THE DISTRIBUTIONAL DATA OF SIMULIIDAE (INSECTA, DIPTERA) SPECIES IN YEŞİLIRMAK RIVER (TURKEY)

Özge BAŞÖREN * and *Nilgün KAZANCI* *

* Hacettepe University, Beytepe Campus, Science Faculty, Biology Department, Hydrobiology Section, TR-06800, Ankara, Turkey, ozzzge@gmail.com, nilgunkazanci@gmail.com

DOI: 10.1515/trser-2015-0046

KEYWORDS: Blackflies, habitat degradation, running water, Simuliidae, Turkey, water quality, Yeşilırmak River basin.

ABSTRACT

This research aims to investigate the Simuliidae fauna of Yeşilırmak River basin and determine the species composition of the collecting sites. The study was carried out in July 2008 and June 2009. One genus and eleven species (*Metacnephia* sp., *Metacnephia subalpina, Simulium (Eusimulium) angustipes, Simulium (Nevermannia) costatum, Simulium (Simulium) argenteostriatum, Simulium (Simulium) bezzii, Simulium (Simulium) ornatum, Simulium (Simulium) trifasciatum, Simulium (Simulium) variegatum, Simulium (Wilhelmia) balcanicum, Simulium (Wilhelmia) lineatum* and *Simulium (Wilhelmia) pseudequinum*) were recorded from 16 collecting sites. The distribution and abundance of Simuliidae species reflect the changes in water quality of Yeşilırmak River, due to agricultural activities and urban areas.

RESUMEN: Datos sobre distribución de Simulidos (Insecta, Diptera) en el Río Yeşilırmak (Turquía).

En este trabajo se determinó la composición específica de la fauna de simúlidos en la cuenca del Río Yeşilırmak en diversos sitios de colecta. El estudio fue llevado a cabo entre junio de 2008 y junio de 2009. En 16 puntos de muestreo se colectaron once especies pertenecientes a un género (*Metacnephia* sp., *Metacnephia subalpina, Simulium (Eusimulium) angustipes, Simulium (Nevermannia) costatum, Simulium (Simulium) argenteostriatum, Simulium (Simulium) bezzii, Simulium (Simulium) ornatum, Simulium (Simulium) trifasciatum, Simulium (Simulium) variegatum, Simulium (Wilhelmia) balcanicum, Simulium (Wilhelmia) lineatum* and *Simulium (Wilhelmia) pseudequinum*). La distribución y abundancia de simúlidos refleja cambios en la calidad del agua en el Río Yeşilırmak, debidos a actividades de agricultura y de áreas urbanas.

REZUMAT: Distribuția simuliidelor (Insecta, Diptera) pe Râul Yeşilırmak (Turcia).

Prezentul studiu are ca scop cercetarea faunei de simuliide din bazinul hidrografic Yeşilırmak și determinarea compoziției la nivel de specie, din stațiile de colectare. Studiul s-a desfășurat în perioada iulie 2008 – iunie 2009. În cele 16 stații de colectare a fost identificat un gen cu 11 specii (*Metacnephia* sp., *Metacnephia subalpina, Simulium (Eusimulium) angustipes, Simulium (Nevermannia) costatum, Simulium (Simulium) argenteostriatum, Simulium (Simulium) bezzii, Simulium (Simulium) ornatum, Simulium (Simulium) trifasciatum, Simulium (Simulium) variegatum, Simulium (Wilhelmia) balcanicum, Simulium (Wilhelmia) lineatum* și *Simulium (Wilhelmia) pseudequinum*). Distribuția și abundența simuliidelor sunt caracteristice pentru calitatea apei râului Yeşilırmak, influențată de activitățile agricole și de ariile urbane traversate.

INTRODUCTION

The species composition of Simuliidae is important when measuring environmental quality of freshwater ecosystems. Specially, filter feeding larvae of blackflies which use dissolved organic matter and plays a key role in nutrient cycle in rivers (Bernotiene, 2006; Zhang et al., 1998).

Several studies demonstrated that the effects of anthropogenic activities have heavily disturbed the aquatic ecosystems in Turkey.

Simuliidae species that respond to various environmental degradations are bioindicators and they are a very useful tool for assessing the quality of running waters. The species composition of Simuliidae can be used as an indicator of agricultural, industrial and urbanization impacts on aquatic ecosystems (Curtean-Bănăduc, 2012; Kazancı, 2006; Lautenschlager and Kiel, 2005; Feld et al., 2002).

The amount of data that has been gathered, in Turkey, on their relationships with habitat quality, habitat preferences and response to degradations is insufficient. However, there has recently been a significant increase in these studies (Ertunç, 2009; Kalafat, 2008; Kazancı, 2006; Şirin, 2001; Adler and Şirin, 2014; Başören and Kazancı, 2012; Başören (Ertunç) and Kazancı, 2011; Başören (Ertunç) and Kazancı, 2012; Başören and Kazancı, 2013; Clergue-Gazeau and Kazancı, 1992; Crosskey and Zwick, 2007; Kazancı and Clergue-Gazeau, 1990; Kazancı and Ertunç, 2008a; Kazancı and Ertunç, 2008b; Kazancı and Ertunç, 2008c; Kazancı and Ertunç, 2010; Başören et al., 2013; Ertunç et al., 2008; Şirin et al., 2015).

This research aims to investigate the Simuliidae fauna of Yeşilırmak River basin and to determine the species composition of the collecting sites and the effects of pollution and degradation on Simuliidae fauna.

MATERIAL AND METHODS

Yeşilırmak River is located in Northern Turkey and it is the third largest basin (38,730 km^2) in Turkey. The catchment covers approximately 5% of Turkey's total area and its length is 519 km. It runs from Eastern Anatolia and into the Black Sea in Samsun (Fig. 1).

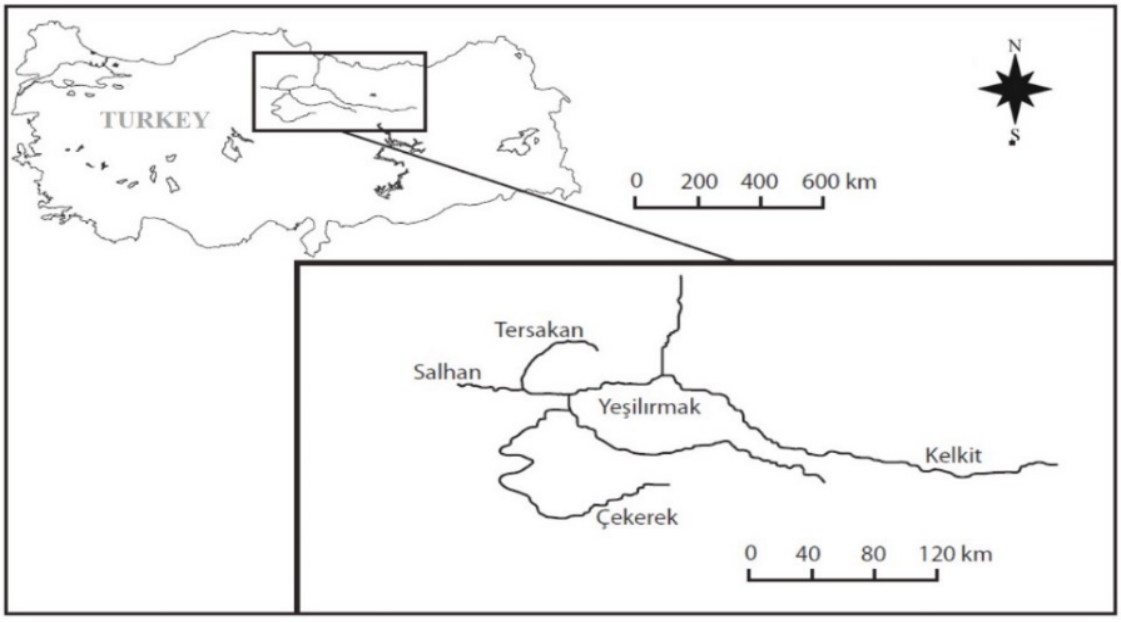

Figure 1: Yeşilırmak River basin.

The habitat quality of the Yeşilırmak River has been affected by various anthropogenic activities such as urban sewage, physical degradation, agricultural and industrial activities (Figs. 2a, b, c). Hydroelectric power plants, regulators and dams are also serious threats to water and habitat qualities of Yeşilırmak River. All these activities have negative impacts on Simuliidae fauna and this was clearly visible in some of the investigated sites.

Larvae and pupae of Simuliidae were collected by a standard pond net and by hand from different types of habitats at each site. Samples were preserved in 80% ethyl alcohol (ethanol). The Leica MZ75 stereomicroscope and Olympus CX21FS1 binocular microscope were used for identification. Individuals of Simuliidae were identified according to Rubtsov (1990), Lechthaler and Car (2005), Crosskey and Zwick (2007).

Water temperature, dissolved oxygen and pH were measured in the field by an YSI 556 multiparameter system. Water samples were also taken from the sites to analyze levels of PO_4-P, NO_3-N, NO_2-N and NH_4-N. These parameters were measured by a Hach DR/890 Datalogging Colorimeter (Tab. 1).

Figure 2a: Some studied sites of Yeşilırmak River.

Figure 2b: Some studied sites of Yeşilırmak River.

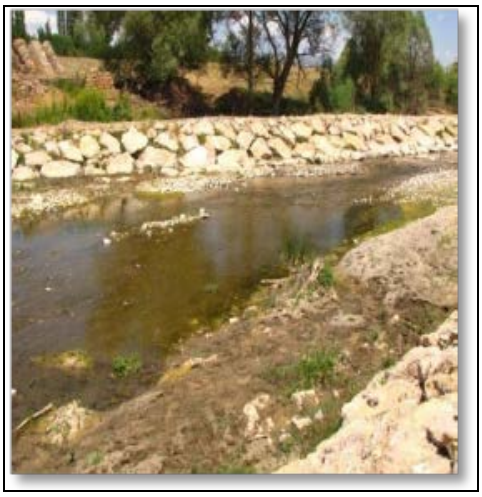

Figure 2c: Some studied sites of Yeşilırmak River.

Klee (1991) and "Regulations of Surface Water Quality Management" prepared by Ministry of Forestry and Water Management (2012) were used to determine the water quality class of the collecting sites.

Blackfly samples were collected from the Yeşilırmak River and tributaries in July 2008 and June 2009. A total of 20 collecting sites (12 sites in 2008, eight sites in 2009) were studied, but Simuliids were found at only 16 sites (10 sites in 2008, six sites in 2009).

RESULTS AND DISCUSSION

Site 1 (08), 2 (08), 3 (08), 4 (08), and 13 (09) were influenced by agricultural activities and urban pollution. The concentrations of PO_4-P and NO_2-N were high in the river due to sewage from urban areas and agricultural runoff. The water qualities of sites 1 (08) and 4 (08) were Class III, site 13 (09) was Class III-IV, site 2 (08) and 3 (08) were Class IV because of two variables (PO_4-P and NO_2-N). Also, all of these sites were physically disturbed. Simuliidae fauna was affected negatively by these deteriorations.

The flow rate of sites 5 (08), 7 (08) and 8 (08) was low because the water level was low due to seasonal conditions. For this reason, the water temperature was high and dissolved oxygen levels were low. Also, agricultural pollution and physical destruction were detected in the stream bed of site 5 (08). The water qualities of these sites were Class III.

The dam is located before site 9 (08), site 10 (08) and site 11 (08). When physicochemical variables were measured and samples were collected, the water was released from the floodgate. The water qualities of these sites were high (Class I and II) because the concentrations of pollutants decreased and values of physicochemical variables were altered. Also, Simuliidae species may have drifted downstream. It is impossible to gather accurate information about the species composition and the water qualities in these sites.

Although there are no agricultural and urban areas around site 14 (09), site 15 (09), site 16 (09), site 17 (09) and site 18 (09), the water qualities of these sites were low (Class III-IV and IV). In these sites, the PO_4-P concentration was high and pH value was low because of snow-melt and rainstorms. This situation is observed seasonally and is defined as episodic acidification (Kazancı, 2009; Wellington and Driscoll, 2004). Simuliidae species as several other aquatic organisms are not able to tolerate acidic waters and they leave their habitat. For this reason, the water quality class and species composition can be misleading in this period.

Table 1: Physicochemical parameters of the collecting sites.

	Water temp. (°C)	Dissolv. oxygen (mg/l)	pH	PO_4-P	NO_3-N	NO_2-N	NH_4-N	Water quality class
1 (08)	23.32	8.15	8.15	0.222	0.294	0.030	0	III
2 (08)	21.52	3.11	7.87	0.378	0	0.073	0.465	IV
3 (08)	23.34	6.71	8.23	0.391	0.294	0.081	0.271	IV
4 (08)	20.81	8.45	8	0.052	0	0.039	0.047	III
5 (08)	25.41	7.24	8.27	0.020	0.023	0.009	0	III
7 (08)	25.06	6.81	8.5	0.150	0.068	0.007	0	III
8 (08)	25.79	5.48	8.72	0.153	0.045	0.006	0	III
9 (08)	18.97	8.75	8.1	0	0	0	0	I
10 (08)	19.75	8.83	8.35	0.147	0.045	0.002	0	II
11 (08)	18.94	7.97	8.35	0.330	0.023	0.006	0	II
13 (09)	14.28	9.04	6	1.94	0	0.0015	0.078	III-IV
14 (09)	19.47	8.81	7.2	2.23	0.023	0.0018	0	IV
15 (09)	15.91	8.94	6.5	1.77	0.113	0.0024	0	III-IV
16 (09)	17.99	8.43	6.9	2.71	0.045	0.0043	0	IV
17 (09)	8.65	12.18	6.3	2.53	0.045	0.0034	0	IV
18 (09)	14.88	10.78	6	2.30	0.113	0.0055	0	IV

As a result of this study, one genus and eleven species (*Metacnephia* sp., *Metacnephia subalpina, Simulium (Eusimulium) angustipes, Simulium (Nevermannia) costatum, Simulium (Simulium) argenteostriatum, Simulium (Simulium) bezzii, Simulium (Simulium) ornatum, Simulium (Simulium) trifasciatum, Simulium (Simulium) variegatum, Simulium (Wilhelmia) balcanicum, Simulium (Wilhelmia) lineatum* and *Simulium (Wilhelmia) pseudequinum*) were recorded from 16 collecting sites (Tab. 2a, b).

The most common species in the Yeşilırmak River were *Simulium (S.) bezzii, Simulium (W.) balcanicum* and *Simulium (W.) pseudequinum*. These three species have a wide-spread distribution in Palearctic Region and they were recorded in many regions in Turkey (Ertunç, 2009; Kalafat, 2008; Kazancı, 2006; Şirin, 2001; Clergue-Gazeau and Kazancı, 1992; Crosskey and Zwick, 2007; Kazancı and Ertunç, 2008a; Kazancı and Ertunç, 2008b; Kazancı and Ertunç, 2008c; Kazancı and Ertunç, 2010; Başören (Ertunç) and Kazancı, 2011; Başören (Ertunç) and Kazancı, 2012; Başören and Kazancı, 2012; Başören and Kazancı, 2013; Başören et al., 2013; Ertunç et al., 2008).

Simulium (S.) bezzii has the ability to survive in eutrophic waters and it can live in physically degraded habitats (Kazancı, 2006; Kazancı and Ertunç, 2010; Lechthaler and Car, 2005). This species prefers mainly oligosaprobic and betamesosaprobic environments (Car et al., 1995). *Simulium (S.) bezzii* was collected from eight sites (site 5 (08), site 8 (08), site 9 (08), site 10 (08), site 11 (08), site 13 (09), site 15 (09) and site 16 (09)). It is expected that this species is found in these sites.

Table 2a: Simuliidae list of collecting sites.

	1 (08)	2 (08)	3 (08)	4 (08)	5 (08)	7 (08)	8 (08)	9 (08)
Metacnephia sp.								
Metacnephia subalpina								
S. (E.) angustipes					*		*	
S. (N.) costatum							*	
S. (S.) argenteostriatum							*	
S. (S.) bezzii					*		*	*
S. (S.) ornatum							*	
S. (S.) trifasciatum							*	
S. (S.) variegatum								
S. (W.) balcanicum	*	*	*	*	*		*	
S. (W.) lineatum						*		
S. (W.) pseudequinum	*		*	*	*		*	

Simulium (W.) balcanicum and *Simulium (W.) pseudequinum* which are other common species, live in similar environmental conditions and do not prefer special habitats (Lautenschlager and Kiel, 2005; Feld et al., 2002). *Simulium (W.) balcanicum* and *Simulium (W.) lineatum* are resistant to temperature changes and they can tolerate increasing temperature (Kazancı, 2006; Stangler and Halgos, 2007). *Simulium (W.) balcanicum* prefers small running waters and it survives in disturbed environments while *Simulium (W.) lineatum* prefers medium-sized and sand-bottom lowland rivers and it survives in hydromorphologically undisturbed sites (Rubtsov, 1990). *Simulium (W.) pseudequinum* can be found in many different freshwater habitats (Feld et al., 2002). These three species prefer mainly betamesosaprobic and alphamesosaprobic environments (Car et al., 1995). *Simulium (W.) balcanicum* and *Simulium (W.) pseudequinum* were collected from the same sites (site 1 (08), site 3 (08), site 4 (08), site 5 (08), site 8 (08) and site 10 (08)). In site 2 (08), *Simulium (W.) balcanicum* was found alone. *Simulium (W.) lineatum* was collected from only site 7 (08). These sites are suitable for the survival of the three species.

Table 2b: Simuliidae list of collecting sites.

	10 (08)	11 (08)	13 (09)	14 (09)	15 (09)	16 (09)	17 (09)	18 (09)
Metacnephia sp.								*
Metacnephia subalpina							*	
S. (E.) angustipes								
S. (N.) costatum								
S. (S.) argenteostriatum								
S. (S.) bezzii	*	*	*		*	*		
S. (S.) ornatum					*	*		
S. (S.) trifasciatum				*	*	*		
S. (S.) variegatum					*			
S. (W.) balcanicum	*							
S. (W.) lineatum								
S. (W.) pseudequinum	*							

Simulium (S.) ornatum has not specific habitat requirements and the distribution of this species is not dependent on water temperature, flow rate and substrate structure (Bernotiene, 2006). It can survive in both in polluted freshwaters and in clean waters (Lechthaler and Car, 2005; Ignjatovic Cupina et al., 2003). For this reason, *Simulium (S.) ornatum* is one of the most common species of Simuliidae family in Europe (Crosskey and Howard, 2004). This species prefers mainly alphamesosaprobic and betamesosaprobic environments, but it is also found in oligosaprobic environments (Car et al., 1995). *Simulium (S.) ornatum* was collected from site 8 (08), site 15 (09) and site 16 (09) and these sites are suitable for the survival of this species.

Simulium (S.) trifasciatum spreads almost all over Europe (Crosskey and Howard, 2004). It is mostly found in small and clean streams (Bass, 1998). The larvae prefer streams with low organic pollution (Bernotiene, 2006). This species is generally found in oligosaprobic and betamesosaprobic environments (Car et al., 1995). It was collected from site 8 (08), site 14 (09), site 15 (09) and site 16 (09). It is expected to find this species at these sites.

Simulium (S.) variegatum is well adapted to high currents and it is found in upland streams (Kiel, 2001). Also, it was determined that this species can live in degraded sites (Lautenschlager and Kiel, 2005). This species prefers mainly oligosaprobic and betamesosaprobic environments, but it is also found in xenosaprobic and alphamesosaprobic environments (Car et al., 1995). It was collected only from site 15 (09), this site is suitable for the survival of this species.

Simulium (E.) angustipes is widely spread all over Europe (Crosskey and Howard, 2004). This species inhabits small, lowland streams which are rich in nutrients (Lechthaler and Car, 2005). It prefers mostly betamesosaprobic environments and is found in epirhithron and metarhithron of running waters (Car et al., 1995). *Simulium (E.) angustipes* was collected from site 5 (08) and site 8 (08). It is to be expected to find this species in these areas.

Simulium (N.) costatum can be found throughout Europe (Crosskey and Howard, 2004). This species prefers small springs and attaches onto plants (Rubtsov, 1990). Also, *Simulium (N.) costatum is* very resistant to low current velocity (Jensen, 1997). It is generally found in oligosaprobic and betamesosaprobic running waters (Car et al., 1995). This species was collected from only site 8 (08) and this site is suitable for the survival of this species.

Simulium (S.) argenteostriatum lives in fast-flowing mountain streams (Lechthaler and Car, 2005). This species prefers mainly oligosaprobic environment but it can also be found in xenosaprobic environments (Car et al., 1995). It was collected only from site 8 (08) like *Simulium (N.) costatum.* The water quality of site 8 (08) was Class III. According to the results of this study, *Simulium (S.) argenteostriatum* can also inhabit moderately polluted sites.

The saprobic level of the *Metacnephia* species is unknown, but species of this genus are usually found in unregulated streams with high water flow (Malmqvist, 1999) and prefer oligosaprobic environments in Spain (Gallardo-Mayenco and Toja, 2002) and in Turkey (Kazancı and Ertunç, 2010). *Metacnephia subalpina* was collected only from site 17 (09) and *Metacnephia* sp. was collected only from site 18 (09). Water quality of these sites was Class IV due to the level of PO_4-P concentration and the site' pH values. These variables were affected by snowmelt and rainstorms. Individuals may have drifted downstream to sampling sites.

The current velocity is very important for many passive filter feeding Simuliidae larvae (Bernotiene, 2006). The larvae and pupae of Simuliidae are affected by any change in river conditions and they could leave their habitat because of these changes (Rubtsov, 1990).

This study shows that the species composition may have been affected by various abiotic and biotic factors. Community structures of Simuliidae were negatively affected by dam impacts in particular.

CONCLUSIONS

According to the results of this study, environmental impacts and pollution were observed in Yeşilırmak River and tributaries. Dams and hydroelectric power plants on the river caused changes in temperature, dissolved oxygen concentrations and flow regime. Other effects of dam and hydroelectric power plants are habitat loss and sedimentation. Also, Yeşilırmak River and surrounding area have been threatened by agricultural pollution and domestic wastes. Due to all these activities, 16 collecting sites located on the Yeşilırmak River were characterized as mainly betamesosaprobic (Class III) and alphamesosaprobic (Class IV).

The community structures of Simuliidae and water qualities of their habitats were negatively affected in the Yeşilırmak River basin. If this continues, diversity of species of Simuliidae and other benthic macroinvertebrates will start to decline. Therefore, the long term physicochemical and biological monitoring of the water quality and controlling the pollution caused by agricultural and domestic wastes is crucially important.

ACKNOWLEDGEMENTS

This research has been supported by Hacettepe University Research Foundation (BAP) (Project leader Mr. Nilgün Kazancı, Project title "Constitution of biotic index for long-term biomonitoring of water quality for Yeşilırmak River by using benthic macroinvertebrates" and Project 0701601005).

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