Diyala Journal for Veterinary sciences
Open Access Journal Published by College of Veterinary Medicine
University of Diyala, Iraq
P-ISSN: 2410-8863
E-ISSN:2958-6178
Vol. 2, NO. 2, June 2024
https://doi.org/10.71375/djvs.2024.02204

General Biology of Sand Fly: A review

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Abstract

The sand fly is an insect that transmits many pathogens. Vector-borne diseases cause a public health problem worldwide. Arthropods that feed on blood transmit a wide range of animal and human diseases that act as transmit of many parasites, such as leishmaniasis. It is a many of diseases caused by different species of *Leishmania*. The type of nutrition depends on the presence of the host, as sand flies take a blood meal from sources available around them for the purpose of reproduction and producing eggs. Sand flies are affected by climatic factors, including temperature in addition to humidity, on the growth and development of it. Geographical distribution occurs in areas where the flies are found and also in Neighboring areas after environmental and climatic changes provide suitable conditions for their survival

Keywords: sand flies; biology, Iraq

Introduction:

Arthropods are invertebrate creatures that number over a million species and make up over 75% of all existing animal species (1). Part of them, which acts as vectors, can transmit a harmful microorganism between animal while having their blood meal (2). Sand flies, an arthropod fallen under the order Diptera Linnaeus, 1758, the family Psychodidae Newman, 1834, and the subfamily Phlebotominae Rondani, 1840. These ectoparasites can be classified into three genera: Phlebotomus Rondani and Berté, 1840, Lutzomyia França, 1924, and Sergentomyia França and Parrot, 1920. They all feed on the blood of vertebrates. (3, 4).

Phlebotominae are blood-feeding insects that have important medical and veterinary implications (6), since it transmits different kinds of pathogens between human and animals (7). It is a generic term for all species of flying, biting, blood-sucking Dipteran found in sandy environments. In the United States, the sand fly may also refer to members of the subfamily Phlebotominae within the Psychodidae. (8). Aapproximately 800 sand fly species known globally, of which, 70 are capable of transmitting illnesses to both animals and humans (9, 10).

Morphological Characters

The sand fly is characterized by its tendency to be fragile and elongated in structure. It is small in size, 1.5-3.5mm in size, and its color is yellow or brown, the body is covered with dense hairs. Eyes are large in size, and the Antennae are long and provided with small hair, mouth parts are short and piercer. It is adapted for piercing and sucking in females and sucking in males.

Its wings are distinguished by thick hair, which extends at an angle of 40 degrees above the body during feeding and in resting position insert and the long legs are cylindrical (3, 11).

The morphological traits vary due to the diverse environmental dwelling in every living group and the geographical characteristics of holes at living places, such as their location and how above the sea level they are. There is also some variation in the phenotype of *Sergentomyia anodontis* sand flies, which might be exploited for future population categorization (12).

The structure of salivary gland in sand flies

Sand flies have two salivary glands, as paired hollow organs enclosed by a single epithelial layer. They consist of a pump, ducts, and a channel The gland are vary in size, and can be homogenous or heterogenous depending on the type of sand fly (13). Heterogenous found in members of subgenus Phlebotomus, while the homogeneous found in *paraphlebotomus* and *Euphlebotomus* and genus *Lutzomyia* (14, 15, 16).

The vertebrate host's skin is damaged by sand fly proboscis during the process of taking a blood meal. By three effective systems, the host fights back through hemostasis, inflammatory processes, and immune systems, which makes it difficult for the parasite to feed successfully. Sand fly saliva consists of a constituent called sialogenins that have anti-hemostatic, anti-inflammatory, and immuno-modulatory characteristics, which assist in coping with this unsuitable host environment and to end the blood meal (16).

The saliva content of sand flies varies not only across species (14, 15), but also between populations from different parts of the world. Saliva protein level varies among colonies and species, maintenance circumstances, and the specificity of methods used to quantify levels of protein (21). Protein contents vary from 0.18 to 0.8µg/gland (21, 22). There are significant differences between blood-feeding females and nonsanguivorous males. The concentration of *P.duboscqi* salivary protein was nearly 30 times higher in females than in males. The number of bands of salivary gland mixture run by SDS-PAGE also varied between both sexes, where 8 protein bands were noted in female , while only one band was observed in male (14). Moreover, the number of salivary proteins was also associated with female age when run on SDS-PAGE at different times (14, 23).

Nutrition of sand fly

Both sexes nourish on herbal fluids and sweet discharges, but females, in addition, suck blood from vertebrates, including humans, domestic animals, dogs, rodents, snakes, lizards, reptiles, amphibians, and birds (24, 25, 26). A variety of sand flies is opportunist and fed on nearby organisms, and they frequently exhibit distinct patterns from the same species in different habitats (27). In addition, there are several species of sand flies in fields, farms, and dog kennels in the world, including, *P. papatasi*, *P. perniciosus*, and *P. Perfiliewi* feed primarily on the blood of animals and humans near fly gathering sites, and in the presence of many animals, it has been discovered that the two species *P. perfiliewi* and *P. perfiliewi* pernicious feed on them (28).

Life Cycle:

Sand flies life cycle consists of four-stage egg, larva, pupa and adult (25). After emergence of adult sand flies mate soon, with the aid of pheromones, at resting sites, the males locate females or on hosts, (29). During a single life cycle the female usually laid 30-70 eggs (25). Consequently, a single egg production occurs during one blood meal, which is then deposited in the soil, holes, roots of trees and animal burrows (30)

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E-ISSN:2958-6178
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The eggs need wet surfaces to stay alive, although they are not placed in freshwater. The eggs hatch within 4-20 days, but this might be delayed in unfavourable weather (25).The larval development is divided into four phases, and the life cycle is finished within 20-30 days, based on the species, climate, and food availability. Unfavourable environmental circumstances (for example, cold, warmth, or dryness) may delay larval growth, extending the process of development by months. Larval feeds on biological and vegetative debris such as moulds, rotting leaves, decomposing arthropods, and faeces from animals. After 6-13 days, the pupa molts and adult sand fly arises to complete its life cycle (31) (figure 1).

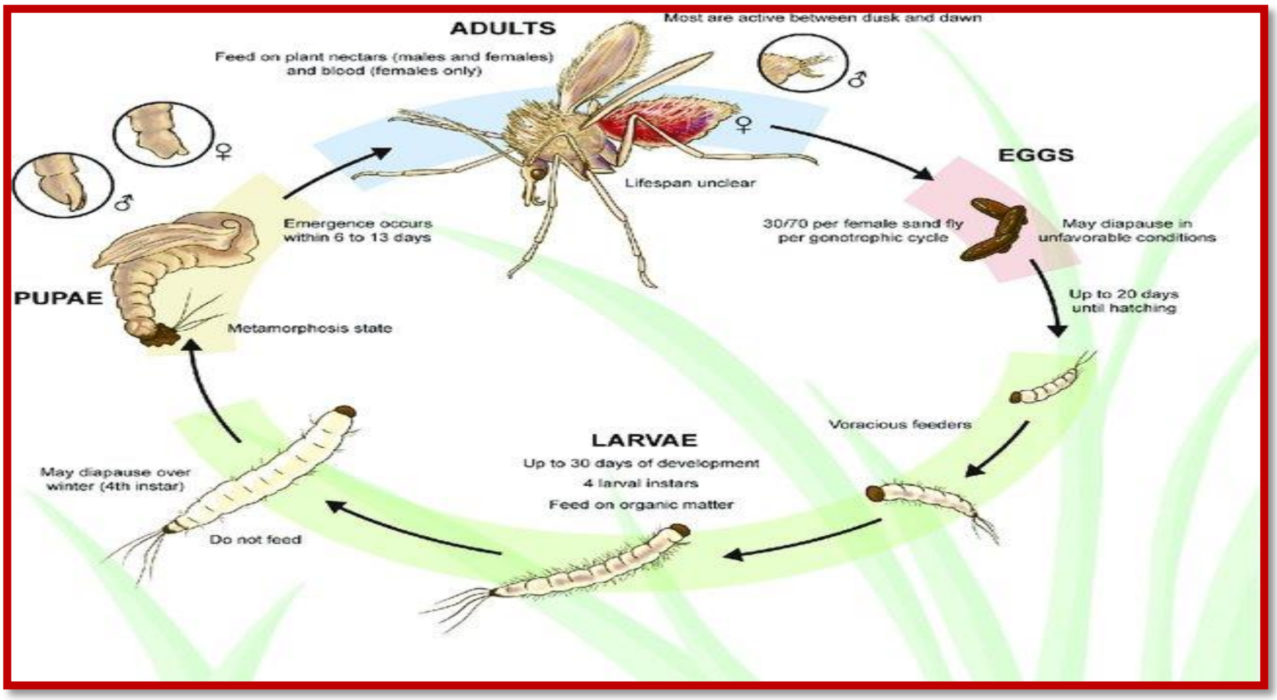

Figure 1: Sand flies life cycle (32,33).

Habitat

Phlebotomus spp. live in humid, warm, and tropical climates, while a few species may be found in locations with mild temperatures and can colonies villages, and city settings. This parasite requires a humid temperature to produce their eggs, while the larvae prefer a chilly, decaying waste, and damp environment. Adults frequently live in rock cracks, caverns, and rat tunnels, and in cold, dim, and damp areas of animal dens and human homes (26, 30). Also, the fly found in insect heaps, plant debris, underneath rocks, which are one of the principal habitats of sandflies (34, 35).

Sand flies of both sexes feed on plant fluids and sugary secretions. Females also feed on blood to create eggs; their mouthparts are used to pierce exposed skin, resulting in a pool of blood from which they feed. Feeding activity is influenced by air movement, temperature, and humidity. Sandflies are weak flies, which hinder flying and diminish biting owing to light breezes. Most species

conditions. The natural death rate of larvae is also affected by the larval density living in the biological substance materials on which they feed (37). Furthermore, it often has low flying ranges, with a small number being observed to go more than 1000 meters (38). Adult sandflies of *Phlebotomous ariasi* were found in France (39) and *Phlebotomous simici* in Austria (5). In contrast, Ph. Perfiliewi in Romania stops activity below 15 °C for a full seven days (40). Sandfly population densities vary throughout the year depending on the weather. Fluctuations in moisture and temperature cause differences in sand fly numbers throughout the cold and/or dry months (30).

Some species in tropical areas are present throughout the year, while others vary may feed after sunset and in the evening when degrees drop and dampness goes up (30). Sand flies can bite indoors in dark rooms or amid plants and trees, particularly if triggered by human movement (36).

Sandflies' development rates, natural mortality, and reproduction rates are all affected by the weather in which they live. Early developmental stages are affected by whether the organic material in which they grow is cold or warm, whilst adults are affected by the surrounding environmental

according to dry and wet seasons. Adult sandflies in temperate areas are not present during the summer, and several species of sandfly have different seasons of activities and daily peaks of stinging. Almost all adult flies are low fliers, as do the majority of horizontally flying species near the sea level. Sandflies in warm and desert locations may spend the winter as mature larvae (25).

Phlebotomus papatasi and *P.sergenti* can be found in any of the European countries of the Mediterranean, Northern Africa, Asia and the Middle Eastern countries. However, minimum winter and suitable summer temperatures are significant for latitudinal variations in species distribution. Broad temperature seasonality shifts may help shed light on the differences in species diversity between the Eastern and Western Mediterranean basin states (41).

Figure 2 Shows light traps for catching sand flies (A), beside rabbit pens (B), in shady areas inside human housing (C), and an engorged female *P. perniciosus* sand fly (42).

Epidemiology:

Sand flies are found in several countries throughout the world (43). Over the last 15 years, when molecular detection methods have been developed, they have enabled arthropods to be used as a tool for geographical and epidemiological observation of the microorganisms they load to obtain specific information on targeted microorganism epidemiology, high information on existing infectious diseases in a geographic area and to aware healthcare professionals to the appearance of the parasite in a particular area (44). Geographic spread into neighboring areas as a result of environmental changes that lead to the availability of adequate circumstances for the continued existence and development of the sand fly, one of over 45 *Phlebotomus* species documented in Europe, North Africa, and the Middle Eastern countries (45).

Sandflies are the primary vectors of *Leishmania* spp. protozoa, which are found in more temperate and warm parts of the world, especially the Eastern Mediterranean region and Central Europe. *P. mascittii* has been reported as an unconfirmed vector of *Leishmania infantum*, which is the most

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widely, distributed species in the European continent. While many aspects of its ecology and biology remain unknown, Relative humidity closely related to sand fly reproduction, as their peaked at 80% of relative humidity and decreasing at higher and lower relative humidity levels. Compared to other species the peak of around 80% is rather high (5).

Tsirigotakis et al. (46) found substantial variations in temperature and moisture requirement for several *Phlebotomus* species in Greek Aegean islands. As well as a drop in activity of *P. perfiliewi* with rising of the rain fall in Romania (40).

The highest activity of *P. sergenti* occurs during the summery and dry seasons, particularly in summer months. A relationship has been observed between the locations' latitude and the presence of sand fly during spring months and the mass type, ranging from only one to several peaks, on a geographic magnitude, On a geographical scale, *P. (Par.) sergenti* centres between 32-37° in latitude in a large interval following the longitude and the highest number of sites with high *P. (Par.) sergenti* activity is located at the latitude 32° (47).

Surprisingly a decrease in sandfly activity was related to the increase in the barometric pressure, suggesting that *P. mascittii* responds to pressure changes (5). The fly snoozes in Central European countries throughout the winter months, whereas sandfly activity often extends from spring to fall in the Mediterranean. It has been also recorded in the Northern states such as Slovakia, Austria, and Germany are mostly active in the summer (48, 49, 50).

Relative to humans, the frequency of sandflies encountering village livestock may affect the feeding of blood and ovipostion tendency of sand flies thus, village-to-village differences in livestock density and availability of cattle feces could greatly influence the rate of sand flies to feed on blood then lay their eggs in cattle excrete (37).

Generally, four sandfly species were identified:, *P.papatasi*, *P.beregeroti*, *P.sergenti* and. *Sergentomiya antennatus* Sandflies have been detected in the Hanifah Valley, Riyadh City, Saudi Arabia, with *P. papatasi* accounting for more than 95% of the overall number. Sandflies had two high rates, one in the middle of July and the second in October. Moreover, a higher number has been recorded in the Southern part of the valley than in the Northern part due to the availability of water sources in the Southern part. However, the number is more correlated to temperature and humidity, which contribute definitely to the rise of sandflies (43).

Treatment

The strategies specifically to stop life cycle and target outdoor populations of sand fly the use of the insecticide fipronil for livestock shows to play an important role in this side (37). Where larval mortality rate of 100% has been recorded at 21 days after drugs use with different concentrations of fipronil giving to livestock (51). Several studies have also reported the susceptibility of sandflies to this treat and demonstrated its value (52, 53, 54, 55).

Control

The fipronil drugs remain in the blood of cattle and are passed in feces of cattle when administered orally, affect the adult sand flies that take blood meals and on larvae when feed on the feces, the effectiveness is depended on the rates of the female sandflies that feed from treated animals, and that lay their eggs in feces which contain on the organic matter (37).

Integrated programs must be implemented to get rid of these types of flies, because they are extremely important for combating disease vectors. Combining a control strategy that depends on the resting sites of adult sand flies {Indoor residual spraying - IRS}, also their gatherings in certain places using insecticides to reduce the number of flies that transmit many diseases with a strategy that encourages host site preferences and egg-laying sites (systemic insecticides) (56).

The success of systematic treatment of livestock with insecticides is one of the important matters in controlling and depends on two factors, one of which is the feeding behavior of the insect and the other is the provision of alternative hosts (57).

Sand flies are active at night when the weather is warm, clear, and with light winds in Iraq (58), which are suitable conditions for the use applying ultra-low volume-based adulticidesas insecticides that kill adult flies and space spraying with ULV is used applied to sand flies control (59). Insecticides were also used in Kenya to eliminate sand flies by use ULV (60).

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Diyala Journal for Veterinary sciences
Open Access Journal Published by College of Veterinary Medicine
University of Diyala, Iraq
P-ISSN: 2410-8863
E-ISSN:2958-6178
Vol. 2, NO. 2, June 2024

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