# INCIDENCE OF LARVAE MOUTHPART DEFORMITIES IN *CHIRONOMUS PLUMOSUS* (DIPTERA: CHIRONOMIDAE) AND *PROCLADIUS* SP. (DIPTERA: CHIRONOMIDAE) FROM PIEDILUCO LAKE, ITALY.

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With 3 figures and 1 table

ABSTRACT: A study of larval mouthpart deformities of *Chironomus plumosus* and *Procladius* sp., in Piediluco Lake (Italy), shows a substantial incidence of deformities throughout the lake basin, which correlates with the hydrological regime of different parts of the lake. The highest incidence of deformities in *C. Plumosus* occurred in instar IV.

RESUMO: Um estudo das deformidades buccais de *Chironomus plumosus* e *Procladius* sp no Lago Piediluco (Italia) demonstra uma incidência substancial de deformidades na área de estudo, relacionada com o regime hidrológico em vários partes do lago. A incidência mais elevada de deformidades em *C. plumosus* occorre no IV estadio.

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## INTRODUCTION

In environmental monitoring of water bodies, the morphological deformities of chironomid larvae offer a useful way of estimating sediment toxicity, unlike other indicators endpoints (e.g. death rate or development time) which can be influenced by non-toxic stressors (VERMEULEN, 1998). The cause of larvae deformities in some chironomids is complex and not yet fully understood. Studies carried out both in the laboratory and with natural populations have indicated a link between morphological deformities of chironomids and the concentrations of toxic substances present in sediments (DICKMAN & RYGIEL, 1996; WARWICK, 1991; JANSSENS DE BISTHOVEN *et al*., 2001). Many of these substances are bound to the fine sediment particles in lakes.

Larval chironomids are exposed to toxic substances via direct contact and ingestion. Morphological deformities in some chironomids, in particular *Chironomus* Meigen, 1803 and *Procladius* Skuse, 1889, are usually apparent in the cephalic capsule structures, in partilcar the mouthparts, antennae, and epipharingean pecten (JEAYASINGHAM & LING, 1997). The aim of this study is to analyse the frequency and the severity of mouthpart deformities of *Chironomus plumosus* (Linnaeus, 1758) and *Procladius* sp. larvae in Piediluco Lake (Central Italy) and the relationship of deformities to lake hydrology.

## MATERIALS AND METHODS

Piediluco Lake (surface: 1.7 km$^2$, volume: 20,000,000 m$^3$, max depth: 20 m) is natural but eutrophic that is regulated for hydroelectric energy production (Fig.1). The lake is connected through two artificial channels to the Rivers Nera and Velino which effectively increase the catchment area from 74 km$^2$ to 3204 km$^2$. The lake functions as a reservoir, subject to daily water level fluctuations that prevent thermal stratification (MEARELLI & TIBERI, 1988). The connections with the Rivers Nera and Velino, located in the north-west zone of the basin confer lotic characteristics to this area due to continuous water circulation. Conversely in the south-east area the system is typically lentic. During 2003, sediments from the southern part were experimentally removed to prevent anoxia.

Benthic samples were collected by dredge. During the Phase I of the study (2003) seasonal samples were taken from five locations in the southern part of the lake (St.1-5) whilst in Phase II the lake's entire littoral zone was sampled in July and November, 2004-2005. Phase II included five additional stations: two stations (A and B) in the eastern sector of the lake, and three stations (C, D, E) situated in the western area at the entrance of the Nera Channel, at the connection of the Velino River and in the area included between these stations (Fig. 1). Analysis of main physical-chemical variables was conducted.

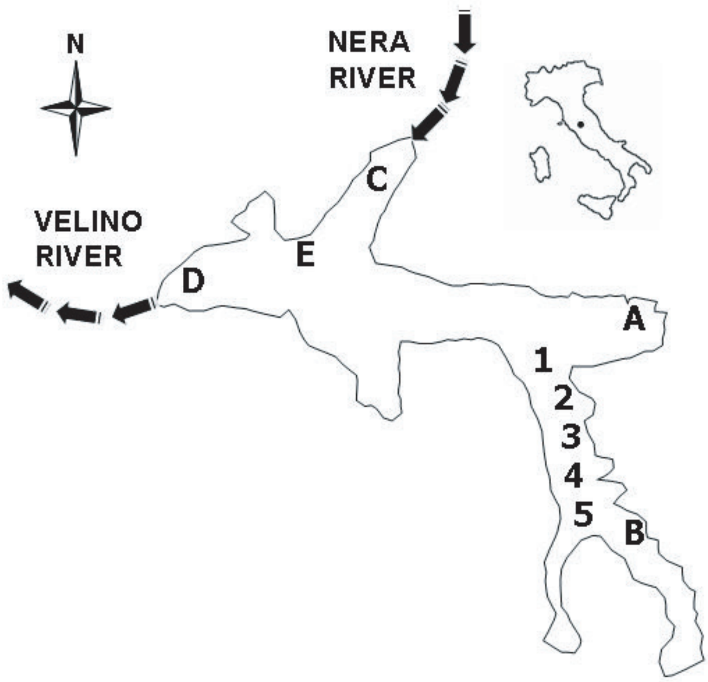


Figure 1. Study area (Piediluco Lake, central Italy) and sampling stations.

For *C. plumosus* larvae three morphometric variables were measured: Head Width (HW), Head Length (HL), Thorax-Abdomen Length (TA). After dissection, cephalic capsules were slide mounted and deformities were classified using a protocol that assigned each specimen to a specific morphological class (modified from JANSSENS DE BISTHOVEN *et al*., 1998):

- Class 1 (CL.1 – specimens without any morphological deformity).

- Class 2 (CL.2 – specimens with weak deformity): one additional or missing tooth, one or two round teeth, weak asymmetry, one bifid tooth, two joined teeth.

- Class 3 (CL. 3 – specimens with strong deformity).

"Köhn gap", very round teeth, two or more additional or missing teeth, no developed teeth, three or more joined teeth.

RESULTS

In *Procladius* (Fig 2) in the southern part of the lake (Phase I), deformity analysis of the *ligula*, showed a deformity incidence of 23.70% (CL.2 + CL.3; 91 of 384 specimens). Strong deformity (CL.3) affected 15.10 % of specimens. In Phase II, focussing on the littoral zone, a frequency of 25 % deformities (43 of 172 specimens examined) was observed. For *C. plumosus* (Figure 3) the incidence of *mentum* deformities is higher. In the southern part of the lake, deformed specimens amount to 56.82 % (400 of 704 specimens) of which 7.95 % was classified as CL.3. The deformity incidence observed for this taxon during Phase II was 32.66 % (743 of 2275 specimens).

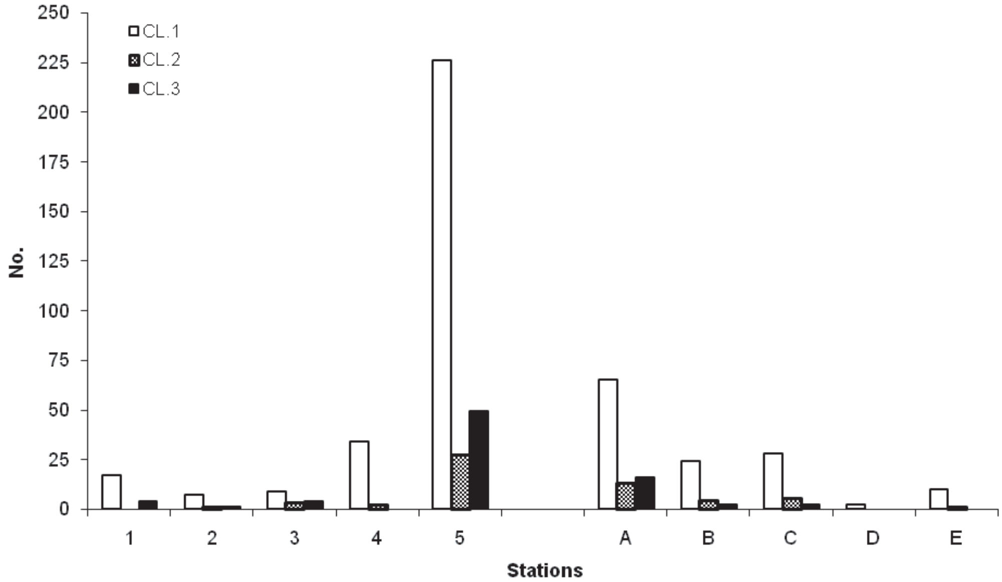


Figure 2. Distribution deformities classes in *Procladius* sp. for each sampling station.

The relationship between deformity and larval instar of each *C. plumosus* specimen was determined by biometric analysis. In the southern area, 96.75 % of deformed specimens belonged to instar IV and the remaining 3.25 % to instar III. In the littoral zone, 83.58 % of deformed specimens were in instar IV, 16.29 % in instar III and 0.13 % in instar II (Table 1).

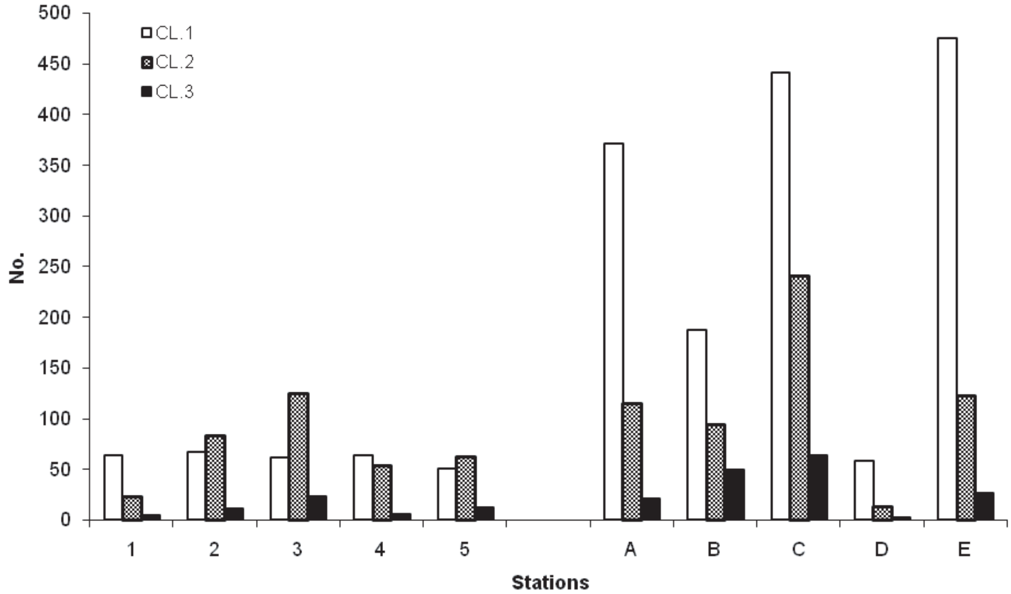


Figure 3. Distribution deformities classes in *C. plumosus* for each sampling station.

TABLE 1**. Deformity incidence *C. plumosus* instars in each sampling station.**

| | Stations | No. | CL.1 | CL.2 | CL.3 | N.V. | Total deformities |
|---|---|---|---|---|---|---|---|
| ***Phase I*** | | | | | | | |
| *II Instar* | 1 | --- | --- | --- | --- | --- | --- |
| | 2 | --- | --- | --- | --- | --- | --- |
| | 3 | 2 | 2 | --- | --- | --- | --- |
| | 4 | --- | --- | --- | --- | --- | --- |
| | 5 | --- | --- | --- | --- | --- | --- |
| *III Instar* | 1 | 27 | 26 | 1 | --- | --- | 1 |
| | 2 | 36 | 34 | 2 | --- | --- | 2 |
| | 3 | 43 | 37 | 5 | 1 | --- | 6 |
| | 4 | 40 | 38 | 2 | --- | --- | 2 |
| | 5 | 20 | 18 | 2 | --- | --- | 2 |
| *IV Instar* | 1 | 62 | 37 | 21 | 4 | --- | 25 |
| | 2 | 125 | 33 | 81 | 11 | --- | 92 |
| | 3 | 163 | 22 | 119 | 22 | --- | 141 |
| | 4 | 82 | 25 | 51 | 6 | --- | 57 |
| | 5 | 104 | 32 | 60 | 12 | --- | 72 |
| ***Phase II*** | | | | | | | |
| *II Instar* | A | 2 | 1 | --- | 1 | --- | 1 |
| | B | --- | --- | --- | --- | --- | --- |
| | C | 2 | 2 | --- | --- | --- | --- |
| | D | --- | --- | --- | --- | --- | --- |
| | E | --- | --- | --- | --- | --- | --- |
| *III Instar* | A | 99 | 76 | 17 | 3 | 4 | 20 |
| | B | 94 | 44 | 9 | 40 | 1 | 49 |
| | C | 216 | 179 | 27 | 8 | 2 | 35 |
| | D | 7 | 7 | --- | --- | 0 | --- |
| | E | 213 | 194 | 14 | 3 | 2 | 17 |
| *IV Instar* | A | 410 | 294 | 97 | 17 | 2 | 114 |
| | B | 240 | 143 | 84 | 9 | 4 | 93 |
| | C | 529 | 260 | 213 | 55 | 1 | 268 |
| | D | 66 | 51 | 13 | 2 | 0 | 15 |
| | E | 413 | 281 | 108 | 23 | --- | 131 |

Seasonal distribution analysis of deformed *C. plumosus* specimens in Phase I, had a deformed: not-deformed specimens ratio (CL.2+CL.3)/CL.1 with the highest value in January (2.58) and the lowest in July (0.15). In Phase II this ratio was the same throughout the year (mean value of 0.42 in July and 0.44 in November).

The Chi-squared Test, practicable only for *C. plumosus*, showed a significant relationship between stations and the incidence of deformities. The frequency of CL.1, was higher than expected at St.1 and lower at St.3. The frequencies of CL.2 and CL.3 were higher than the expected at St.3, moreover CL.2 was lower frequency than expected at St.2 ($\chi^2_8 = 49.83$, $p<0.01$). In Phase II, the Chi-squared Test showed a significant relationship ($\chi^2_8 = 96.33$, $p<0.01$) with the frequency of deformed specimens lower than expected at St.A (CL.3) and at St. E (CL.2 and CL.3). Conversely a higher number of deformed specimens than expected were found at St.B (CL.3) and at St.C (CL.2).

## DISCUSSION

*C. plumosus* and *Procladius* sp., the most abundant chironomids of Lake Piediluco, show a higher rate of larval mouthpart deformities than that which can be attributed to the normal genetic variability in populations of uncontaminated sites which are generally < 1% (WARWICK, 1980; WIEDERHOLM, 1984). *C. plumosus* showed the highest incidence of deformities throughout the study. Deformed specimens occurred more abundantly in the southern area (particularly in the central part, St.3), where water circulation is reduced. However a high incidence of deformities occurred in the littoral zone throughout the lake, particularly at St.C situated near the confluence of the Nera, which carries pollution from intense trout farming activity upstream.

Almost all deformed specimens belonged to instar IV which is exposed to toxic sediment substances for the longest period indicating that the high frequency of deformities is related to high levels of sediment contamination. High copper concentrations have been measured in the Piediluco Lake sediments (51.1-66.7 mg/kg; MOROZZI *et al*., 1998).

In conclusion, larvae of *Procladius* sp. and *C. plumosus* in Piediluco Lake have a high incidence of mouthpart deformities. *C. plumosus* is the best bioindicator, because it closely reflects the condition of the sediment, influenced by the hydrological regime of the lake. Chironomid cephalic deformities indicate the condition of lake sediments, and of the whole lacustrine ecosystem, providing information that probably could not be obtained through community analysis or physical-chemical analysis.

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