Trophic characterization of *Dictyogenus alpinus* (Pictet, 1842 - Plecoptera, Perlodidae) nymphs in the high Po Valley (NW Italy)

Caracterización trófica de las ninfas de *Dictyogenus alpinus* (Pictet, 1842 - Plecoptera, Perlodidae) en el alto Valle del Po (NO Italia)

S. Fenoglio & T. Bo

University of Piemonte Orientale, Di.S.A.V., Via Bellini n. 25, 15100 Alessandria, Italy.
E-mail: fenoglio@unipmn.it

Recibido el 13 de diciembre de 2004. Aceptado el 27 de diciembre de 2004.

ISSN: 1130-4251 (2004), vol. 15, 167-174

Key words: *Dictyogenus alpinus,* feeding habits, gut contents, Po river.
Palabras clave: *Dictyogenus alpinus,* hábitos alimenticios, contenidos digestivos, Río Po.

Summary

Feeding habits of *Dictyogenus alpinus* nymphs (Plecoptera, Perlodidae) have been investigated in three station of the high Po Valley (NW Italy). This species is the most representative predaceous stonefly of the Alps but few is known about its trophic ecology. In this study, we examined the gut content of 70 nymphs. We detected an evident trophic preference in the diet of *D. alpinus*: preys ingested are dominated by few taxa, in particular Chironomidae and *Baetis* sp., independently from their availability in the substratum. Results also indicate that *D. alpinus* are not strictly carnivorous, but they feed partially on fine vegetal detritus and algae.

Resumen

Se estudian los hábitos alimenticios de las ninfas de *Dictyogenus alpinus* (Plecoptera, Perlodidae) en tres estaciones del Alto Valle del Po (NO Italia). Esta especie es el plecóptero predador más representativo de los Alpes, pero se conoce poco sobre su ecología trófica. En este estudio examinamos los contenidos digestivos de 70 ninfas. Detectamos una preferencia trófica evidente en la dieta de *D. alpinus*: las presas ingeridas están dominadas por unos pocos taxa, en particular Chironomidae y *Baetis* sp., independientemente de su dispo-

nibilidad en el substrato. Los resultados también indican que *D. alpinus* no es estrictamente carnívoro, sino que se alimenta en parte de detrito fino vegetal y de algas.

INTRODUCTION

In the last decades, biological monitoring needs gave a strong impulse in the knowledge of taxonomy and systematic of benthic invertebrates, but large elements of their ecology remain at the moment practically unknown (Merritt & Cummins, 1996). In particular, there is a growing interest in feeding habits of aquatic insects, for its importance in stream food web structure (Huhta *et al.*, 1999), functional organization of lotic systems (Rosi-Marshall & Wallace, 2002), and auto-ecological patterns (Elliott, 2000). Large invertebrate predators present a main role in fishless aquatic systems, where they act as top-down control elements in the benthic community (Wipfli & Gregovich, 2002). These predators are mainly represented, in lentic habitats and low flowing waters, by Odonata Anisoptera and Zygoptera, Coleoptera Hydroadephaga, and Hemiptera Heteroptera, but in lotic systems they are mostly represented by Plecoptera Systellognatha (Allan, 1995).

Dictyogenus alpinus (Pictet, 1842) (Plecoptera: Perlodidae) is a typically alpine and orophilous taxon, inhabiting oligotrophic hyporhitral environments from 900 to 2000 m a.s.l. (Consiglio, 1980), so that Aubert (1959) considered *D. alpinus* the most representative element of the alpine stonefly fauna. This species is reported in Italy only for the alpine northern regions (Fochetti, 1995) and Ravizza Dematteis & Ravizza (1988) first reported this taxon for the high Po Valley. *D. alpinus* is known to be a predator such as all Perlodidae (Merritt & Cummins, 1996) but there are no data about trophic preferences or diet of this species in Italian alpine systems.

The aim of our study is to provide new data about feeding habits of *D. alpinus* nymphs, investigating in particular the existence of prey preference and altitudinal patterns.

MATERIALS AND METHODS

In the days 27-28 October 2004, we collected *D. alpinus* nymphs in the High Po valley, Natural Park of the Po river, analysing populations of three different environments. Samplings were conducted in the first hours of the morning. We examined 24 specimens from Pian del Re (hypocrenal environment, 2020 m a.s.l. – UTM 349056 - 4951524), 38 from Pian della

Regina (alpine prairie stream, 1750 m a.s.l. – UTM 357750 - 4951547), and 8 from Ponte Riondino (coniferous forest stream, 1540 m a.s.l. – UTM 352240 - 4951614).

Moreover, using a Surber net (mesh 255 μm), we collected eight samples from each of the three sites to assess the taxa presence and abundance of the natural population of benthic invertebrates. Samples were preserved in 95% ethanol. In the laboratory, all organisms were counted and identified to the genus level, except for Coleoptera Hydraenidae, Lumbriculidae and early instars of some Diptera, which were identified to the family level.

Dictyogenus alpinus nymphs were removed from the sample, measured (total length, 0.1 mm accuracy) and processed to assess food consumption by means of gut contents analysis. Guts were removed and the contents of the alimentary canal were analysed by the transparency method for slides (Faure's fluid) with a NIKON SMZ 1500 light microscope (60-100 X) with JVC TK-C701EG videocamera. Smaller nymphs were analysed without removal of the guts, using the transparency method for slides proposed by Dr. C. L. Bello (Tierno de Figueroa & Sanchez-Ortega, 2000; Tierno de Figueroa *et al.*, 2003). Identification of prey was based on sclerotized body parts, particularly head capsules, mouthparts and leg fragments. We also compared gut contents with the natural composition and abundance of macroinvertebrate communities in the riverbed. Feeding preferences were quantified using an electivity index (McCormick, 1991):

$$E^* = [W_i - 1 / N] / [W_i + 1 / N]$$

where

$$W_i = [r_i / p_i] / [\Sigma r_i / p_i]$$

In this formula, r_i = the proportion of ingested species, p_i = the relative abundance in the benthic community, and N = the number of food items. This index ranges from −1 to 1. A value of −1 means total avoidance, 1 indicates preference and 0 indicates indifference.

RESULTS

In total, we collected 1456 stream invertebrates and we examined the gut contents of 70 *D. alpinus* nymphs. Benthic communities were composed of typical orophilous and stenothermic taxa (Table I); both abundance (individuals/m^2) and taxonomic richness were similar in the three stations (respectively 796 ind./m^2 and 24 taxa in the Pian del Re, 922 ind./m^2 and 25 in the Pian della Regina and 912 ind./m^2 and 25 taxa in the Ponte Riondino station).

Table I.—Relative abundance (%) of macroinvertebrates collected in the natural riverbed in the three sampling stations. (*) FFG: functional feeding groups (Cg= collectors-gatherers; F= filter feeders; P= predators; Sc= scrapers; Sh= shredders).
Tabla I.—Abundancia relativa (%) de macroinvertebrados colectados en el lecho natural del río en las tres estaciones de muestreo. (*) FFG: Grupos funcionales de alimentación (Cg= colectores; F= filtradores; P= depredadores; Sc= raspadores; Sh= fragmentadores).

Taxon		*FFG**	*Pian del Re*	*Pian della Regina*	*Ponte Riondino*
			rel. abund.	*rel. abund.*	*rel. abund.*
Plecoptera	*Leuctra* sp.	Sh	0.00	0.22	1.32
	Nemoura sp.	Sh	0.25	1.52	10.53
	Protonemura sp.	Sh	0.25	0.00	3.07
	Dictyogenus alpinus	P	6.03	8.24	1.75
	Perlodes jurassica	P	10.05	0.00	0.00
	Rhabdiopteryx alpina	Sh	0.00	0.22	3.29
	Isoperla sp.	P	13.82	8.89	4.17
	Chloroperla sp.	P	0.50	2.39	0.66
Ephemeroptera					
	Ecdyonurus sp.	Sc	4.77	8.24	13.60
	Epeorus alpicola	Sc	0.00	16.27	5.26
	Rhithrogena sp.	Sc	15.83	4.77	11.62
	Baetis sp.	Cg	1.51	1.08	3.07
Trichoptera					
	Hyporhyacophila sp.	P	2.01	0.22	1.75
	Rhyacophila sp.	P	12.06	4.99	2.63
	Philopotamus sp.	F	0.00	0.43	14.69
	Drusus sp.	Sh	9.55	28.85	8.11
	Hydropsyche sp.	F	0.25	0.00	0.00
Diptera					
	Hapalotrix lugubris	Sc	0.00	0.22	0.22
	Chironomidae	Cg	5.78	6.07	0.88
	Atherix sp.	P	0.00	1.08	1.54
	Psychodidae	P	0.25	0.22	0.00
	Empididae	P	0.00	0.22	0.00
	Limoniidae	P	0.25	0.00	0.44
	Hexatoma sp.	P	0.00	0.43	0.00
	Prionocera sp.	Sh	1.51	0.65	1.97
	Simuliidae	F	0.00	0.65	0.00
	Lispe sp.	P	2.26	0.00	0.00
	Paleodixa sp.	P	0.00	0.00	0.22
Coleoptera					
	Hydraenidae	Sc	1.51	0.65	1.10
	Elmis sp.	Cg	0.25	0.00	0.00

Table I.—*(Continuation).*
Tabla I.—*(Continuación).*

Oligochaeta			0.00	0.00	0.00
	Eiseniella tetraedra	Cg	0.50	0.00	0.22
	Lumbriculidae	Cg	0.25	0.00	0.22
Platelminta					
	Crenobia alpina	P	10.30	2.60	7.68
Hydracarina		P	0.25	0.87	0.00

Most of food ingested by *D. alpinus* nymphs consisted in insect larvae but algae and vegetal fine fragment were found in a notable number of specimens (47% of individuals). The guts of 4 specimens were empty; interestingly, all four specimens without food were small instars collected in the highest station. Comparing gut contents of the three *D. alpinus* populations, we detected no significant quantitative difference (i.e.=number of preys consumed; ANOVA $F_{2,68}$=2.64, P=n.s.) but interestingly we noticed a significant qualitative difference (i.e.=number of taxa eaten; ANOVA $F_{2,68}$=20.36, P<0.001). In the highest station we found meanly 2.65 taxa/individual gut, while in Pian della Regina this value was 3.84 and in Ponte Riondino was 5.50. According to the results of other studies concerning Systellognatha diet (Siegfried & Knight, 1976), among the Diptera consumed, the most important prey item were Chironomidae, among the Ephemeroptera were *Baetis* sp. nymphs and among the Trichoptera were Hydropsychidae larvae. Comparing gut contents with the array of available prey living on and among substrates, we detected some interesting elements; first, although some groups were abundant and widespread on the river bottom, they were virtually absent in the diet: in particular, large organisms such as Rhyacophilidae or organisms living in particular microhabitats, such as Blephariceridae. Furthermore, Chironomidae and *Baetis* sp. were always the most important component in the *D. alpinus* diet, also if their importance diminishes according to the altitude (Fig. 1).

DISCUSSION

Studies on carnivorous Plecoptera diet represent an useful tool to investigate lotic food webs, behavioural and ecological aspects of stream organisms (Allan, 1982), but there are few studies related to Alpine organisms. Apparently, *D. alpinus* adults rely on the rich diet of the pre-imaginal stage.

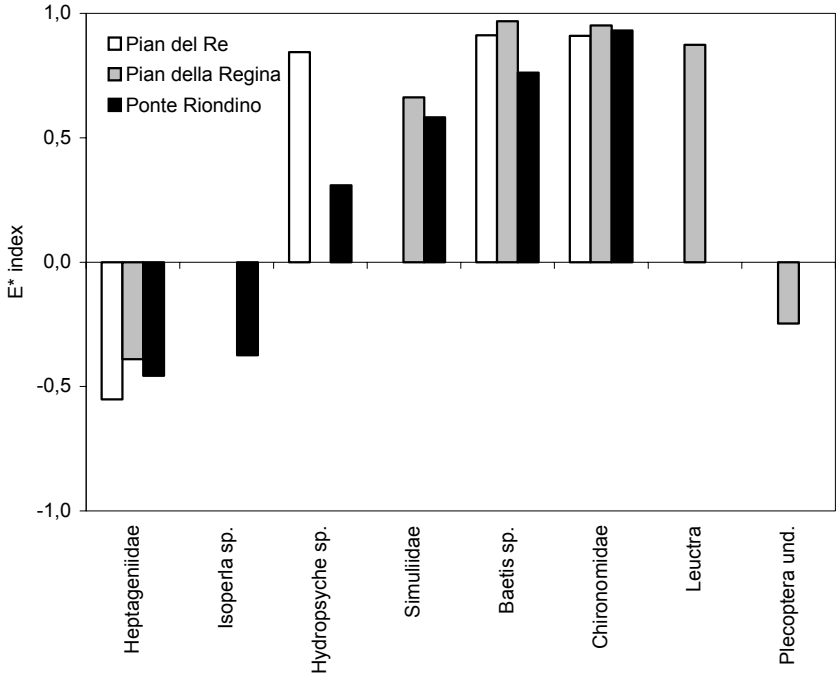

Fig. 1.—Electivity index (E*) for the macroinvertebrate taxa in the diet of *D. alpinus* nymphs in the high Po Valley.
Fig. 1.—Índice de electividad (E*) para los taxa de macroinvertebrados en la dieta de *D. alpinus* en el alto Valle del Po.

This hypothesis has been presented for other Perlidae and large-sized Perlodidae, in which a considerable quantity of solid food has not been found in any studied species (Fenoglio & Tierno de Figueroa, 2003). In this work, we found that *D. alpinus* nymphs were not strictly carnivorous, but they partially feed also on vegetal detritus and algae. This results agree with the findings of other studies, where it is reported that vegetal material is an important component in the diet of some Perlodidae, such as *Arcynopteryx* (Lillehammer, 1988), *Isoperla* and *Perlodes* (Berthélemy & Lahoud, 1981). In *Isoperla acicularis*, the importance of vegetal material is highest in young instars and diminishes according to the age and dimensions of the nymphs (Berthélemy & Lahoud, 1981).

Diets were dominated by chironomids and *Baetis* sp., with indeterminate mayflies, Heptageniidae, indeterminate stoneflies, *Leuctra* sp. and Simuliidae comprising secondary dietary items.

Contrasting to the findings of some studies relating to other Systellognatha (Dudgeon, 2000; Fenoglio, 2003), the diet of this carnivorous stonefly indicates the existence of trophic selection mechanisms, with a preference for few particular taxa, independently from their availability in the substratum. We could hypothesized that environment (for example, microhabitat distribution) or behaviour (for example feeding activity of the preys) are on the basis of this trophic preference.

ACKNOWLEDGEMENTS

We thank J. M. Tierno de Figueroa for suggestions that greatly improved our manuscript. This work was supported by Parco del Po Cuneese grants (Interreg ALCOTRA III A AQUA).

BIBLIOGRAPHY

Allan, J. D. 1982. Feeding habits and prey consumption of three setipalpian stoneflies (Plecoptera) in a mountain stream. *Ecology*, 63: 26-34.

— 1995. *Stream ecology. Structure and function of running waters.* Chapman & Hall. London, 388 pp.

Aubert, J. 1959. *Plecoptera. Insecta Helvetica I.* Fauna. La Concorde, Lausanne, 140 pp.

Berthelemy, C. & Lahoud, M. 1981. Regimes alimentaires et pieces buccales de quelques Perlodidae et Perlidae des Pyrenees (Plecoptera). *Ann. Limnol*., 17: 1-24.

Consiglio, C. 1980. La distribuzione dei Plecotteri italiani. In: *Lavori della società italiana di biogeografia – Il popolamento delle acque interne italiane*: 383-393.

Dudgeon, D. 2000. Indiscriminate Feeding by a Predatory Stonefly (Plecoptera: Perlidae) in a Tropical Asian Stream. *Aquatic Insects*, 22: 39-47.

Elliott, J. M. 2000. Contrasting diel activity and feeding patterns of four species of carnivorous stoneflies. *Ecol. Entom*., 25: 26-34.

Fenoglio, S. 2003. Feeding habits of *Anacroneuria* nymphs (Plecoptera Perlidae). *Boll. Soc. Entomol. Ital.,* 135: 15-17.

Fenoglio, S. & Tierno de Figueroa, J. M. 2003. Observations on the adult feeding of some *Neoperla* and *Anacroneuria* species (Plecoptera, Perlidae). *Afr. Ent*., 11: 138-139.

Fochetti, R. 1995. Plecotteri. In: Minelli, A., Ruffo, S. & La Posta, S. (Eds.) *Checklist delle specie della fauna italiana*. Bologna, 3 pp.

Huhta, A.; Muotka, T.; Juntunen, A. & Yrjonem, M. 1999. Behavioural interaction in stream food webs: the case of drift-feeding fish, predatory invertebrates and grazing mayflies. *J. Anim. Ecol*., 68: 917-927.

Lillehammer, A. 1988. *Stoneflies (Plecoptera) of Fennoscandia and Denmark*. Scandinavian Science Press. Leiden, 165 pp.

McCormick, P. V. 1991. Lotic protistan herbivore selectivity and its potential impact on benthic algal assemblages. *J. N. Am. Benthol. Soc*., 10: 238-250.

MERRITT, R. W. & CUMMINS, K. W. 1996. *An introduction to the aquatic insects of North America*. Kendall / Hunt. Dubuque, IO, 862 pp.

RAVIZZA DEMATTEIS, E. & RAVIZZA, C. 1988. Les Plécopteres de la vallée supérieure du Po (Alpes Cottiennes). Notes faunistiques et écologiques. *Annls. Limnl*., 24: 243-360.

ROSI-MARSHALL, E. J. & WALLACE, J. B. 2002. Invertebrate food webs along a stream resource gradient. *Fresh. Biol*., 47: 129-141.

SIEGFRIED, C. A. & KNIGHT, A. W. 1976. Prey selection by a Setipalpian Stonefly nymph, *Acroneuria* (*Calineuria*) *californica* Banks (Plecoptera, Perlidae). *Ecology*, 57: 603-608.

TIERNO DE FIGUEROA, J. M. & SANCHEZ-ORTEGA, A. 2000. Imaginal feeding of twelve species of Nemouroidean stonefly (Insecta, Plecoptera). *Ann. Ent. Soc. Am*., 93: 251-253.

TIERNO DE FIGUEROA, J. M.; SEZZI, E. & FOCHETTI, R. 2003. Feeding in the genus *Tyrrhenoleuctra* (Plecoptera Leuctridae). *Boll. Soc. Ent. Ital.*, 134: 207-210.

WIPFLI, M. S. & GREGOVICH, D. P. 2002. Export of invertebrates and detritus from fishless headwater streams in south-eastern Alaska: implication for downstream salmonid production. *Fresh. Biol*., 47: 957-969.