RECORDS OF CHIRONOMIDAE LARVAE LIVING ON OTHER AQUATIC ANIMALS IN BRAZIL

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Abstract

In this study, we report forty-nine cases of Chironomidae larvae living on other animals in Brazilian aquatic ecosystems, including a wide range of hosts, such as hydrozoans, snails, insects and fish. We also discuss some empirical difficulties to establish the ecological interactions between chironomids and their hosts.

Key words: *Chironomidae, aquatic insects, mollusks, fish, ecological interaction, hosts*

Resumo

Neste estudo nós reportamos 49 ocorrências de larvas de Chironomidae vivendo sobre o corpo de outros organismos aquáticos, tais como hidrozoários, moluscos, insetos e peixes, em ambientes aquáticos brasileiros. Nós também discutimos algumas dificuldades práticas para se estabelecer o tipo de interação ecológica entre Chironomidae e seus hospedeiros.

Palavras-chave: *Chironomidae, insetos aquáticos, moluscos, interações ecológicas, hospedeiros*

1. Introduction

Chironomidae larvae living on different aquatic animals have been reported by many authors (see revisions in Steffan 1967, White et al. 1980, Tokeshi 1993, Tokeshi 1995, Jacobsen 1995, Ashe & O'Connor 2002). In the Neotropical region, there has been an increasing number of studies on this subject in recent years (Freihofer & Neil 1967; Fittkau 1974; Roback 1977; Epler 1986; De La Rosa 1992; Epler & De la Rosa 1995; Gonser & Spies 1997; Callisto & Goulart 2000; Dorvillé et al. 2000; Vilella et al. 2002). Particularly in Brazil, our knowledge about these ecological interactions is too fragmented and no attempt has been made to summarize the information already existent.

The primary scope of the present work is to present an updated list of the records of chironomids living on other aquatic animals in Brazilian aquatic systems, including several new concurrencies. Subsequently, we comment on some empirical difficulties and criteria to study interactions between chironomids and their hosts, given that our understanding of natural interactions may be distorted due to many problems, such as: 1) incompleteness, ambiguity and inconsistency of interspecific interactions' definition and classification (see conceptual discussion in Abrams 1987 and Bronstein 2001), and methodological constraints and lack of minimal information necessary to understand the relationship between mechanism and effect related to the ecological interactions.

2. Material and Methods

We have gathered data from three different sources: 1) the majority of the new data were obtained from studies on Chironomidae in the State of São Paulo, within the project "Inventory and Biology of freshwater Crustacean, Insects and Mollusks of the State of São Paulo" BIOTA-FAPESP Biodiversity; 2) most larvae of chironomid living on fish were obtained from the project "Inventory of Fish of the Streams from Passa Cinco, State of São Paulo" (Fragoso et al. 2003); 3) we also added information extracted from articles and from personal communication (the identification level and the morphospecies considered by each author were maintained in this work). In sources 1 and 2, the larvae were sorted out from their hosts, mounted in slides, and identified up to the possible taxonomic level, considering the limited knowledge of the Neotropical fauna. Given that most works were not specifically designed to examine ecological interactions between chironomids and their hosts, we do not consider quantitative information in this study.

The organisms are deposited in the collection of the Laboratório de Entomologia Aquática da Universidade Federal de São Carlos, SP, Brazil. We did not include chironomids living in/on freshwater sponges because this subject will be addressed in a future study.

We use the term "interactions between chironomids and their hosts" (ICH) to express all kind of interactions that may be obtained by a direct observation of a chironomid larvae living on the body of other aquatic animal. This term does not implicate in any interpretation of mechanisms and effects of the interaction between organisms. We emphasize our position about the use of some ecological terms, like phoresy, association, symbiosis, commensalisms, and others, which are very dependent on population level information (data not available in this study).

3. Results and discussion

3.1 Brazilian records of chironomids on other freshwater animals

Forty-nine cases involving Chironomidae living on the bodies of other animals are reported; 20 are new records and 29 are based on other studies or personal communications (Table 1) (Figure 1). The chironomid larvae showed a wide range of hosts (hydrozoans, snails, insects and fish), as pointed out by Steffan (1967) and Tokeshi (1995).

In general, our results corroborate those shown by Tokeshi (1995): amongst insects, Plecoptera, Ephemeroptera, Megaloptera and Odonata were the most frequent hosts. Some characteristics make them suitable as hosts, such as bigger cryptic benthic species with low mobility. Other common aquatic insects like Diptera, Hemiptera and non-insects like Mollusca were poorly represented. We have not found any chironomid living on non-case bearing Trichoptera, Crustacea and Coleoptera, which is probably related to the grooming behavior in the first two groups and smooth tegument in the latter.

In relation to vertebrate hosts, we have added new occurrences of the relatively well reported, but scarcely known interaction between *Ichthyocladius* and fish (see comments below). It is important to note that although we have found no report on chironomid living on non-fish vertebrates and it is unlike that obligatory relationships between chironomid and these animals exist, we believe that further studies focused on alligators, turtles, aquatic birds, and others vertebrates, would bear interesting results about, for instance, transport of eggs and chironomid larvae.

Species belonging to *Corynoneura* group were the most frequent in ICH in this study as well as in Tokeshi (1995) and Jacobsen (1995). Some genera within *Corynoneura* group seem to have species in obligate relationships with their hosts, like *Epoicocladius, Nanocladius* (Plecopteracoluthus), *Symbiocladius*, and *Tempisquitoneura* with species of Ephemeroptera, Megaloptera and/or Plecoptera, and *Ichthyocladius* (recently placed into *Corynoneura* group by Mendes et al. 2004) and fish. In this sense, an inevitable question emerges: have obligatory ICH evolved from commensal ancestors? The subject is controversial (see Jacobsen 1995) but, at least, within the *Corynoneura* group, the monophyletism

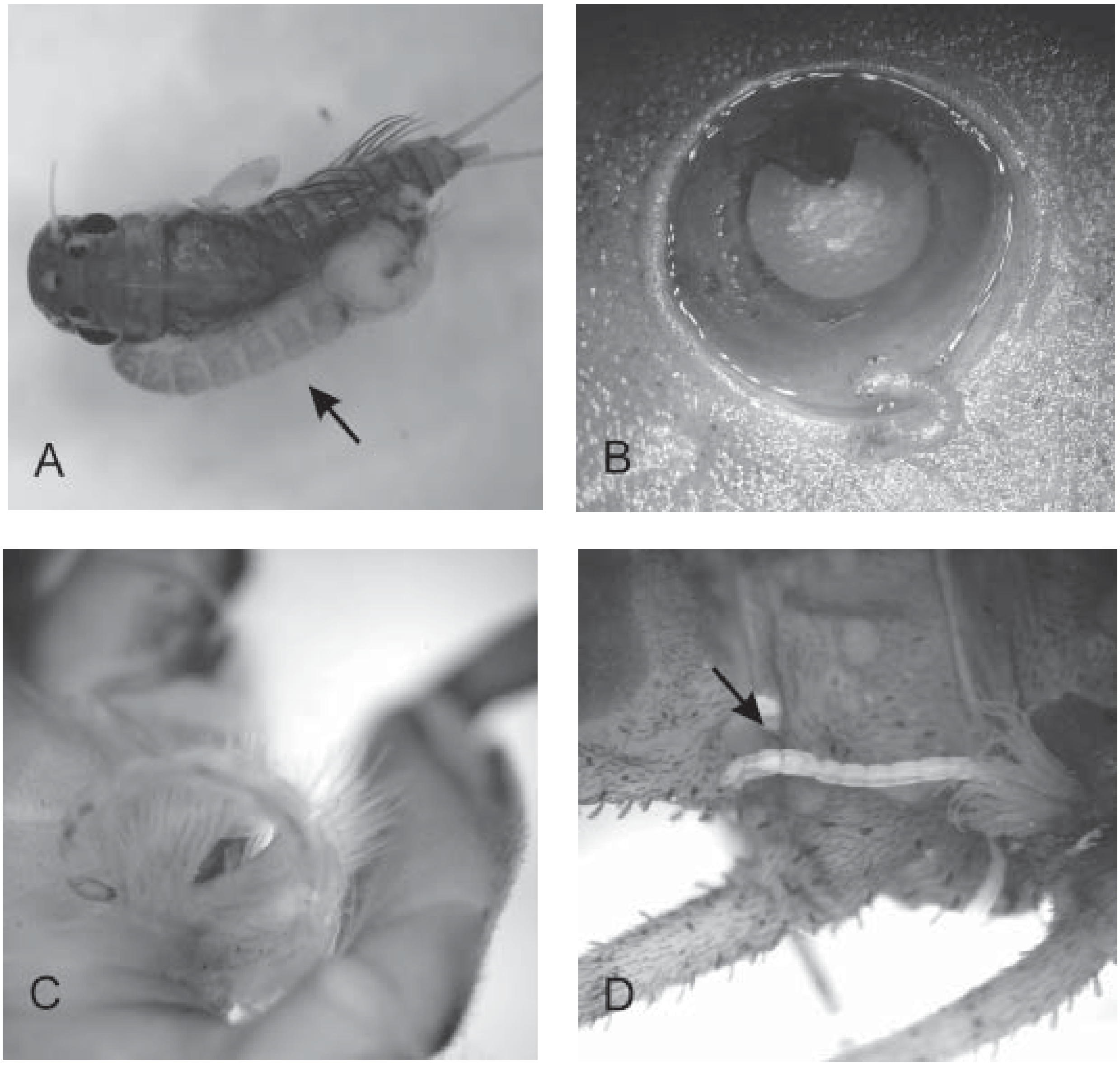

Figure 1. Chironomidae larvae on other aquatic animals. (A) Larva of Corynoneura group sp.2 attached to abdominal segments of Farrodes *(Ephemeroptera); (B) Larva of* Ichthyocladius *attached to head of* Hypostomus *(Pisces); (C) Larva of Corynoneura group sp.1 attached to thorax of* Kempnyia colossica *Navás, 1934 (Plecoptera); (D) Larva of* Corynoneura *attached to abdominal segments of* Corydalus *(Megaloptera).*

Table 1. Records of chironomid larvae living on other aquatic animals in Brazilian aquatic ecosystems. In order to avoid space-consuming in the table, we included taxa followed by author's name and data only for species level.

Records of chironomid larvae living on other aquatic animals in Brazilian aquatic ecosystems

Chironomidae	**Host**	**Aquatic system, Location (Geographical coordinates)**	**Reference**
Cardiocladius	Pupae of *Simulium pertinax* Kollar, 1832; and *Simulium spinibranchium* Lutz 1910 (Diptera)	Stream, Pirenópolis, Goiás	Present study
cf. *Corynoneura*	*Corydalus* (Megaloptera)	Stream, Serra do Cipó and Serra da Canastra, Minas Gerais (19º-20ºS, 43º –44ºW and 20º 00'-20º 30'S, 46º 15'-47º 00'W)	(Callisto et al., in press)
Corynoneura	*Corydalus nubilus* Erichson, 1848 (Megaloptera)	Stream (Igarapé), Presidente Figueiredo, Amazonas (02º01'07" S, 59º49'28" W)	C. A. S. de Azevedo and S. R. M.Couceiro (data unpublished)
Corynoneura group	*Kempnyia colossica* Navás, 1934 (Plecoptera)	Stream, P.E.Intervales, São Paulo (24º18'S, 48º25'W)	Present study
Corynoneura group	*Farrodes* (Ephemeroptera)	Stream, Estação Biológica de Boracéia, São Paulo (23º32'S,	Present study
Corynoneura group	*Corydalus* (Megaloptera)	Stream, Ipeúna, São Paulo (22º22'42"S, 47º46'40"W)	Present study
Corynoneura group	*Argia* (Odonata)	Stream, Estação Biológica de Boracéia, São Paulo (23º32'S, 45º51'W)	Present study
Corynoneura group	*Corydalus* (Megaloptera)	Stream, Estação Biológica de Boracéia, São Paulo (23º32'S, 45º51'W)	Present study
Corynoneura group	Belastomatidae (Hemiptera)	Stream, Ipeúna, São Paulo (22º22'42"S, 47º46'40"W)	Present study
Cricotopus	*Corydalus nubilus* Erichson, 1848 (Megaloptera)	Stream (Igarapé), Presidente Figueiredo, Amazonas (02º01'07" S, 59º49'28" W)	C. A. S. de Azevedo and S. R. M.Couceiro (data unpublished)
Endotribelos	Leptoceridae (Trichoptera)	Stream,Cananéia, São Paulo (24°54'12.6" S, 47°58'36.9" W)	Present study
Goeldichironomus neopictus Trivinho-Strixino & Strixino,	*Pomacea* (Mollusca)	Stream, São Carlos, SP (22º00'S, 47º54' W)	Present study
Ichthyocladius	*Kronichtys* (Pisces)	Stream, P.E. Intervales, São Paulo (24º18'S, 48º25'W)	(Mendes et al., in press)
Ichthyocladius	*Harttia spp* (Pisces)	São Francisco River (20º30'0"S, 46º50'0"W)	(Mendes et al., in press)
Ichthyocladius	*Hypostomus cf. garmani* (Pisces)	São Francisco River (20º30'0"S, 46º50'0"W)	(Mendes et al., in press)
Ichthyocladius	*Ancistrus brevipinnis* (Regan, 1904) (Pisces)	Brazil	Fittkau (1974) and Freihofer & Neil (1967)
Ichthyocladius	*Ancistrus bufonius* (Valenciennes, 1840) (Pisces)	Brazil	Fittkau (1974) and Freihofer & Neil (1967)
Ichthyocladius	*Ancistrus triradiatus* (Pisces)	Brazil	Fittkau (1974) and Freihofer & Neil (1967)

Ichthyocladius	*Ancistrus cirrhosus* ? (Valenciennes, 1836) (Pisces)	Iguassu River, Brazil	Fittkau (1974) and Freihofer & Neil (1967)
Ichthyocladius	*Plecostomus strigatceps* (Regan, 1908) (Pisces)	Mogi-Guassu River, São Paulo	Fittkau (1974) and Freihofer & Neil (1967)
Ichthyocladius	*Xenocara gymnorhynchus* (Pisces)	Brazil	Fittkau (1974) and Freihofer & Neil (1967)
Ichthyocladius	*Trichomycterus mirissumba* (Costa, 1992) (Pisces)	Preto River, Rio de Janeiro	Nessimian et al. (2003)
Ichthyocladius	*Pareiorhina rudolphi* (Gosline, 1947) (Pisces)	Preto River, Rio de Janeiro	Nessimian et al. (2003)
Ichthyocladius	*Hisonotus depressicalda* (Miranda-Ribeiro, 1918)	Stream, Ipeúna, São Paulo (22º22'42"S, 47º46'40"W)	Present study
Ichthyocladius	*Hypostomus* (Pisces)	Stream, Ipeúna, São Paulo (22º22'42"S, 47º46'40"W)	Present study
Ichthyocladius	*Corumbataia* cuestae *Britski* , 1997 (Pisces)	Stream, Ipeúna, São Paulo (22º22'42"S, 47º46'40"W)	Present study
Ichthyocladius	*Hypostomus* (Pisces)	Stream, Araraquara, São Paulo (21º49'S, 47º57'W)	Present study
Ichthyocladius	*Kronichthys heylandis* (Boulenger, 1900) (Pisces)	Stream, P.E. Intervales, São Paulo (24º18'S, 48º25'W)	Sazima et al. (2001)
Ichthyocladius	*Ancistrus* sp (Pisces)	Stream, P.E. Intervales, São Paulo (24º18'S, 48º25'W)	Sazima et al. (2001)
Ichthyocladius	*Ancistrus* sp. (Pisces)	Stream Reserva Biológica da Serra Geral, Rio Grande do Sul (29º32'-29º38' S; 50º08'-50º13' W)	Villela et al. (2002)
Ichthyocladius	*Hemipsilichthys nudulus* Reis & Pereira (Pisces)	Stream Reserva Biológica da Serra Geral, Rio Grande do Sul (29º32'-29º38' S; 50º08'-50º13' W)	Villela et al. (2002)
Ichthyocladius	*Hemipsilichthys* sp.1(Pisces)	Stream Reserva Biológica da Serra Geral, Rio Grande do Sul (29º32'-29º38' S; 50º08'-50º13' W)	Villela et al. (2002)
Ichthyocladius	*Hemipsilichthys* sp.2 (Pisces)	Stream Reserva Biológica da Serra Geral, Rio Grande do Sul (29º32'-29º38' S; 50º08'-50º13' W)	Villela et al. (2002)
Nanocladius	*Traulodes* (Ephemeroptera)	Stream, Serra do Cipó, Minas Gerais (19º-20º S, 43º–44º W)	Callisto & Goulart (2000)
Nanocladius	*Kempnyia tijucana* Dorvillé & Froehlich, 1997 (Plecoptera)	Stream, P.N. da Tijuca, Rio de Janeiro (22º55'S-23º00'S and 43º11'W-43º19'W)	Dorvillé et al. (2000)
Nanocladius	Perlidae (Plecoptera)	Stream Reserva Biológica da Serra Geral, Rio Grande do Sul	Villela et al. (2002)
Nanocladius sp.1	*Anacroneura* (Plecoptera)	Stream, P.E.Intervales, São Paulo (24º18'S, 48º25'W)	Present study
Nanocladius sp.2	*Anacroneura* (Plecoptera)	Stream, P.E.Intervales, São Paulo (24º18'S, 48º25'W)	Present study
Parachironomus	*Pomacea* (Mollusca)	Stream, São Carlos, SP (22º00'S, 47º54' W)	Present study

Parachironomus	*Cordylophora* (Hydrozoa)	Paraná River, Três Lagoas, São Paulo/Mato Grosso do Sul (20º45'S, 51º40'W)	Present study
Rheotanytarsus	Libellulidae (Odonata)	Stream (Igarapé), Presidente Figueiredo, Amazonas(02º01'07" S, 59º49'28" W)	C. A. S. de Azevedo and S. R. M.Couceiro (data unpublished)
Rheotanytarsus	*Elasmothemis cannacrioides* (Calv., 1906) (Odonata)	Stream, Luiz Antônio, São Paulo (21º 32'04.2''S, 47º 41'14'' W)	Ferreira-Peruquetti & Trivinho-Strixino (2003)
Rheotanytarsus	*Heteragrion* (Odonata)	Stream, Campos de Jordão, São Paulo (22º 30'- 22º 41'S, 45º 27'S- 45º 31'W)	Ferreira-Peruquetti & Trivinho-Strixino (2003)
Rheotanytarsus	*Castoreschna* (Odonata)	Stream, Campos de Jordão, São Paulo (22º 30'- 22º 41'S, 45º 27'S- 45º 31'W)	Ferreira-Peruquetti & Trivinho-Strixino (2003)
Rheotanytarsus	*Elasmothemis cannacrioides* (Calv., 1906) (Odonata)	Stream, Ipeúna, São Paulo (22º22'42"S, 47º46'40"W)	Present study
Rheotanytarsus	*Elasmothemis constricta* (Calv., 1898) (Odonata)	Stream, Corumbataí, São Paulo	Present study
Rheotanytarsus	*Argia* (Odonata)	Stream, Estação Biológica de Boracéia, São Paulo (23º32'S, 45º51'W)	Present study
Thienemaniella	*Corydalus nubilus* Erichson, 1848 (Megaloptera)	Stream (Igarapé), Presidente Figueiredo, Amazonas (02º01'07" S, 59º49'28" W)	C. A. S. de Azevedo and S. R. M.Couceiro (data unpublished)
Thienemanniella	*Argia modesta* Selys (Odonata)	Stream, Campos de Jordão, São Paulo (22º 30'- 22º 41'S, 45º 27'S- 45º 31'W)	Ferreira-Peruquetti & Trivinho-Strixino (2003)

with a commensal ancestor deserves more attention.

3.2 Distribution of the ICH cases in Brazil

The ICH occurrences reported here, including in Amazonas, São Paulo, Goiás, Minas Gerais, Rio Grande do Sul and Rio de Janeiro states, seem to indicate that ICH occurs in a wide area in Brazil. The number of cases per region may simply reflect the sampling effort and number of research in the Southern region. The majority of the Brazilian occurrences came from studies that were not specifically designed to answer quantitative questions on ICH, so that it is difficult to portray how common or rare the ICH are in frequency, abundance, and distribution.

Most occurrences have come from lotic aquatic systems. Unfortunately, data on Chironomidae and their hosts is scarce in lentic systems. Therefore, although it may be premature to seek broad answers to questions like whether or not Chironomidae living on other animals are more common in certain habitats, some reasonable predictions that merit further investigation can be offered. First, considering the possible benefits of commensalism in the chironomid discussed by Tokeshi (1995), ICH should be more common in lotic system. Second, considering that many chironomids and their potential hosts may have low tolerance to some kinds of antropic impacts, the richness of ICH must be lower in impacted areas.

3.3 Methodological constraints

Tokeshi (1995) points out that studies of ecological relationships often lack sufficient analytical rigor. Several aspects contribute to this situation: most of the relationships are established by observing dead organisms or live organisms under artificial conditions, little information about population dynamics of the species involved are available, and the behavior of the majority of the larvae is unknown. Moreover, basic questions such as whether the larvae benefit the host organism in any way (for example, cleaning some parts of their body) and how the chironomid larvae (e.g. *Ichthyocladius*) colonize the host organism remain unanswered. In the majority of the cases, we assume that the interaction between a chironomid larvae and larger animals may benefit the larvae by decreasing predation risks, increasing mobility, improving protection from disturbances, improving opportunity to feed, and also eliminating metabolic waste (Saffo 1992, Tokeshi 1993). However, there is not much information about it in natural environments.

Food relationships are extremely difficult to define for a group of insects like the chironomids, which have a varied natural diet (Pinder 1986). The association between *Nanocladius* and mayfly nymphs (Jacobsen 1995 for review) represents a good example of the challenge to establish the ecological category that depends on information about food relations. In the literature, we find different levels of interactions and/or different interpretations, such as phoresy (Callisto & Goulart 2000; Vilella et al. 2002), symphoresy (Epler 1986), symbiosis (Jacobsen 1995) and parasitism (Doucett et al. 1999; Caldwell & Wiersema 2002). This diversity of categories may originate from different aspects: (1) conceptual confusion, (2) behavior flexibility or different feeding strategies of the *Nanocladius* larvae (Vilella et al. 2002), (3) different levels of association between *Nanocladius* species and their hosts, and (4) use of different criteria and analytical tools to establish the relationship.

Because of the breadth and complexity of potential factors involved in relationships in natural systems, some degree of flexibility in applying criteria to establish the ecological relationship is necessary. However, for the sake of comparison and communication, some standardization is also needed. Some comments that may be useful for future research are included below.

Evaluation of possible injuries caused by the larvae to host organisms (e.g. gill deformation) and the position and location of the larvae may indicate indirectly some interactions, but it is important to note that the position of the larvae may result from environmental stimuli, life stage, feeding behavior and others.

The larvae oriented with their heads facing the body of the host may be interpreted as a sign of feeding behavior and, consequently, of parasitism, but this position may also represent that the larvae ceased feeding and started the pupation process or yet this position may be related to negative phototaxis when observed in stereomicroscope with high light.

Direct behavior observation of larvae and their hosts, considering ethological approaches and including behavior quantitative analysis, are strongly recommended to elucidate possible interactions (for example, whether the larvae clean the body of their hosts).

Indirect observation of possible activity or their effects may also contribute to establish the relationship. For example, Svensson (1980) noted lower densities of ciliates on the bodies of a mayfly when the *Epoicocladius flavens* (Mallock) larvae were present, indicating that the larvae probably clean the host body. Another example is provided by Condreanu (1939). His study of the relationship between *Symbiocladius rhithrogenae* (Zavr.) and nymphs of Ephemeroptera demonstrated that the larvae feed on the host's hemolymph and induce a cancer-like proliferation of blood cells within the host that may be beneficial to the larvae.

Analysis of larval gut contents by direct observation through a microscope can help the interpretation of the relationship, but it is not sufficient to know whether the larvae feed or not from parts of their hosts, because is practically impossible to observe haemolymph in gut contents.

Thus, the use of other methodologies, such as stable isotope analysis as reported by Doucett et al. (1999), is advisable.

Studies focusing in population dynamics of chironomid and their hosts (e.g. Svensson 1980; Peckarsky & Cowan 1991; Pennuto 1998; Pennuto 2000) are fundamental to understand the ecological aspects of inter and intraspecific interactions of larvae on hosts and set up the mechanisms and effects of interaction between them. Furthermore, symbiotic interaction categories and a cost-benefit model for the evolution of symbiosis (Matsuda & Shimada 1993) should be established considering the fitness involved in the relationships. Hence, information about a possible increase of fit or not of both participants associated is necessary.

Another aspect to be considered is the interspecific relationship within community and ecosystem context, regarding ecological and evolutionary perspectives, as pointed out by Abrams (1987), Kawanabe & Iwasaki (1993), Tokeshi (1999) and Vilella et al. (2002). According to Abrams (1987), ecologists should realize that the interaction between two populations may change when the size of the populations changes or when other populations with which they interact change, and it depends on many other biotic and abiotic factors working in multiple spatial and temporal scales. Ecological interactions are not fixed entities that can be easily classified.

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