

Original Article

Notes on the Iran Caddisflies and Role of Annulipalpien *Hydropsychid* Caddisflies as a Bio-monitoring Agent

Naseh Malekei-Ravasan¹, Abbas Bahrami¹, Mansoreh Shayeghi¹, Mohamad Ali Oshaghi¹, Masomeh Malek², Allah Bedasht Mansoorian³, *Hassan Vatandoost¹

¹Department of Medical Entomology and Vector Control, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

²Department of Biology, Tehran University, Tehran, Iran

³Department of Parasitology, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

(Received 20 Nov 2012; accepted 9 Feb 2013)

Abstract

Background: Eco-faunistic studies are inevitable step in environmental researches. Aquatic organisms like caddisflies are known as biological indicators for water quality assessment and water resource management. They have special role for energy flow in the freshwater habitats as food web and food chain among aquatic creatures.

Methods: In addition to an extensive literature review on Iran Caddisflies, a field study was carried out in Lavasan river flows in north east of Tehran to collect aquatic insects using D-frame nets and or direct search on stone beneath. The water quality was measured using analytical method.

Results: Literature revealed record of 62 trichopteran species in the country comprising 14 families. The most abundant species belonged to the Hydropsychidae. Herein we report presence of the Annulipalpien *Hydropsyche sciligra* H Malicky, 1977 in the study area. Habitat water quality of *H. sciligra* resembled human drinkable water. However presence of snail, *Physa acuta* and fish *Capoeta buhsei* in the water sampling area indicated inferior quality.

Conclusion: From ecological point of view caddisfly larvae are predators of most important medical vectors like mosquitoes, blackflies and midges. Also they are useful and important indicator for monitoring physicochemical effects in the nature, so that they can be used for bio-monitoring program. From medical point of view, wing hairs or other body parts of caddisflies can be inhalant and contact allergens in Trichopterists and in sensitive individuals who come in contact.

Key words: Caddisfly, Hydropsyche, Faunistics, Bio-monitoring, Iran

Introduction

Trichoptera, is one of the largest insect orders presenting in aquatic ecosystems. The order includes 3 suborders Spicipalpia, Annulipalpia and Integripalpia each one containing four, eight, and 33 families, respectively. The aquatic larvae assemble a portable case (Integripalpia, and two of four families of “Spicipalpia”) or fixed retreat (Annulipalpia), except for those of a pair of “free-living” spicipalpian families. The net, retreat, case, and pupal structures of caddisfly larvae that filter fine organic matter or larger particles are among the most in-

tricate and complex structures built by insects, at least among the non-social orders (Holzenthal et al. 2007).

Trichoptera and Lepidoptera, concoct the Amphiesmenoptera super order (Kristensen 1991). Their presenting and archaic lineages diversification ascribe to the Triassic and the middle Jurassic respectively. The earliest prototrichopteran dates to the mid-early Permian (Kristensen 1997). So, Trichoptera depict a significant and important branch on the tree of life, whose present distribution and bioge-

*Corresponding author: Dr Hassan Vatandoost,
Email: hvatandoost1@yahoo.com, vatando@tums.ac.ir

ography is reflective of those past events that have affected the distribution and diversification of earth's entire freshwater biota. For instance extinction of an endemic alpine caddisfly, *Rhyacophila angelieri* (Rhyacophilidae) was predicted with reduced melt water inputs (Brown et al. 2007).

The role of Trichopteran larvae in trophic dynamics and energy flow in the freshwater habitats seems to be inevitable (Resh and Rosenberg 1984). Both of habitats and inhabitants of these ecosystems affected strongly and environmentally intimidated. Trichoptera are applicable and important for monitoring physicochemical effects, and are widely used in biomonitoring programs in developed countries (Lenat 1993, Resh and Unzicker 1975, Dohet 2002).

Hydropsychidae Curtis (1835), with about 1,500 described species, is the 3rd largest family in Trichoptera and the most diverse of the net-spinning Annulipalpans. Five subfamilies are currently recognized: Arctopsychinae, Macronematinae, Hydropsychinae, Diplectroninae, and Smicrideinae. Hydropsychinae contains 19 prevalently genera from all biogeographic regions, which the largest genera include *Hydropsyche* Pictet (275 species), *Ceratopsche* Ross and Unzicker, often considered a subgenus of *Hydropsyche* (100 species), and *Cheumatopsyche* Wallengren (260 species) (Scheffer 1996, Holzenthal et al. 2007).

Hydropsychid larva exhibits a large spectrum of tolerance values and is used in biomonitoring programs throughout the world. For example, North Carolina Biotic Index (NCBI) tolerance values for hydropsychids range from 0.0 for *H. carolina* ranks to 8.8 for *H. betteni* Ross (on a scale of 0–10, with 0= least tolerant of pollution) (Lenat 1993).

One of the major environmental issues that the world faces today is the water crisis (Aldhous 2003). Industrial activities and urbanization have raised pollution in rivers, streams, and lakes in developing countries. Most sewage enters waterways without ade-

quate treatment, and the water quality is being degraded (Langergraber and Muellegger 2005). Loss of freshwater for human consumption is correlated with cease to existing aquatic biodiversity. A critical step is to describe aquatic biota to help developing countries build efficient, fast, and inexpensive techniques to diagnose and monitor negative perturbations to water quality. The use of aquatic organisms as indicators of water quality is a standard method in management of water resources. The pros and cones of the use of macro-invertebrates in biological monitoring were outlined. Among the pros is that the taxonomy of many groups is very well known and identification keys are available. This pro is true for the United States and Europe, and Australia, but lack of taxonomic knowledge and identification manuals is the greatest barrier to the development of biological monitoring studies in other regions like our country (Resh 1995, Bonada et al. 2006).

The Iranian Trichoptera fauna mostly was studied by non-autochthonous researchers (Schmid 1959, Malicky 1986, Mirmoayedi and Malicky 2002, Mey 2004, Malicky 2004, Chvojka 2006) based on collections of 62 species from the 23 provinces of Iran. Despite the evolutionary, ecological, environmental, and adorable importance of the Trichoptera, there is a little knowledge about ecology with emphasizing habitat characteristics of Iranian Trichoptera. So, to cover this brevity firstly we collected some caddisflies, then listed families presenting in Iran with emphasizing Hydropsychidae family species and finally measured water quality of surrounding larval habitat and some ecological features of Lavasan district, Tehran, capital of Iran.

Materials and Methods

This bi-seasonal (summer/winter) study was conducted on Lavasan River runs in Northeast of Tehran capital of Iran. The rampant climate of the region is cold Mediterranean. Water

temperature was measured using thermometer during sampling. We collected immature stages of the Trichoptera by D-frame nets and/or removing river floor stones from three different habitat types run, riffle and stream bank locating in the way of the running water where larvae stick their retreat under/beside of the stones. The retreats and probably harboring immature insect preserved in 70% ethanol and transferred to the School of Public Health (SPH) laboratory. The key morphological characters of the extracted immature Trichoptera plus retreats general feature were examined under microscope (Olympus SZX12) through taken high resolution photos. Water samples were collected in summer 2010, prior the seasonal rains start. The specimens were taken in autoclavable pyrex bottle w/cap 250 ml, previously acid-washed and rinsed with copious amounts of distilled water. Electrical conductivity (EC) and total dissolved solids (TDS) was measured using EC/TDS HACH CO150 meter. The pH was determined using Suntex TS-2 pH meter. Color and turbidity of the water samples were examined with HACH Data Logging Spectrophotometer 2010. The data was analyzed to establish a relationship between the water quality and Trichoptera fauna.

Results

Totally seven caddises and only one larva (without retreat) was collected during two referral season in summer and winter 2010. Larval and pupal characteristics of *H. sciligra* are shown in figures 1 through 11 and 12 through 16 respectively. Faunistic investigation was carried out and reinforced using two information resources including available published data on Iranian Trichoptera and the Trichoptera World Checklist Database Search. The collected retreats were identified as *Hydropsychid* sp. (Fig. 12). With regard to being lethargic collected larva in the winter

season, probably Trichoptera overwinter in larval stage in this region.

Hydropsychidae

Larvae of this family are easily separated from others by the hard sclerotized plates on the top of each thoracic segment and highly branched gills on venter of abdominal segments (Fig. 1,2). Each branched gills have 30 or more filaments on venter of thoracic segments and on most abdominal segments (Fig. 6). Larvae of *Hydropsyche* distinguished from other hydropsychid genera by pair of large sclerites in inter-segmental fold posterior to prosternal plate of prosternum (Pescador and Rasmussen 1995).

According to the World Checklist database (Morse 2010) there are 62 trichopterid species in Iran comprising 14 families. Suborders, families, number of species, Case/Retreat making, feeding type and Biotic Index Values (RBP) of Iran caddisflies are shown in table 1. On the basis of mentioned source 18 reported Iranian Hydropsychidae members are presented in Table 2.

In addition to the caddisflies we collected two invasive following biota that may have impact on the results explanations.

Bladder Snail, *Physa acuta* Draparnaud 1805 (Gastropoda: Physidae)

This snail has cosmopolitan distribution and has been spread through human agency around the world (Dillon et al. 2002). It is prevalent in lentic waters, especially in rich, disturbed and/or artificially eutrophic environments. *P. acuta* is a “weedy” or R-selected species (Dillon 2000). Its rapid maturation, high reproductive rate, and ease of culture have made it the “fruit fly of malacology”. *P. acuta* is easily the most successful physid, having been dispersed worldwide and found in a variety of few habitats. It is a generalist and reproduction selected. It can survive well under harsh conditions, as long as they are short-lived. Other life-cycle characteristics are high

proliferation rates, high passive dispersal capacities and high tolerance to polluted water (Bernot et al. 2005). A high adaptability to changing environmental characters is thought to enhance invasiveness of *P. acuta* (Kefford and Nugegoda 2005).

***Capoeta buhsei* Kessler, 1877 Cyprinidae (Synonym: *Varicorhinus nikolskii* Derjavin, 1929)**

Capoeta was reviewed by Karaman (1969) who recognized seven species that two of them, *C. buhsei* and *C. fusca* are restricted to Iran. *C. buhsei*, ray-finned fish, a benthopelagic species in freshwater systems, is found in the

Lake Namak basin, Iran. *C. buhsei* has been assessed as least concern due to its relatively large range, and a lack of widespread threats in the area (Bianco and Banarescu 1982, Coad 1998, Devi and Boguskaya 2009, Krupp and Schneider 1989).

Analyzing water quality

Water quality of Lavasan river in the summer 2010 was measured and its mean physico-chemical characteristics at the time of sampling were as follow: EC 376 $\mu\text{s}/\text{cm}$, pH 8.43, TDS 188 mg/L, NTU 13.7 NTU, water temperature (at noontime and 50 cm depth) 22.2 °C.

Table 1. Suborders, families, number of species, case/retreat making, feeding type and Biotic Index Values (RBP) of Iran caddisflies are shown

Suborder	Family	No of species	Case/Retreat making	feeding group	Biotic Index Values (RBP)
Annulipalpia	Ecnomidae	2	fixed retreat	Predator, Collectors.	0.0
	Hydropsychidae	18	fixed retreat	Collector (filterer)	4.0
	Polycentropodidae	2	fixed retreat	Collector/Shredder/Predator	6.0
	Pseudoneureclipsidae	2	fixed retreat	grazers	0.0
	Psychomyiidae	8	fixed retreat	Collector (gatherer)	2.0
	Philopotamidae	3	fixed retreat	Collector (filterer)	3.0
Integripalpia	Leptoceridae	5	portable case	Shredder/Collector/Predator	4.0
	Sericostomatidae	1	portable case	Shredder/Collector (gather)	3.0
	Lepidostomatidae	3	portable case	Shredder	1.0
	Limnephilidae	5	portable case	Scraper/Shredder	4.0
Spicipalpia	Glossosomatidae	2	portable case	Scraper/Collector (gatherer)	0.0
	Hydroptilidae	9	portable case, fixed retreat, free-living	Piercer/Scraper/Shredder	4.0
	Hydrobiosidae	1	free-living	Predator	0.0
	Rhyacophilidae	1	portable case	Predator/Scraper	0.0

Data for Biotic Index Values (RBP) column from Hilsenhoff WL (1988)

Table 2. 18 type species records of Hydropsychidae from Iran and neighborhood countries

Subfamily	Taxon	Distribution	Region	Reference
Dipteroninae	<i>Dipterona vairyra</i>	Iran Albania	Baharestan	Mirmoayedi and Malicky, 2002 Olah, 2010
	<i>Cheumatopsyche processuata</i>	Iran, India, Pakistan, Myanmar and Vietnam	*****	Mirmoayedi and Malicky, 2002 Olah et al 2008 Olah and Johanson, 2008
	<i>Hydropsyche consanguinea</i>	Iran Iran Iraq	Chalus, Damavand, Azarbaijan-E-Gharbi (Takht Soleyman), Lorestan (Lenje Abad)	Chvojka, 2006 Mirmoayedi and Malicky, 2002 Al-Zubaki and Al-Kayalt, 1987
	<i>Hydropsyche demavenda</i> (Syn: <i>H. integrate</i>)	Iran China	Damavand	Mirmoayedi and Malicky, 2002 Huang et al 2005
	<i>Hydropsyche djabai</i>	Iran Iran Turkey	Azarbaijan-E-Gharbi (Takht Soleyman), Minoudasht, Golestan-Forst, Damayand	Mirmoayedi and Malicky, 2002 Chvojka, 2006 Sipahiler, 2004
	<i>Hydropsyche mahrkusha</i>	Iran Turkey Turkey	Mazandaran, Alborz-Gebirge, Chalus-Karadj Assalem- Hashtpar, Moghan	Mirmoayedi and Malicky, 2002 Sipahiler, 2004 Sipahiler, 2007
	<i>Hydropsyche resslia</i>	Iran Turkey	Alborz Valley, Chalus	Mirmoayedi and Malicky, 2002 Sipahiler, 2007
	<i>Hydropsyche sakarawaka</i> (Syn: <i>H. remmerii</i>)	Iran	Chalus-Karaj	Mirmoayedi and Malicky, 2002
	<i>Hydropsyche sciligra</i> (Syn: <i>H. gracilis</i>)	Iran Turkey Caucasus	North site of Alborz, Chalus, Makou, Qazvin, Minoudasht	Mirmoayedi and Malicky, 2002 Sipahiler, 2007 Ivanov, 2011
	<i>Hydropsyche supersonica</i>	Iran Iran	Gilan (Gichob), Nowshahr	Mirmoayedi and Malicky, 2002 Chvojka, 2006
	<i>Hydropsyche iokaste</i>	Iran	Amol- Chalus	Mirmoayedi and Malicky, 2002
	<i>Hydropsyche bujnurdica</i>	Iran	Bojnurd	Botosaneanu, 1998
	<i>Potamyia psamathe</i>	Iran	Bushehr	Chvojka, 2006
	<i>Cheumatopsyche flavellata</i>	Iran Iran Turkey	Tehran (Eyn Varzan), Minoudasht, Rasht, Fars (Firuz Abad, Khollar), Khuzestan (Izeh)	Mey, 2004 Chvojka, 2006 Olah, 2010
	<i>Cheumatopsyche persica</i>	Iran Iran Turkey	Hormozgan (Khoshangan), Khuzestan (Si Mili, Izeh) Azarbaijan-E-Gharbi (Chuplu), Kermanshah (Khosrow Abad), Fars (Posht Chenar, Firuz Abad), Lorestan (Bavineh), Zanjan (Sorkkeh Dizaj), Chaharmahal Va Bakhtiyari and Kerman	Mey, 2004 Chvojka, 2006 Olah, 2010
	<i>Hydropsyche esfahanica</i>	Iran	Isfahan	Mey, 2004
	<i>Hydropsyche lundaki</i>	Iran	Hamadan (Alanje)	Chvojka, 2006
	<i>Hydropsyche masula</i>	Iran	Masuleh River	Olah and KA Johanson, 2008

*****= unknown



Fig. 1. Free living larva

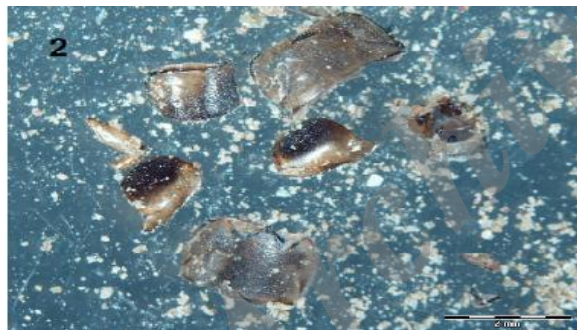


Fig. 2. Larval sclerites (found in the retreat)



Fig. 3. Larval anal projections



Fig. 4. Prosternum



Fig. 5. Anterior part of the body showing trochantin and long antennae



Fig. 6. Abdominal gills, with up to 10 filaments



Fig. 7. Dorsum of abdomen showing club hairs



Fig. 8. Distinctly yellow V- shaped mark on the frontoclypeus

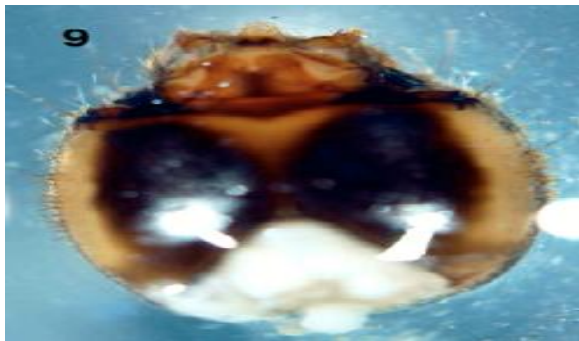


Fig. 9. Two large brown smudges underside view of head capsule



Fig. 10. Robust prothoracic leg



Fig. 11. Sclerites on the abdominal sternum VIII and IX

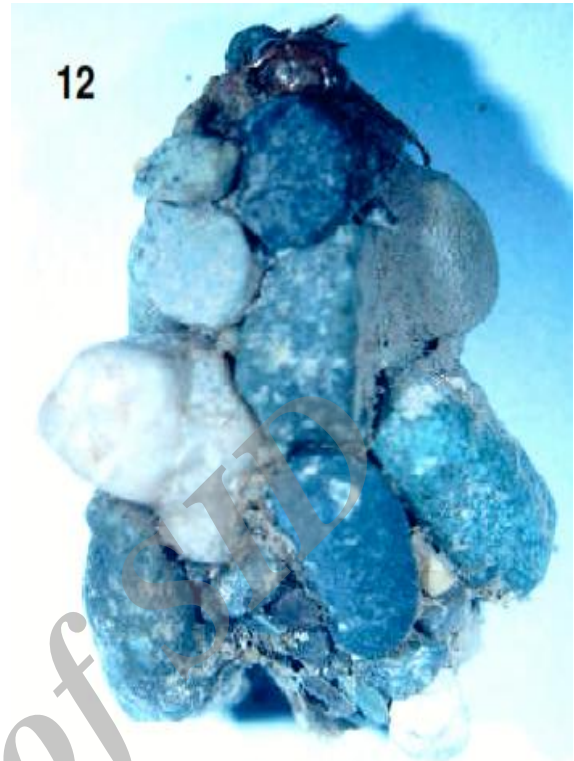


Fig. 12. Retreat containing pharate adult (late pupa) of *H. sciligra*



Fig. 13. extracted pharate adult



Fig. 14. pupal anal projections



Fig. 15. Features on the abdominal segments.



Fig. 16. Features with more resolution on the abdominal segments

Discussion

Faunistic studies of geographical areas, such as countries, states, watersheds, bio-geographical regions, or even conservation areas, are a very important resource for environmental studies. Ecologists, taxonomists and natural resource managers benefit from these data. Iran caddisflies were collected from 23 provinces including Azarbaijan-E-Gharbi, Azarbaijan-E-Sharqi, Ardebil, Esfahan, Fars, Gilan, Mazandaran, Golestan, Tehran, Alborz, Qazvin, Hamadan, Hormozgan, Kerman, Kermanshah, Khuzestan, Kordestan, Lorestan, Sistan va Baluchestan, Bushehr, North Khorsan, Chaharmahal bakhtiari and Zanjan provinces mostly by non-autochthonous researchers. Caddisfly species of Iran are more prevalent along the Alborz and less along Zagros mountain ranges. From the literatures the northern fauna of Iran clearly close to the European-Mediterranean fauna, whereas, in the southern

part of the country there is a gap which connects Africa and South Asia (Malicky 1986).

In this study we collect specimens from Tehran province and evaluated some morphological characters like head, thorax, legs, and abdomen accessories on both larva and late pupa body but we don't find any similarity in introduced species in manuals and published Hydropsychidae keys. Except for chetotaxi standpoint that our collecting larva due to lacking minute spines and scale hairs but having club hairs on dorsum of abdomen (Fig. 7) was very similar to the *Hydropsyche (Ceratomyche) sparna* (Pescador and Rasmussen, 1995). Although all collecting specimens in our study were identified as *Hydropsyche sciligra* (H Malicky 1977 Synonym: *H. gracilis* AV Martynov, 1909) by Vladimir D. Ivanov, an expert trichopterologists from Russia, however, further molecular investigations are under processing to complete species taxonomy confirmation. This species were reported only from Iran, Turkey and Caucasus and there is no any report from other part of the world (Morse 2010). Nevertheless, the Iranian caddisfly fauna is still incipient, and data are lacking from many regions.

Insect faunas present in the fluvial waterbodies provide a valuable resource to increase our understanding of both succession patterns of ecosystem development at individual sites and spatial comparisons between sites of a similar age (Amoros et al. 1987)

Morphological traits can be as predictors of niche requirements so appraisal of the aquatic macro-invertebrates will provide indication of water quality. Different macro-invertebrates have different tolerances to pollution. Among the 4 categories of the water bugs sensitivity to pollution, caddisflies larvae together with Alderflies and water mites are categorized as sensitive bugs (Hunter-Central Rivers Waterwatch). Family Hydropsychidae, are actually tolerant of poor water quality, but would be counted as indicators of good water quality with other Trichoptera in an

Ephemeroptera-Plecoptera-Trichoptera (EPT) Index (Voshell 2002).

Water quality determines the 'goodness' of water for particular purposes. Our collecting water was colorless, odorless liquid, and maybe with an insipid taste. On the basis of WHO guidelines these samples were generally clean even drinkable (WHO Geneva, 2008). Indian recommended standard for drinking water quality parameters for pH, Turbidity (NTU), TDS (mg/L) and EC ($\mu\text{s}/\text{cm}$) are 6.5–8.5, 5, 500 and 400 respectively (IS: 10500 1991). Three cases of our results fall into these categories except for TDS that was 2.5 times less than introduced value. EC and TDS of presented in this study is reagent of freshwater rivers characteristics.

Meanwhile we collected some snails and some fish against these guidelines indicating inferior quality of water and its contamination with human and animal excretions. Probable reasons for these controversial findings may be due to ecological changes as a result of growing urbanization in Lavasan River upstream. Another less important reason may be related to geographical condition of the place. Lavasan district have a temperate climate and because of vicinity to Tehran metropolis, where many mansions and country houses belonging to wealthy families were built there in recent year. So reliability of aquatic insects versus water samples as measures of aquatic ecosystems safety must be noticed with more subtlety.

As we see, in one hand both the literature review (Brown et al. 2007) and current study indicate that caddisflies are good agent for bio-monitoring and on the other hand organisms like the snail (*P. acuta*) and the fish (*C. buhsei*) couldn't be a suitable indicator due to high adaptability to changing environmental characters so these vicissitudes must be explored through monitoring of physico-chemical characteristics.

Salinity, a measure of the dissolved salts in the water, is measured as either TDS or as

EC. A sample's EC can be converted to TDS and vice versa. Sources of salinity include urban and rural run-off containing salt, fertilizers and organic matter. Land use issues related to high levels of salinity include clearing of vegetation and the resultant rise in the water table, excessive irrigation, groundwater seepage and runoff containing dissolved solids from industry, sewage, and agriculture and storm water. While an appropriate concentration of salts is vital for aquatic plants and animals, salinity that is beyond the normal range for any species of organism will cause stress or even death to that organism (Hunter-Central Rivers Waterwatch). The accepted taste threshold for TDS is 500–1000 mg/L. Very low TDS can leave water tasting flat. High TDS is associated with scaling corrosion and possibly unhealthy levels of salt. For non drinking purpose up to 1800 mg/L can be managed with frequent check on taps and infrastructure for scale build up (WHO, Geneva 2008).

The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (NTU). To some extent, how much light reflects for a given amount of particulates is dependent upon properties of the particles like their shape, color, and reflectivity. Suspended solids usually enter the water as a result of soil erosion from disturbed land or can be traced to the inflow of effluent from sewage plants or industry. Turbidity measurements also take into account algae and plankton present in the water (Hunter-Central Rivers Waterwatch). WHO establishes that the turbidity of drinking water shouldn't be more than 5 NTU, and should ideally be below 1 NTU. Therefore, low NTU values indicate high water clarity, while high NTU values indicate low water clarity. (WHO, Geneva 2008).

pH varies naturally within streams as a result of photosynthesis. Geology, soils types and different runoff affect pH. Extreme values of pH can cause problems for aquatic fauna. A

pH range of 6.5–8 is optimal for freshwater (Hunter-Central Rivers Waterwatch).

Temperature of a waterway is significant because it affects the amount of dissolved oxygen in the water. The amount of oxygen that will dissolve in water increases as temperature decreases. Water at 0 °C will hold up to 14.6 mg of oxygen per liter, while at 30 °C it will hold only up to 7.6 mg/L. Temperature also affects the rate of photosynthesis of plants, the metabolic rate of aquatic animals, rates of development, timing and success of reproduction, mobility, migration patterns and the sensitivity of organisms to toxins, parasites and disease. Life cycles of aquatic organisms are often related to changes in temperature. Temperature ranges for plants and animals can be affected by manmade structures such as dams and weirs and releases of water from them (Hunter-Central Rivers Waterwatch).

While net-spinning and retreats maker caddisflies are filter feeders and use in bio-monitoring programs, free-living ones that build neither cases nor nets are predaceous on the most important medical vectors including mosquitoes, blackflies and midges and use in biological control programs. Larvae of hydrophilidae feed on mosquitoes larvae and are therefore relatively important predators of mosquitoes (Hintz 1951, Nielson and Nielson 1953). The 2–3 cm long larvae of *Phrynganea sp* and *Limnephilus sp* have often observed capturing larvae of the snow-melt mosquitoes (Culicidae: *Culiseta* and *Aedes*) (Becker et al. 2010). Rhyacophila larvae are generally predaceous, feeding on Simuliidae (black fly) larvae, Chironomidae (midge) larvae and pupae, and the pupae of other caddisflies (Thut 1969, Wiggins 2004).

Caddisflies normally are not considered medically important insects. They can cause allergic responses (asthma and dermatitis) in sensitive individuals who come in contact with wing hairs or other body parts. Trichopterists who collect adult caddisflies by aspiration may receive significant exposure to wing hairs.

The literature suggests that hypersensitivity to caddisflies may be quite common among allergy patients. The range of reported responses is broad, ranging from minor annoyance to near incapacitation. Some patients sensitized by exposure to caddisfly antigens have developed cross-reactivity to shellfish and stings of venomous insects. This could result in life-threatening situations for individuals with a predisposition for severe IgE-mediated reactions (anaphylaxis) due to contact with arthropod proteins (David E. Bowles)

Acknowledgements

We would like to thank Dr Vladimir D Ivanov, a thoroughbred trichopterologist, from the Department of Entomology, Faculty of Biology, Sent Petersburg State University for identifying and providing some good advises. We also express gratitude to Dr Mahmood Ali Mohammadi from Department of Environmental Health Engineering, SPH, TUMS for testing of water quality.

References

- Aldhous P (2003) The world's forgotten crisis. *Nature*. 422: 251–253.
- Amoros C, Roux AL, Reygrobellet JL, Bravard JP, Pautou G (1987) A method for applied ecological studies of fluvial hydro systems. *Regul Rivers* 1: 17–36.
- Becker N, Petric D, Zgomba M, Boase C, Madon M, Dahl C, Kaiser A (2010) *Mosquitoes and their control*. Springer, Heidelberg, Dordrecht, New York.
- Bernot RJ, Kennedy EE, Lamberti GA (2005) Effects of ionic liquids on the survival, movement, and feeding behavior of the freshwater snail *Physa acuta*. *Environ Toxicol Chem*. 24: 1759–1765.
- Bianco PG, Banarescu P (1982) A contribution to the knowledge of the Cyprinidae of Iran (Pisces, Cypriniformes). *Cybium*. 6(2): 75–96.

- Bonada N, Prat N, Resh VH, Statzner B (2006) Developments in Aquatic Insect Biomonitoring: A Comparative Analysis of Recent Approaches. *Annu Rev Entomol.* 51: 495–523.
- Bowles DE (1992) The medical importance of caddisflies. *Braueria* 19: 24.
- Brown LE, Hannah DM, Milner AM (2007) Vulnerability of alpine stream biodiversity to shrinking glaciers and snowpacks. *Glob Change Biol.* 13: 958–966.
- Chvojka P (2006) Contribution to the knowledge of the caddisfly fauna (Trichoptera) of Iran: description of new species and new distributional data. *Acta Entomol Mus Nat Pragae.* 46: 245–255.
- Coad BW (1998) Systematic biodiversity in the freshwater fishes of Iran. *Ital J Zool.* 65: 101–108.
- Devi R, Boguskaya N (2009) *Capoeta buhsei*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011. 2. Available at: <http://www.iucnredlist.org>.
- Dillon RTJr, Wethington AR, Rhett JM, Smith TP (2002) Populations of the European freshwater pulmonate *Physa acuta* are not reproductively isolated from American *Physa heterostropha* or *Physa integra*. *Invertebr Biol.* 121(3): 226–234.
- Dillon RTJr (2000) The ecology of freshwater molluscs. Cambridge University Press, Cambridge, United Kingdom.
- Dohet A (2002) Are caddisflies an ideal group for the biological assessment of water quality in streams? *Nova Supplementa Entomologica (Proceedings of the 10th International Symposium on Trichoptera).* 15: 507–520.
- Hintz HW (1951) The role of certain arthropods in reducing mosquito populations of permanent ponds in Ohio. *Ohio J Sci.* 51: 277–279.
- Hilsenhoff WL (1988) Rapid field assessment of organic pollution with a family-level biotic index. *J North Am Benthol Soc.* 7: 65–68.
- Holzenthal RW, Blahnik RJ, Prather AL, Kjer KM (2007) Order Trichoptera Kirby, 1813, (Insecta), caddisflies. *Zootaxa.* 1668: 639–698.
- Hunter-Central Rivers Waterwatch, Water Quality Parameters and Indicators, Fact Sheet 2, Hunter-Central Rivers Catchment Management Authority, Available at: <http://www.waterwatch.nsw.gov.au>.
- IS: 10500 (1991) Indian standards for drinking water, Bureau of Indian Standards N. Delhi, India. 1–9: 179–182.
- Karaman MS (1969) Revision der Kleinasiatischen und Vorderasiatischen Arten der genus *Capoeta* (*Varicorhinus* partim) Mit. Hamburg Zoology Museum. 66: 17–54.
- Kefford Ben J Nugegoda D (2005) No evidence for a critical salinity threshold for growth and reproduction in the freshwater snail *Physa acuta*. *Environ Pollut.* 134(3): 377.
- Kristensen NP (1991) Phylogeny of extant Hexapods, p. 125–140 in: Naumann ID (ed). In *Insects of Australia. A Textbook for Students and Research Workers.* Second edition, 1, CSIRO (publ.), Cornell University Press, Melbourne University Press, Ithaca, Melbourne.
- Kristensen NP (1997) Early Evolution of the Lepidoptera+Trichoptera Lineage: Phylogeny and the Ecological Scenario. In Grandcolas, P. (editor), *The Origin of Biodiversity in Insects: Phylogenetic Tests of Evolutionary Scenarios.* *Mém Mus Natn Hist Nat.* 173: 253–271.
- Krupp F Schneider W (1989) The fishes of the Jordan River drainage basin and Azraq Oasis. *Fauna Saudi Arabia.* 10: 347–416.
- Langergraber G Muellegger E (2005) Ecological Sanitation—a way to solve global sanitation problems. *Environ Int.* 31: 433–444.

- Lenat DR (1993) A biotic index for the south-eastern United States: derivation and list of tolerance values, with criteria for assigning water-quality ratings. *J N Am Benthol Soc.* 12: 279–290.
- Malicky H (1986) Die Köcherfliegen (Trichoptera) des Iran und Afghanistans. *Z Arbgem Öst Ent.* 38: 1–16.
- Malicky H (2004) Neue Köcherfliegen aus Europa und Asien. *Braueria.* 31: 36–42.
- Mey W (2004) Beitrag zur Trichoptera-Fauna Armeniens und des Iran (Trichoptera). *Entomol Nachr Ber.* 48: 81–87.
- Mirmoayedi A Malicky H (2002) An updated check-list of caddisflies (Insecta, Trichoptera) from Iran, with new records. *Zool Middle East.* 26: 163–168.
- Morse JC (Ed) (2010) Trichoptera World Checklist. Available at: <http://entweb.clemson.edu/database/trichopt/index.htm> [accessed 15 March 2010].
- Nielsen ET Nielsen AT (1953) Field observations on the habits of *Aedes taeniorhynchus*. *Ecology.* 34: 141–156.
- Pescador ML Rasmussen AK (1995) Identification manual for the caddisfly (Trichoptera) larvae of florida, entomology center for water quality florida A and M University Tallahassee, Florida.
- Resh VH Rosenberg DM (1984) The ecology of aquatic insects. New York: Praeger Publishers, Holt Saunders Ltd.
- Resh VH (1995) Freshwater benthic macroinvertebrates and rapid assessment procedures for water quality monitoring in developing and newly industrialized countries, In: Davis, WaS, T (Ed) Biological Assessment and Criteria. Lewis Publishers, Boca Ration, Florida. 167–177.
- Resh VH Unzicker JD (1975) Water quality monitoring and aquatic organisms: the importance of species identification. *J Water Pollut. Control Fed.* 47: 9–19.
- Scheffer PW (1996) Phylogenetic relationships among subfamily groups in the Hydropsychidae (Trichoptera) with diagnoses of the Smicrideinae, new status, and the Hydropsychinae. *J N Am Benthol Soc.* 15: 615–633.
- Schmid F (1959) Trichoptères d’Iran. *Beitr Entomol.* 9: 200–219, 376–412, 683–698, 760–799.
- Thut RN (1969) Feeding habits of larvae of seven Rhyacophila (Trichoptera: Rhyacophilidae) species with notes on other life history features. *Ann Entomol Soc Am.* 62: 894–898.
- Voshell JR (2002) A Guide to Common Freshwater Invertebrates of North America. Mc Donald and Woodward Publishing Co. Blacksburg, VA.
- Wiggins GB (2004) Caddisflies: the underwater architects. University of Toronto Press, Toronto.
- WHO (2008) Guidelines for drinking-water quality [electronic resource]: incorporating 1st and 2nd addenda, Vol.1, Recommendations. 3rd ed. WHO, Geneva.