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FRESHWATER MACROINVERTEBRATE COMMUNITIES IN BALDWIN COUNTY, GEORGIA

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ABSTRACT

Freshwater ecosystems are critical habitats for maintaining biodiversity, often providing refuge for organisms especially in urban settings. Baldwin County, GA is home to many freshwater lakes that are part of the Oconee River watershed. Despite ongoing water quality monitoring, aquatic macroinvertebrates are under studied in the area. Aquatic macroinvertebrate diversity of one forested and one residential lake in Milledgeville, GA was documented for the first time. Despite low sample size, community composition was significantly different between lakes, with 27 families in Lake Laurel (forested), 44 families in Lake Oliver Hardy (residential), and only 19 families collected from both lakes. Seasonal trends revealed the highest diversity in the summer. These data provide a baseline for the potential use of monitoring aquatic ecosystem health using aquatic macroinvertebrates in Milledgeville, GA.

Keywords: central Georgia, bioindicator species, Lake Laurel, Lake Oliver Hardy, Oconee River, water quality

INTRODUCTION

Macroinvertebrates contribute to the function of freshwater systems by providing ecological functions such as nutrient cycling through shredding organic matter and water filtration. They also play a major role in bottom-up and top-down control of ecosystems through algal grazing and predation on organisms at lower taxonomic levels (Wallace et al. 1996). For example, snails (Gastropoda), caddisflies (Trichoptera), and mayflies (Ephemoptera) act as grazers (Holomuzki and Biggs 2006). Snail grazing has been found to mediate competition by decreasing shade for some macrophytes (Brönmark 1989). Amphipods (Amphipoda) and stoneflies (Plecoptera) act as shredders (Heino 2005). Shredders are known to be valuable contributors to decomposition in stream systems (Balibrea et al. 2020). Dragonflies (Odonata) are voracious predators, which apply top-down pressures on the system (Wallace et al. 1996). Macroinvertebrates are also an important food source for many fish species, some of which are commercially valuable (Wallace et al. 1996). Evaluating community composition of freshwater invertebrates can aid in the overall understanding of the ecosystems they inhabit.

Aquatic macroinvertebrates are easy to collect and are relatively abundant, making them an accessible and convenient resource for several environmental monitoring studies. One reason these organisms can be used in environmental monitoring studies is that they respond to various water pollutants and disturbances, providing an effective warning system of any decline in water quality, which is often more accurate than many chemical assessments (Shafie et al. 2017). The spatial and temporal population trends of freshwater bioindicators, such as amphipods and midge larvae, allows researchers to determine negative patterns through disturbances (Shafie et al. 2017)

Anthropogenic disturbances in freshwater streams and lakes occur more frequently in residential areas compared to forested areas. Residential areas are often highly urbanized, which can create environmental stressors on the water bodies in surrounding ecosystems, often negatively affecting native aquatic species (Brown et al. 2005). Residential areas often experience elevated rates of storm drain runoff containing pesticides, heavy metals, organic chemicals, and excess nutrients from lawns (Brown et al. 2005). These anthropogenic impacts on water quality can lead to the gradual decline and behavioral modification of several endangered populations and keystone species (Magle and Angeloni, 2008). The impacts can also lead to shifts in ecosystem function and habitat modification, that can result in further changes to macroinvertebrate species richness and biodiversity (Seidu et al. 2018). Moreover, anthropogenic disturbances can result in permanent modifications of ponds and lakes such as the alteration and cessation of flow rate or an increase in diversity in areas with open canopies (Seidu et al. 2018). Any changes impacting aquatic systems will result in species richness and diversity changes and will impact anthropogenic activities that utilize ponds and lakes.

Aquatic habitats surrounded by dense forests typically have higher water quality than those in residential areas. Forests provide high-quality water to streams and diverse aquatic habitats because of the biological, chemical, and physical characteristics of the soil (Neary et al. 2008). Root growth, as well as disturbances from animals, allow the soil to increase its porosity, which dramatically reduces the rate of surface runoff (Neary et al. 2008). This prevents streams, rivers, ponds, and lakes from being subjected to pesticides and fertilizers, which reduces the instances of eutrophication and the likelihood of the establishment of nonnative species. Within forested areas, vegetated riparian zones serve as a valuable buffer between different ecosystems. These zones act as crucial filtration systems that effectively trap and remove excessive amounts of sediment, phosphorus, and nitrogen, that would otherwise contaminate freshwater bodies through runoff (Wenger, 1999). Soil plant buffer zones have been shown to significantly decrease nitrogen and phosphorus concentrations in lentic freshwater systems (Jin et al. 2022). Moreover, these zones also have the ability to remove harmful substances such as herbicides and pesticides, thus promoting the overall health and well-being of these vital water systems. By doing so, riparian zones significantly reduce the likelihood of eutrophication events occurring and allow for freshwater ecosystems to contain a higher quality of water (Wenger, 1999).

This study compared the aquatic macroinvertebrate communities between two lakes in Milledgeville Georgia: Lake Laurel and Lake Oliver Hardy. Each lake is surrounded by different amounts of vegetation, which affects freshwater input and water drainage. Lake

Laurel is surrounded by forest habitat and is expected to have a higher water quality and aquatic macroinvertebrate diversity than Lake Oliver Hardy, which is surrounded by a residential neighborhood.

MATERIALS & METHODS

Aquatic macroinvertebrates were collected seasonally from February 2021 to November 2022 using Hester Dendy sampling devices (Figure 1) from Lake Laurel and Lake Oliver Hardy in Milledgeville, GA. One device was deployed in each lake for two weeks in November, February, May, and August for two consecutive years (eight samples in total). Invertebrates were extracted from the samplers and stored in 70% EtOH before each sample was rough sorted into morphospecies. All specimens that are likely to colonize a benthic sampler were identified to family level, with the exception of worms, which were identified to order level due to the difficulty of identification.

Figure 1. Hester Dendy sampling device.

Lake Laurel covers 17.8 acres with a perimeter of 1.1 kilometers. This lake is fed by Champion Creek which is part of the Lower Oconee sub-basin hydrologic unit (https://waterdata.usgs.gov/monitoring-location/02222500/#period=P1Y). Lake Laurel is classified as forested with vegetation surrounding the lake (Figure 2).

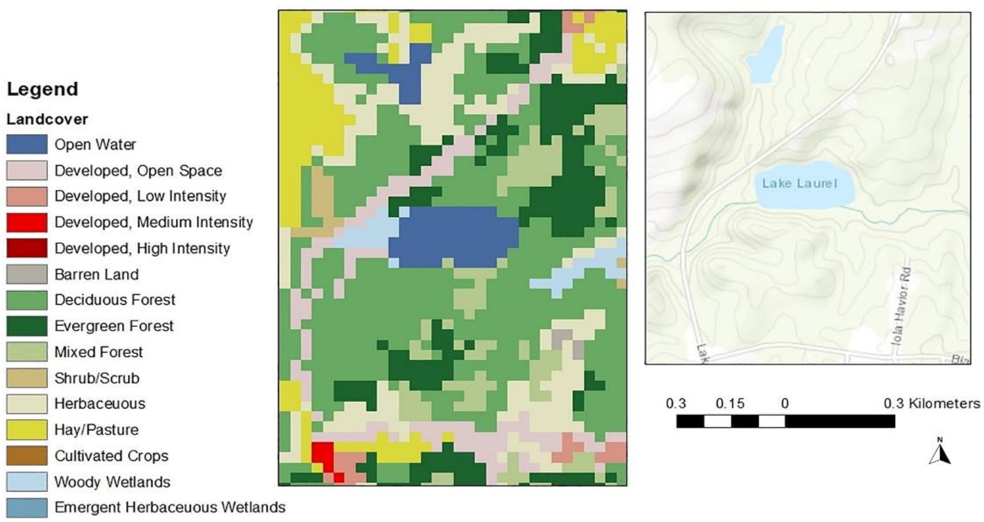

Figure 2. GIS map of Lake Laurel showing surrounding landcover (NAD 1983, UTM 17N).

Lake Oliver Hardy covers 18.3 acres with a perimeter of 1.5 kilometers. This lake is fed by surface runoff from the Oconee River. Lake Oliver Hardy is classified as residential with homes and businesses surrounding the lake (Figure 3).

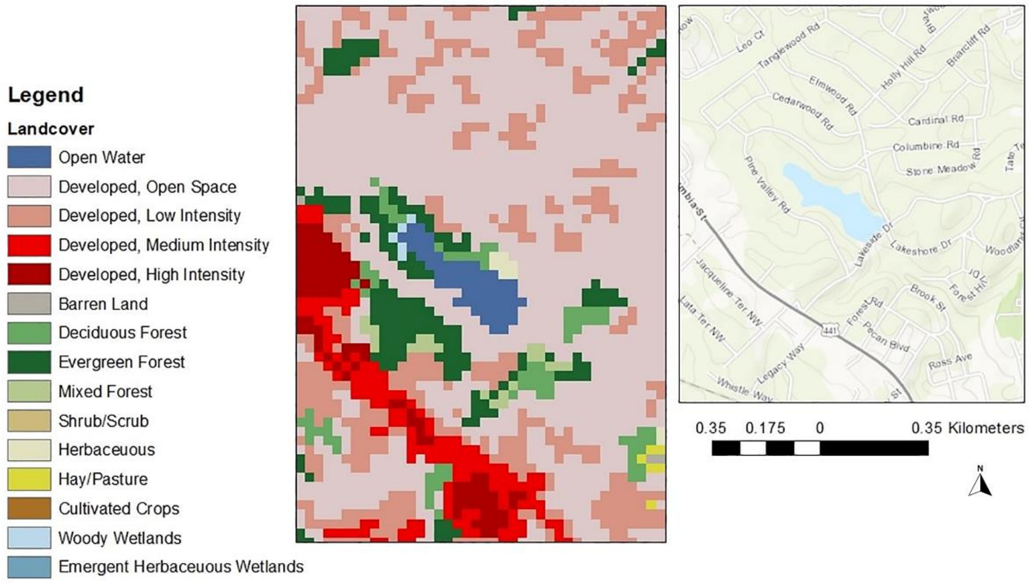

Figure 3. GIS map of Lake Oliver Hardy showing surrounding landcover (NAD 1983, UTM 17N).

Data analyses were done at both the order and family level. All worms were removed from the family-level analyses because they were identified to order level. The Pearson's Chi-Squared test of Independence was used to assess differences in abundance of families and orders at each lake. Bray Curtis Dissimilarity was plotted on a non-metric multi-dimensional scaling plot with 95% confidence ellipsoids to compare family and order composition between the two sites. Data were analyzed in R v3.6.3 (R Core Team 2020) utilizing the Vegan Package (Oksanen et al. 2022).

RESULTS

Aquatic macroinvertebrate communities from Lake Laurel and Lake Oliver Hardy are documented for the first time (Table 1). Family composition differed significantly between lakes (ChiSquare p = .0026) with no difference found between years. Water quality parameters did not differ between lakes. Over two years, specimens from 27 families were collected from Lake Laurel with midges (Chironomidae) and cladocerans (Sididae) dominating the samples (Figure 4).

In contrast, specimens from 44 families were collected from Lake Oliver Hardy with midges (Chironomidae), ostracods (Cyprididae), and amphipods (Hyallelidae) dominating the samples (Figure 4). Only 19 of the families were collected from both lakes. Diptera represented the most prevalent order at both lakes. Lake Laurel also had high numbers of cladocerans (Cladocera), while Lake Oliver Hardy had high numbers of annelids (Haplotaxida) (Figure 5).

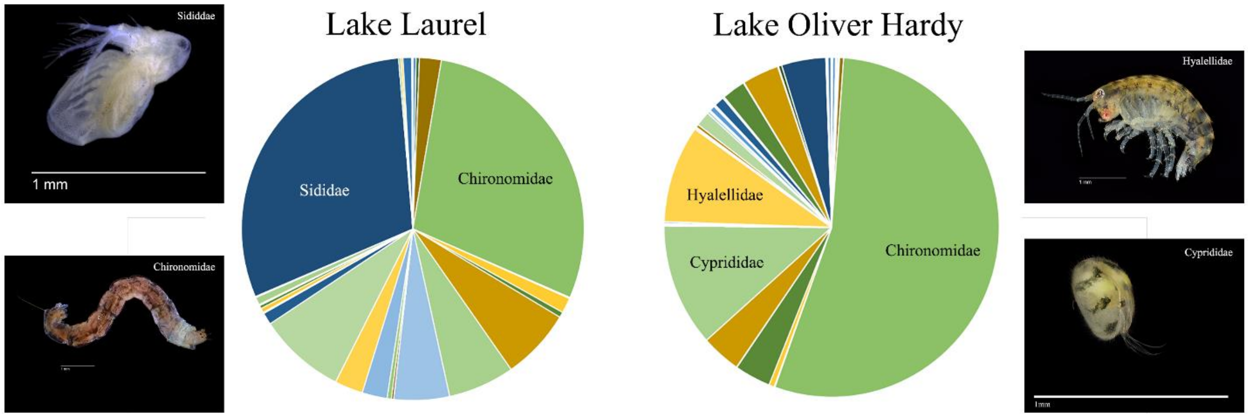

Figure 4. Abundance of macroinvertebrate families at Lake Laurel and Lake Oliver Hardy over a two-year period. Families are listed in Table 1.

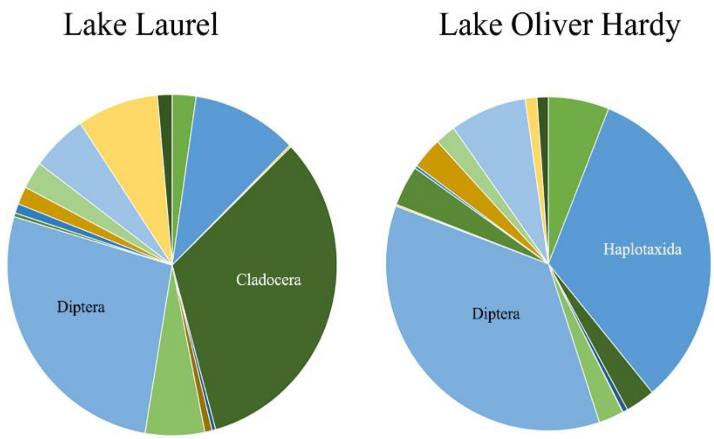

Figure 5. Abundance of Orders at Lake Laurel and Lake Oliver Hardy over a two-year period. Orders are listed in Table 1.

Order composition was similar between sites with the 95% confidence ellipsoids touching on the NMDS plot (Figure 6A). However, non-overlapping ellipsoids suggest that the sites have different community compositions at the family level (Figure 6B).

Overall, macroinvertebrate diversity was highest in the summer at both family (Figure 7A) and order levels (Figure 7B). In contrast to the combined diversity, Lake Oliver Hardy had the highest diversity in the spring due to several single representatives in additional families. Family composition was significantly different only in the fall (ChiSquare p = 0.0261), but the analyses suggest we do not have enough data to see actual differences.

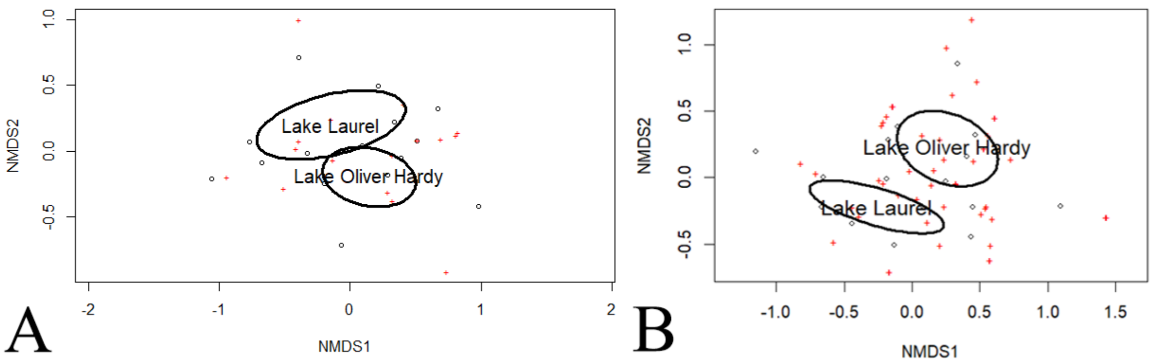

Figure 6. Non metric multidimensional scaling plots comparing macroinvertebrate diversity at Lake Laurel and Lake Oliver Hardy with 95% confidence ellipsoids. A. Order-level analysis, B. Family-level analysis.

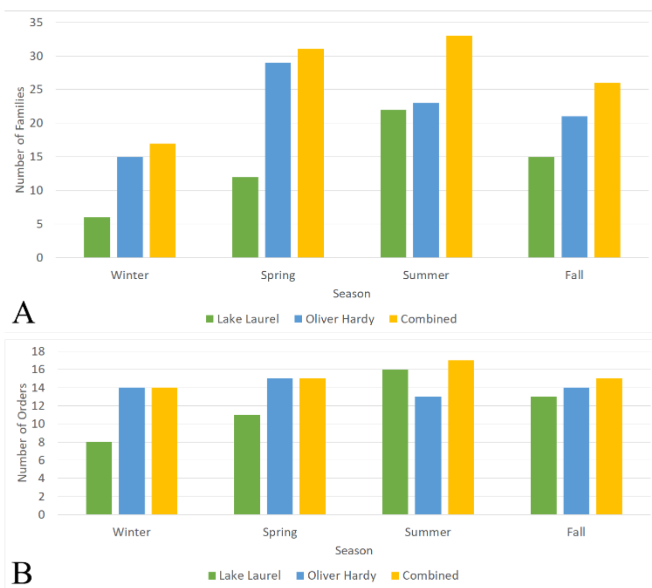

Figure 7. Macroinvertebrate Diversity at Lake Laurel, Lake Oliver Hardy, and combined by Season A. Family abundance. B. Order abundance.

DISCUSSION

The composition and richness of aquatic macroinvertebrates is undocumented in Milledgeville, GA and can yield valuable insights into both the overall health of surrounding environments and further develop an understanding of aquatic macroinvertebrates communities. This study reveals the differences between macroinvertebrate community composition at Lakes Laurel and Oliver Hardy in Milledgeville, GA, with higher diversity documented at Lake Oliver Hardy. Macroinvertebrates, because of their varying sensitivity to abiotic and biotic factors, are fundamental bioindicators, whose presence can determine the overall health of freshwater systems. The differences in land cover surrounding led us to classify Lake Laurel as forested and Lake Oliver Hardy as residential. Residential lakes can differ from forested lakes in water quality (Henny and Meutia 2014), which may explain the differences in community composition at each lake. Programs such as Georgia-Adopt-A-Stream classify organisms as either tolerant, somewhat sensitive, or sensitive based on their required dissolved oxygen levels. Other groups and organizations may use different water quality parameters such as pH (Yuan 2004).

The abundance of midges (Chironomidae) at both lakes may suggest good water quality at both study sites. The abundance of midge suggests that the plates, which contain complex surfaces and mimic wood habitats are suitable habitats for many chironomid species (Wilbanks et al. 2020). However, the presence of caddisflies (Trichoptera) at Lake Laurel might indicate a higher water quality and a minimum number of pollutants. Alternatively, Lake Oliver Hardy had high numbers of annelids (Haplotaxida) and planarians (Tricladida), which are classified as tolerant to pollution (He et al 2019; Lewis 2014). Dominance by tolerant organisms in an aquatic system generally indicates poor water quality, as they will often out-compete organisms that are more sensitive to pollutants. Organisms such as dragonflies (Odonata) and amphipods (Amphipoda) can tolerate a moderate level of pollution but are still relatively sensitive bioindicators.

Organisms such as cladocerans (Sididae) and ostracods (Cyprididae) are not generally used as bioindicators by Georgia Adopt-A-Stream but are sensitive to other factors. The presence of cladocerans is highly dependent on food sources rather than water quality (Thorp and Covich 2001). The main food source for cladocerans is phytoplankton (Fairchild, 1980), suggesting a eutrophic environment at Lake Laurel. Ostracods are sensitive to a variety of other factors such as changes in salinity, temperature, conductivity, depth, and composition of the water (Coayla-Peñaloza et al 2023).

The physical condition of these lakes can also determine the overall health of the lakes. Both lakes are classified as drainage lakes fed by the Oconee River. The Oconee River has stream inputs such as Little Fishing Creek and Tobler Creek, streams within the lower Oconee sub-basin, that have impacted fish biota due to nonpoint or unknown sources (ArcGis Hub 2022). However, further research on these lakes should consider hydrology to specify if either of these lakes can be considered as a groundwater drainage lake. If these lakes are mainly fed by streams (rather than groundwater) nutrient levels are often high and water exchange takes place more rapidly. This can result in variable water quality depending on the amount of runoff and human activity in the watershed (Shaw et al. 2004).

Despite Lake Laurel being adjacent to a forested area, the sampling site was primarily covered in tall grasses and did not have high tree coverage, creating an aquatic system exposed to more direct sunlight compared to Lake Oliver Hardy. Liner at al. (2008) showed that low amounts of sunlight due to canopy cover can result in low water temperatures, reduced growth of algal and herbaceous vegetation and low dissolved oxygen concentrations from the decomposition of leaf litter by microorganisms. Romanuk and Levings (2003) reported that aquatic arthropod abundance was eight times greater in environments that contain a significant amount of vegetation than areas that did not have vegetation. The decrease in canopy covering and increase in aquatic vegetation at Lake Laurel might explain why some sensitive insect families, such as mayflies (Ephemeroptera) and aquatic beetles (Coleoptera) were present at Lake Laurel and absent at Lake Oliver Hardy. Lake Oliver Hardy is in a residential area near a major road, both of which serve as sources of nonpoint pollutants, yet the sampling site did have some canopy cover.

A variety of studies have focused on the wetlands of Milledgeville (Liner et al. 2008), but few studies have been conducted on the several lakes of Milledgeville. An increase in sample size would allow the documentation of a definitive community composition of Lakes Laurel and Oliver Hardy. Seasonal trends would be more defined, with macroinvertebrate abundance and species composition shifting in response to changes in weather patterns. Moreover, an increase in the sample size would allow for a more accurate representation of the bioindicator organisms present at each lake. An ongoing study conducted over multiple years would clarify which families of macroinvertebrates are most abundant at each lake and would allow for higher powered statistical analysis. This is the first report of aquatic macroinvertebrates from Milledgeville, GA, demonstrating community composition differences between two lakes. Future research can expand upon the differences and continue to document the diversity of the area.

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Table 1. Numbers of macroinvertebrates collected at Lake Laurel and Lake Oliver Hardy each season. W = winter, Sp = spring, Su = summer, F = fall, 21 = year 2021, 22 = year 2022.

Order	Family	Lake Laurel								Lake Oliver Hardy							
		W21	Sp21	Su21	F21	W22	Sp22	Su22	F22	W21	Sp21	Su21	F21	W22	Sp22	Su22	F22
Amphipoda	Hyalellidae		17	2			1	6		1	20	26	75	46	113		4
Calanoida	Temoridae							2									
Cladocera	Chydoridae								1	1		1					
	Daphniidae				1		1	48	1								
	Holopediidae							1	22				5				
	Sididae			3	3	1	4		282		17	11	103				
Coleoptera	Dytiscidae														9		
	Haliplidae							3	1								
	Hydrophilidae														9		
	Scirtidae												1		9		
	Staphylinidae														1		
Collembola	Entomobryidae													1	1		
	Poduridae				7												
	Willowsia			1													
Cyclopoida	Cyclopidae				1		5	13	46	15	12	22	24	2	26		16
Diptera	Blephariceridae										3						
	Ceratopogonidae		2	15	1		1		1		6			5	1		
	Chironomidae	19	8	56	81	37	3	37	40	10	1036	168	180	77	26	25	146
	Culicidae															1	
	Sciomyzidae																1
Ephemeroptera	Caenidae									1	3						
	Ephemerellidae															2	
	Leptophlebiidae															1	
	Tricorythidae															1	
Gastropoda	Lymnaeidae															4	
	Physidae					1		1	1		2		2		2	10	51
	Planorbidae					1				4	21	1	2	2	16	3	60
	Valvatidae												1				2
Haplotaxida	-	12	34	7	26	15	3	7	4	339	871	7	70	196	50	1	21
Hemiptera	Gerridae			2													
	Naucoridae														3		1
	Veliidae			1			1	1	5				2		1		2
Odonata	Aeshnidae									3							
	Coenagrionidae			3				11			15						1
	Corduliidae							5		1	94	4		2		2	4
	Lestidae										3						

	Libellulidae												2		1	2	11
Podocopida	Cyprididae	1	15	16	4	10	14		1		154	97	24	12	63		9
Trichoptera	Hydroptilidae		6	50	3	4	3	9	5	1	30	1	6	5			
	Philopotamidae							1									
	Phryganaeidae								4								
	Polycentropodidae			1											1		
	Brachycentridae			3							1						3
	Leptoceridae										1	6					
Tricladida	-	2	6	5		5		1		3	29	1	18	45			
Trombidiformes	Hydrodromidae											3					
	Limnesiidae										1						
	Mideopsidae			2			1	8					5		16	7	2
	Oxidae										1						
	Pionidae													2			
	Unionicolidae			1			1					2		1			
	Arrenuridae						1		2		1		5		2		1
	Hydrachnidae										3	1					