Black Flies of the Danube (Diptera, Simuliidae)

Gunther Seitz: IAD, Expert Group Leader "Saprobiology", District Government of Lower Bavaria, Landshut, Germany, e-mail: gunther.seitz@reg-nb.bayern.de

Introduction - Biology of Black Flies

There is hardly any other group of insects that is better suitable for the biological indication of running waters than the black flies family comprising 2000 species worldwide. The aquatic life stages are strongly associated with running water habitats; the larvae's special way of living makes it possible to settle running waters of all geographical latitudes, whether polar brooks that are only ice free for a few weeks, subtropical wadies in desert regions or rivers of tropical rain forests. From high alpine springs and streams down to large lowland rivers, the preimaginal stages are an important part of the zoocoenosis of all running waters. An unpaired proleg at the larval thorax and a special posterior hook circlet at the abdomen allow the larvae of this morphologically homogeneous family to settle areas with highly variable currents including habitats with flow velocities of 2.5 m/s and more *(Figure 1)*. Here, where the current provides the food "free domicile", the larvae (except for very few specialised species without head fans) primarily feed on the ultrafine particulate organic matter (UPOM) consisting of bacteria, algae, detritus and other particles with a size < 50 µm using their head fans as passive filter feeders. With a density of up to 20,000 individuals per dm² they do not only make an important contribution to the self purification within the aquatic ecosystem but also to a considerable increase in food quality for other in-stream detritus feeders as during gut passage UPOM is converted into a coarse fine particulate organic matter (FPOM) that is now enriched with bacteria. Apart from this fact, both, the preimaginal stages *(Figure 1 and 2)* and the emerged imagos *(Figure 3)* constitute an important share of the food spectrum of all predacious aquatic invertebrates as well as of some vertebrates.

The larvae are able to reach their preferred aquatic habitat by moving like a looper and using a security thread of silk produced by the salivary glands. However, the adult females *(Figure 3)* determine the distribution pattern of single species in the different running water types. By seeking in a targeted and unerring way the breeding areas that will later offer the best development possibilities for the aquatic stages, the flying female insects (black flies) perceive the structure and quality of the riparian zone, the distribution of floodplain forest and open landscape structures and can "recognize" the variable current patterns in the stream or river.

Health Problems

Except for a few autogenous species, the females of many species demand a blood-meal for the oogenesis to cover the increased need for proteins. In this context the family has achieved a formidable notoriety on a world scale: While in our latitudes this may lead to annoyance for human beings and animals due to bites, in some cases, however, also to illness, death or mass mortality in cattle ("simuliotoxicosis") such as the event in the Middle and Lower Danube region caused by *Simulium colombaschense* in the 1920s and 1930s, the biting activities of certain species in the tropics have devastating effects on resident people. Due to the transfer of nematodes during blood sucking, millions of people suffer from river blindness (onchocercosis) that may cause dermatitis, nodular skin lesion and complete blindness. Thus, the WHO tries to reduce the populations of transfer species by means of onchocercosis abatement programmes in which Bacillus *thuringiensis israeliensis* preparations are spread into running waters. It is apparent that for medical and economic reasons the black flies belong to the best examined merolimnic insect families worldwide.

Figure 1. *Simulium ornatum, larva (photograph: B. Eiseler)*

Water Quality Indicator

In applied limnology, the indicator function of the pre-imaginal stages is especially important when assessing the biological water quality based on the saprobic system as distinct species tolerate different saprobic levels. This applies also for the biological classification of acidification of running waters in the soft water regions of the crystalline mountains. It could be proven empirically that only certain species of the hypocrenal and the epirhithral are able to tolerate the increase of acidity caused by air pollution. With the implementation of the Water Framework Directive of the European Union, the recording and description of natural or at least semi-natural coenoses in all macrozoobenthos groups becomes more important. Achieving "good ecological quality" of all water bodies is dependent on the composition of their aquatic communities. Due to their habitat preference within the longitudinal zonation of running waters and their preference for natural in-stream, riparian and floodplain structures, the black flies are good indicators of human-induced deviations from an undisturbed reference site.

Figure 2. Simulium (Wilhelmia) equinum, pupa (photograph: B. Eiseler)

A good example to demonstrate the indicator value of black flies is the Danube River. More than 80% of the length of the Danube are regulated for flood protection, and approximately 30% are additionally impounded for hydropower generation, mainly in the upper part where a total of 59 dams have been built along the river's first 1,000 kilometres. Whereas most of the aquatic fauna of the Danube is generally known over the past 40 years (e.g. Dudich 1967, Literáthy et al. 2002), up to now an apparent lack of data on black flies is evident. The aim of a recently arranged study was therefore to summarize the known and often scattered data on the black flies of the Danube, to complete this pool with actual own findings, to identify the gaps in our knowledge of the black fly fauna, and to stimulate further studies in this field (Jedlicka & Seitz 2008).

The Danube Black Flies

In a nutshell: thirty one nominal black fly morphospecies have been recorded in the River Danube, including the headwaters Breg and Brigach *(Table 1)*. The most comprehensive data are from the Slovac-Hungarian section (Middle Danube, 21 species before damming), the German stretches (Upper Danube, 19 agreed taxa), the Austrian and the Pannonian Plain section (Upper respectively Middle Danube, each with 10 species) and the Serbian-Romanian section (Middle Danube, 7 species before damming). Very little data are available from the Lower Danube with Bulgaria, Romania (including the Ukrainian part of the delta) as well as the Hungarian Danube Bend (Middle Danube). The species assemblages showed one phenomenon of the River Danube:

Figure 3. Simulium (Wilhelmia) equinum, imago female (photograph: B. Eiseler)

the usual typical longitudinal zonation of the river along the longitudinal gradient sensu Vannote et al. (1980) is not continuous but is interrupted by inversions of the rhithral and the potamal. This means that the rhithral and potamal stretches with their characteristic species assemblages alternate between lotic and lentic stretches, not as transition assemblages but as quite well differentiated units. A local inversion is found in the Bavarian stretch near Kelheim, where the Danube breaks through the Franconian Alb. The first major inversion is below the alpine Inn, resulting in a hyporhithral character. The second inversion is located below Bratislava, where the Danube breaks through the promontories of the West Carpathians, while the third inversion follows more than 600 km downstream of the Iron Gate.

Species	**Upper Danube** (sources to Krems, km 2001)	**Middle Danube** (Krems to Turnu Severin, km 931)	**Lower Danube** (Turnu Severin to Sulina, km 0)
Prosimulium hirtipes (Fries)		○	
Prosimulium rufipes (Meigen)		○	
Prosimulium tomosvaryi (Enderlein)	●	●/○	
Metacnephia danubica (Rubtsov)		○	
Simulium (Boophthora) erythrocephalum (De Geer)	●	●	
Simulium (Byssodon) maculatum (Meigen)		●	
Simulium (Eusimulium) angustipes Edwards		●	
Simulium (Eusimulium) aureum species-group	●		
[Simulium (Nevermannia) angustitarse (Lundström)] [1]	●		
Simulium (Nevermannia) carpathicum (Knoz)	●		
Simulium (Nevermannia) cryophilum (Rubtsov)	●		
Simulium (Nevermannia) lundstromi (Enderlein)	●		
Simulium (Nevermannia) vernum Macquart	●	●/○	
Simulium (Obuchovia) auricoma Meigen		○	
Simulium (Simulium) argenteostriatum Strobl		○	
Simulium (Simulium) argyreatum Meigen	●	○	
Simulium (Simulium) colombaschense (Scopoli)	●	●	●
Simulium (Simulium) degrangei Dorier & Grenier		○	
Simulium (Simulium) galeratum sensu Knoz	●	●	
Simulium (Simulium) monticola Friederichs		○	
Simulium (Simulium) morsitans Edwards	●	○	
Simulium (Simulium) noelleri Friederichs	●	●	
Simulium (Simulium) ornatum Meigen	●	●	
Simulium (Simulium) posticatum Meigen	●		
Simulium (Simulium) reptans (Linnaeus)	●	●	
Simulium (Simulium) variegatum Meigen	●		
Simulium (Simulium) voilense Sherban		●/○	
Simulium (S.) vulgare Dorogostaisky, Rubtsov & Vlasenko		●	
Simulium (Wilhelmia) balcanicum (Enderlein)	●	●	
Simulium (Wilhelmia) equinum (Linnaeus)	●	●	●
Simulium (Wilhelmia) lineatum (Meigen)	●	●	
[1] *probably a misidentification*			

Table 1. Species occurrence in the main Danube reaches (from Jedlicka & Seitz 08, simplified). Black circles indicate occurrence of species at any time and location; open circles indicate that the species was found only before damming, i.e., the loss through impoundment; a combination of both circles shows that the species is still present but has been lost in impounded stretches

As to the anthropogenic impacts the actual investigations showed that the second inversion is due to the construction and operation of the Gabčíkovo hydropower station, since 1992 a thing of the past: the species number declined from 21 to 9. The first to disappear were all the rhithral species; the community structure changed from the earlier rhithral to the potamal and the species composition shifted towards the fauna of the adjacent lowland flows with one dominant species with highest relative abundance. At the Iron Gate the situation changed to a lesser extent than it did at Gabčíkovo where about 80% of the discharge is diverted into the canal and the old channel receives some 20%. At the Iron Gate the water flow was not diverted, and the stream velocity did indeed decrease, but it remains up to 1 m per sec, which is suitable for rheophile species. Nevertheless, the dominant species before damming decreased substantially and the relative abundance of lowland species increased in the same way that one had found at Gabčíkovo more recently. One species was no longer found: the damming of Iron Gate has probably caused the global extinction of *Metacnephia danubica.*

The Danube catchment area is considered as a zone of zoogeographic interest, as it has contacts with the Quaternary refugia and was also crossed by postglacial colonization routes as the Balkans were apparently a source of colonization for all species in the east and for many species in the west for which the ice-capped Alps were an initial barrier to their northward expansion; at present, the Danube also remains the southern corridor of colonization routes for modern invasive species. Due to the fact that the Danube flows through four ecoregions the number of black fly species is – also beside investigation and taxonomic problems – surely not definitive. A higher number of species may be expected in the source rivers Breg and Brigach, where the occurrence of montane rhithral species can be anticipated by analogy with the rhithral stretches of other mountain headwaters. An increase in the species number is also to be expected in the reaches of the Lower Danube where actual investigations are needed that can help assessing and monitoring the possible influences of prospecting anthropogenic activities.

References

Dudich E (1967): Systematisches Verzeichnis der Tierwelt der Donau mit einer zusammenfassenden Erläuterung. In: Liepolt R (ed.), Limnologie der Donau – Eine monographische Darstellung. Kapitel V: 4–69 (Schweizerbart) Stuttgart

Jedlicka L, Seitz G (2008): Black flies of the River Danube (Diptera, Simuliidae). Lauterbornia 62: 93–119, Dinkelscherben

Literáthy P, Koller-Kreimel V, Liška I (2002) (eds.): Final Report of the Joint Danube Survey, 261 pp. (International Commission for the Protection of the Danube River, ICPDR) Vienna

Vannote RL., Minshall GW, Cummins KW, Sedel J R, Cushing CE (1980): The river continuum concept. Canadian Journal of Fishery and Aquatic Science 37: 130–137, Toronto