Does predator benefits prey? Commensalism between *Corynoneura* Winnertz (Diptera, Chironomidae) and *Corydalus* Latreille (Megaloptera, Corydalidae) in Southeastern Brazil

Marcos Callisto[1, 2]; Michael D.C. Goulart [1]; Pablo Moreno [1] & Rogério P. Martins [2]

[1] Departamento de Biologia Geral, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais. Caixa Postal 486, 30161-970, Belo Horizonte, Minas Gerais, Brasil.
[2] Corresponding author.

ABSTRACT. Commensalism between *Corydalus* Latreille, 1802 (Megaloptera, Corydalidae) and *Corynoneura* Winnertz, 1846 (Diptera, Chironomidae, Orthocladiinae) larvae was recorded in Indaiá stream, at 1,380 m a.s.l. (Parque Nacional da Serra do Cipó, 19°-20°S, 43°-44°W) and in the headwaters of São Francisco river, at 1,300-1,700 m a.s.l. (Parque Nacional da Serra da Canastra, 20°00'-20°30'S, 46°15'-47°00'W), in Minas Gerais state, Brazil. Seventy eight *Corydalus* larvae (range 22-88 mm) were sampled: 61 in the Indaiá stream and 17 in other two streams. Twelve *Corydalus* larvae (22-79 mm) in the Indaiá stream and three out of 15 larvae in the headwaters of São Francisco river (38-50 mm) had *Corynoneura*, larvae and pupae on their gills (3rd to 6th) and a few larvae attached to the abdominal segments of larger *Corydalus* larvae (> 25 mm). Sixty-nine larvae of *Corynoneura* were found in the regurgitated material from *Corydalus*. It is remarkable that by attaching to larger body size predators, prey could become free from predator bouts and could also be transported by them.
KEY WORDS. Headwater stream; phoresy; predator-prey relationship; São Francisco river.

RESUMO. **O predador beneficia sua presa? Comensalismo entre *Corynoneura* Winnertz (Diptera, Chironomidae) e *Corydalus* Latreille (Megaloptera, Corydalidae) no Sudeste do Brasil.** Comensalismo entre *Corydalus* Latreille, 1802 (Insecta, Megaloptera, Corydalidae) e *Corynoneura* Winnertz, 1846 (Insecta, Diptera, Chironomidae, Orthocladiinae) foi registrado no córrego Indaiá situado a 1.380 m de altitude no Parque Nacional da Serra do Cipó (19-20°S, 43-44°W) e nas nascentes do rio São Francisco a 1.300-1.700 m de altitude no Parque Nacional da Serra da Canastra (20°00'-20°30'S, 46°15'-47°00'W), Minas Gerais, Brasil. Setenta e oito larvas de *Corydalus* (tamanhos: 22-88 mm) foram coletadas: 61 no córrego Indaiá e 17 em outros córregos. Doze larvas de *Corydalus* (tamanhos: 22-79 mm) no córrego Indaiá e três encontradas nas nascentes do rio São Francisco (tamanhos: 38-50 mm) apresentaram larvas e pupas de *Corynoneura* em suas brânquias (3ª a 6ª) e algumas larvas fixadas nos segmentos abdominais de grandes *Corydalus* (> 25 mm). Sessenta e nove larvas de *Corynoneura* foram retiradas do material regurgitado por *Corydalus*. É importante observar que fixados aos predadores de grande tamanho corporal as presas se tornam livres de outros predadores além de serem transportados por eles.
PALAVRAS-CHAVE. Foresia; relação predador-presa; rios de cabeceira; rio São Francisco.

Commensalism has received less attention from ecologists than competition, predation and parasitism. Associations between chironomids and their hosts have been often interpreted as commensalisms, whereby the chironomid derives certain advantages from its association with its host, while the host is unharmed but derives nothing in return (Pennuto *et al*. 2002). Roque *et al*. (2004) emphasized an increasing number of studies on this subject in the Neotropical region, but the knowledge about these ecological interactions is fragmented and no summary of information is available. Chironomid-host associations have involved symbioses, including parasitism (Jacobsen 1998) and symphoresy (de la Rosa 1992, Pennuto 1997). Commensalism and phoretic associations have been also reported between Chironomidae and a variety of aquatic macroinvertebrates including Trichoptera (Steffan 1967), Ephemeroptera (Callisto & Goulart 2000), Plecoptera (Steffan 1967, Dorvillé *et al*. 2000), Hemiptera (Roback 1977), Odonata (Rosenberg 1972), Megaloptera (Furnish *et al*. 1981, Pennuto 1998, 2000, 2003, de la Rosa 1992) and snails (Mancini 1979). Nevertheless, some authors assume that phoresy is relatively uncommon among chironomids (*e.g*. White *et al*. 1980), while others argued for the opposite (*e.g*. Roback 1977).

This paper describes commensalism between *Corydalus* and *Corynoneura*. We tested the hypothesis that *Corydalus* body size influences the occurrence and numbers of commensal *Corynoneura* larvae and pupae that could be attached to their bodies.

MATERIAL AND METHODS

Seven stream sections (ranging from 2nd to 7th order and between 1,300-1,700 m a.s.l.), 6 located in Doce River basin, Cardeal Mota and Jaboticatubas municipalities, Serra do Cipó National Park (19º 2'-34', 43º27'-38ºW); and one headwater stream in São Francisco River basin, São Roque de Minas village, Serra da Canastra National Park (20º00'-20º30'S, 46º15'-47º00'W), Minas Gerais State, Southeastern Brazil were sampled. These are black-water streams, acidic (pH 4.0-5.0), well oxygenated (> 90 % saturation), with low electrical conductivity (< 150 mS/cm), and low nutrient contents (e.g., P-PO_4 < 10µg/l, N-NH_4^+ < 970 µg/l) (see details in Callisto *et al.* 2004).

Megaloptera larvae were collected manually in rainy (November-March) and dry (May-September) seasons from 1993-1997 and 1999-2000, following a stream order (2nd-7th) longitudinal gradient along Indaiá stream, Peixe river (Doce river watershed) and from headwaters of the São Francisco river watershed (a 2nd order reach). The two most representative substrates (gravel and sand, leaves and branches of riparian vegetation) were sampled along each river stretch totaling 252 samples (18 samples in each sampling period, two times per year in rainy and dry seasons). Samples were taken using a Surber sampler (0.250 mm mesh) with an area of 0.0625 m^2 and additional qualitative samples were collected in all studied ecosystems by using hand nets (0.250 mm mesh) from which Corydalids were sorted.

Five *Corydalus* specimens with no attached chironomids larvae and pupae were placed in vials with 10% formalin in order to induce regurgitation. Abdominal gills of *Corydalus* larvae were also checked for chironomids presence in laboratory. Eggs were counted by direct observations. Commensal larvae of *Corynoneura* attached to *Corydalus* bodies were sorted out from their hosts, mounted in slides, identified, preserved in 70% alcohol and deposited in the Collection of Benthic Macroinvertebrates of the Institute of Biological Sciences, Federal University of Minas Gerais.

RESULTS AND DISCUSSION

Seventy-eight *Corydalus* larvae were collected, 16 of which hosted *Corynoneura* (eggs = 16, larvae = 145, and pupae = 29). Body length of *Corydalus* larvae ranged from 22 to 88 mm, with a 40-50 mm modal class. Amongst the 16 larvae of *Corydalus* carrying commensals, 1 up to 33 *Corynoneura* larvae were found per individual (*Corydalus* body size between 30 and 88 mm). *Corynoneura* larvae were attached mainly to abdominal segments and under gills (Tab. I). Eggs and pupae of *Corynoneura* were found only ventrally under gills and on the 1st to 4th abdominal segments, on both sides of the host. Differences between the location of attachment of larvae versus eggs and pupae were not found. Up to five pupae were found once on the same larva of *Corydalus*. These results reinforce de la Rosa (1992), Tokeshi (1999), and Roque *et al.* (2004) claims that amongst the insects, Megaloptera is one of the most frequent host group, together with Plecoptera, Ephemeroptera and Odonata. Bigger low mobile cryptic benthic species are also pointed out as responsible for their suitability as hosts. The same authors assume that this interaction might benefit the chironomids by decreasing predation risks, increasing mobility, improving protection from disturbances, improving opportunity to feed, and eliminating metabolic waste. Nevertheless, information on natural environments concerning prey preferences, foraging behavior, and life history characteristics may be involved, but are still unavailable to the Neotropics.

Filamentous algae were found attached to the dorsal proleg filaments on the abdomen of two *Corydalus* larvae. Observations under a dissecting microscope showed *Corynoneura* larvae among the algae. Larval position on the host seems not to vary with the developmental stage of the chironomid (1st-2nd larvae group versus 3rd, 4th, and pupae, $\chi^2 = 19.35$, $p > 0.05$). Our data suggest there is no evidence of intraspecific competition for certain positions on hosts. Therefore there are no apparent benefits for occupying a particular site on host body.

The regurgitated gut contents from five *Corydalus* larvae (58-83 mm body size) from Indaiá stream (5th order reach) in February 2000, yields sixty-nine *Corynoneura* larvae (10, 25, 7, 13, 14 in each). It is supposed that eaten *Corynoneura* were directly taken from their preferred stream substrates (filamentous algae, mosses and debris), since those attached to the *Corydalus* larvae were unavailable as prey.

Commensal relationships between *Corynoneura* and *Corydalus* were relatively common in sandy bottom streams, such as in the Indaiá stream (2nd up to 6th order stretches) and in the Peixe river (7th order stretch). Previous studies on stream ecosystems in the headwaters of Serra do Cipó and Serra da Canastra National Parks showed that *Corynoneura* was very abundant (Galdean *et al.* 1999b, 2001). *Corynoneura* was normally found on surfaces covered by filamentous algae, mosses and debris (Galdean *et al.* 1999 a, b). The *Corynoneura* Megaloptera host colonizing behavior is unknown. de la Rosa (1992) suggested that drifting *Thienemanniella* Kieffer, 1911 could settle on the substrates and actively seek megalopteran larvae. Hayashi (1988) suggested that large megalopterans tend to prey on insects much larger than chironomids and thus, the size of the megalopteran used as a host by the chironomids seem to diminish the risk of becoming prey.

Bigger *Corydalus* larvae had higher numbers of larvae and pupae of *Corynoneura* ($R^2 = 0.752$, $p < 0.05$). The location of eggs, larvae and pupae on the gills suggests that eggs can be laid on the water and then drift to *Corydalus* gills, where the *Corynoneura* life cycle takes place. This association only occurs on larger *Corydalus* larvae (> 20 mm), in headwater streams probably because: 1) larger larva are more active predators than smaller ones, showing fast movements and higher amount of prey ingestion; 2) the greater trophic resources are (greater surface area, larger surface structures) associated with a larger host

Table I. Summary statistics for *Corynoneura* attached to *Corydalus* sp. hosts in study streams in Minas Gerais State, Brazil. Terminology according to MARGOLIS *et al.* (1982) and BUSH *et al.* (1997): Prevalence = % of hosts examined harboring > 1 midge. Infestation intensity = number of *Corynoneura* on on *Corydalus* host. Location = stream name and stretch where *Corydalus* were collected. Location of attachment = typical local environment in which midges occur in the *Corydalus* body. (AS) Ventral and lateral surfaces of abdominal segment, (ASd) dorsal surface of abdominal segment, (bG) below gill, (d) dorsal, (G) gill.

Location	Samplings	Location of attachment	# Hosts	# *Corydalus* larvae examined	Midges (n)	Pupae (n)	Eggs (n)	Prevalence	Infestation intensity	Host size (mm)
Indaiá stream 2nd order	Rainy/dry 1999-2000	bG, AS	1	5	1-3	2	–	0.20	0.28	22
Indaiá stream 3rd order	Rainy/dry 1999-2000	bG, AS	2	8	2-6	5	2	0.25	0.31	30-50
Indaiá stream 4th order	Rainy/dry 1993-1997 1999-2000	bG, AS, ASd, G	7	25	1-33	5	8	0.28	0.29	30-83
Indaiá stream 5th order	Rainy/dry 1999-2000	bG, AS	1	7	1-3	4	1	0.14	0.18	35
Indaiá stream 6th order	Rainy/dry 1999-2000	As, G, ASd	1	16	1-5	5	3	0.06	0.08	79
Peixe river 7th order	Rainy/dry 1993-1997 1999-2000	As, G, ASd	1	2	1-9	3	2	0.50	2.50	88
São Francisco Headwater (2nd order)	Dry 1999	As, bG	3	15	1-5	5	–	0.20	0.30	38-50

(TOKESHI 1986); 3) larger hosts are larger "islands" for drifting or searching larvae (TOKESHI 1986). Alternatively, *Corydalus* larvae may search for prey in those microhabitats where eggs, larvae and pupae of *Corynoneura* are. Sediment then is lifted from the substrate into the water column and *Corynoneura* may attach to the gills or abdominal segments of *Corydalus* (JACOBSEN 1998). *Corynoneura* larvae may also actively seek *Corydalus* larvae, larger *Corydalus* larvae may release a stronger chemical or physical cue for searching larvae than smaller larvae (SVENSSON 1979). *Corydalus* gills seem to be a safe site for *Corynoneura* development (out of predation pressure). We believe that the use of isotopic comparisons would confirm this commensal relationship in studied streams and rivers. Alternatively, it could clarify if *Corynoneura* were functioning as parasites, as proposed by DOUCETT *et al.* (1999), when attached chironomids feed directly on the host rather than on detritus.

ROQUE *et al.* (2004) reported forty-nine cases of Chironomidae larvae living on other animals in Brazilian freshwaters, including invertebrates and fishes. Biotic interactions such as commensalism and predator-prey relationships could be key factors in the maintenance of species diversity, especially in the tropics (ROBINSON 1978, ROHDE 1992).

ACKNOWLEDGMENTS

We thank Peter S. Cranston for identification of *Corynoneura* material and to Ole A. Sæther for his comments on *Corynoneura* taxonomy, A. Contreras-Ramos was contacted for *Corydalus* confirmation. We appreciated comments on an early version of the manuscript by Geraldo W. Fernandes, Paula Eterovick, Manuel A. Graça and Marcos S. Barbeitos. This study was supported by grants from the Fundação de Amparo à Pesquisa do Estado de Minas Gerais, Conselho Nacional de Pesquisa e Desenvolvimento (CNPq), Pró-reitorias de Graduação, Pesquisa e Extensão of the Universidade Federal de Minas Gerais, Instituto Brasileiro de Meio Ambiente, US Fish and Wildlife Service. M. Callisto and R.P. Martins received research scholarships from CNPq.

REFERENCES

BUSH A.O., K.D. LAFFERTY; J.M. LOTZ & A.W. SHOSTAK. 1997. Parasitology meets ecology on its own terms: Margolis *et al.* revisited. **Journal of Parasitology**, Washington, **83**: 575-583.

CALLISTO M. & M. GOULART. 2000. Phoretic association between *Nanocladius* (*Plecopteracoluthus*) sp. (Chironomidae: Diptera) and *Thraulodes* sp. (Leptophlebiidae: Ephemeroptera) **Anais da Sociedade Entomológica do Brasil**, Curitiba, **29** (3): 1-4.

CALLISTO M.; M. GOULART; A.O. MEDEIROS; P. MORENO C.A. & ROSA. 2004. Diversity assessment of benthic macroinvertebrates, yeasts, and microbiological indicators along a longitudinal gradient in Serra do Cipó, Brazil. **Brazilian Journal of Biology**, Rio de Janeiro, **64** (4): 743-755.

de la Rosa, C.L. 1992. Phoretic associations of Chironomidae (Diptera) on Corydalidae (Megaloptera) in northwestern Costa Rican streams. **Journal of the North American Benthological Society**, New York, **11**: 316-323.

Dorvillé L.F., J.L. Nessimian & A.M. Sanseverino. 2000. First record of symphoresy between a nymph of a stonefly *Kempnyia tijucana* (Plecoptera; Perlidae) and a chironomid larva *Nanocladius* (*Plecopteracoluthus*) in the neotropics. **Studies on Neotropical Fauna and Environment**, Tubingen, **35** (2): 109-114.

Doucett, R.R.; D.J. Giberson & G. Power. 1999. Parasitic association of *Nanocladius* (Diptera: Chironomidae) and *Pteronarcys biloba* (Plecoptera: Pteronarcyidae): insights from stable-isotope analysis. **Journal of the North American Benthological Society**, New York, **18** (4): 514-523.

Furnish J., D. Belluck; D. Baker & B.A. Pennington. 1981. Phoretic relationships between *Corydalus cornutus* (Megaloptera: Corydalidae) and Chironomidae in eastern Tennessee. **Annals of Entomological Society of America**, New York, **74**: 29-30.

Galdean N., F.A.R. Barbosa; M. Callisto; L.A. Rocha & M.M.G.S.M. Marques. 1999a. A proposed typology for the rivers of Serra do Cipó (Minas Gerais, Brazil) based on the diversity of benthic macroinvertebrates and the existing habitats. **Traveaux Museum Historie Naturale "Grigore Antipa"**, Bucharest, **41**: 445-453.

Galdean N.; M. Callisto & F.A.R. Barbosa. 1999b. Benthic macroinvertebrates of the head-waters of river São Francisco (National Park of Serra da Canastra, Brazil). **Traveaux Museum Historie Naturale "Grigore Antipa"**, Bucharest, **41**: 455-464.

Galdean N.; M. Callisto & F.A.R. Barbosa. 2001. Biodiversity assessment of benthic macroinvertebrates in altitudinal lotic ecosystems of Serra do Cipó (MG – Brazil). **Revista Brasileira de Biologia**, Rio de Janeiro, **61** (2): 239-248.

Hayashi, F. 1988. Life-history variation in a dobsonfly, *Protohermes grandis* (Megaloptera, Corydalidae) – effects of prey availability and temperature. **Freshwater Biology**, Oxford, **19** (2): 205-2016.

Jacobsen, R.E. 1998. The symbiotic relationship of a chironomid with its ephemeropteran host in an Arizona mountain stream. **Journal of the Kansas Entomological Society**, Kansas, **71**: 426-438.

Mancini, E.R. 1979. A phoretic relationship between a chironomid larva and an operculate stream snail. **Entomological News**, Ontario, **90**: 33-36.

Margolis, L.; G.W. Esch; J.C. Holmes; A.M. Kuris & G.A. Schad. 1982. The use of ecological terms in parasitology (report of an ad hoc committee of the American Society of Parasitologists). **Journal of Parasitology**, Washington, **68** (1): 131-133.

Pennuto, C.M. 1997. Incidence of Chironomid phoretics on Hellgrammites in streams of Southern Maine. **Northeastern Naturalist**, Maine, **4**: 285-292.

Pennuto, C.M. 1998. Seasonal position patterns and fate of a commensal chironomid on its fishfly host. **Journal of Freshwater Ecology**, La Crosse, **13**: 323-332.

Pennuto, C.M. 2000. Effects of larval density and movement behavior on emergence success of a midge commensal. **Aquatic Ecology**, New York, **34**: 177-184.

Pennuto, C.M. 2003. Population dynamics and intraspecific interactions of an ectosymbiotic midge in a river in southern Maine, USA. **Journal of the North American Benthological Society**, New York, **22**: 249-262.

Pennuto, C.M.; C.L. Wooster-Brown & C.A. Belisle. 2002. Infestation intensity and prevalence of an ectosymbiotic midge under variable environmental and host conditions. **Canadian Journal of Zoology**, Ottawa, **80** (12): 2061-2071.

Roback, S.S. 1977. First record of a chironomid larva living phoretically on an aquatic hemipteran (Naucoridae). **Entomological News**, Ontario, **88**: 192.

Robinson, M.H. 1978. Is tropical biology real? **Tropical Ecology**, Cambridge, **19** (1): 30-50.

Rohde, K. 1992. Latitudinal gradients in species diversity: the search for the primary cause. **Oikos**, Lund, **65**: 514-527.

Roque, F.O.; S. Trivinho-Strixino; M. Jancso & E.N. Fragoso. 2004. Records of Chironomidae larvae living on other aquatic animals in Brazil. **Biota Neotropica**, São Paulo, **4** (2): 1-9.

Rosenberg, D. 1972. A chironomid (Diptera) larva attached to a libellulid (Odonata) larva. **Quaestiones Entomologicae**, Florida, **8**: 3-4.

Steffan, A.W. 1967. Ectosymbiosis in aquatic insects, p. 207-289. *In*: S.M. Henry (Ed.), **Symbiosis.** New York, Academic Press.

Svensson, B.S.1979. Pupation, emergence and fecundity of phoretic *Epoicocladius ephemerae* (Chironomidae). **Holartic Ecology**, Lund, **2**: 41-50.

Tokeshi, M. 1986. Population ecology of the commensal chironomid *Epoicocladius flavens* on its mayfly host *Ephemera danica*. **Freshwater Biology**, Oxford, **16**: 235-243.

Tokeshi, M. 1999. **Species coexistence**: **ecological and evolutionary perspectives**. Oxford, Blackwell Science, 245p.

White T.R.; J.S. Weaver III & R.C. Fox. 1980. Phoretic relationships between Chironomidae (Diptera) and benthic macroinvertebrates. **Entomological News**, Ontario, **91** (3): 69-74.

Received in 07.VI.2005; accepted in 07.III.2006.