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Unusual median pores of *Alona* head shields recovered from recent and pre-industrial sediments of Alpine lakes

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ABSTRACT

We report the finding of Alona *(*affinis-quadrangularis*) - type headshields with atypical median pores, recovered from the sediments of high-mountain lakes. Subfossil Cladocera remains were analyzed in the framework of the European Project EMERGE (2000-2002, European Mountain lakes Ecosystem: Regionalisation, diaGnostic & socioeconomic Evaluation), to evaluate changes in their assemblages consequent to industrial pollution. Observed response includes an increase in* A. affinis *with respect to* A. quadrangularis *after industrialization. According to the literature, the atypical head shields are most probably attributable to* A. affinis. *However, being detected in high mountain lakes, these remains may be interpreted as a result of mutations, as the intensity of UV radiation is high in these environments. In this sense, they might be interpreted as the abnormal* Daphnia*'s and* Chydorus*' ephippia, which were also detected in the sediments of these lakes.*

Key words: subfossil cladocera, head pores, Alona*, alpine lakes*

1. INTRODUCTION

Head pores of the Chydoridae are of great taxonomic and phylogenetic significance (Frey 1959; Olesen 1996). Together with size, general shape, and sculptures, they are the most important diagnostic trait for identification of chydorids to genus, species and even subspecies level. Head shields' pores are also one of the three diagnostic traits (i.e. thoracic limbs and suspension of mandibles) that Frey (1967) first used to outline phylogenetic relationships in the family Chydoridae.

Head shields of *Alona* species typically have three median pores (MPs) in a row; the presence of two large MPs in a row has been regarded by Smirnov (1971) as a distinctive trait for a new genus, *Biapertura* (with two species, *B. affinis* and *B. intermedia*), which subsequently Flössner (2000) re-ascribed to the genus *Alona*, being the character "number of pores" by itself considered insufficient for maintaining two separate genera. *Alona quadrangularis* (O.F. Müller 1785) and *Alona affinis* (Leydig 1860) differ from the other species of the genus in that they have a pointed, instead of broadly rounded, head shield's posterior margin. As suggested by Frey (1959), there has been considerable confusion between these two congeneric species, because their morphology is very similar. Berg (1929) suggested that the shape of postabdomen and the presence or absence of setae of the basal spine of the claw were perhaps the best characters for separating the species, if indeed they had to be regarded as separate species. Some investigators (e.g. Keilhack 1909 and Weigold 1910) also considered *A. affinis* as a subspecies of *A. quadrangularis*. The latter is reported by Frey (1967) as the type species of the subfamily Aloninae. It is relatively simple to distinguish the two species in the sediments, whenever their head shields are well preserved; shape and size are basically the same, but the number of median pores is different: two in *A. affinis*, three in *A. quadrangularis*. Being the number of median pores of the head shield a distinctive trait for the diagnosis of the species, we think that the occasional finding of *Alona* head shields having the size and shape of *A. affinis* and/or *A. quadrangularis*, but differing from the typical ones in the number of the median pores, is worth of being published in a specific, short note.

The atypical head shields were recovered from sediments of lakes in Southern Central (Pennine and Lepontine) Alps, which were sampled in the framework of the European Project EMERGE (2000-2002, European Mountain lakes Ecosystem: Regionalisation, diaGnostic & socioeconomic Evaluation).

The Project was focused on: 1) assessing the status of remote mountain lakes through Europe; 2) establishing reference conditions for each site using historical source and palaeolimnological techniques; 3) up-scaling the knowledge from single sites or regions; 4) assessing the extent to which climate variability, separately from and in combination with pollutant stresses, influences the status of these lakes.

2. SAMPLING SITES

The sampled lakes are located in the Southern-Central part of the Italian Alps (the so-called Central-Southern district of the EMERGE Project; Fig. 1). Altitude ranged between 1910 m a.s.l. (Lake Muino Inferiore) and 2422 m a.s.l. (Lake Sfondato; Tab. 1).

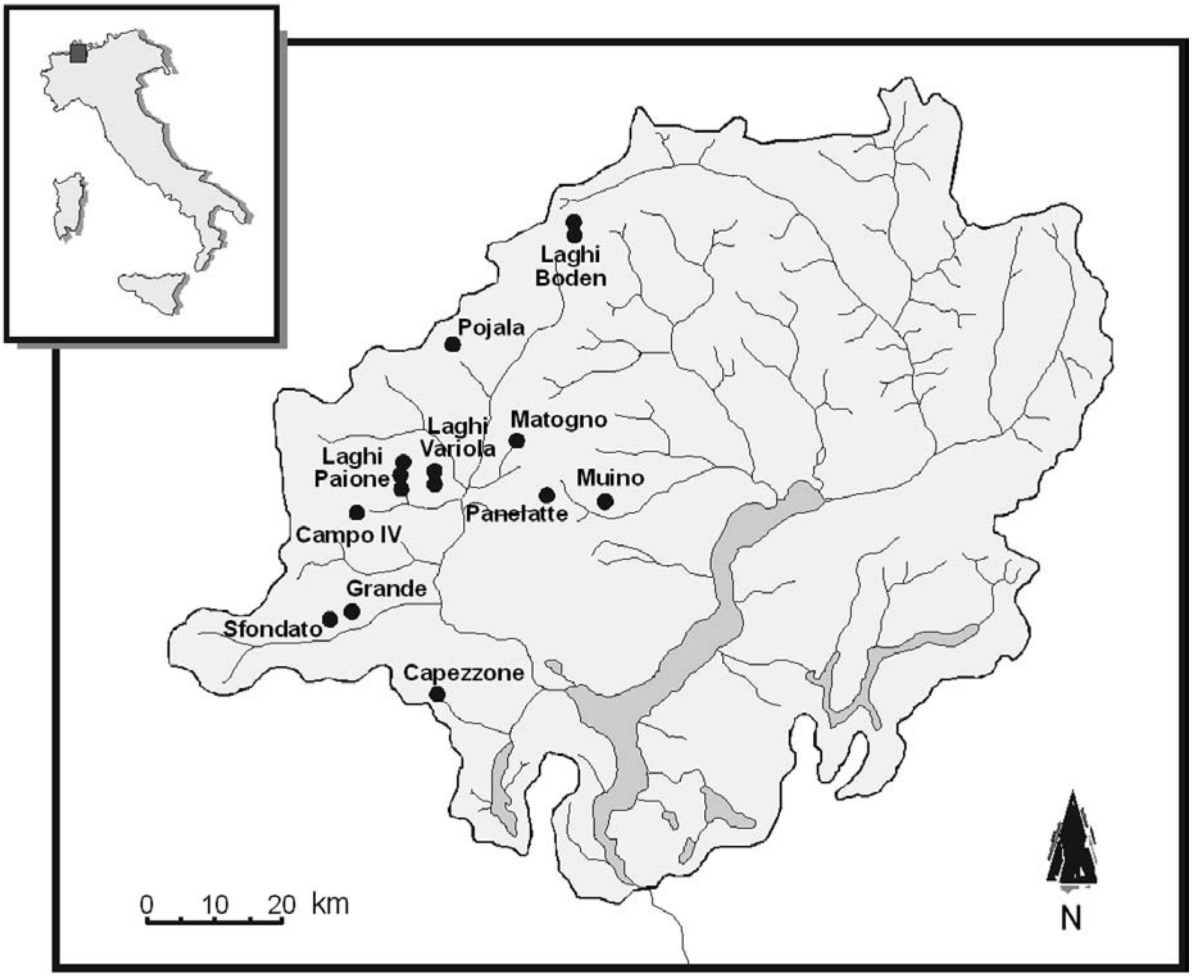

Fig. 1. Lakes sampled in the Italian Southern Central Alps. From: Manca & Armiraglio (2002).

Tab. 1. Main physical and chemical characteristics of the sampled lakes. From: Manca & Armiraglio (2002).

Lake	Max depth (m)	Lake area (km^2)	Mean temp. (°C)	Cond. 20°C ($\mu S\ cm^{-1}$)	Total Alk. ($\mu eq\ L^{-1}$)	pH (average)	TP ($\mu g\ L^{-1}$)
Panelatte	5	0.560	12.30	18.21	113	7.11	5
Paione Inferiore	14	0.868	14.00	13.10	39	6.65	2
Paione Medio	5	0.735	11.50	12.83	34	6.53	5
Paione Superiore	12	0.653	12.90	8.98	3	6.02	4
Muino Inferiore	2	0.100	15.00	9.80	32	6.42	7
Variola Medio	4	0.689	9.55	9.93	16	6.21	2
Variola Superiore	4	0.903	8.95	10.35	17	6.31	4
Matogno	15	3.031	11.53	80.20	756	7.96	4
Boden Inferiore	7	5.879	9.30	57.25	523	7.98	2
Boden Superiore	6	2.831	8.60	48.90	415	7.81	2
Capezzone	7	0.940	8.43	22.38	138	6.83	4
Grande	6	0.751	6.25	7.33	0	5.73	1
Sfondato	3	0.475	4.30	8.54	0	5.58	2
Pojala	16	5.696	7.53	33.08	251	7.19	6
Campo	7	0.751	5.20	49.65	381	7.35	2

Acidic rocks prevail, with gneiss and schists; only three lakes (Lake Boden Inferiore and Lake Boden Superiore, as well as Lake Matogno) are located in areas where carbonate rocks are most abundant. PH, taken as the average value along the water column, was almost uniformly distributed between 5.58 (Lake Sfondato) and 7.98 (Lake Boden Inferiore). Total alkalinity ranged between 0 μeq L^{-1} (Lake Sfondato and Lake Grande) and 756 μeq L^{-1} (Lake Matogno). Total phosphorus concentration was very low, the highest value being around 7 μg P L^{-1} (Lake Muino Inferiore).

3. MATERIALS AND METHODS

A short core was collected from each lake by a gravity corer; the recent Cladocera communities (*ca* last 5 years, according to Guilizzoni *et al*. 1992) were reconstructed from an analysis of the top 0.5-1 cm sediment while the 15-17 cm levels referred to the pre-industrial period (pre-1850; EMERGE Protocol 2000). Cladocera sub-fossil remains were counted on *ca* 3 g wet weight of sediment, after treating the sample with the method proposed by Frey (1986) and following the recommendations of the EMERGE Protocol (2000). At least 200 remains were counted and identified following Frey (1960) at magnifications between 100 and 200x.

4. RESULTS AND DISCUSSION

By comparing the recent/pre-1850 cladoceran communities of the Italian lakes, it is evident an increase in the relative importance of *A. affinis* with respect to *A. quadrangularis*; while in the pre-industrial period the two species were equally important, *A. affinis* is definitely the most abundant species in the recent communities of the lakes (Fig. 2).

In addition to the normal types, with two (*A. affinis*) or three (*A. quadrangularis*) median pores, we observed three types of abnormal head shields so far not reported in the literature, namely (Fig. 3):

1. head shields with a transition from two to three median pores;
2. head shields with an elongated, abnormal, median pore;
3. head shields with a single median pore, drop like or rounded;
4. head shields without median pores.

The atypical head shields were rare: one or at maximum two of them were recovered from each sample. They were mainly found in recent sediments (top). In one lake only (Lake Paione Superiore) they were recovered also from the pre-1850 sediment sample.

Atypical pores were found in 5 of the 15 lakes sampled (Tab. 2): all these lakes, with the exception of Lake Pojala, are at present acidic, with a very low alkalinity (Tab. 1) and a low conductivity. They are located in remote areas, and their trophic status is oligo ultra-oligotrophic.

Tab. 2. Head shields of *Alona* (*affinis* + *quadrangularis*) with atypical median pores recovered from sediments of Alpine lakes.

Head shield median pores	Lake, sample
Transition from two to three pores	Sfondato, bottom
	Capezzone, top
1 pore	Paione Medio, top
	Paione Superiore, bottom
	Variola Medio, top
Without pore	Paione Superiore, top
	Pojala, top

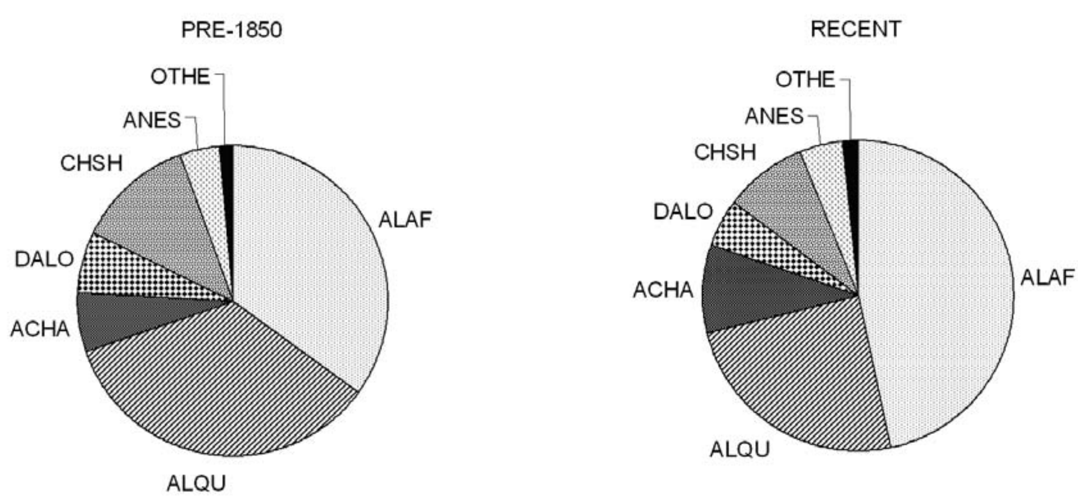

Fig. 2. Abundance of Cladocera taxa recovered from recent and pre-1850 sediments of lakes in the Italian Alps. Legend: ALAF: *Alona affinis*; ALQU: *Alona quadrangularis*; ACHA: *Acroperus harpae*; DALO: *Daphnia longispina* group; CHSH: *Chydorus sphaericus*; ANES: *Alonella excisa*; OTHE: other taxa (from: Manca & Armiraglio, *ibidem*).

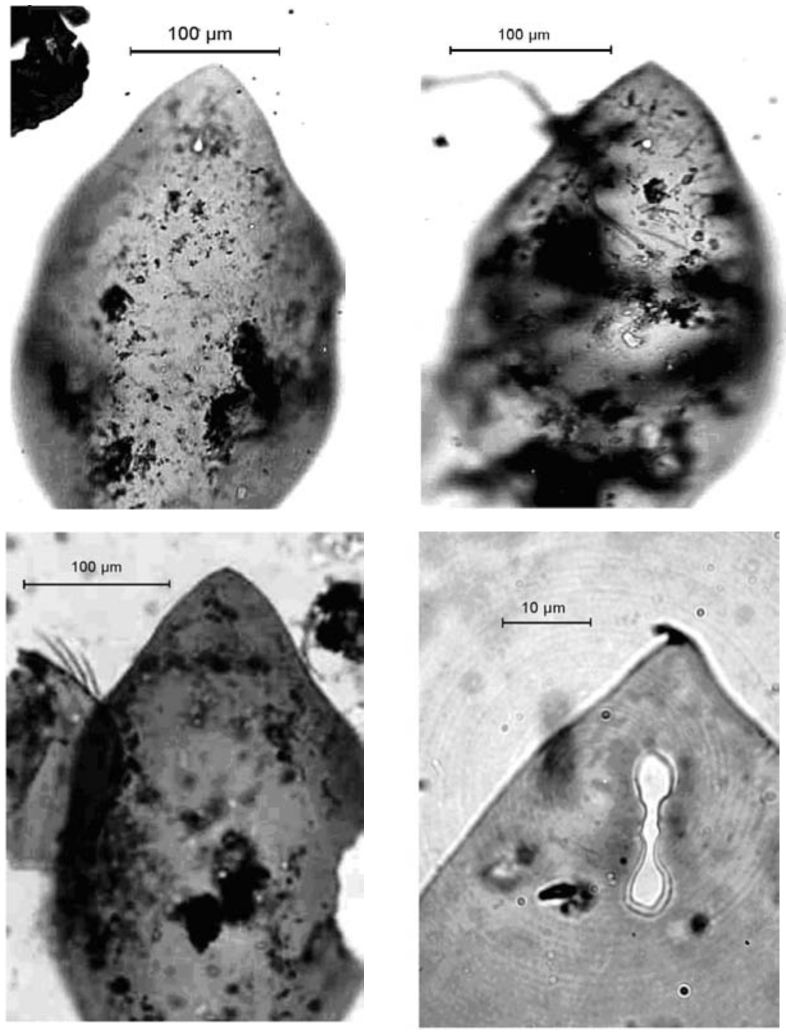

Fig. 3. *Alona* (*affinis-quadrangularis*) head shields: from upper to lower left clockwise: with one, drop-like MP, with one MP, without MP, with a transition from two to three MPs.

5. DISCUSSION

As the distinction between *A. affinis* and *A. quadrangularis* in sediments is largely based on the possibility of detecting two/three distinct median pores in the head shield, the detection of an "intermediate" situation (transition from 2 to 3 median pores) does not allow us to attribute the remain to any of the mentioned species. Such a transition might be interpreted as an hybridisation between the two parental species (males were occasionally found in the sampled lakes). If other intermediates will be found, the diagnostic trait "number of median pores" might be interpreted as the "number of lateral antennae" in the rotifers *Conochilus unicornis* and *C. hippocrepis* (one or two distinct antennae, respectively). The finding of gradual intermediates between the latter two, first recorded by Burckhardt (1943) in lakes at high elevation in the Alps and Northern Spain, was regarded by Pejler (1956) as a result of introgressive hybridization, and by Anderson (1953) as the stock from which the extreme types arose later by differentiation. According to Anderson's terminology, the two-three pores in *Alona (affinis + quadrangularis)* might be a case of "sympatric introgression", i.e. introgression between two species of much the same geographical distribution, separated by "ecological barriers".

However, according to Sinev (1997, 2006 pers. com.) a careful examination of the anatomy of the sexual appendages of the two species does not seem to confirm the possibility of hybridization.

As a whole, head shields with a single, small median pore are very rare in chydorids. Frey (1967) reported this character in a genus (*Euryalona*) of India lowlands; a single pore is also found in two genera of the subfamily Chydorinae of the Southern hemisphere (*Monope* and *Rak*). The case of a single, elongated, drop-like pore, found in some of the lakes we sampled (Fig. 3), might be interpreted as a transition from one to two pores. Or, it might be interpreted as an anomaly.

The third case, of head shields without any median pore of the *A. affinis-quadrangularis* type, has been reported so far only for *Alona globulosa* (Frey 1967), a species typical of lowlands and with a head shield very different in shape from those of *A. affinis-quadrangularis*. A sort of transition from one-pore to no-pore has been reported in the ontogenesis of a genus in the subfamily Chydorinae, which, having a median pore only in juveniles (first instar), has been named *Ephemeroporus* (Frey 1982; Margaritora 1969, 1985).

None of the structure we describe in this paper was so far reported in the specific literature (Smirnov 1971). It may be of some relevance the fact that they were detected in high elevation lakes, which are subject to intense UV exposure.

6. CONCLUSIONS

The detection for the atypical median head shields pores in the two sibling species *A. affinis- A. quadrangularis* in remote, high elevation lakes can be interpreted as resulting from mutations, as the intensity of UV radiation is high in these environments. That being the case, our finding can be comparable to that of abnormal *Daphnia* (unilocular instead of bilocular) or *Chydorus* (bilocular instead of unilocular) ephippia (Freyer & Frey 1981). Both types of abnormal ephippia were detected in one of the studied lakes (Lake Paione Superiore; Cammarano & Manca 1997).

Despite having no direct proof, we are inclined to think that the intermediate three-two pores' type may be the result of an hybridization. Unfortunately, we were not able to observe other intermediates, indicative of a continuum, to interpret our finding as the result of introgressive hybridization, as already described for other characters in organisms from high-mountain lakes in Europe.

On the whole, the different types might represent different species in the group *A. affinis* - *A. quadrangularis* or a polymorphism within the same species. At present, when pores are not typical we cannot distinguish between the two, at least from their most common remains (head shields) in the sediments. According to Sinev (pers. comm.), however, we should attribute all the head shields with non-typical median pores reported in the present note (no pore, 1 pore, and two pores with something in between) to the species *A. affinis*. We think that genetic analysis is probably the only way to fully disentangle the problem of species-specific diagnosis of individuals with atypical head pores.

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