Assessing the Fauna of Aquatic Insects for Possible Use for Malaria Vector Control in Large River, Central Iran

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Abstract- Insects with over 30,000 aquatic species are known as very successful arthropods in freshwater habitats. Some of them are applied as biological indicators for water quality control, as well as the main food supply for fishes and amphibians. The faunistic studies are the basic step in entomological researches; the current study was carried out emphasizing on the fauna of aquatic insects in Karaj River, northern Iran. A field study was carried out in six various sampling site of Karaj River during spring 2013. The aquatic insects were collected using several methods such as D-frame nets, dipping and direct search on river floor stones. Specimens were collected and preserved in Ethanol and identified by standard identification keys. Totally, 211 samples were collected belonging to three orders; Plecoptera, Trichoptera and Ephemeroptera. Seven genuses (Perla, Isoperla, Hydropsyche, Cheumatopsyche, Baetis, Heptagenia and Maccafferium) from five families (Perlidae, Perlodidae, Hydropsychidae, Batidae, Heptagenidae) were identified. The most predominant order was Plecoptera followed by Trichoptera. Karaj River is a main and important river, which provides almost all of water of Karaj dam. So, identification of aquatic species which exist in this river is vital and further studies about systematic and ecological investigations should be performed. Also, monitoring of aquatic biota by trained health personnel can be a critical step to describe water quality in this river. Understanding the fauna of aquatic insects will provide a clue for possible biological control of medically important aquatic insects such as Anopheles as the malaria vectors.

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Keywords: Aquatic insects; Faunistic; Karaj River; Iran

Introduction

Insects are known as very successful arthropods in freshwater and brackish water habitats. The success of aquatic insects to exploit of these habitats can be confirmed by their diversity and abundance in most types of freshwater resources. Over 30,000 aquatic insect species have been identified that exist in freshwater; in contrast, only several hundred are marine (1).

The larval stage of mayflies (Ephemeroptera), dragonflies and damselflies (Odonata), stoneflies (Plecoptera), alderflies (Megaloptera), lacewings (Neuroptera), flies (Diptera), caddiesflies (Trichoptera), moths (Lepidoptera) and wasps (Hymenoptera) are known as residents of freshwater, although the adults are terrestrial. Also, some species of beetles (Coleoptera) and bugs (Hemiptera) are aquatic but which their larval, nymphal and adult stages exist in the water which called fully aquatic (2).

Some orders such as Ephemeroptera, Plecoptera and Trichoptera (EPT), are known as an environmental condition indicator in water resources. In the United States, the number of EPT species is often applied as a "biological indicator" of water quality (3).

One of the environmental topics that the world faces today is the water crisis (4). Industrial activities and urbanization have raised pollution in rivers, streams, and

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lakes in developing countries. Most sewage enters waterways without adequate treatment, and the water quality is being degraded (5).

The use of aquatic insects is a standard method and an efficient, fast, and inexpensive technique of management of freshwater resources, monitoring of aquatic biota in water recourses by trained health personnel can be a critical step to describe water quality in developing countries (6). For instance, Trichoptera species are suitable and important for monitoring physicochemical effects, and are suggested for widespread use in biomonitoring programs in developed countries (7,8).

In addition to "biological indicator" role, in freshwater ecosystems, aquatic insects have another important function in nutrient recycling and decomposition (9). These abilities are due to various functions of their feeding such as shredders, scrapers, filter feeders and predators. Also the role of some aquatic insects such as Trichopteran larvae has been proven in trophic dynamics and energy flow (6). Moreover, they are the main food supply for fishes and amphibians (2).

Although, in Iran, published faunistic studies about aquatic insects are rare, however the results indicate the richness and biodiversity of fauna. Some researchers have identified and reported the various families of orders Odonata, Ephemeroptera, Hemiptera, Trichoptera, Coleoptera and Diptera from Iran (6,10-17). Also, the aquatic beetle fauna of Iran was nearly known. Fifty one species belonging to 40 genera and 14 families from the Esat Azerbaijan province have been reported. Similar studies have been conducted in Fars, Guilan, Mazandaran, Ardabil and Khuzestan Provinces. Dytiscidae, Gyrinidae, Haliplidae, Hydrophilidae and Noteridae had the most abundance (18-23). Furthermore, in the new study which was done on Iranian Simulidae, 23 nominal species were identified (24).

Due to the importance of freshwater insects as mentioned previously, and few faunistic studies in Iran, this study was carried out with a focus on the fauna of aquatic insects in Karaj River.

Materials and Methods

Study area

This study was conducted on Karaj River located in Karaj province in the north of the central plateau of Iran. This river with 67 km in length is situated in 36°11'N 51°35'E, comes from the Alborz Mountains and leads to Amir-Kabir (Karaj) Dam (25,26) . Some studies have mentioned 450 × 106 m3 for the annual mean flow rate at its entrance to the Dam (27). Karaj River has permanent flow and its higher branches due to snow contain more water. Thus, the hydrological regime of the Karaj River can be classified as Nivopluvial (snowy–rainy).This area has been formed from various stones including; sandstone, dolomite, shale, limestone, quartzite, and tuff (25) (Figure 1).

Collection methods and identification

Aquatic specimens were collected using several methods including D-frame nets, dipping and direct search on river floor stones in 6 various sampling sites during spring 2013. The various habitat types were examined; full and partial sunlight, shaded, with and without vegetation, as well as in fast and slow flow. Specimens were picked up using forceps and placed in glass jars with labels and preserved in Ethanol (Figure 2). Labels indicate the sampling site and date of collection. All collected samples were identified using morphological characteristics of standard keys (2,28,29).

Results

Totally, 211 samples were collected belonging to three orders; Plecoptera, Trichoptera, and Ephemeroptera (Table1).

Table 1. Aquatic insects collected from the various sampling sites, Karaj River, 2013

No	Order	Family	Genus	Total No.
1	Plecoptera	Perlidae	Perla	105
2		Perlodidae	Isoperla	1
3	Trichoptera	Hydropsychidae	Hydropsyche	30
4		Hydropsychidae	Cheumatopsyche	8
5	Ephemeroptera	Batidae	Baetis	25
6		Heptagenidae	Heptagenia	24
7		Heptagenidae	Maccafferium	18

Seven genuses (Perla, Isoperla, Hydropsyche, Cheumatopsyche, Baetis, Heptagenia and Maccafferium) from five families (Perlidae, Perlodidae, Hydropsychidae, Batidae, Heptagenidae) were identified.

The most predominant family and genus were Perlidae (49.7%) and Perla (49.7%) belonging to Plecoptera order. It was followed by Hydropsyche (14.2%) from Trichoptera order.

Isoperla genus (Plecoptera: Perlodidae) has the lower population size (0.5%).

The identified species are listed in Table 1. Also the captured nymphs of Plecoptera and Ephemeroptera are shown in figures 3 and 4, respectively. Figures 2 and 5 show Trichopteran eggs, larvae and case.

Figure 1. (a, b) Two sampling sites, Karaj River

Figure 2. (a) Trichopteran larva, case and eggs. (b, c, d) Bring out and pick up the larvae with forceps

Figure 3. Plecoptera: (a) Nymph. (b) Lateral gills on thoracic segments

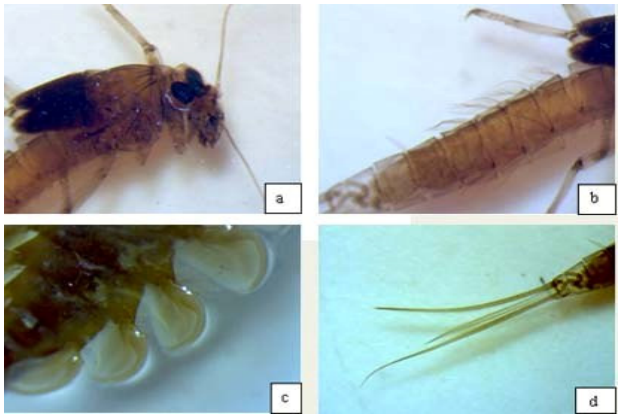

Figure 4. Ephemeroptera: (a) Mature nymph. (b, c) Abdominal gills. (d) Caudal filaments

Figure 5. Trichoptera: (a) larvae.(b) Anal proleg and claw.(c, d) Pupal cases

Discussion

This investigation provides the first formal data with regard to the aquatic insects' fauna in a part of Karaj River as a main and important river in Iran.

In the present study, were collected various species belonging to Plecoptera. This order which commonly named the stoneflies, comprise about 2000 species (30). There are many investigations on stoneflies biology in rivers. These papers describe that the adults are most abundant near streams, particularly those with a rapid flow. They lay several thousand eggs in the water and the nymphs locate on the underside of stones. According to the literatures, many species of this order breed only in cool running waters or cold lakes and the upper limit of temperature had been reported around 250 C. The nymphs' tracheal gills are not leaf-like as the May flies, but they are thread-like structures containing tracheas. The nymphs feed on small insects, such as May fly nymphs, and possibly on the vegetable matter (diatoms) but they are desirable food for fish. After fully grown the nymphs leave the water and molt for the last time on land (30,31).

In our study, Plecoptera species were collected in spring. Also the literature review showed their nymph stage is not tolerant to the warm conditions. In warm lands they are usually limited to forested rivers (30,32).

In Iran, in a similar study, this order has been reported from the north of the country (32) but in contrast to our result, it wasn't collected in Kashan rivers in the center (31).

In a recent investigation, two families of Plecoptera were identified: Perlidae and Perlodidae. In similar research Perlodidae was reported from the north of Iran but Perlidae not collected (32).

The Perlidae was the most predominant family in our study. It has a total of 84 species in 15 genera. This

family is widespread throughout the world except Antarctica and parts of Africa. Their life cycle varies between one and three years. The adults appear in the summer, are dynamic and usually be attracted to the light traps. Perlidae is collected in cool and clear rivers and sometimes can be found in warm rivers. Their nymph can move quickly. In stagnant water, due to no water movement over their gills, they shift the body up and down to get oxygen. Also they hunt all types of invertebrates as a predator. The larvae of this family are commonly found under stones where an abundance of prey can be found. The Perlodidae also can be found in running waters under stones. They are sometimes found along the edges of cold lakes. These stoneflies have one generation per year. Most of them emerge in the spring or fall and pass the hot summer months as aestivation in eggs stage (33).

Trichoptera was another aquatic insects' order which collected from Karaj River. This order has reported from northeast of Tehran Province, Lavasan River (6) and center of Iran (31), previously. The successive project for preparation of the Trichoptera World Checklist (TWC) was done in 2009. The TWC recorded valid extant taxa including; 13,574 species, 308 subspecies and 609 genera of 47 families. According to the World Checklist database, there are 62 Trichopteran species in Iran comprising 14 families (34).

The family Hydropsychidae which was identified is a cosmopolitan group of Trichoptera. In similar results this family was collected from various parts of Iran; center: including Kashan and Isfahan (31,35), North: Mazandaran (36), Northeast: Bojnord, South and West: Bushehr and Hamedan (37). Larvae of Hydropsychidae family are easily identified by the hard sclerotized plates on each thoracic segment and vastly branched gills on ventral of abdominal segments (6). They make silken seine-like nets for collection of food such as floating tiny organic matter or drifting invertebrates (38). Like most Trichoptera larvae, hydropsychids are sensitive to changes in dissolved oxygen levels and organic pollution (39). The Biotic Index Values (RBP) of Hydropsychidae as one of the Iranian caddisflies is reported 4.0 (6).

The genus Hydropsyche (Trichoptera: Hydropsychidae) was identified in this study with the second most abundance. These larvae are filter-feeding and consume everything that trapped in their nets, such as algae and tiny animals (40). As well as Cheumatopsyche larvae are significant ecological components in freshwater lotic ecosystems all over the world that necessitate these species for accurate water-quality assessment (41).

The order Ephemeroptera (common name may fly) which was identified in the present study is one of the most archaic of winged insect groups. In the nymphal stages, they can be found in lakes or streams under rocks. The mature nymphs come to the water surface and turn into flying insects. Unlike most insects they typically have two winged stages. It is the only insects' order that molts after getting functional wings. The first winged stage is called the subimago, which is a sub-adult stage. Then they molt to form the true adult with reproductive ability, called the imago (42).

Baetidae is a family of mayflies which was identified in this study. It has about 900 described species that are classified as one of the smallest groups of mayflies. Their breeding sites include a wide range of habitats from lakes and streams to ditches. Some species can be found in polluted streams (43,44). This family has been reported from saline habitats such as the wetlands of the Zarrineh estuary at the south of Urmia Lake in northwestern Iran (10).They feed mainly on algae in the nymphal stage as strong swimmers. Due to their good swimming, they name minnow mayfly. (43,44).

Heptageniidae (Synonym: Ecdyonuridae) is another family of Ephemeroptera collected in this study. It has over 500 species distributed in most regions of the world. Heptageniids breed generally in streams with the fast flow but some species have been observed in stagnant waters. The nymphs have a flattened shape and usually dark color (45). In consistence to our study, both of families Heptageniidae and Baetidae were reported from Kashan Rivers, the center of Iran (31).

Although the mentioned aquatic insects normally have no medically important, some of them such as Trichoptera can cause allergic responses in sensitive persons (6). Researchers have showed that some of the orders such as caddis flies are known as biological indicators for water quality assessment (6). They explained that the groups which are sensitive to pollution (Ephemeroptera, Plecoptera, Trichoptera) in contaminated areas are reduced and vice versa, the resistant groups Diptera (Chironomidae and Simullidae) are increased (45).

Karaj River is a main and important river which provides almost all of water of Karaj (Amir-Kabir) dam. Thus, identification of aquatic species which exist in this river is vital. The lack of indigenous taxonomic knowledge and local identification keys were the limitations of the present study, although the international identification keys were available.

It is recommended that further studies about systematic and ecological investigations should be supported and performed on aquatic insects which exist in this important habitat. As well as, monitoring of aquatic biota by trained health personnel can be a critical step to describe water quality in this river.

In Iran, several studies are conducted regarding malaria in which different aspects are published. These include insecticide resistance monitoring (14,46-56) sibling species, molecular study, new record (57-63) novel methods for vector control (64-69), faunestic study (70,71), use of plants for larval control (53,72-85) using bed nets and long lasting impregnated nets (86-92), morphological studies (93-95), malaria epidemiology (96-101), ecology of malaria vectors (13,16,17,102-106), community participation (91,107), vector control (12), repellent evaluation(108), anthropophic index of malaria vectors(109-111), and training (112,113).

The presence of predators in the breeding places may reduce the abundance of Anopheles and result in a reduction of malaria cases.

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