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Mayfly communities in two Neotropical lowland forests

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In 2006, the Stroud Water Research Center conducted inventories of stream macroinvertebrates in the Peninsula de Osa in Costa Rica and the Madre de Dios watershed in eastern Peru. Both areas have extensive lowland tropical rainforests under threat from road development, tourism, poaching and gold mining. The mayfly communities of the two regions were substantially different in family relative abundances. In Osa the mayfly community was more or less evenly divided among Baetidae, Leptohyphidae, and Leptophlebiidae. In streams where one group was clearly dominant, this was most often Leptohyphidae. By contrast, in the Madre de Dios watershed Leptophlebiidae was often 75% or more of the mayfly fauna while Leptohyphidae was 20% or less. In both Osa and Madre de Dios, EPT indices were calculated for impacted streams and relatively undisturbed streams. However, physical characteristics such as stream size and substrate diversity were often a better predictor of community composition than human activity.

Keywords: Ephemeroptera; Costa Rica; Peru, Osa; Madre de Dios; disturbance; water quality

Introduction

In 2006, the Stroud Water Research Center conducted two water quality studies in rivers and streams of the Madre de Dios watershed of the Amazon Basin in southeastern Peru, and of the eastern Peninsula de Osa in southwestern Costa Rica (Figures 1–3). The objectives of these studies were to obtain baseline data on the macroinvertebrate communities in basin streams, test water quality metrics to see if they distinguished between impacted and (relatively) pristine streams, and to communicate findings to resource managers and people in local communities.

Despite the large geographic spread and biogeographic differences between the two areas, they have several things in common that made them attractive study sites. Both lowland areas still have large tracts of primary rainforest. Substantial fractions of both areas are enclosed in the national park systems of Costa Rica and Peru. In both areas there have been numerous studies of plants (Gentry 1990; Quesada,

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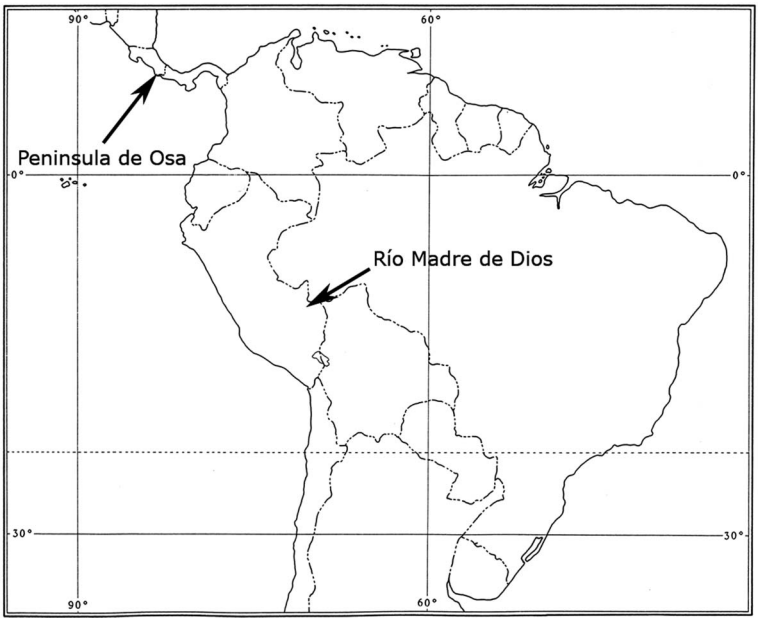
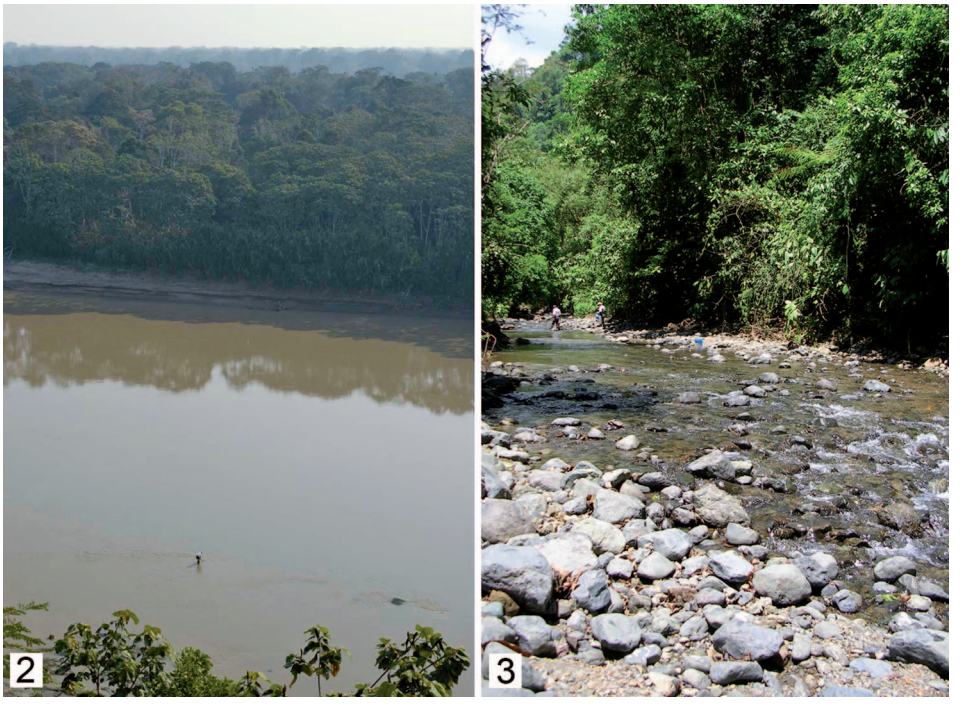


Figure 1. Map of South America showing sampling localities.



Figures 2–3. (2) Río Madre de Dios, a sampling site in Peru; (3) Río Bonito, a sampling site in Costa Rica.

Jiménez, Zamora, Aguilar and Gonzáles 1997) and vertebrates (Savage 2002; Goulding, Cañas, Barthem, Forsberg and Ortega 2003) but the invertebrate faunas (except for Lepidoptera) are still poorly known. Finally, despite having large areas in protected status, threats to the forests in both areas are grave, and increasing. In Osa, illegal hunting, periodic incursions of gold mining, and tourist development are putting pressure on Osa and Piedras Blancas national parks. In the Madre de Dios Region the completion of a bridge over the Río Madre de Dios will clear away the last obstacle to completion of the Inter-Oceanic Highway, being constructed to eventually link the coastal ports of Peru with the Atlantic coast of Brazil. Completion of this road will cause a huge influx of "civilisation" into the still relatively isolated region.

Here we present the data on the mayfly communities found in the streams of these two regions.

Methods

In Peru, 23 sites were collected, ranging from large rivers to tiny rainforest streams. Sites were divided into three classes based on the condition of the surrounding land: urban (one site), agricultural (six sites), and forest (15 sites). In Costa Rica, seven sites were collected; three streams had paired sites with an upstream site in relatively intact forest and a downstream site in pasture (two sites) or in an oil palm plantation (one site). The remaining site was in a lightly deforested area upstream from a field station on the Río Piro. Collecting was done by D-frame net and Surber sampler, and with artificial substrate samplers. For Peru artificial substrates consisted of plastic mesh bags filled with pieces of either palm (Arecaceae) or *Inga* (Fabaceae) leaves. For Costa Rica, substrates were mesh bags filled with rocks (rock bags). We varied the type of artificial substrates because in Peru most of the streams we sampled were sand bottomed with leaf packs being the principal solid substrate. By contrast, most of the Costa Rican streams had extensive gravel or cobble substrate.

In Peru, a brief initial survey was made in April 2006, and the main collecting effort took place 14–31 August 2006. Artificial substrates were retrieved approximately a month later. In Costa Rica the first visit to the sites was from 17 to 19 February 2006 when D-frame net collections were made and six rock bags were placed at each site. All sites were visited again from 11–13 March 2006. At this time a second D-frame net collection was made at each site. Rock bags were retrieved and their contents washed into sieves. The content of a given sieve was subsampled to reduce sample processing time. Three subsamples were preserved from each rock bag: two of 1/16 and one of 1/8 of the area of the sieve. Also four Surber samples were collected from riffles at each site, and a subsample of 1/4 the contents of each Surber was preserved. Streams in both Peru and Costa Rica were sampled during their respective dry seasons, since streams in both areas are largely inaccessible during their rainy seasons.

To compare the communities of the impacted and unimpacted streams, EPT (total number of taxa [identified to genus] of Ephemeroptera + Plecoptera + Trichoptera at each site) was calculated. For the Madre de Dios (Peru) samples, only the D-frame net samples were included since the artificial leaf packs contained almost exclusively Chironomidae. For Peninsula de Osa samples the counts of EPT are the sum of taxa from rock bag, Surber, and D-frame net samples.

Results

Community structure

A comparison of the taxa found in Madre de Dios and Peninsula de Osa (Table 1; Figures 4 and 5) shows that Madre de Dios had 34 mayfly genera as opposed to 28 for Osa. Madre de Dios had three families not found in Osa (Coryphoridae, Oligoneuriidae, Polymitarcyidae) and twice as many genera of Leptophlebiidae. Osa had a slightly higher number of Baetidae genera and twice as many Leptohyphidae genera as Madre de Dios. When relative numbers of individuals are compared (Figures 4 and 5), the striking feature of the Madre de Dios mayfly community was the overwhelming dominance of the Leptophlebiidae and the relative scarcity of Leptohyphidae.

Human disturbance

In neither Madre de Dios (Figure 6) nor Peninsula de Osa (Figure 7) was the EPT metric able to cleanly separate disturbed sites from undisturbed forested sites. The largest number of taxa was actually found at a disturbed site on the Osa. Six of the seven Osa sites had EPT totals of 20 or more while only four of the 12 Madre de Dios sites had EPT values of 20 or higher. In Madre de Dios, the EPT metric was able to distinguish all but one of the conserved (undisturbed forest) from non-conserved (impacted) sites, but in Osa the performance of the EPT metric indicated that factors affecting water quality were more complicated than a simple forested versus deforested (agriculture) dichotomy.

Discussion

The structures of the mayfly communities in the two regions of this study were substantially different. Most striking was the scarcity of Leptohyphidae in the Madre de Dios watershed. This scarcity is puzzling because there appears to be no physical reason why Leptohyphidae should not be as abundant in Madre de Dios as in Peninsula de Osa. Although we focused on cobble and gravel streams in our Osa sampling, this watershed also has abundant, small, slow-moving streams with leaf packs and submerged wood, physically similar to many of our Madre de Dios sites. But while leptohyphids are abundant in such habitats in Osa (and elsewhere in Central America as well as in Trans-Andean [Pacific coast] Ecuador), they were absent or rare in Madre de Dios. Within the Leptophlebiidae, the most common genera in Osa were small *Thraulodes* species and *Farrodes*. In Madre de Dios, these genera were present but less common than *Miroculis*, an Amazon Basin endemic.

The dominance of Leptophlebiidae and relatively depauperate state of Leptohyphidae in mayfly communities of Madre de Dios are unique to our experience of working with Neotropical mayfly faunas. We know of no temporal or substrate variation between the two sites that could account for our results. Further lowland stream inventories along both sides of the Andes will be needed to determine if our data represent a true biogeographic pattern or local variation.

Except for one site in Madre de Dios (Q2miradorcicra), the EPT values in this watershed diminished with increasing levels of disturbance. We are unable at this time to explain the Miradorcicra anomaly but there is some anecdotal evidence that some sort of disturbance may have occurred at this site in the past.

Table 1. Comparison of mayfly communities of the Madre de Dios watershed, Peru, with those of the eastern Peninsula de Osa, Costa Rica.

Taxon	Madre de Dios	Peninsula de Osa
Baetidae		
Americabaetis	**	****
Aturbina	*	
Baetodes deficiens		*
Baetodes noventus		****
Baetodes: undet.		**
Callibaetis	*	
Camelobaetidius	*	****
Cloeodes	**	**
Cryptonympha	*	
Fallceon		*****
Guajirolus	**	***
Nanomis		*
Paracloeodes	*	*
Varipes		+
Waltzoyphius	**	
Baetidae: undet	**	
Caenidae		
Brasilocaenis	**	
Caenis	*	**
Coryphoridae		
Coryphorus	+	
Euthyplociidae		
Campylocia	***	
Euthyplocia		+
Leptohyphidae		
Allenhyphes	**	*
Amanahyphes	**	
Asioplax		*
Cabecar serratus		+
Epiphrades undatus		***
Leptohyphes	***	*****
Tricorythodes	**	*****
Vacuperinus packeri		*
Leptohyphidae: undet.		*
Leptophlebiidae		
Ecuaphlebia	***	
Farrodes	***	****
Fittkaulus	**	
Hagenulopsis	**	**
Hydrosmilodon	+	
Hylister	**	
Miroculis	*****	
Paramaka	**	
Terpides	**	*
Thraulodes	****	*****
Tikuna atramentum		*
Tikuna bilineata	*	
Traverella	***	+

(*continued*)

Table 1. (*Continued*).

Taxon	Madre de Dios	Peninsula de Osa
Ulmeritoides	**	
Leptophlebiidae: undet.		*
Oligoneuriidae		
Lachlania	*	
Polymitarcyidae		
Asthenopus	+	
Campsurus	*	

Symbols: +, one individual; *, 2–10 individuals; **, 11–50 individuals; ***, 51–150 individuals; ****, 151–300 individuals; *****, >300 individuals.

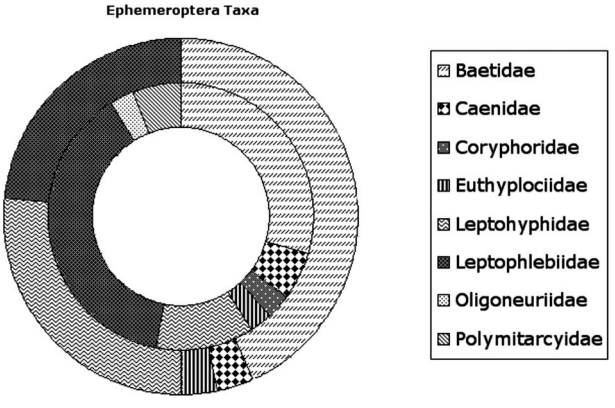


Figure 4. Taxa richness (number of genera) of Ephemeroptera in Peninsula de Osa, Costa Rica, and Madre de Dios, Peru. Outer ring: Osa; inner ring: Madre de Dios.

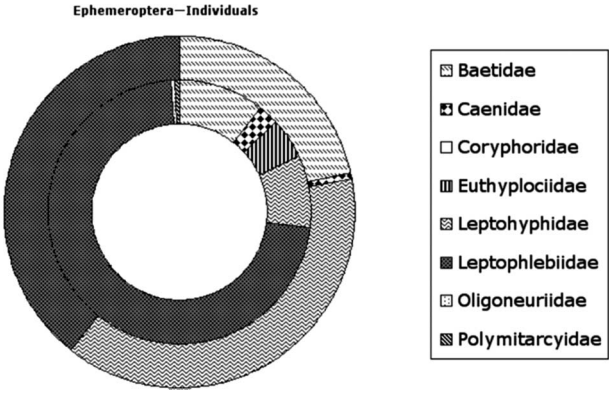


Figure 5. Relative numbers of individuals of Ephemeroptera in Peninsula de Osa, Costa Rica, and Madre de Dios, Peru. Outer ring: Osa; inner ring: Madre de Dios.

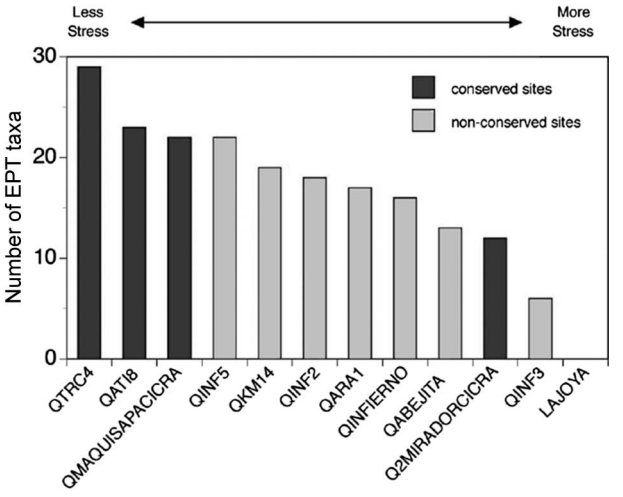


Figure 6. Number of EPT taxa collected at selected sites in Madre de Dios, Peru, from both D-net and leaf-pack samplers. Sites are arranged in descending order based on EPT richness (La Joya had 0 EPT taxa) (figure redrawn from Jackson and Flowers 2007).

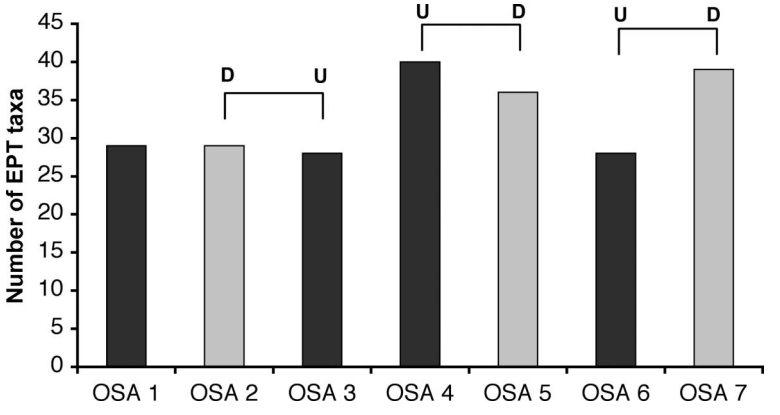


Figure 7. Number of EPT taxa collected at sites in Peninsula de Osa, Costa Rica, from D-net, Surber, and rock samplers. Brackets above connect pairs of sites: U, upstream; D, downstream. Shade of bars as in Figure 6.

The poor performance of the EPT metric in separating the Osa sites may actually be good news for the water quality of this area. Although we paired forested upstream sites with obviously disturbed (mostly deforested pasture) downstream sites, there was no apparent pattern of anthropogenic alteration of the mayfly communities. Two disturbed sites (Figure 7: sites 5 and 7) are large rivers with an abundance of microhabitats in their streambeds. This, and the generally good condition of the water, probably worked to maintain high stream diversity despite the relatively depauperate bank vegetation along the rivers. All Osa streams are subject to spates during the rainy season, which can drastically alter their beds, thus 'levelling' the differences between areas with and without human disturbance of the

riparian zone. Although the Peninsula de Osa is much more developed at present than the Madre de Dios watershed, we were unable to find any Osa streams with the high levels of pollution found in the urban site in Madre de Dios.

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