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SPECIES COMPOSITION OF MOSQUITOES IN MARGALLA HILLS NATIONAL PARK, ISLAMABAD, PAKISTAN

[a]Rabia Arooj, [a]Amjad Rashid Kayani, [a]Bushra Allah Rakha, [b]Imran Bodlah, [c]Muhammad Rizwan

[a] Department of Zoology, Wildlife and Fisheries, Pir Mehr Ali Shah, Arid Agriculture University Rawalpindi, Murree Road, Rawalpindi, Pakistan.

[b] Department of Entomology, Pir Mehr Ali Shah, Arid Agriculture University Rawalpindi, Rawalpindi, Pakistan.

[c] Department of Agronomy, Pir Mehr Ali Shah, Arid Agriculture University Rawalpindi, Rawalpindi, Pakistan.

A B S T R A C T

Many maladies, such as malaria, yellow fever, dengue fever, and filariasis, are transmitted by mosquitoes. Mosquitoes are dipteran insects of family Culicidae within Phylum Arthropoda. This insect has cosmopolitan distribution. Herein we have investigated the species composition of mosquito fauna in Margalla Hills National Park during 2022-23. Adults, pupae, and larvae of mosquitoes were collected from multiple sampling sites in the study area. Dip net was used for the collection of immature stages. The adult were collected using sweep nets and aspirators. The obtained specimens were mounted on entomological pins after the collection and killing of adult mosquitoes. Representative specimens of each mosquito species were attached to a miniature platform via the thorax. Utilizing standard taxonomic keys, adult mosquitoes were identified. During the course of present study, a total of eleven species; *Anopheles stephensi* Liston, *Anopheles maculatus* Theobald *Armigeres subalbatus* Coquillett, *Armigeres kuchingensis* Edwards, *Aedes aegypti* Linnaeus, *Aedes albopictus* Skuses, *Aedes vittatus* Bigot, *Culex quinquefasciatus* Say, *Culex theileri* Theobald, *Lutzia raptor* Edwards and *Mansonia uniformis* Theobald, were identified. The scientific names, synonyms, habitat description, and body measurements of collected specimens were provided alongside their collection dates. Current study would provide basic information for Government agencies and policy makers in the management of different mosquito vectors in Pakistan.

Keywords: Distribution; Forest; Habitat; Islamabad; Mosquitoes

Corresponding Author: Rabia Arooj
Email: rabiaarooj1996@gmail.com

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INTRODUCTION

Mosquitoes are responsible for the transmission of diseases such as malaria, dengue fever, Zika virus, and West Nile virus, all of which have serious human health consequences (Lee et al., 2018). Malaria is a major global health concern, notably in Pakistan. Malaria infections are spread by infected female Anopheles mosquito bites. Genus *Anopheles* is the is one of the most important genera being renowned to be involved in arboviral transmission, while other genera, *Aedes* and *Culex* are medically important and considered as vector different diseases causing pathogen (Dahmana and Mediannikov, 2020).

Mosquitoes play an important role in the food chains of many ecosystems, although their impact is often seen negatively due to their position as disease vectors. Certain mosquito species in genus *Toxorhynchites*, feed on plant nectar and thus have the ability to pollinate plants. Although their contribution to pollination is modest in comparison to other insects such as bees and butterflies, research has shown that they are involved in pollinating some plant species (Gaye et al., 2019). Mosquito larvae and adults are vital food sources for a variety of creatures. Mosquito larvae are the principal food supply for aquatic species such as fish, amphibians, and other insects such as dragonflies and damselflies (Kitching, 2001). Birds, bats, spiders, and other insectivorous animals consume adult mosquitoes (Bradshaw et al., 2016). While these ideas emphasize mosquitoes' ecological roles, it is crucial to remember that the

detrimental impact of mosquitoes as disease vectors should not be neglected.

Malaria is a major global health concern, notably in Pakistan. Malaria infections spread through infected female *Anopheles* mosquito bites. From 2006 to 2021, in a systematic review and meta-analysis conducted by Khan et al. (2023) on malaria prevalence in Pakistan. They found a pooled malaria prevalence of 23.3% in the country. Dengue fever is prevalent in different parts of Pakistan. The most occurrences have occurred in urban regions, notably heavily populated cities like as Lahore, Karachi, and Rawalpindi. According to one study, Karachi alone accounted for more than half of all dengue cases documented in the country. Several factors contribute to Pakistan's high dengue incidence. These include rapid urbanization, improper sanitation, waste management systems, water storage practices, and suitable climatic conditions. Furthermore, disease propagation is aided by a lack of understanding about preventive measures, as well as delayed diagnosis and treatment (Khan et al., 2018).

Because of quick transmission, increased human activity, and global climate change, the danger of vector-borne disease has increased. It is critical to examine the current state of illnesses in order to manage future vector-borne disease issues. Pakistan is a subtropical country where vector-borne diseases are a problem. Pakistan, like other Asian countries, is undergoing considerable climate change, which is conducive to mosquito-borne disease epidemics. Controlling mosquito populations and preventing disease transmission remain critical public health priorities. In Pakistan, urbanization has contributed to a rise in the danger of mosquito-borne diseases (Li et al., 2014). The combination of unplanned urban growth, poor infrastructure, and limited access to basic services produces ideal circumstances for mosquito proliferation and disease transmission. Punjab offers a great deal of seasonal and biological variability. Changes in climatic circumstances have resulted in recurrent epidemics of mosquito-borne diseases such as dengue fever as a result of increased urbanization caused by fast expanding populations (Naeem-Ullah and Akram, 2009). As a result, understanding the ecological factors that drive population variations is critical for controlling the vector and infections. It has a semi-arid subtropical climate. The region is in the monsoon belt. It is a significant ecological hotspot in Pakistan, with a variety of habitats for different flora and wildlife. Various studies on the wildlife found in the Margalla Hills National Park have been conducted, but insect species, particularly mosquitoes, remain undiscovered. Mosquitoes are vectors for a variety of human and animal diseases. They may be of equivalent importance in forest ecosystems adjacent to urban centers. As a result, there is a need to investigate the species makeup of mosquitos in the forest ecosystem.

MATERIALS AND METHODS

Study area

Margalla Hills National Park is located at 33˚48′N and 73˚10′E, directly to the north of Islamabad, the Capital tertiary of Pakistan. International Union for the Conservation of Nature (IUCN) has placed Margalla Hills in Management Category V (Protected Landscape). It has a subtropical semi-arid climate. Rainfall occurs in two seasons: summer (July - September) and winter (up to March).

In the winter temperature is between 1 and 15 degrees Celsius and in the summer it is between 20 and 40 degrees Celsius. On average 1,000 mm of rainfall occurs annually.

Sampling

The study area was visited one to two times per week for sampling. The specimens was collected from various localities in the study area like walking trails 1, 2, 3, 4, 5 and 6 at dawn and dusk. The majority of the adult mosquitoes were collected using sweeping nets and aspirators Dipper was used for larval collection from aquatic habitats.

Experimental design

The collected specimens were transferred to the Laboratory of Biosystematics, Department of Entomology, PMAS-Arid Agriculture University for morphological analysis. Mouth operated aspirator was used to transfer mosquitoes from plastic jars to the insect collecting jars. The collected larvae and pupae were reared under lab condition; adults were shifted to collecting jars through aspirators. The cyanide-killing jar was used to kill the collected specimens.

Pinning and labeling

Entomological pins were used to mount the specimens. Identified specimens were affixed to a small platform via thorax. Specimens were labeled with collector’s name, collection date, collection site and habitat.

Identification

Identification of the species were carried out by latest and most relevant literature provided by Qasim et al. (2014); Barraud (1934); Becker et al. (2010) and Rueda (2004) using Labomed (CZM6) stereoscope with Digital camera (CE 920, eCAM 3000) fixed attached with same microscope was used to prepare the images of material. All identified species were deposited in the Ecology Laboratory of the Department of Zoology, Wildlife and Fisheries, PMAS Arid Agriculture University Rawalpindi.

RESULTS

Genus *Anopheles* Meigen, 1818

***Anopheles stephensi* Liston, 1901**

Anopheles metaboles Theobald, 1902; *Mysorensis* Sweet & Rao, 1937; *Neocelha intermedia* Rothwell, 1907; *An. folquei* Mello, 1918

Diagnosis

Adults: medium size, about 2.50- 4.0 mm. Palps smooth and pale yellow with three distinct bands spots; palpomere IV, white basally and apically; palpomere V completely pale. Female slender whilst males possessed larger apexes and club-shaped palpi. Apex of palpi with two pale stripes (Figure 1). Femora and tibiae of the legs covered with yellowish scales. Foreleg with longer basal and apical bands mid- and hind-legs. Femurs and tibia white and spotted. The sterna V-VIII and terga II-VIII covered in pale scales. Three dark spots could be seen in the anal vein of wing, scutal fossa having yellowish scales throughout. Costa with five white specks (Figure 2). Veins 2, 2.1, and 3 with dark patches. Hairs and tiny scales coated the abdomen. The second, third, and eighth tergites with thin scales overall.

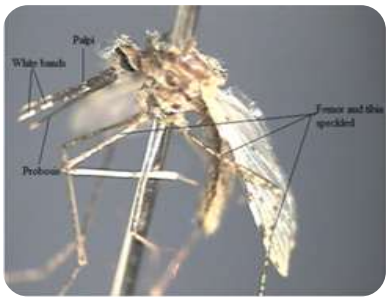

Figure 1: *Anopheles stephensi*; Palpi of female.

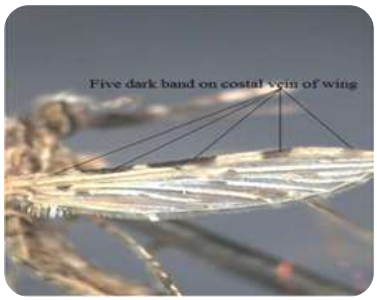

Figure 2: *A. stephensi*; Wing with different ornamentation

Measurements

Forewing: 2.5 to 4 mm

Body Length: 4 to 8 mm

Material examined

Trail 2: 4-VII-22, 1♂. 14-IV-23, 1♀. 23-V-23, 1♀. 18-VI-23, 1♂.Trail 3: 11-VII-22, 1♂. 10-IV-23, 1♀. 15-V-23, 1♀. 3-VI-23,1♂. Trail 4: 2-VII-22, 1♂. 5-IV-23, 1♀. 16-V-23, 1♂. 21-VI-23, 1♀. Trail 5: 9-VII-22, 1♂,1♀. 15-IV-23, 1♀. 14-V-23, 1♂. 24-VI-23, 1♀. Trail 6: 7-VII-22, 1♂. 12-IV-23, 1♀. 10-V-23, 1♂. 6-VI-23, 1♀.

Comments

The specimens were identified using standard identification keys based on descriptions of their palps, wings, abdomen, and legs (Glick, 1992) and they were found to be similar. Specimens were collected during March-December from seepage water or a small stream with a gentle flow. Trails were mountainous areas; has been proved as breeding environment in studies by Vatandoost et al. (2006). So our results are in line with their studies.

***Anopheles maculatus* Theobald, 1901**

An. maculates Christophers, 1938; *An. dravidicus* Christophers, 1924; *Anopheles metaboles* Stephens, 1902; *Anopheles willmori* Leicester, 1908; *Pseudowillmori* Theobald, 1910**.**

Main identification characters

Antenna with tiny white scales on torus, palps thick, vertical scales at base. Pale scales border the compound eye. Palpi with three pale bands: two of equal length and one shorter and farther away. Median portion of the thorax with delicate white scales. Wing; costal veins having three black dots (Figure 3). Veins 2, 2.1, and 4 had spots. Scales medium-in length, but sometimes they appear longer. Preapical dark scales were longer than apical. Scaled sterno-pleurae. Front femora slightly raised basally. Cerci black, with pale scales on the dorsally. Tibia with little dots. Dark femora with pale patches (Figure 4). Fore tarsi with basal and apical bands; band on the third or fourth segment absent (Figure 5). Abdominal scales unequal in length. Lateral and posterior scales black. Abdominal segmentsV and VII having lines medially.

Material examined

Trail 3: 12-VII-22, 1♀. 7-VIII-22, 1♀. 10-IX-22, 1♂. 23-X-22, 1♀. 6-III-23, 1♀. 19-VI-23, 1♀. Trail 4: 12-VII-22, 1♀. 7-VIII-22, 1♂. 10-IX-22, 1♀. 23-X-22, 1♀. 6-III-23, 1♀. 19-VI-23, 1♂. Trail 5: 2-VII-22, 1♀. 14-VIII-22, 1♂. 13-IX-22, 1♀. 20-X-22, 1♀. 18-III-23, 1♀ 9-VI-23, 1♂.

Comments

According to the published literature on *Anopheles maculates* by Barraud (1934); Becker et al. (2010) and Attaullah et al. (2021), specimens were identified. From April to November, specimens were gathered in the Margalla Hills. During this time period, Attaullah et al.

(2021) also collected this species in Malakand and Dir Lower, Pakistan.

Figure 3: *Anopheles maculatus*; Three on coastal vein.

Figure 4: *A. maculatus*; Femora and dark spots present tibia spotted.

Figure 5: *Anopheles maculatus*; Apical part of hind tarsomeres IV and entire and entire V with pale scales.

Genus *Culex* Linnaeus, 1758

***Culex quinquefasciatus* Say, 1823**

Culex fatigans Wiedemann, 1828; *Culex aestuans* Wiedemann, 1828; *Culex singulatus* Doleschall, 1856; *Culex cubensis* Bigot, 1857; *Culex reesii* Theobald, 1901

Main identification characters

Body size ranged from 3.90 to 4.2 mm. The head displayed a light brown color, with the center featuring the lightest spot. The length of the antennae and proboscis was almost identical, though in rare cases, the antennae were slightly shorter. Palpi brown. The flagellum thirteen segmented that were with few or no scales. Golden brown scales covered the scutellum and mesonotum. Pleurae with a patch of white scales that was uniform in colour. The scales on the thorax were tiny and curved. Wings were with dark, thin scales. From the base to the knee, the hind femora were dark brown (Figure 6). Tarsi completely dark. Pale scales were seen on the first tergite of the abdomen. Tergite II and IV had basal black and brown stripes (Figure 7). On the basal side of each tergite, the abdomen exhibited pale, narrow, rounded stripes.

Figure 6: *Culex quinquefasciatus*; Hind femora dark brown from base to knee (not paled).

Figure 7: *Culex quinquefasciatus*; Abdomen with basal band.

Material examined

Trail 1: 10-VII-22, 1♂, 1♀. 17-VIII-22, 2♂ 1♀. 11-IX-22, 1♀. 18-VI-23, 1♀. Trail 2: 14-VII-22, 1♂. 17-VIII-22, 1♂, 1♀. 9-IX-22, 1♀. 20-VI-22, 1♂, 1♀. Trail 3: 13-VII-22, 1♂, 1♀. 5-VIII-22, 2♀. 10-IX-22, 1♂,1♀. 12-VI-23, 1♂. Trail 4: 1-VII-22, 1♂, 2♀. 8-VIII-22, 1♂ 2♀. 11-IX-22, 2♀. 19-

VI-23, 1♂, 1♀. Trail 5: 22-VII-22, 1♂, 2♀. 4-VIII-22, 1♂, 2♀. 12-IX-22, 2♀. 29-VI-23, 1♂,1♀. Trail 6: 4-VII-22, 1♂, 1♀. 12-VIII-22, 1♂, 1♀.21-IX-22, 1♀. 14-V-23, 1♂. 3-VI-23, 1♀.

Comments

Specimens were identified using the keys in "The fauna of British India including Ceylon and Burma" by Barraud (1934) and the taxonomic descriptions of the proboscis, thorax, wings, and tarsi provided by Sirivanakarn and Belkin (1980); Darsie and Ward (2005) and Qasim et al. (2014). The palpi and proboscis of this species, found only in India, are a distinctive brown colour, and the palpi are only about a sixth as long as the proboscis. The femurs and the rest of the lower legs are a dark brown colour as well. The *Culex quinquefasciatus* mosquito is one of the most common in the Indian subcontinent during the months of June, July, and September. Attaullah et al. (2021) reported this species during different months of the year excepting January and February from Malakand and Dir Lower, Pakistan.

***Culex (Culex) theileri* Theobald, 1903**

Main identification characters

The head was brown, and the back and top of the head had pale, straight, thin scales. The palpi were dark, and there was a lighter band in the middle (Figure 8). Proboscis with a light ring. The scales on the mesonotum were dark brown. Scales were on the pleurae, the back of the pronotum, and the scutellum. The scales on wings were thin and long and look dark. All of the tibiae and femora of the front and middle legs, as well as the tibiae of the front and middle legs, had pale lines that run the whole length. The side of the back tibia was not white. The prealar scale patch, the upper and lower mesokatepisternal scale patches, and the prealar scale patch were all put together to make a single patch.

Material examined

Trail 3: 11-VII-22, 1♂. 7-VIII-22, 1♂, 1♀. 10-IX-22, 1♀. 18-V-23, 1♂, 1♀. 21-VI-23, 1♀. Trail 4: 3-VII-22, 1♂, 1♀. 16-VIII-22, 1♂ 1♀. 11-IX-22, 1♀. 25-V-23, 1♂. 19-VI-23, 1♀. Trail 5: 10-VII-22, 1♂, 1♀. 20-VIII-22, 1♀. 10-IX-22, 1♀. 7-V-23, 1♂. 18-VI-23, 1♀.

Comments

The species was observed consistently throughout the year, but in varying numbers. It plays no function in disease transmission and feeds primarily on mammals. Compared to Barraud (1934), distinguishing features include a proboscis with a pale ring, the last two segments of the palpi being longer than the proboscis and curving upward, and a white mark or line underneath. *Cx. theileri* is found at high elevations (1000 to 3000m) in the Himalayan region. The specimens of this species were collected from different localities of Margalla Hills National Park, situated on the north-eastern side of Islamabad Capital Territory at a height of 1,604 meters above sea level (Maqsood and Chapman, 2000). In a study, adults of this species were captured resting in vegetation in secondary forests and along the margins of swamps and rivers near sunset and their larvae from stagnant water from Lahore Pakistan (Manzoor and Butt, 2015). We also collected the adults from the similar habitat so our results are consistent with their observations. Studies done in Iran in the past came to similar conclusions. The larvae of *Cx. theleri* were found with plants in natural and permanent environments (Sofizadeh et al., 2017).

Genus Lutzia Theobald, 1903

Lutzia* (*Metalutzia*) *raptor Edwards

Synonym: *Culex barraud*, 1921

Main identification characters

The head displayed narrow pale scales, in males; the last two segments of palpi were hairy, upturned, and longer than the proboscis. However, in females the palpi were only one-fourth the length of the proboscis. The lower side of the mesepimeron of thorax had at least four bristles (Figure 9). Pale scales were present on the legs' mid femur, rear femur, and tibia. The apical stripes of the abdomen tergites were either orcherous or whitish in colour. The last few parts were wider than the first few.

Material examined

Trail 1: 15-VII-22, 1♀. 3-VIII-22, 1♂. 20-V-23, 1♂. 13-VI-23, 1♂. Trail 2: 10-VII-22, 1♂. 19-VIII-22, 1♀. 14-V-23, 1♀. 28-VI-23, 1♂. Trail 5: 1-VII-22, 1♂. 12-VIII-22, 1♂. 11-V-23, 1♀. 25-VI-23, 1♀.

Comments

The specimens were compared to Barruad's (1934) published description of *the* species. This species is extensively distributed on the western side of India, including Punjab, Bombay, and the central provinces of Bangladesh and Burma, and is primarily found in areas with low temperatures. Qasim et al. (2014) reported this species from Murree Hills with similar habitat as collected during current studies.

Genus *Armigeres* Theobald, 1901

***Armigeres* (*Armigeres*) *subalbatus* Coquillett, 1898**

Armigeres panalectoros Giles, 1902; *Culex ventralis* Walker. 1961; *Culex subalbatus* Coquillett, 1898

Main identification characters

The vertex of this species was covered with broad white scales, while white scales border the eyes. Additionally, there were black and bluish scales visible. The clypeus was

primarily black. The palpi and proboscis were both black-brown. The palpi was approximately one-third (1/3) the length of the proboscis. From the mesonotum to the root of the wing, pearly yellow scales form lines and edges. Numerous dark brown scales cover the dorsum of the thorax, with paler scales interspersed occasionally, forming a median line from the front margin of the thorax to the scutellum. The trilobed scutellum was distinguished by its distinct filaments. The pronotum possessed a dark brown hue. On wings, there were slender, dark scales. The legs had a brownish-black hue. The femur was white from the proximal end to the knee joint. The tibia and tarsus lack rings of pallid colour. When observed from behind, the legs had a whitish hue. The talons had a structure of teeth. The dorsal side was characterized by a brownish-black hue, whereas the lateral sides had white markings (Figure 10).White basal bands and black apical bands on the third and fourth segments (Figure 11).

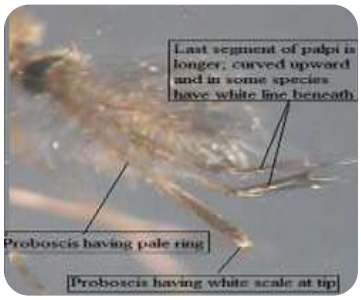

Figure 8: *Culex theileri*; Proboscis and palpi.

Figure 9: *Lutzia raptor*; Four or more lower mesepimeral bristle.

Figure 10: *Armigeres subalbatus*; White markings on lateral side.

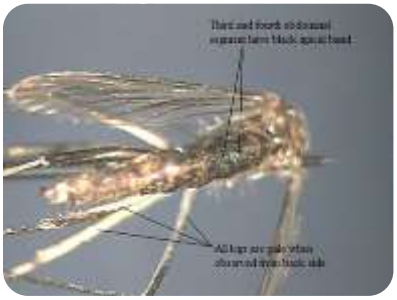

Figure 11: *Armigeres subalbatus*; Third, fourth abdominal segments with black apical bands.

Material examined

Trail 1: 2-VII-22, 2♂ . 14-VIII-22, 1♂, 1♀. 20-IX-22, 1♂, 2♀. 13-X-22, 1♂, 1♀. 15-XI-22, 1♀. Trail 2: 12-VII-22, 1♀ . 23-VIII-22, 1♀. 16-IX-22, 1♂. 19-X-22, 1♀. 12-XI-22, 1♂. Trail 3; 14-VII-22, 1♂. 4-VIII-22, 1♀. 15-IX-22, 1♀. 23-X-22, 1♂. 27-XI-22, 1♀. Trail 4: 24-VII-22, 2♂, 3♀. 14-VIII-22, 1♂, 2♀. 18-IX-22, 2♀. 2-X-22, 1♂, 1♀. 16-XI-22, 1♂, 2♀. Trail 5: 17-VII-22, 2♂, 3♀. 19-VIII-22, 1♂, 2♀. 13-IX-22, 2♀. 12-X-22, 1♂, 1♀. 17-XI-22, 1♂, 2♀.

Comments

When collected samples are compared to the keys for identifying them in "The fauna of British India including Ceylon and Burma" by Barraud (1934) and Qasim et al. (2014), they are very different. One important trait is that the mesonotum doesn't have well-developed yellow lines. Also, the palpi are about one-third (1/3) as long as the proboscis, which is different from the recognized species. Also, there are no white markings on the sides of the dorsal side of the belly. Barraud (1934) wrote that this species is common from Assam to Punjab, spreading to Burma and all over India, including Ceylon. Lam-Phua et al. (2019) recently recorded this species from Singapore. This species was previously known as *Armigeres obturbans* (Walker) as cited by Colless (1957) as one of the two prevalent species in Singapore. **Macdonald (1958)** listed "*Ar. obturbans* (= *subalbatus*)" ranging from India to New Guinea and northern Australia via the Malay Archipelago. Ramalingam (1987) and Jeffery et al. (2010) clarified the *Ar. obturbans* versus *Ar. subalbatus* records, noting that although Lee et al., (1988) determined that *Ar. obturbans* is a valid species, it is restricted to the island of Sulawesi (= Celebes) and *Ar. subalbatus* is the correct name for the common Southeast Asian species previously called *Ar. obturbans*. Recently, Lee et al. (2012) collected nine female *Ar. subalbatus*

specimens on Singapore's Ubin Island. Mehmood and Naeem (2022) reported this species from Pothwar region of Pakistan and found its population year-round in Pothwar region. They observed that the population was present in November and December, but low due to the extremely low temperature and high humidity.

***Armigeres (armigeres) kuchingensis* Edwards, 1915**

Armigeres nongpohensis Barraud, 1927

Main identification characters

The colour of the proboscis and palpi brownish-black. The vertex covered with broad, white scales, while the remainder of the body covered with flat, bluish-black scales. The dorsal surface of the thorax clothed with dark brown scales of narrow width. The mesothorax was covered with white-appearing scales. The extremities had a brownish hue. On the exterior side of the posterior femur, up to the knee, there was a pale hue. When viewed from the rear, the legs had a pallid appearance. The tarsal claws of the middle extremities were comparable in size (Figure 12). Brownish hue on both the dorsal and ventral surfaces of abdomen. The abdomen's ventral surfaces were covered with white scales. The abdominal sterna III-VI were entirely covered with pale scales, whereas the scutum had a lateral border of white scales that did not extend completely around the margin. Abdominal sternum VII exhibitd a basal dark band.

Material examined

Trail 1: 4-VII-22, 1♂. 14-VIII-22, 1♀. 14-IX-22, 1♀. 23-V-23, 1♀. 18-VI-23, 1♂. Trail 2: 4-VII-22, 1♂, 2♀. 14-VIII-22, 1♂, 1♀. 14-IX-22, 1♂, 3♀. 14-X-22, 1♂. 23-V-23, 1♂, 1♀. 18-VI-23, 1♂, 2♀. Trail 4: 4-VII-22, 1♀. 14-VIII-22, 1♀. 14-IX-22, 1♂. 14-X-22, 1♀. 23-V-23, 1♀. 18-VI-23, 1♀. Trail 5: 4-VII-22, 2♀. 14-VIII-22, 1♂, 1♀. 14-IX-22, 1♂, 1♀. 14-X-22, 1♀. 23-V-23, 1♀. 18-VI-23, 2♀.

Comments

The collected specimens were identified using the identifying characteristics provided by Sidiq et al. (2021); Barraud (1934) and were found to be comparable. They reported observing this species in Indonesia and noted that it is widespread in Bangladesh, Cambodia, India, Indonesia, Laos, Malaysia, Nepal, the Philippines, Thailand, and Vietnam. Mehmood et al. (2022) reported the year-round occurrence of this species in the Pothwar region, excluding December. In this research, this species is discovered for the first time in Margalla Hills National Park. Mehmood and Naeem (2022) reported it from forest areas in the Jhelum and Chakwal districts of Pothwar; however, this is the first study to examine this species in Margalla Hills National Park.

Genus *Aedes* Meigen, 1818

***Aedes (stegomyia) aegypti* Linnaeus, 1762**

Culex calopus Meigen, 1818; *Culex argenteus* Poiret, 1787; *Culex fasciatus* Fabricius, 1805

Main identification characters

The adult mosquito was small to medium-sized and about 4 to 7 millimeters long. In the middle of the head, between the eyes, and going down, there were flat, silvery-white scales (Figure 13). Two of the clypeus's scales were white. The middle of the scutum had lines that were yellowish or white. The white marks on these strips look like lyres. Also, the mesepimeron had two different, well-separated patches (Figure 14). The trilobed scutellum had scales that were a pale white color. The middle leg had white lines going from the bottom to the top. The front and middle tarsi had white tips. From section one to four, there was a white mark at the bottom of the back legs that was easy to see. The spots on the belly, called tergites, can be black or brown. The bottoms of the second and fourth tergites were white, and the seventh tergite has two small white dots. At the bottom of the first and seventh parts, there were white spots. Most of the time, the belly was dark brown to black, but there were white scales on it.

Material examined

Trail 1: 12-VII-22, 1♂, 1♀. 3-VIII-22, 1♂, 2♀. 9-IX-22, 1♂, 1♀. 14-X-22, 1♀. 16-III-23, 1♂. 19-IV-23, 1♂, 1♀. 4-V-23, 1♀. 23-VI-23, 2♀.Trail 2: 18-VII-22, 1♂, 1♀. 15-VIII-22, 1♀. 7-IX-22, 1♀. 23-X-22, 1♂. 16-III-23, 1♀. 13-IV-23, 1♀. 18-V-23, 2♀, 1♂. 21-VI-23, 1♂, 2♀. Trail 3: 14-VII-22, 1♀. 15-VIII-22, 1♀. 12-IX-22, 1♀. 24-X-22, 1♂. 6-III-23, 1♀. 2-IV-23, 1♀. 5-V-23, 2♀, 1♂. 7-VI-23, 1♀. Trail 4: 18-VII-22, 1♂, 1♀. 27-VIII-22, 1♂, 2♀. 20-IX-22, 1♂, 1♀. 14-X-22, 1♂, 1♀. 28-III-23, 1♀. 12-IV-23, 1♀. 19-V-23, 1♂. 4-VI-23, 1♀. Trail 5: 5-VII-22, 1♂, 1♀. 18-VIII-22, 1♂, 1♀. 23-IX-22, 1♀. 13-X-22, 1♂, 1♀. 17-III-23, 1♀. 8-IV-23, 1♀. 15-V-23, 1♂. 21-VI-23, 1♀. Trail 6: 2-VII-22, 1♂, 1♀. 14-VIII-22, 1♂, 2♀. 23-IX-22, 1♂, 1♀. 19-X-22, 1♂, 1♀. 27-III-23, 1♀. 9-IV-23, 1♀. 5-V-23, 1♂. 3-VI-23, 1♀.

Comments

Aedes aegypti is extensively distributed throughout India, including Burma and Assam, and has been discovered at a variety of altitudes, including the Hindkush at an altitude of 3,200 meters (9,600 feet). It has also been documented in the Mediterranean, Punjab, Africa, and Atlantic. The collected specimens were examined and identified using Attaullah et al. (2021); Khan et al. (2018); Qasim et al. (2014); Sudeep and Shil (2017) and Rueda (2004) published descriptions. The primary identifying characteristics consist of a brown or black scutellum on the thorax with two sub median longitudinal white stripes. The

mesepimeron displays two distinct, well-separated white regions. Attaullah et al. (2021) identified this species as one of the predominant mosquito species in Malakand and Dir Lower, Pakistan, throughout the year with the exception of January and February. Manzoor et al. (2020) found this species in fresh water, open drains, discarded containers, flower pots, tyres, and tree holes in different parts of Lahore.

Figure 12: *Armigeres kuchingensis*; Claws of the middle leg comparable.

Figure13: *Aedes aegypti*; Clypeus with two white sclaes.

Figure 14: *Aedes aegypti*; Two distinct patches on mesepimernon.

***Aedes (stegomyia) albopictus* Skuses, 1894**

Aedes samarensis Ludlow, 1903; *Aedes nigritia* Lulow, 1910; *Aedes quasinigritia* Ludlow, 1911

Main identification characters

Scales that were white and silvery were arranged in different shapes. The male's antennae were noticeably bushier than those of the female. The males' maxillary palps were also longer than their proboscis, but the females' were much shorter. Males had silverier tarsi on their back legs. The tip of the proboscis was dark, and the top of the last part of the palps has scales that look like silver. Compound eyes were very different from each other. The proboscis was dark. The scutum had a thin, pale or white strip that runs along its length (Figure 15). Near the base of the wing, near the front of the mesonotum, there were flat, silvery-white scales. On the mesepimeron, there was a V-shaped spot of white scales (Figure 16). The scutellum had three lobes and silvery white scales all over it. There was no white stripe going along the front of the midfemur. At the bottom of the tarsus, there were white lines. One to four bands were on the back tarsi. The colour of the abdominal tergites ranged from brownish to black. On the second, fourth, and seventh parts of the abdomen, white bands were seen.

Material examined

Trail 1: 12-VII-22, 1♂, 1♀. 23-VIII-22, 1♀. 4-IX-22, 1♂. 13-X-22, 1♀. 26-VI-23, 1♀.Trail 2: 14-VII-22, 1♂. 23-VIII-22, 1♂. 15-IX-22, 1♀.21-X-22, 1♀. 29-VI-23, 1♀. Trail 3: 12-VII-22, 1♂. 19-VIII-22, 1♀. 26-IX-22, 1♀.12-X-22, 1♀. 19-VI-23, 1♀. Trail 4: 12-VII-22, 1♀. 19-VIII-22, 1♀. 26-IX-22, 1♀. 12-X-22, 1♂. 19-VI-23, 1♀. Trail 5: 2-VII-22, 1♀. 19-VIII-22, 1♀. 23-IX-22, 1♀. 24-X-22, 1♂.17-VI-23, 1♀. Trail 6: 2-VII-22, 1♀. 23-VIII-22, 1♀. 13-IX-22, 1♀.28-X-22, 1♂. 13-VI-23, 1♀.

Comments

These specimens were identified by consulting the published descriptions of Qasim et al. (2014); Rueda (2004); Barraud (1934). Important identifying characteristics include a thoracic scutellum with a single, submedian, longitudinal white stripe. Instead of distinct, discrete white scale patches, the mesepimeron has white patches in the shape of a V. This species is primarily found in tree holes, with occasional occurrences in man-made gravel pools. This species is prevalent throughout India, including Burma and Assam, and has a large range. Attaullah et al. (2021) studied this species year-round in Malakand and Dir Lower, Pakistan, excluding the months of December through March. This species was

discovered by Manzoor et al. (2020) in a variety of habitats, including tree cavities.

Figure 15: *Aedes albopictus*; Median longitudinal white line present on scutum.

Figure 16: *Aedes albopictus*; White patch on mesepimeron.

***Aedes vittatus* Bigot, 1861**

Aedes brumpti Neveu-Lemaire, 1905; *Aedes albopunctata* Theobald, 1907

Main identification characters

There were white and silver scales on the head. The apex of the palpi was coloured white. On the slender vertex of this species were silvery white scales. Clypeus with silvery white scales. Palpi with silvery-white ends and predominantly narrow scales along all veins. The mesonotum of the thorax has between four and six tiny white patches (Figure 17). Three pairs of miniature scutum spherical, silvery white dots. The tibia had white rings in the middle, while the femur had white rings near the point. Each tibia is a dark colour with white patches and a white sub basal band. Four tarsomeres had white stripes; the fifth tarsomere was entirely white. The tergites of the abdomen were brownish to black in colour. There were white bands on the second, fourth, and seventh abdominal segments.

Material examined

Trail 3: 4-VII-22, 1♂. 23-VIII-22, 1♂. 19-IX-22, 1♀. 12-X-22, 1♀. 25-VI-23, 1♀. Trail 4: 3-VII-22, 1♀. 16-VIII-22, 1♀. 27-IX-22, 1♀.2-X-22, 1♂.15-VI-23, 1♂. Trail 5: 12-VII-22, 1♂, 1♀. 28-VIII-22, 1♀. 4-IX-22, 1♀.20-X-22, 1♂.18-VI-23, 1♂, 1♀.

Comments

These specimens were compared and identified using the 1934 publication "The fauna of British India including Ceylon and Burma" by Barraud, Khan et al. (2018) and Sudeep and Shil (2017). The distinguishing characteristics are four to six small white patches on the mesonotum, preapical white rings on the femora, and medial white rings on the tibiae. This species is widespread in India, including Burma and Assam, and has an extensive distribution range. *Aedes vittatus* is present in Africa, Asia, and Southern Europe of the Old World. It inhabits both the interior and exterior of dwellings. It typically inhabits natural habitats such as rock pools and tree holes (Diallo et al., 2014; Sudeep and Shil, 2017), but its ecological adaptability allows it to survive in man-made receptacles (Schaffner et al., 2009). Attaullah et al. (2021) investigated this species year-round, excluding January and February, in Malakand and Dir Lower, Pakistan. Recent reports of this species from the Islamabad region of Pakistan have been compiled by Jabeen et al. (2022).

Genus *Mansonia* Blanchard, 1901

***Mansonia (mansonioides) uniformis* Theobald, 1901**

Mansonia reversus Theobald, 1901; *Mansonia australiensis* Giles, 1902; *Mansonia marquesensis* Dyar, 1925

Main identification characters

The proboscis was straight and looked like two tubes joined together. Palpus had a few yellowish scales at its tip**.** There was either a black mark at the end or a dark brown ring around the middle of the base. The top and back of the head had yellow and brown scales that stand up straight. The yellow and brown scales on the palpi, which make up one-third of the proboscis, contrast with the yellow scales on the tori. The area from the middle of the back to the base of the wings had a mix of green and brown scales. The thoracic area had a mix of wide white scales and thin pale scales in a patchy pattern (Figure 18). A pair of longitudinal greenish stripes run along the scutum, and there are no clearly defined round spots.The post pronotum is covered in thin, curved scales. The scales of a III–VII–S are typically pale; an VIII–Te has robust chitinized hooks.There were either four or five slanted marks on the hind leg. On the tibia and tarsus, there were also marks that are a bit yellowish. Fe-III, with about five bands of pale scales; Ta-III, with entire pale bands 1-5 at the back. Large, irregular, and scaled wings of varying shades of dark and light. Some of the specimens had bright bands at the top. Most of the time, the abdomens had

a mix of yellow and dark brown colours. On the eighth tergite, there was a black tooth made of chitin that is made up of three different patches (Figure 19).

Material examined

Trail 4: 16-VII-22, 1♂, 1♀. 18-VIII-22, 1♂, 2♀. 4-IX-22, 1♂, 2♀.13-X-22, 1♀. Trail 5: 23-VII-22, 1♂, 1♀. 29-VIII-22, 1♂, 2♀. 15-IX-22, 1♂, 1♀.9-X-22, 1♀.

Comments

Compared to the observations made by Barruad in 1934, this species is predominantly found in Assam, Peninsular, Burma of India, Sri Lanka, Africa, Japan, and Australia. It was discovered in densely vegetated and verdant regions. *Ma. uniformis* is a species found on every continent. It transmits lymphatic filariasis and a number of viruses, including Bunyamwera, Chikungunya, Spondweni, and Wesselbron (Faust and Dobson, 2015). Knight and Stone (1977) report that it inhabits the Ethiopian (Afrotropical), Oriental, and Australasian regions east of the Bismarck Archipelago, Japan, and the Ryukyu-Retto. This species inhabits wet, marshy habitats and is one of the most aggressive biters. It can occur at any time of day or night (Van Den Assem, 1959). They typically assault in groups at night and seek refuge during the day. Sidiq et al. (2021) investigated this species from Indonesia. Manzoor et al. (2020) discovered this species in pure water in various Lahore locations.

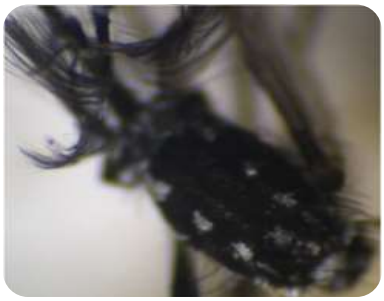

Figure. 17: *Aedes vittatus*; Four to six white spot on thorax.

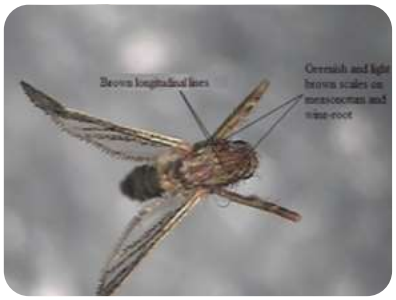

Figure. 18: *Mansonia uniformis*; Green and light brown scales on mesonotum.

Figure. 19: *Mansonia uniformis*; 8th segment of abdomen have black tooth in three patches.

DISCUSSION

During the present study, a total of 11 species of mosquitoes were identified namely, *Anopheles stephensi*, *Anopheles maculatus*, *Armigeres subalbatus*, *Armigeres kuchingensis*, *Aedes aegypti*, *Aedes albopictus*, *Aedes vittatus*, *Culex quinquefasciatus*, *Lutzia raptor*, *Culex theileri*, and *Mansonia uniformis* from various localities. According to **Zoya (2013)**, Rawalpindi and Islamabad are preferred habitat to 11 different species. Similarly Pal and Aziz (1985) were conducting a survey of the presence of malarial parasites in a selected human population at Rawalpindi and Islamabad, they collected seven Anopheline species. Recently Attaullah et al. (2021) explored the diversity of mosquitoes, distribution pattern along with seasonal occurrence in diverse habitats of Malakand and Dir Lower. According to them, 14 species belonging to *Anopheles*, *Culex*, and *Aedes* inhibit various habitats of the studied area round the year.

As a result of Pakistan's various geographical features and climate, the country's mosquito population is made up of a wide variety of species. Because Pakistan is home to such a diverse collection of ecosystems-mountains, plains, and coastal regions, to name a few it serves as an ideal breeding site for a number of different kinds of mosquito. *Anopheles, Culex, and Aedes* are the three species of mosquito that are found across the country with the

highest frequency. It is well-known that *Anopheles* mosquitoes are responsible for the transmission of malaria, and their prevalence is particularly high in rural and semi-rural areas that include standing bodies of water. On the other hand, *Culex* mosquitoes are prevalent in both urban and rural areas, and they are notorious for transmitting diseases like West Nile virus and Japanese encephalitis. *Culex* mosquitoes are present almost everywhere. Mosquitoes of the genus *Aedes*, specifically *Aedes aegypti*, are common in urban areas and are known to be the vectors for the transmission of diseases such as dengue, chikungunya, and the Zika virus. The geographic distribution of different mosquito species in Pakistan is impacted not only by natural forces but also by the activities of humans (Manzoor et al., 2020). As a result of the substantial rainfall that occurs during the country's monsoon season, there are many more places where mosquitoes can lay their eggs, which contributes greatly to the growth of the mosquito population. The presence of abandoned containers and tyres, which can serve as breeding grounds for *Aedes* mosquitoes, is another factor that contributes to the expansion of mosquito populations (Sudeep and Shil, 2017). This factor is exacerbated by urbanization and insufficient waste management practices. In addition, it is possible that climate change will play a role in affecting the distribution and abundance of mosquito species across the country, which might potentially lead to alterations in the pattern of disease. The government of Pakistan and the health authorities there has undertaken a variety of initiatives in order to battle diseases that are spread by mosquitoes. These include distributing mosquito nets in areas that are prone to malaria, spreading public awareness campaigns to educate populations about the necessity of eliminating mosquito breeding habitats, and undertaking vector control programs. However, in order to successfully monitor and control the diversity of mosquito species, continual efforts are required. This is due to the fact that there are limited resources, population expansion, and the effects of climate change. It is imperative that these issues be addressed in order to reduce the negative impact that diseases carried by mosquitoes have on the public health in Pakistan.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

AUTHOR'S CONTRIBUTION

All authors contributed and supported towards writing of this manuscript.

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