deionized water. Temperature was kept constant at 20°C and a light regimen of 12 h light, 12 h dark was maintained with Philips TL tubes 40W/33RS providing 1800 lux cm<sup>-2</sup> s<sup>-1</sup> (Bertagnin climate chambers type 500). Optimum experimental conditions were determined after preliminary tests under different temperature and light conditions. The seeds were checked daily and considered as germinated when the radicles reached 2 mm in length.

### Results of Germination Tests

The results, shown in Table I, reveal the good germination ability of *Heteranthera rotundifolia* and *Heteranthera reniformis* seeds in May and June. Germination percentages as high as 95% and 72% respectively were reached after just 5 days and 100% was obtained after another 10 days, for *H. rotundifolia* and *H. reniformis*.

By contrast, despite exhibiting good germination ability, *Cotula coronopifolia* seeds attain or exceed 80% germination only after 15 days culture in May and June.

The germination behaviour observed in 1986 reflects that noted in tests conducted in 1983 and 1984.

### Discussion and Conclusions

The three species and their biology in Sardinia will be examined separately in relation to germination tests and field observations.

#### *Cotula coronopifolia* L.

This species, a native of S. Africa (Tutin, 1976), is almost considered cosmopolitan due to its extremely wide distribution. It readily adapts to a wide variety of climates and environments. In its country of origin it thrives in humid marshlands and flowers from May to February (Adamson & Salter, 1950) or September to May in brackish and freshwater of Australia (Aston, 1977).

In the authors' opinion, the most likely hypothesis to explain its spread, is that advanced by Corillon & Lollierou (1956) but its extension and subsequent establishment is undeniably to be attributed to its broad ecological range. In Sardinia this species grows equally well in fresh or sea-water marshes on wet or dry sandy-loamy soils and on filler soils (De Martis & Marchioni, 1975). It flowers from April-May to September-October and throughout this period produces an extremely larger number of seeds (35-50 per capitulum) which can germinate over different periods of time (see Tab. I, about 80-90% in 15 days) provided that humidity is minimum. Its biological cycle is closely related to the absence or continuous presence of water, hence it can be either an annual (T scap) or a stoloniferous perennial (I scd). In view of its biology, it is easy to understand why this species has spread and established so rapidly. In one rice-field in Sardinia it has colonised the ground to such an extent that any further cultivation of those salty soils termed "recovered" (Marchioni, 1967) is now compromised. This harmful adventitious plant was later sighted in other places in Sardinia (De Martis & Marchioni, 1975). It was recently found in a marsh near rice-fields in the Oristano region (Marchioni Ortu & De Martis, 1984).

#### *Heteranthera rotundifolia* (Kunth) Griseb.

Originating from the subtropics of America, this species has spread to the Caribbean islands, South America (except Perù and Chile), Mexico, Brazil and the United States. This species has been introduced into rice-fields in N. Italy (Horn, 1985; Soldano in litteris) and in Sardinia (sub *H. limosa* (Swartz) Willd., Marchioni & De Martis, 1982).

In its native habitat it is a semi-aquatic annual plant with a procumbent stem growing in ephemeral pools and small ponds and flowering in summer (Horn, 1985). Like *H. limosa* (Barret & Seaman, 1980), this species, after chasmogamic and/or cleistogamic flowering, also dies, regardless of environmental conditions.

In Sardinia it first appeared around 1980 in the rice-fields of the Oristano region and later in those of Muravera (Marchioni & De Martis, 1982). Here it quickly spread by seeding even to the ridges.

It thrives in aquatic environments where the seeds germinate in sandy-loamy soils producing annual seedlings and/or rarely stoloniferous stems, rooting at the nodes. It flowers and bears fruit between July and September-October. The high number of seeds produced per capsula (250-300) and their germination percentage (Tab. 1) explain the rapidity with which this species propagates.

#### *Heteranthera reniformis* Ruiz & Pavon

This species, an autochthon of central-southern America, is now found in the West Indies, Mexico, Florida, Texas, and in North Connecticut, New York State, Kentucky, Indiana, Illinois, Missouri and Nebraska (Hausman, 1947; Small, 1903; Britton & Brown, 1913). It is a stoloniferous perennial and produces numerous new roots at its nodes, which enable it to survive, propagating even when it is cut up into several pieces (Russo & Pruneddu, 1970).

In its original habitat it grows in low water or muddy places, flowers between July and September and bears fruit continuously until October. Propagation is secured mainly by the high number of seeds produced, but also by the propagules of the creeping stem which survive in muddy soils.

The spread of this species is also attributed to contamination of rice seeds.

In Sardinia *Heteranthera reniformis*, in our opinion acquired very recently, was first sighted in 1984 in a rice-field in the Oristano region. Here it has established between plants of *Heteranthera rotundifolia* on the edges of the rice-fields. The seedlings quickly develop creeping stoloniferous stems which attach to the muddy substratum by means of the numerous roots emerging from the nodes.

Flowering begins towards the end of July, as in its natural habitat, and continues until October, reaching a maximum in August. Fruit is borne during the same period with the formation of loculicid capsules which release the seeds into the surrounding water. Some seeds can germinate immediately and in the rice harvesting season (October) numerous seedlings can be observed, their survival depending on climatic conditions. The ability of this species to spread is therefore related to the presence of humid zones, to the good germination percentage of its seeds (Tab. I) and to the production of stolons penetrating into the muddy layer which ensure vegetative reproduction. *Heteranthera reniformis* grows by invading those spaces left by *Cyperus difformis*, *Cyperus fuscus*, *Scirpus maritimus* and *Heteranthera ss.pp.* which seem to keep it under control, by checking, for the time being, its spread.

*C. coronopifolia*, *H. rotundifolia* and *H. reniformis*, with their crassula-like habit and prolific stem and leaf growth, deprive the rice plant (*Oryza sativa* L.) of space, light and nutrients, especially nitrogen, though the extent of this deprivation is not easy to assess.

**Table I.** Germination percentage of *Cotula coronopifolia*, *Heteranthera rotundifolia* and *Heteranthera reniformis* seeds in April, May and June, after 5, 10 and 15 days culture in deionized water: temperature 20°C, alternating light (12 h per day emitted by Philips TL 40W/33RS).

Month	Days	<i>Cotula</i>	<i>H. rotundifolia</i>	<i>H. reniformis</i>
April	5	—	—	5 ± 1.1
	10	4 ± 0.2	76 ± 2.1	74 ± 0.5
	15	30 ± 0.9	97 ± 1.6	88 ± 2.4
May	5	1 ± 1.2	95 ± 0.8	14 ± 0.5
	10	7 ± 1.0	97 ± 0.6	76 ± 0.5
	15	82 ± 0.5	100 ± 0.0	88 ± 0.4
June	5	2 ± 1.4	68 ± 1.2	72 ± 1.6
	10	12 ± 0.8	86 ± 0.4	84 ± 0.5
	15	89 ± 0.6	100 ± 0.0	100 ± 0.0

These species are therefore rapidly spreading adventitious weeds suited to humid environments such as rice-fields where ecological conditions are similar to those of their native habitat. All three originate from hot, temperate, subtropical climates with hot dry summers and wet winters where average annual rainfall is about 600mm and average summer temperature around 22°C and where temperatures remain around 10°C for at least four months of the year (America: California, N. Mexico, Arizona, Florida; S. Africa: Cape Town) (Strahler, 1975). "Mediterranean climates", where a dry summer is followed by a cold rainy season can be included in this category (Emberger, 1955). Based on his phytoclimatic study, Arrigoni (1968) also ranks the whole of Sardinia as having a "Mediterranean climate". In the Sardinian rice-fields of Muravera and the Oristano region where *Cotula* and *Heteranthera* thrive, annual

rainfall is 661 mm and 566 mm respectively, while summer temperatures average 23°C, just one degree higher than the native habitat of these species. Hence the climatic conditions to which these species are exposed during their biological cycle in Sardinian rice-fields reflect pretty accurately those of their countries of origin.

Moreover, the fact that in their original habitat these species grow on sludge in marshlands and swamps, explains why they grow in our rice-growing areas where, at least during part of the growing cycle (May-June) the new weeds find ideal environmental conditions to reproduce by seed. In Sardinia, seeds of these three weeds germinate in the rice-fields in May and June, when the fields are flooded and dried thus enabling the seedlings to attach to the muddy soil and grow. The plants flower and bear fruit mainly in August and September and during this time the two *Heteranthera* species produce numerous seeds which lie on the ground until next year's growth. *Cotula* flowers and bears fruit practically all year round (May to February) releasing seeds which can always germinate and produce seedlings which thrive even out of water. This adaptability, in conjunction with its dispersal by transhumant cattle grazing on the rice stubble, contributes without doubt to its establishment in non-marshy soils (De Martis & Marchioni, 1975). On the other hand, *Heteranthera* can propagate in the Sardinian rice-fields not only by seeds but also by means of migratory Anatidae which feed on them (Mabbot, 1920 in Fassett, 1940).

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#### REFERENCES

- Adamson, R.S. and Salter, T.M. (1950) *Flora of Cape peninsula*. Juta et Co., Ltd., Cape Town and Johannesburg, p.806.
- Arrigoni, P.V. (1968) Fitoclimatologia della Sardegna. *Webbia*, 23: 1-100.
- Aru, A. and Baldaccini, P. (1961) Contributo alla pedologia dell'Oristanese. I suoli sulle alluvioni del Tirso e sui detriti di falda del Monte Arci. C.R.S.A., Soc. Poligr. Sarda, Cagliari, pp. 1-42.
- Aston, H.I. (1977) *Aquatic plants of Australia*. Melbourne University Press, pp. 63-65.
- Barrett, S.C.H. and Seaman, D.E. (1980) The weed flora of California rice-fields. *Aquat. Bot.* 9: 351-376.
- Britton, N.L. and Brown, H.A. (1913) *An illustrated flora of northern United States and Canada*. 1. Dover Publication, New York, pp. 463-464.
- Corillon, R. and Lollierou, Ch. (1956) Sur l'extension récente et les caractères des végétations à *Cotula coronopifolia* L. (Composées) des rives du Trieux. *Bull. Soc. Sci. Bretagne*, 31: 102-106.
- De Martis, B. and Marchioni, A. (1975) Areale di *Cotula coronopifolia* in Sardegna. *Boll. Soc. Sarda Sci. Nat.* 15: 63-72.
- Emberger, L. (1955) Une classification biogéographique des climats. *Rec. des Trav. des Lab. de Bot. Géol. et Zool. Fac. Montpellier* Ser. Bot. 7:3-43.
- Fassett, N.C. (1940) *A Manual of Aquatic Plants*, McGraw-Hill Book Company, New York, London, pp. 172-173.
- Hausman, E.H. (1947) *The Illustrated Encyclopedia of American Wild Flowers*. Garden City, New York, pp. 393-394.
- Horn, C.N. (1985) A systematic revision of the genus *Heteranthera*. Ph. D. dissertation, Univ. Alabama (unpublished).
- Mabbot, D.C. (1920) In Fassett 1940, pp. 172-173.
- Marchioni, A. (1967) Sulla presenza in Sardegna di *Cotula coronopifolia* L. *Ann. Bot. (Roma)* 29:913-916.
- Marchioni, A. and De Martis, B. (1982) Su alcune avventizie nuove per la flora di Sardegna. *Atti Soc. Tosc. Sc. Nat. Mem.*, Serie B, 89: 61-66.

- Marchioni Ortu, A. and De Martis, B. (1984) Ecophysiologie de quelques, mauvaises herbes des cultures au centre méridional de la Sardaigne: *Cotula coronopifolia* et *Heteranthera limosa* en rizière. Proc. EWRS 3rd Symp. on Weed Problems in the Mediterranean Area, Oeiras, 3-5 April 1984, pp. 73-77.
- Piccoli, F. (1979) Flora e vegetazione delle casse di espansione di Campotto e Valle Santa (Ferrara). *Lav. Soc. Ital. Biogeogr., Nuova Ser. 4: 1-32.*
- Piccoli, F. and Gerdol, R. (1981) *Rice-field weed communities in Ferrara province (Northern Italy). Aquat. Bot. 10: 317-328.*
- Pignatti, S. (1957) La vegetazione delle risale pavese. *Arch. Bot. & Biogeogr. It. 33:145.*
- Pirola, A. (1964) Flora vascolare delle risaie Italiane. *Il Riso 2: 115-138.*
- Pruneddu, F. (1969) Una nuova infestante delle risaie: *Heteranthera* spp. *L'informatore Agrario 66: 733-734.*
- Russo, S. and Pruneddu, F. (1970) Controllo preliminare con l'azide potassica di *Heteranthera* spp., nuova infestante della risaia. *Il Riso 3: 207-213.*
- Small, J.K. (1903) *Flora of Southeastern United States.* New York, pp.243-244.
- Strahler, A.N. (1975) *Physical Geography.* J. Wiley & Sons, New York.
- Tutin, T.G. (1976) *Cotula* L. In *Flora Europaea, 4. Cambridge, p. 177.*