Introduction

Although the practice of limnological sciences in an island located in the middle of the Mediterranean Sea and characterised by a semi-arid climate could appear, at a first sight, somewhat misplaced, limnology in Sicily is in some way related to one of the finest scientists of this century who tightly linked his name to limnology: G. E. Hutchinson. Actually, one of the excursions most requested by those researchers involved in limnology who reach the island, and Palermo in particular, is to the sanctuary of Santa Rosalia and the nearby little pond (Fig. 1) which was the scenario of one of the most famous papers by Hutchinson (1959). In addition, part of the second volume of his monumental work "A Treatise on Limnology" (Hutchinson 1967) was written while he was in Palermo as a guest at the Institute of Zoology of the University.

The aim of this short article is to trace the history of limnology in Sicily, from the end of the last century up to the present, and pay a little homage to a scientist to whom limnology is deeply indebted.

Before Hutchinson: the natural lakes

Due to its insular and climatic conditions, Sicily is characterised by a drainage network formed by numerous short, torrent-like rivers, and by a few small, natural lakes. The geological characteristics of the island strongly condition the quality of these small waterbodies which generally have surface areas of less than 0.2 km². An extremely simplified geological division of the island results in two large zones. A northern zone consists of numerous stratigraphic-structural units in overthrust, mainly dolomitic and carbonate rocks, and metamorphic rocks. A southern zone is for the most part comprised of...
carbonate rocks which, after the tectonic phase of the Middle Miocene, were covered by sediments and evaporites, with widespread outcrops of sulphate and gypsum rocks. As a consequence, the ponds located in the southern zone often have high conductivity values, generally above 1000 uS per cm. In addition, some brackish lakes are located in the plains distributed along the coasts, influenced by the nearby sea water. The only really fresh waterbodies are located in the northern mountain chain, at altitudes above 900 metres.

The earliest observations on Sicilian lentic waters go back more than a century; in particular, at the end of the 19th century, some of the issues regarding the natural lakes had already been brought into focus. Doderlain (1878), Moniez (1889) and Vinciguerra (1896) gave the first accounts of the fishes present on the island, whereas Monterosato (1896) described the variability of the bivalve *Unio elongatulus* C. Pfeiffer in the Sicilian torrents. Marinelli (1896) offered the first scientific geomorphological description of Lake Pergusa, an endorheic saline waterbody located in the middle of the evaporite zone which had, at that time, a depth of 12 m and which is now less than 2 m deep.

Subsequent studies on natural waterbodies concentrated on the geomorphology of landslide lakes or lakes created by the dissolution of the gypsum tableland (Marinelli 1900; De Gregorio 1910; Cumin 1953), and on zooplankton (Brehm 1926; Berzins 1954). However, many of the waterbodies no longer exist because of land reclamation which took place up to the first half of the 1950s. Lake Pergusa, the largest natural lake of the island, has been the object of more specific research because of its red-water phenomena, attributed to blooms of red photosynthetic bacteria (Brunelli & Maldura 1929; Forti 1933) and highly dense populations of the calanoid copepod *Arctodiaptomus salinus* (Daday) (Baldi 1929).

**After Hutchinson: from natural to man-made lakes**

During the last thirty-five years there has been a notable increase in limnological publications. In addition, these studies show a more careful and integrated approach to the limnological aspects of waterbodies, compared with the early studies. In a certain way, it is possible to say that the first studies based on a limnological approach are restricted to this last period only. In particular, a research team from the University of Messina carefully studied for many years a meromictic brackish lake, Lake Faro, characterised by the stable presence of hydrogen sulphide in the hypolimnion and a layer of red water at depths between 9 and 12 metres (Genovese 1963), caused by phototrophic sulphur bacteria (Triiper & Genovese 1968; Sorokin & Donato 1975; Acosta-Pomar, Bruni et al. 1988).

Faranda (1977) compiled a first inventory of the waterbodies suitable for aquaculture and investigated their main chemical, physical and biological
characteristics, paying attention to phytoplankton, zooplankton, fish composition and biomass. Margaritora, Mastrantuono et al. (1982) studied in detail the freshwater entomostracan fauna, whereas Pesce & Galassi (1987) investigated the copepods of groundwaters.

The aquatic vegetation of mountain lakes, studied by Brullo et al. (1994), was found to be quite rich in taxa such as bladderwort Utricularia australis R. Br., and least duckweed Wolffia arrhiza (L.) Wimm, which reach their southern distribution limit in Sicily. The largest of these mountain lakes, Lake Biviere di Cesaro, was also studied by Barone et al. (1989) and Naselli-Flores & Barone (1991) with respect to phytoplankton and zooplankton communities. Lake Biviere di Cesaro is characterised by a cyclic red-water phenomenon due to neustonic blooms of Euglena sanguinea Ehrenberg.

Another red-water lake on Sicily, Lake Pergusa, was the object of numerous investigations mainly addressed to its microbiology (Genovese et al. 1977; Faranda et al. 1977; Bruni & Pulicano 1978) and to its geomorphological and geophysical features (Agnesi et al. 1986; Battaglia, Cimino et al. 1991).

In addition to the lakes, Sicilian rivers also have been investigated. In particular, fish populations were studied by Tigano & Ferrito (1986), Zava & Violani (1991) and Ferrito & Tigano (1995), whereas Riggio (1978) analysed the chemical and biological characteristics of one of the largest saline Sicilian rivers, the River Platani. Naselli-Flores et al. (1995) investigated the macroinvertebrates of the River Belice, with particular attention to the bivalve mollusc Unio elongatulus C. Pfeiffer.

The increase in human population density at the end of the 1950s made natural waterbodies quite insufficient for irrigation purposes and for supplying water to the principal urban centres. The last 35 years have therefore seen an accelerated construction of numerous dam reservoirs, and early studies on the artificial lakes were mostly concerned with hydraulic engineering problems rather than limnological aspects (Bigalli, Dolcimascolo et al. 1980). The problem of the quality of the stored waters arose later, underlined by frequent mass fish mortalities in the summer months. The first limnological studies on reservoirs were those by Barone, Calvo et al. (1982), Barone (1983, 1985), Calvo et al. (1984) and Cotta-Ramusino & Crosa (1988). These investigations, which focused on eutrophication problems and phytoplankton dynamics, were the first studies carried out seasonally on phytoplankton in Sicilian fresh waters.

The recent years

In 1986, the Sicilian Region assigned to the Dipartimento di Scienze Botaniche of the University of Palermo, the study of all the waterbodies, both natural and artificial, with a water surface area greater than 0.2 km$^2$, in order to assess their trophic status with regard to utilisation for irrigation and drinking purposes.
The commitment of this study was born from a theoretical investigation carried out by Barone et al. (1986) who highlighted the fact that most of the Sicilian reservoirs were affected by ongoing eutrophication processes which could interfere with the programmed usage of the stored waters. The results, published in 1993 and distributed at the 5th ILEC Conference which was held in Stresa (Italy) in the same year, outlined the critical situation of waters stored in Sicilian reservoirs, mainly due to sewage water which reached the reservoirs without any prior treatment (Calvo, Barone et al. 1993).

The plankton communities of these reservoirs were studied in detail by Barone et al. (1991) and Naselli-Flores & Barone (1994). The results showed the important role played by physical processes in the reservoirs, with particular reference to the filling and withdrawing constraints. Moreover, the biogeographical distribution patterns of zooplankton assemblages were studied by calculating a diversity index which took into account, along with species diversity, the chorological diversity and the diversity of the ecological roles of the different species (Naselli-Flores et al. 1997).

A weekly investigation carried out for three years on a hypertrophic reservoir (Lake Arancio) highlighted the strong influence that the separation in time of inflow and outflow had on the regulation of the structure of the plankton community (Barone & Naselli-Flores 1994, 1995; Naselli-Flores & Barone 1995). Moreover, the dynamics of the zooplankton community were also found to be affected by the fluctuations in water level, through the effect that these events may have on the reproductive success of fish (Naselli-Flores & Barone 1997a). Finally, the results of an investigation carried out by comparing the structure of the phytoplankton community and its dynamics in two reservoirs with different trophic status, led to the suggestion that water movements have great importance in regulating the structure of the assemblage, whereas the nutrient concentrations may affect only the quantity of biomass present in the lake (Naselli-Flores & Barone 1997b).

**Concluding remarks**

Less than ten years ago a naturalistic symposium was organised on the island of Pantelleria to celebrate the 30th anniversary of the paper "Homage to Santa Rosalia or why are there so many kinds of animals?" by G. E. Hutchinson (Massa 1990). On that occasion limnologists, entomologists, ornithologists and naturalists met to discuss the deep implications that the works of Hutchinson have had in all the fields of natural and ecological sciences. Since then, about forty papers have been published on limnological topics and those cited here are just a framework for a brief account of the development of limnology in Sicily. Again, the name of Hutchinson comes back in the history of the natural sciences of the island and again, in a certain way, it is linked to the development of Sicilian limnology.
References


