

SEASONAL VARIATION IN THE CHIRONOMIDAE (DIPTERA) COMMUNITIES OF TWO FAROESE STREAMS

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Abstract

Seasonal variation of freshwater invertebrate communities is strongly influenced by abiotic factors including temperature and precipitation which, in turn, are predicted to be affected by climate change. It is important to study these effects, not least since they may affect higher trophic levels and ecosystem dynamics.

Our aim with this study was to compare the seasonal variation of the community composition of Chironomidae (Diptera) in two streams in the Faroe Islands and to see how this related to abiotic factors. Additionally, we studied the life cycle of *Tvetenia calvescens* (Edwards 1929), the dominant species in the streams. For this purpose, Chironomidae larvae were collected from two adjacent streams of different sizes in the Faroe Islands at regular intervals over the course of 15 months.

We found that *Tvetenia calvescens* was the most abundant species in the streams, followed by *Eukiefferiella minor* (Edwards 1929). The community composition varied in different months and between the two streams and was shaped by water temperature and flow velocity.

Larval densities were generally higher in the smaller stream than in the larger stream, but densities were not correlated with water temperature, monthly temperature amplitude or flow velocity.

We found that in both streams *Tvetenia calvescens* was bivoltine with adult emergence in May/June and September/October.

Introduction

Aquatic invertebrate communities are subject to seasonal variation in various biotic and abiotic factors. These variations are reflected at the higher trophic levels feeding on invertebrates (Kreiling et al. 2021) and aquatic invertebrates can constitute an important part of the diet of surrounding terrestrial fauna (Gratton et al. 2008). In this way, seasonal variation may affect not only the ecology

of the aquatic system but also the surrounding terrestrial ecosystem.

Temperature is commonly cited as influencing seasonal variation in aquatic invertebrate communities (Soulsby et al. 2001, Bottazzi et al. 2011, Kreiling et al. 2021). However, it might not be the water temperature per se which determines community composition but rather the temperature variability, i.e., the daily or annual amplitude of the temperature. The invertebrate communities in Alpine spring brooks, for example, change due to a decreased annual variability in water temperature along an altitudinal gradient from lowland to high alpine springs (von Fumetti et al. 2017).

The basis of community changes are the responses of species to biotic and abiotic factors. One well known response is the growth and development rate of Chironomidae larvae, which is influenced by temperature (Taylor 1981, Pinder 1986, Reynolds and Benke 2005) and can determine whether a species produces one or several generations annually (Oliver 1971). Even populations of the same species inhabiting different water bodies in close vicinity may show variation in their voltinism, as a study on *Chironomus pseudothummi* Strenzke 1959 in two small ponds in England showed (Smith and Young 1973). It is likely that fluctuations in temperature can induce variation in voltinism, both in neighbouring and within the same water body (Tokeshi 1995, Hannesdóttir et al. 2012). Other variables such as variations in food supply, water depth, or photo period may likewise influence the voltinism of chironomid species (Tokeshi 1995).

In the Faroe Islands, streams are subject to a high temperature variability in addition to an altitudinal temperature gradient. The Faroe Islands are an island group consisting of 18 mountainous islands situated at 62° N, 7° W in the North Atlantic Ocean. Streams in the Faroes have very small catchment areas, typically between 0.1 and 1 km² and the

main stream channels reach only lengths from several hundred meters to 7.3 km for the longest river (Hansen and Gíslason 2010). Most of the stream channels are situated below 200 m asl, and more than three quarters are on sloping surfaces, i.e., fast flowing mountainside channels. The basaltic bedrock is mostly impermeable to water. At the same time, precipitation is high with some places having an average annual rainfall of more than 4000 mm (Hansen and Gíslason 2010). Consequently, discharge of streams fluctuates greatly between high water masses after heavy rainfalls and falling dry during the rare drier periods (Hansen and Gíslason 2010). Despite originating in springs, the Faroese streams are highly influenced by precipitation and show thus characteristics of run-off streams in which water temperature follows the ambient air temperature (Kiilerich 1928, Hansen and Gíslason 2010). As the dark streambeds can absorb energy from the sun, water temperature in shallow streams can occasionally even reach several degrees above ambient air temperature (Hansen and Gíslason 2010).

Despite the numerous streams, ponds and lakes in the Faroes only few studies have been conducted which focus on freshwater ecosystems (Christoffersen 2002). The aquatic invertebrate fauna of the Faroe Islands is species poor, as a result of the stochastic distribution of freshwater fauna on the North Atlantic Islands (Gíslason 2005, Gísla-

son 2021). Whereas in most parts of the world, a large proportion of the invertebrate fauna are EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa, Ephemeroptera and Plecoptera as well as Odonata are entirely absent in the Faroese streams (Hansen and Gíslason 2020). Trichoptera are present with 20 species belonging to seven families (Hansen and Gíslason 2020). By far the most species-rich taxon in Faroese freshwaters is Chironomidae (Diptera) with 72 recorded species in 42 genera (Gíslason 2005, unpublished data).

The Faroe Islands are predicted to be affected by climate change (Pachauri et al. 2015). In this regard, it is important to study the effects of temperature and precipitation on freshwater invertebrate communities, especially since Chironomidae have been shown to be excellent bioindicators (Molineri et al. 2020) and freshwater invertebrate communities are being used to evaluate freshwater quality (Begum et al. 2022).

The aim of this study was to compare the seasonal variation in chironomid community composition and the life cycle of *Tvetenia calvescens* (Edwards 1929) as the dominant species in two adjacent streams differing in their environmental characteristics, namely water temperature and flow velocity. We proposed the following predictions:

I. We expect variation in the density and community composition of chironomids within each stream

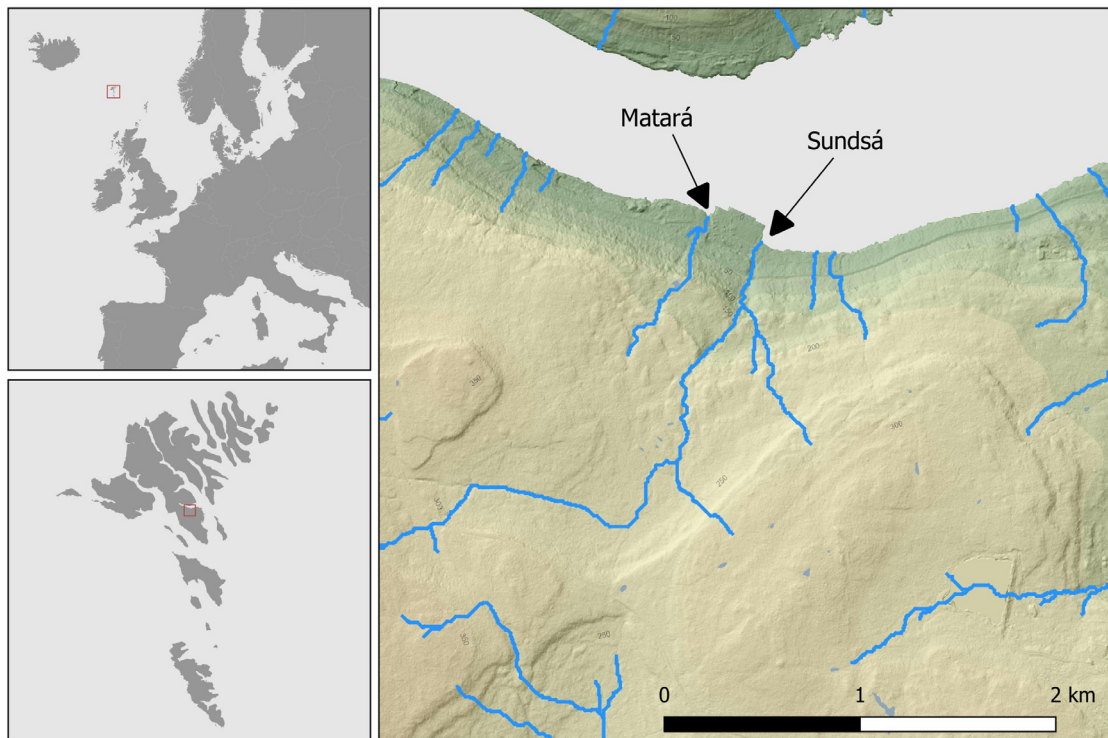


Figure 1. Map of the Faroe Islands with the location of the two sampled streams, Matará and Sundsá.

throughout the year, in accordance with seasonal variation of water temperature and flow velocity.

II. We expect differences in the chironomid community of the two streams. The community of the larger stream should be more stable (i.e., less seasonal variation), due to less variation in temperature and flow velocity.

III. We expect differences in the life cycle of *Tvetenia calvescens* in the two streams. One generation or a more stretched out life cycle in the smaller and less stable stream compared to two generations or a shorter life cycle in the larger and more stable stream.

Material and Methods

The two study streams are located on the island Streymoy in the Faroe Islands, situated on a slope above the main road and about 8 kilometres north of the capital Tórshavn. Although the streams are just 350 m apart in neighbouring water basins, they differ in size, average discharge, and substrate. The smaller stream, Matará (Lat. 62.047937N, Long. -6.849097W), has a main channel length of 1000 m, a maximum width of 15 m, runs from 230 m asl to the sea, and has an average discharge of 10 L/s. The larger stream, Sundsá (Lat. 62.045890N, Long. -6.843184W), has a main channel length of 3800 m, a maximum width of 20 m, runs from 350 m asl to the sea, and has an average discharge of 200 L/s (Fig. 1). Both streams are relatively steep at the sampling locations leaving nearly naked bedrock as substrate which to some degree is covered by moss and diatoms. Matará, the smaller stream, has a larger proportion of moss and diatom cover and at one point within the sampling stretch a depression which can contain some sand.

From both streams, benthic invertebrates were collected monthly between March 2009 and May 2010. At each sampling date, invertebrates were collected at ten locations along each stream, using a Surber sampler with an area of 0.0196 m² and a mesh size of 200 µm. Invertebrates were stored in 70 % ethanol. To describe the physico-chemical properties of the two streams, water temperature, pH, flow velocity, depth, and conductivity were measured at each location at the time of sampling. Conductivity was measured using EcoSense EC300 (YSI Environmental 2003) and pH was measured using Orion 230A (Orion Research Inc. 2000). Water temperature was measured with both the pH and conductivity meter, and the mean was used in cases where values differed between measurements. Data on air temperature was obtained from a nearby (1 km) weather station operated by Landsverk (the Faroese public building and transportation authority).

The water temperature in Sundsá and Matará, and the air temperature next to the two streams was measured once every hour by TinyTag temperature loggers from May 2010 to May 2011. The loggers were unavailable to us from the start of the study which explains the mismatch between the invertebrate sampling and the temperature data by a year. The monthly amplitude of the air temperature was calculated by averaging the differences between the daily minimum temperature and the daily maximum temperature over a month.

The invertebrates in the Surber samples were sorted under a dissecting stereomicroscope and counted. From each Surber sample a random subsample of approximately 50 chironomid larvae were mounted on glass microscope slides and fixed in Hoyer's mounting medium (Anderson 1954), unless the number of individuals in the sample was close to or less than 50 in which case all chironomid larvae were mounted. Mounted Chironomidae were identified, and the total number for each taxon in the sample was calculated based on its proportion in the subsample. Identification to lowest possible taxonomic level was done under a Leica DMLB compound microscope (Leica Microsystems, Mannheim, Germany). Chironomid larvae were identified using keys by Wiederholm (1983) and Schmid (1993). Before mounting, the larval head widths were measured under a Leica MZ6 stereo microscope (Leica Microsystems, Mannheim, Germany) with 0.025 mm accuracy using a graticule ocular in the microscope. The head capsule widths were compared with those found by Schmid (1993) and based on these the larvae were grouped to instars.

Due to resource limitations, we were unfortunately not able to process Chironomidae in the samples for all the months. Thus, we included only eight months for Sundsá and 12 for Matará. For the same reason, not all ten Surber samples collected at each sampling time were processed. In some instances, invertebrates were identified from only every second Surber sample. The average of all processed Surber samples per month and stream was used to characterize density and community composition of Chironomidae larvae over the year.

Statistical analysis was done using the software R (version 4.2.1, R Core Team 2022). Correlations between environmental variables were assessed by pairwise scatterplots and correlation coefficients using the function `chart.Correlation` in the package `PerformanceAnalytics` (Peterson and Carl 2020). Furthermore, the variance inflation factors (VIF) were obtained using the function `corvif` (Zuur et al. 2009). All resulting VIF values were below 5, indicating that there was no collinearity between

variables, and thus all environmental variables were retained for analysis. The correlation between density of Chironomidae larvae and water temperature, monthly temperature amplitude, and flow velocity was tested with linear regressions (function `lm` in the `stats` package).

The differences in the chironomid community composition between the two streams and among sampling months were summarized with Bray-Curtis distances. The dependency of those differences on the explanatory variables (water temperature, average monthly temperature amplitude, conductivity, pH, depth, flow velocity, sampling month, and stream) were analysed by running a permutational multivariate analysis of variance (`adonis2` function in the `vegan` package; Oksanen et al. 2022). The ordination of samples based on the Bray-Curtis distances, and the association of the environmental variables to the main axes were visualised with nonmetric multidimensional scaling (NMDS) using the functions `metaMDS` and `envfit` in the `vegan` package.

Results

Water temperature varied from 2°C in winter to 18°C on sunny summer days. The water temperature of both streams followed ambient air temperature (Fig. 2). Average monthly amplitudes in air temperature ranged from 2.5°C in August 2009 to 4.2°C in April 2010. The water temperature in the smaller stream Matará was more stable over the year with an average of 9.3±3.9°C, whereas Sundsá had an average temperature of 10.0±4.4°C (Table 1). The flow velocity in Matará was also more stable with an average velocity of 0.8 ±0.2 m s⁻¹ whereas Sundsá had an average flow velocity of 1.0±0.4 m s⁻¹ (Table 1).

Average chironomid densities ranged from 117 individuals/m² in Sundsá in September 2009 to 7,331 individuals/m² in Matará in May 2010. Densities were higher in the smaller stream Matará than in the larger stream Sundsá for all months except May 2009. Density of Chironomidae larvae was not correlated with water temperature (adjusted R-squared = 0.1653, F-statistic = 3.971, p-value = 0.066, Fig. 3), monthly temperature amplitude (adjusted R-squared = 0.0036, F-statistic = 1.069, p-value = 0.3149) or flow velocity (adjusted R-squared = 0.1350, F-statistic = 3.030, p-value = 0.107).

We found a total of 23 chironomid taxa, identified to genus or species level (Table 2). In some cases, congeneric species were combined under a higher taxonomic level to be able to include individuals into the analysis for which identification to species level was not possible, e.g., early instars (Table 2). This resulted in 20 taxa being included in the analysis. Both streams were dominated by chironomids of the subfamily Orthocladiinae, with *Tvetenia calvescens* being the most abundant species, followed by *Eukiefferiella minor* (Edwards 1929). Chironomid communities differed between Matará and Sundsá, with a higher proportion of *Tvetenia calvescens*, *Synorthocladius semivirens* (Kieffer 1909), and *Rheocricotopus effusus* (Walker 1856) in Matará (Fig. 4) and a higher proportion of *Dia-mesa* spp. Meigen 1835 and *Orthocladius frigidus* (Zetterstedt, 1838) in Sundsá (Fig. 5). *Eukiefferiella claripennis* (Lundbeck 1898), *Limnophyes* sp. Eaton 1875, *Trissopelopia* sp. Kieffer 1923, and *Macropelopia* sp. Thienemann 1916 were found in Matará but not in Sundsá (Table 2).

Chironomid community composition was shaped by water temperature, conductivity and flow ve-

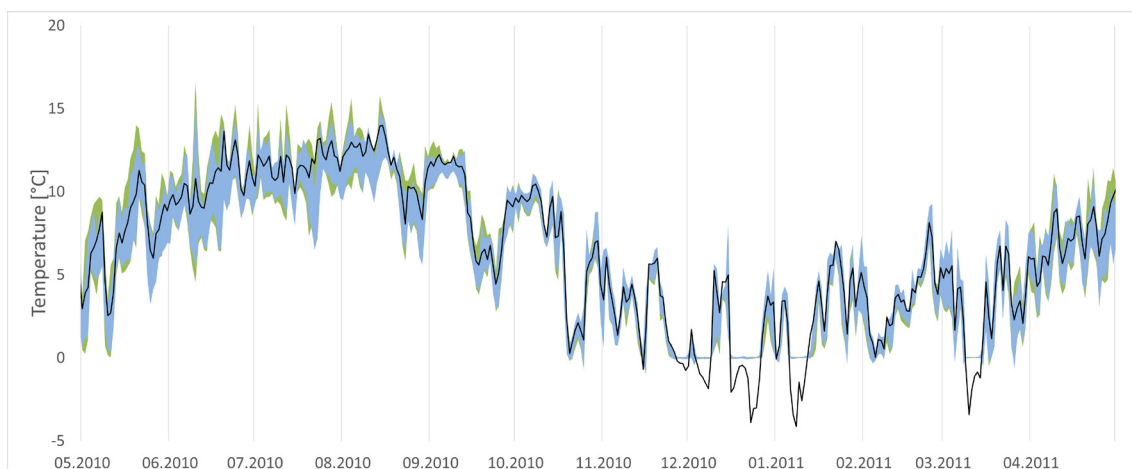


Figure 2. Daily temperature changes in Sundsá and Matará over a year. Water temperature of Sundsá (in green) and Matará (in blue) follow air temperature (black).

Table 1. Attributes of the two studied streams.

Stream	Basin (km ²)	Maximum altitude (m asl)	Sample altitude (m asl)	Longitude	Latitude	Length (m)	Maximum width (m)	Average velocity (m s ⁻¹)	Average water temperature (°C)
Matará	0.38	230	40	62.048	-6.849	1000	15	0.8	9.3
Sundsá	3.49	350	60	62.046	-6.843	3800	20	1	10.0

locity and differed between the two streams (Table 3, Fig. 6). Although month was not a significant variable in the analysis, there was seasonal variation in the chironomid communities in both Matará (adjusted R-squared = 0.0270, F-statistic = 2.99, p-value = 0.002) and Sundsá (adjusted R-squared = 0.0274, F-statistic = 3.88, p-value = 0.001). However, communities were more similar in different months within a stream than in the same month between streams, with the exception of November 2009 in Matará and September 2009 in Sundsá, which group with the other stream, respectively (Fig. 6a). *Rheocricotopus effusus*, *Cricotopus* sp. van der Wulp 1874 and the Tanytopodinae *Trissopelopia* sp. and *Macropelopia* sp. were associated with relatively high temperatures and high conductivity, whereas *Diamesa* spp., *Pseudodiamesa* sp. Goetghebuer 1939 and *Eukiefferiella minor* (Edwards, 1929) were associated with high flow velocity (Fig. 6b).

Life cycle patterns of *Tvetenia calvescens* were similar in the two streams (Fig. 7). The measurements of head capsule widths did not allow for a clear separation into instars I and II, and II and III. However, instar IV did clearly separate from instar III. Despite some overlap it seems that there are two generations with adult emergence in May/June and September/October in both streams (Fig. 7).

Discussion

Community composition of chironomids in the two streams varied throughout the year as we had predicted (I.) and was associated with water temperature. Density, on the other hand and contrary to our prediction, was not influenced by water temperature. Neither temperature amplitude nor flow velocity affected density or community composition.

We had furthermore predicted (II.) that there were differences in the chironomid communities between the two streams, which was supported by our results. Larval densities were much higher in the smaller stream (Matará) than in the larger stream (Sundsá) and community composition in the samples differed more between the two streams than between sampling months. We had expected that the community of the larger stream would be more stable than that of the smaller stream but found the opposite.

Lastly, we predicted (III.) differences in the life cycle of the dominant chironomid species, *Tvetenia calvescens*, in the two streams. This hypothesis was not supported by our results, showing the same life cycle pattern in both streams.

Although Chironomidae was the dominant taxon in the invertebrate communities of the streams, their

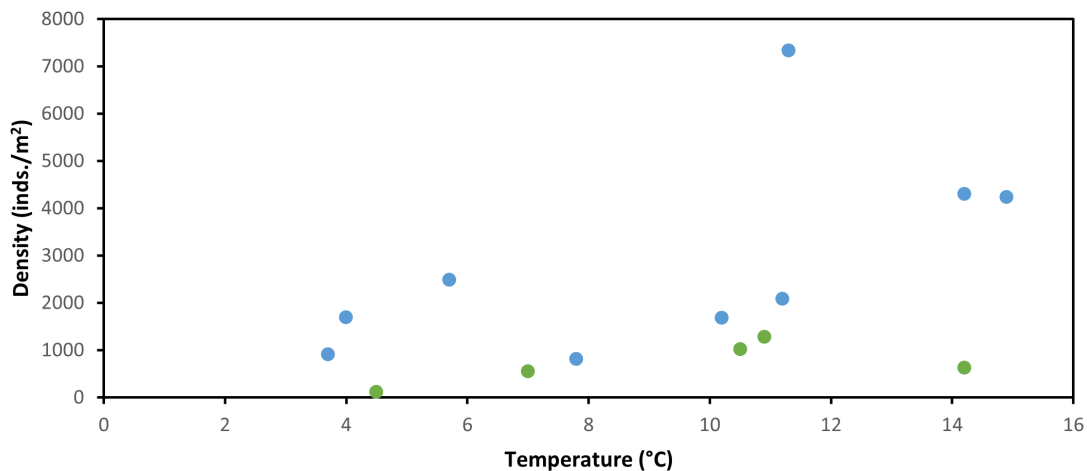


Figure 3. Average density of chironomid larvae per sampling occasion in relation to water temperature. The larger stream Sundsá in green and the smaller stream Matará in blue dots. Standard Deviation lies between 141 and 5944 but is not shown for the sake of clarity.

Table 2. Chironomid species found in Matará and Sundsá in this study. Species acronyms indicate the taxa included in the analysis and are used in Figures 4, 5, and 6.

Species	Acronym	Matará	Sundsá
Podonominae			
<i>Parochlus kiefferi</i> (Garrett 1925)	Pak	x	x
Tanypodinae			
<i>Trissopelopia</i> sp. Kieffer 1923	Tri	x	
<i>Macropelopia</i> sp. Thienemann 1916	Mac	x	
Diamesinae			
<i>Diamesa</i> spp. Meigen 1835	Dia	x	x
<i>Diamesa bohemani/zernyi</i> species group			
<i>Diamesa bertrami/latitarsis</i> species group			
<i>Pseudodiamesa</i> sp. Goetghebuer 1939	Pse	x	x
Orthoclaadiinae			
<i>Chaetocladius</i> spp. Kieffer 1911	Cha	x	x
<i>Chaetocladius dentiforceps</i> species group			
<i>Chaetocladius piger</i> species group			
<i>Cricotopus</i> sp. van der Wulp 1874	Cri	x	x
<i>Eukiefferiella claripennis</i> (Lundbeck, 1898)	Euc	x	
<i>Eukiefferiella minor</i> (Edwards, 1929)	Eum	x	x
<i>Eukiefferiella</i> sp. Thienemann 1926	Euk	x	x
<i>Limnophyes</i> sp. Eaton 1875	Lim	x	
<i>Metriocnemus eurynotus</i> (Holmgren, 1883)	Mee	x	x
<i>Metriocnemus</i> sp. van der Wulp 1874	Met	x	x
<i>Orthocladus</i> spp. van der Wulp 1874	Ort	x	x
<i>Orthocladus frigidus</i> (Zetterstedt, 1838)			
<i>Orthocladus oblidens</i> (Walker, 1856)			
<i>Rheocricotopus</i> sp. Thienemann & Harnisch 1932	Rhe	x	x
<i>Synorthocladus semivirens</i> (Kieffer 1909)	Syn	x	x
<i>Thienemanniella</i> sp. Kieffer 1911	Thi	x	x
<i>Tvetenia calvescens</i> (Edwards 1929)	Tve	x	x
Chironominae			
<i>Tanytarsus</i> sp. van der Wulp 1874	Tan	x	x
<i>Micropsectra</i> sp. Kieffer 1909	Mic	x	x

densities were low compared to densities of chironomid larvae in streams elsewhere (Nolte 1991). Both streams have a solid basaltic streambed with little loose material and aquatic vegetation, as is typical for streams on slopes in the Faroes (Hansen and Gíslason 2010). The scarcity of sand, gravel, submersed macrophytes and mosses, and therefore limited microhabitats and suitable substrate, might explain the low chironomid densities (Ilmonen and Paasivirta 2005). The recorded difference between the streams, with higher density in Matará, can be attributed to the higher moss and diatom cover offering more microhabitats for the chironomids. However, densities were comparable to those in

glacial and non-glacial high mountain streams with similarly little aquatic vegetation (Lods-Crozet et al. 2001, Lencioni and Rossaro 2005). Neither water temperature, monthly temperature amplitude or flow velocity influenced the chironomid density. Similarly, densities of Chironomidae larvae in glacial streams in different regions of Europe varied a lot between sites, seemingly not dependent on water temperatures and flow velocities (Lods-Crozet et al. 2001).

Despite the close vicinity of the streams and overall similar environmental conditions, the chironomid communities differed. Both streams were inhabited by typical cold-stenothermal taxa such as

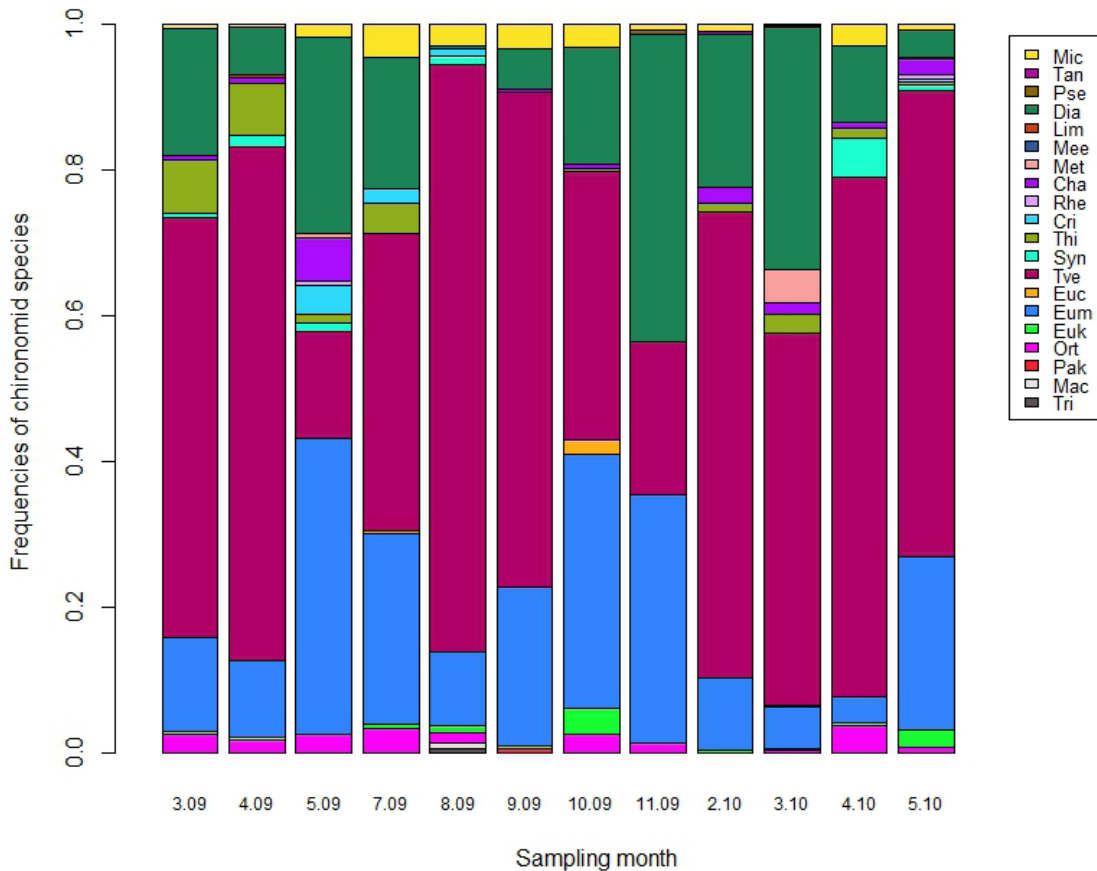


Figure 4. Seasonal variation of the chironomid community of Matará. Bar labels refer to month and year. Species acronyms as in Table 2.

Diamesa spp. and *Orthocladus frigidus* and taxa adapted to high flow velocity like *Tvetenia calve-scens*, *Synorthocladus* sp., and *Rheocricotopus effusus*. However, the former two taxa were relatively more abundant in the larger stream Sundsá whereas the latter three were more abundant in the smaller stream Matará. In addition to these differences in relative abundances of taxa, four species were exclusively found in the smaller stream Matará, including the only two species of Tanypodinae, *Trissopelopia* sp. and *Macropelopia* sp., found in the study. Thus, even streams which are similar in geographical location and environmental variables can harbour different communities which consequently might be differently affected by seasonal changes. The relatively more stable environmental conditions (i.e., water temperature and flow velocity) of the smaller stream Matará compared to the larger stream Sundsá was reflected in a more stable Chironomidae community with less seasonal variation in its composition. Matará also had a slightly higher taxa richness than Sundsá. This supports the point that small water bodies can contribute

much to regional biological diversity and ecosystem services (Biggs et al. 2017).

Water temperature strongly influenced separation of chironomid communities in the ordination plot. Similar results were found in comparable studies of aquatic communities, for example in streams in the Cairngorm Mountains, Scotland (Soulsby et al. 2001) and in boreal springs in Finland (Virtanen et al. 2009). Likewise, flow velocity contributed to the variance in the ordination and was slightly higher in the larger stream, Sundsá.

Except for larvae of *Rhyacophila dorsalis* (Curtis 1834) (Trichoptera) present in both streams, there is a distinct absence of large predators in the two streams studied. The Tanypodinae recorded from one sample in Matará (Table 2) accounted for less than 0.5% of the individuals in that sample and can not be expected to have an influence on the overall community. Common predators in aquatic habitats in the Faroes are water beetles in the family Dytiscidae (Hansen and Kreiling 2022) as well as Brown trout (*Salmo trutta* Linnaeus 1758) and

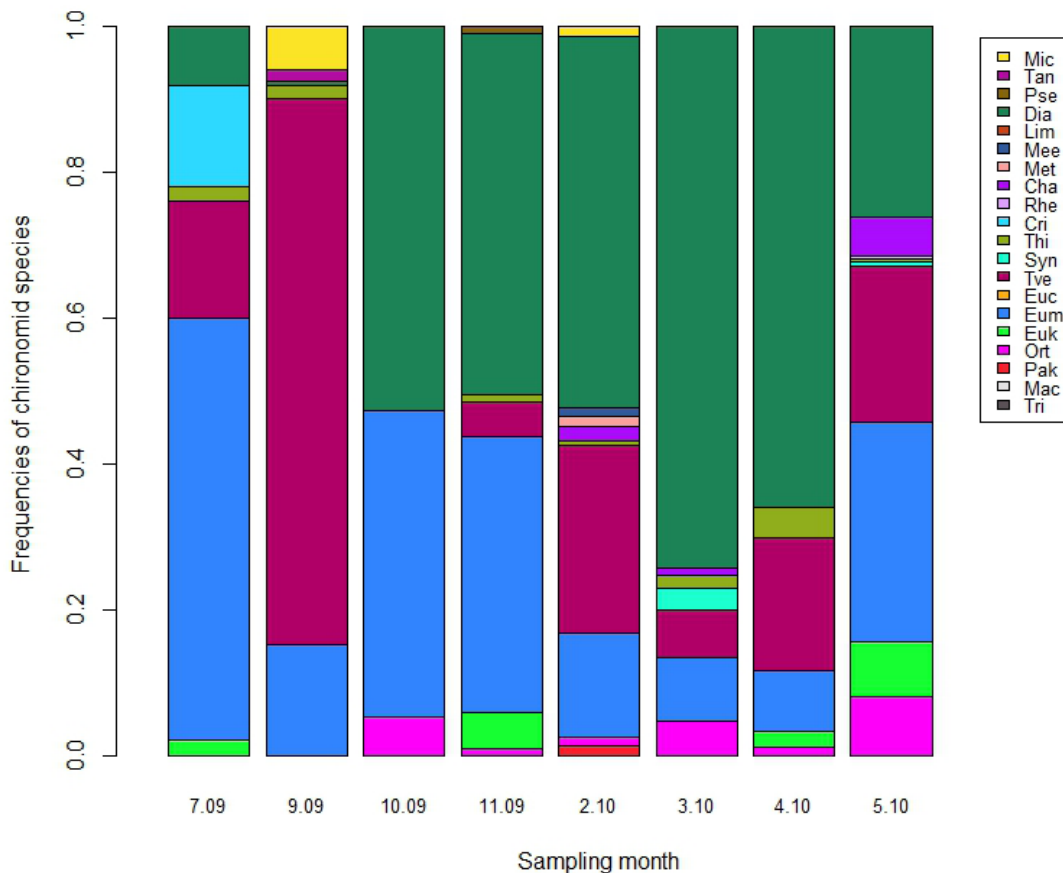


Figure 5. Seasonal variation of the chironomid community of Sundsá. Bar labels refer to month and year. Species acronyms as in Table 2.

Three-spined stickleback (*Gasterosteus aculeatus* Linnaeus 1758) (Christoffersen 2002). These taxa are, however, absent in steep and shallow streams such as Matará and Sundsá. Amphibia and Odonata which are common aquatic predators elsewhere in Europe, are not natively occurring in the Faroes at all. The observed seasonal variation and between-stream differences in the chironomid community composition is thus not likely to be a result of selective predation via top-down regulation (Kreiling et al. 2021).

In both streams, the tube-building *Tvetenia calvescens* (Orthocladiinae) was the dominant Chironomidae species and showed similar life cycle pattern with two generations per year. Based on the occurrence of instar IV larvae, adult emergence supposedly happened during May in the first generation with over-wintering larvae and in July for the second, shorter summer generation. In a study on seasonal variation of Chironomidae in a small stream in Germany, Nolte (1991) found the highest densities of *Tvetenia* larvae in June. In that

stream, there seemed to have been only one generation with over-wintering larvae which showed up early in the year in the samples (Nolte 1991). Unfortunately, we lack data for Matará and Sundsá in June in our study but considering abundances in months for which data is available, *Tvetenia* abundances in both streams peak in May and August/September (Figs. 4 and 5). It is documented that Chironomidae develop slower and have longer life cycles in colder environments - even stretching one generation over seven years in extreme cases (Butler 1982) - whereas the same species can complete several generations a year in temperate regions (Pinder 1986). Although far from being this extreme, the uni- versus bivoltinism of *Tvetenia* in Nolte's (1991) compared to our study could be due to differences in stream water temperatures. In the present study, average stream temperatures (9.3°C and 10.0°C) were higher than in the small stream (7.6-8.2°C) investigated by Nolte (1991). Up to five generations a year have been recorded for the species from English rivers (Tokeshi 1986).

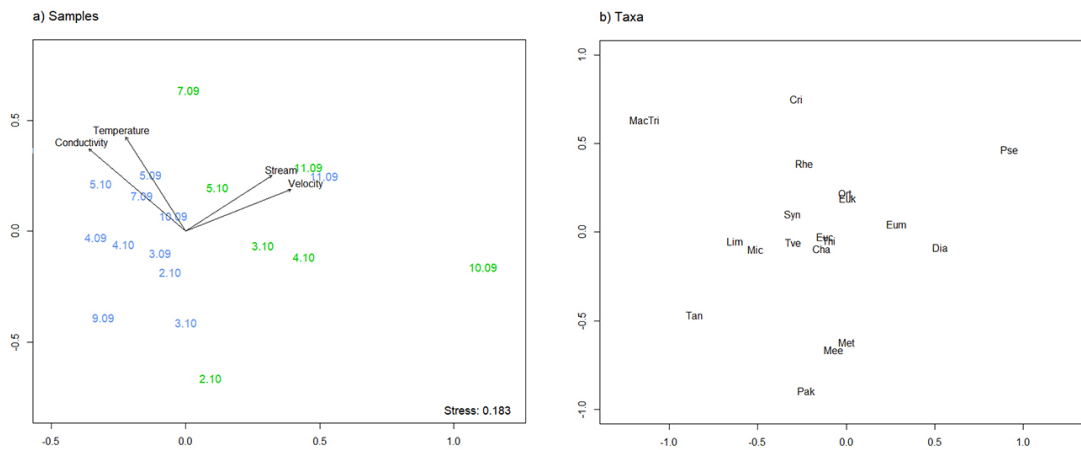


Figure 6. Non-metric multidimensional scaling (NMDS) plots illustrating the distribution of (a) communities and (b) Chironomidae taxa in the larger stream Sundsá (green) and smaller stream Matará (blue). Significant associations ($p < 0.05$) of the environmental variables to the axes are shown with arrows. Taxa acronyms are listed in Table 2.

Although we did not attempt to analyse life cycles of other species, we can conclude a few general seasonal patterns. Larvae of *Micropsectra* sp. were most abundant in late summer. *Metriocnemus* spp. was mainly found in winter and spring which corresponds with the findings of Nolte (1991). Abundances of *Eukiefferiella* minor peaked in May but larvae were present in fairly even numbers all year round. *Diamesa* spp. reached their highest abundances early in the year, in February and March and then again as a presumably second generation in July. Both observations concur with Nolte's study, which found an even distribution for *Eukiefferiella* across the year and an early occurrence for *Diamesa* (Nolte 1991). Likewise, emergence of *Eukiefferiella* minor were observed all year round in a 13.3°C warm spring-fed stream in Iceland whereas in a colder (5.3°C) neighbouring stream emergence occurred mainly in May (Hannesdóttir et al. 2012).

Lotic communities have been shown to respond to climatic variables which can cause changes at the

ecosystem level (Jourdan et al. 2018). Temperature and precipitation are impacted by climate change (Pachauri et al. 2015) and our results show that these variables (precipitation through flow velocity) shape Chironomidae communities. This study did not aim to directly relate freshwater invertebrate dynamics to climate change but considering that Chironomidae are the most abundant benthic invertebrates in streams, climate change can affect both freshwater and terrestrial ecosystems in the Faroe Islands.

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Table 3. Dependence of chironomid community composition on environmental variables. Asterisks behind p-values indicate level of significance as * <0.05 , ** <0.01 .

Variable	NMDS1	NMDS2	r ²	p-value
Stream	0.742	0.671	0.472	0.045 *
Month	0.550	0.835	0.416	0.067
Temperature	-0.460	0.888	0.642	0.003 **
Temperature amplitude	-0.988	-0.156	0.215	0.288
Conductivity	-0.699	0.715	0.743	0.002 **
pH	-0.492	-0.871	0.033	0.846
Depth	-0.218	0.976	0.089	0.647
Velocity	0.880	0.475	0.507	0.029 *

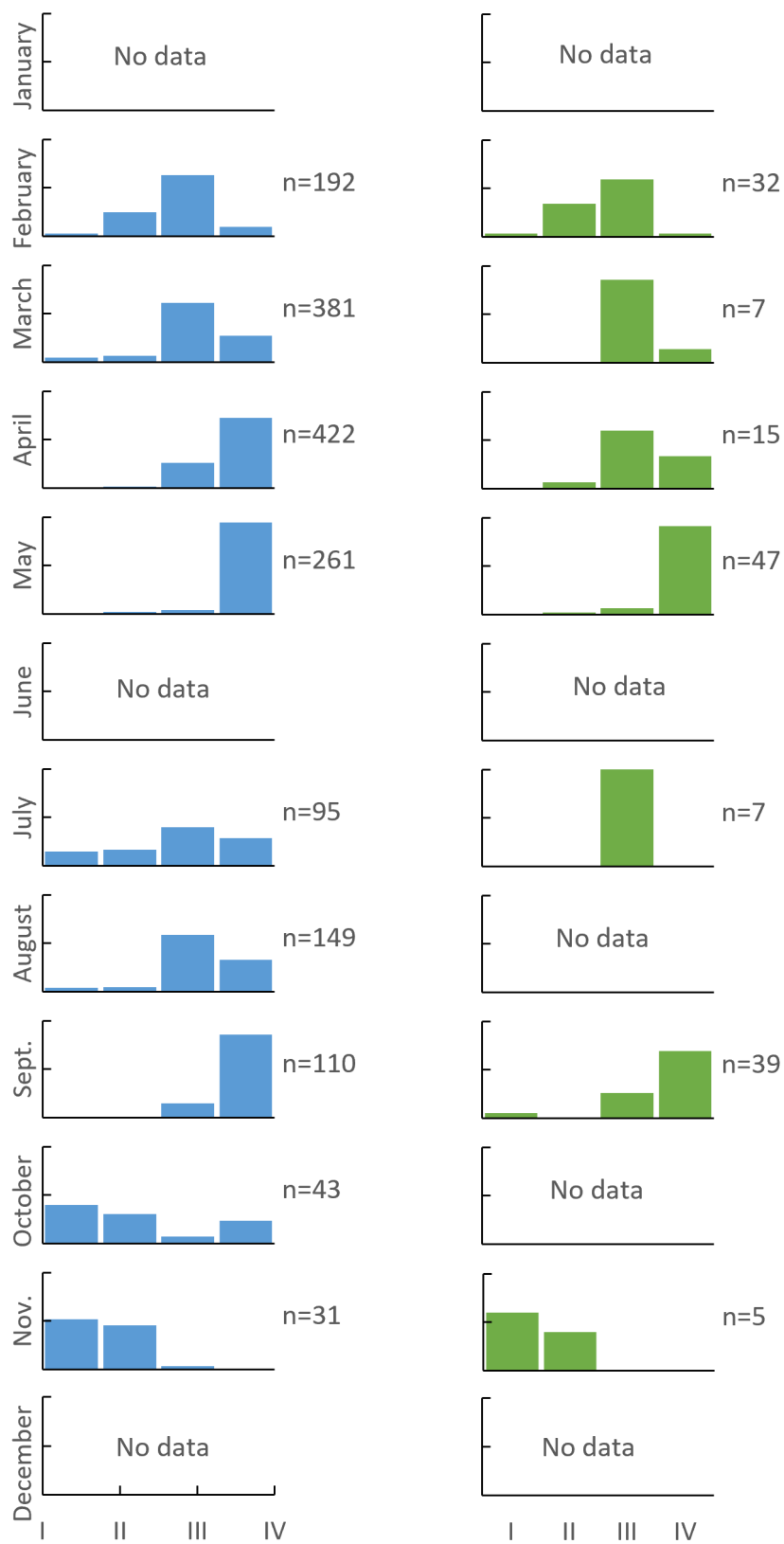


Figure 7. Relative abundance of *Tvetenia calvescens* life stages (instars I, II, III and IV) in the smaller stream Matará (blue) and larger stream Sundsá (green). Black lines indicate emergence of adults.

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