Al-Muthanna J. For Agric Sci Print ISSN: 2226-4086 Online ISSN:2572-5149
https://muthjas.mu.edu.iq/ Vol. 11 , Issue 2. 2024 http://doi.org/10.52113/mjas04/11.2/11

The Study of Types and Shape of Hearing Organs in The Suborder Ensifera and Compare them with Other Species

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Received 25/8/2024 Accepted on 8/9/2024 Published on 15/12/2024

Abstract

In this study, five species were recorded under the suborder Ensifera which included the Gryllidae family; 1- *Acheta domesticus* (Linnaeus, 1758), 2- *Eumodicgryllus bordigalensis* (Latreille, 1804), 3- *Gryllus bimaculatus* (DeGeer, 1773), and the Tettigoniidae family; 4- *Neoconocephalus troips* (Linnaeus, 1758), and 5- *Neoconocephalus robustus* (Scudder, 1862). The hearing organs of these species were different in shape, but they were similar in the type (the tympanic type), and in the location of the leg of the front leg. With regard to the Gryllidae family, both males and females possess a bean-like hearing organ, which consists of two openings. The front opening (the anterior cavity) is a very small opening on the front side of the front leg, and on the back side of the leg the front leg is the hearing organ. It is an opening larger than the front (the back cavity is larger than the front), and it resembles a bean. As for the Tettigoniidae family, males and females have hearing organs similar in shape and size on the front and back sides of the front leg, and the hearing organ is in the form of a narrow, elongated rod-shaped slit.

Key words: Gryllidae family, Ensifera

Introduction

Insect hearing has evolved independently several times in the context of intraspecific communication and detection of predators by converting sensory organs into ears (**12**). These ears are divided into two types of hearing organs referred to as near-field and far-field receptors, the near-field receptors are represented by the ears, antennae and sensory hairs, while the field receptors are The far side is represented by the tympanic ears, but they are unified in the chordotonal organs that innervate the insect ears, They are complex mechanoreceptors of the first type that are distributed throughout the insect's body and work to detect a wide range of mechanical stimuli,

(**2**) In mosquitoes, the antennae ears are located in the second segment of the pedical, represented by Johnston's organ. (**6**) fleas, honey bees and some types of flies (**7**), the ear tympanum, which is a double structure, each of which is composed of a thin drum-like tympanic membrane called the eardrum, tendinous organs, and air sacs from the trachea, and it is the most well-known sound organ in terms of structure and description anatomical and distribution within insect species. It is considered the most complex and advanced hearing organ (**14**). The tympanic ears vary in shape and location, as they are located in several parts of the body as in cockroaches and tettigoniidae, the hearing organ is located in the forelegs Acrididae and Cicadidae carry the hearing organ in the first abdominal segment (**11**) insects use the hearing organ in various behavioral contexts, especially for interspecific communication, to attract a mate, determine the location of the parasitic host, and avoid predators (**9, 3**).

Methods and materials

1- Specimens Collection

Specimens were collected from the agricultural fields of two stations in Basra Governorate, namely Abu Al-Khasib District and Al-Deir District, in May 2023. specimens by hand picking and then transferred to the laboratory for photographed and dissecting the hearing organ.

2-Preservation and photograph samples

A- The samples obtained through the field survey were kept in the refrigerator after killing them at a temperature of -18 °C for 24 hours, after reported the location, the data of the collection and the name of the collecter until the diagnosis and dissection process was carried out.

B- Diagnosis of the specimens

The samples were diagnosed based on the morphological and anatomical characteristics (**4 , 1, 13, 5**). Each sample was placed in a 3 cm diameter Petri dish. The samples were dissected using an insulin syringe to cut the body parts. Measurements of the large parts were taken using a ruler. The unit of measurement for the body and body parts was mm. Photographs of the insects and insect parts such as the head, thorax, abdomen, end of the abdomen, wings and legs were taken using an iPhone 12 Pro Max camera. The samples were stored in Petri dishes in the refrigerator after photographing. specimens of the order

Orthoptera, family Gryllidae , Tettigoniidae were identified based on the external appearance characteristics, internal anatomy of the organs, and the abdominal end of the samples by Prof. Dr. Ali Dharb Shaaban, University of Basra - College of Education-Qurna (Department of Life Sciences), and according to taxonomical keys of families, genera, and species of the order Orthoptera .

3- Anatomy of hearing Organ

After dissecting the insect under a dissecting microscope using a very fine needle (insulin syringe), the hearing organ was placed on a slide containing a drop of Canada Balsam. The hearing organ was photographed and measurements were taken with a 4X graduated lens.

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Results

1- *Acheta domesticus* (Linnaeus, 1758**) Description**

The General Description: It has medium size body. The length is 31 mm. The colour is yellowish brown. (*Pic.1A,B*).

The Head: the head is 5 mm and wide. The eyes are lateral and oval exophthalmos and there are three dark straps on its back, (*Pic.2*).

The Antenna: The antennas are linear and covered with soft dense hair, divided, thin, and brown. The base is cup like root is tube like short. The whips consist of cylinder like knots and symmetrical, (*Pic.3*).

Pronotum: It is a rectangular plate and 4 mm in length and 9 mm in width. It overs with black hair with stitches. It lies in the middle and straight with two dark brown spots in form of a triangle, (*Pic.4*).

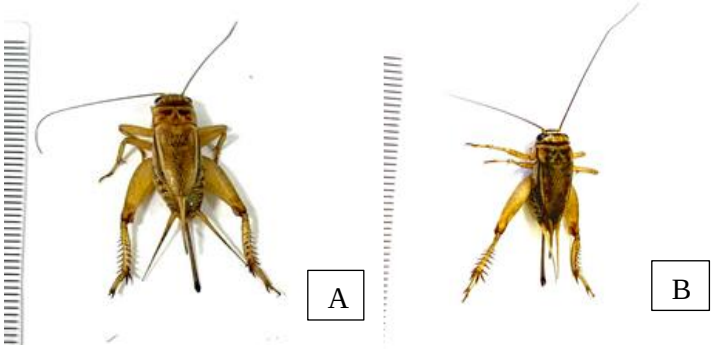
The Hinder Tibia: It is 20 mm in length and 4 mm in width. It is covered with soft dense hair. The femur is huge and enlarged with small circle spots. The leg is tubal. It has eight pairs of thorny spurs the longest are four and lie at the end of the tibia. The wrist consist of two pieces. The first piece is big with nine pairs of small thorny spurs. Between the two pieces of the wrist, there are to thorns. The second piece carries at its end two claws (*Pic.5*).

The Forewing: It is a thick wing 12 mm in length and 5 mm in width with curved sides. It hides the abdomen rings. The linear veins are straight and the diagonal veins are dense and cover the last part of the wing in form of a net, (*Pic.6*).

The Hind Wing: the hind wing is 18 mm in length and 7 mm in width and in form of transparent thin membrane. They are longer than the body, (*Pic.7*).

The Abdomen: the abdomen is short 20 mm in length. It carries at its end a pair of anal antennas 19 mm in length. It covers with soft dense hair with egg laying member 12 mm in length. It is a long plate with sharp spare like tips, (*Pic.8*).

Hearing Organ (Type A,B): the hearing organ is a pair of holes similar to elliptical drums. It lies at the base of front tibia. Its length is 0.6 mm and its width is 0.2 mm. Its external part is olive like surrounded with accurate chitin cilia, which are cellular veins for the leg. The inner part is concave and the outer tip is convex tends to inner part and covers the acoustic systems hole like a bean. The front acoustic side is a small circular opening, (*Pic.9A,B, C* ,)



Pic (1): *Acheta domesticus*

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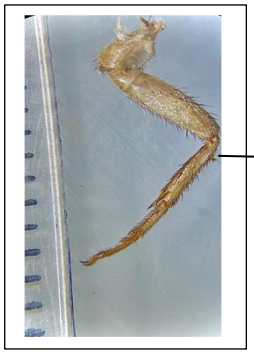
Pic (2): The head

Pic (3) Antenna

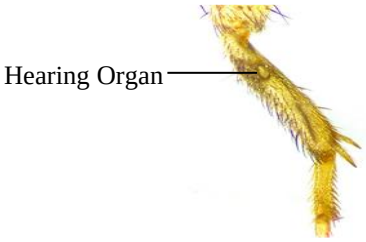
Pic (8) : The Abdomen

Pic (4): The anterior dorsal plate



Pic (9A):Location of the hearing Organ in the Jumping legs

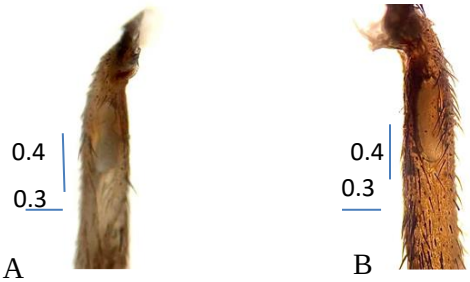
Pic (5) : The Hinder Tibia



Pic 9B: : The hearing Organ , Front

Pic (6): The Forewing

Pic (7) The Hind Wing



Pic 9C: Internal anatomy of the auditory organ from the back, Two types

2- *Ephippicogryllus bordigalensis* (Latreille, 1804) Description

The General Description: It has medium size cylinder body. The length is 42 mm. The colour is light brown with spots and the wings are long. Hinder legs are strong with enlarged thigh, (*Pic. 10*).

The Head: the head is 4 mm in length, blackish brown with spots in light brown. The eyes are complex and dark brown lie at the head's sides. (*Pic.*11).

The Antenna: The antennas are linear, thin, dark brown, covered with soft dense hair, divided, and long. The base is cup like and the root is tube like short. The whips consist of cylinder like knots and symmetrical in size, *(Pic12*)

Pronotum: The Pronotum is a rectangular plate and 3 mm in length and 8 mm in width. It overs with black hair it lies in the middle and straight with two blackish brown spots spread on the plate surface, (*Pic.*13).

The Forewing: the forewing is a thick wing 8 mm in length and 5 mm in width. The first part of the wing is light brown with linear straight long veins, which are clearly seen and dark brown in colour. They form with the diagonal veins a rectangular. The second part is transparent with crossed unseen veins, (*Pic.14*).

The Hind Wing: the hind wing is 17 mm in length and 6 mm in width and in form of transparent thin membrane. They are longer than the body and stretched to the end of the body in form of thin straps, (*Pic.*15).

The Hinder Tibia: the hinder tibia is 19 mm in length and 3 mm in width, light brown with black spots. It is covered with soft dense hair. The femur is huge and enlarged with small circle spots. The leg is tubal. It has five pairs of thorny spurs in form of four claws at the end of the tibia. The wrist consist of two pieces with two thorns in between. The second piece carries at its end two claws and there is no pad between them, (*Pic.*16).

The Abdomen: the abdomen is short 16 mm in length and 4 mm in width. It carries at its end a pair of anal antennas. It covers with soft dense hair with egg laying member 10 mm in length. It is a long plate with sharp spare like tips and ends in light brown colour (*Pic.*17).

The Hearing Organ: the acoustic member is a pair of holes similar to elliptical drums. It lies at the base of front tibia. Its length is 0.05 mm and its width is 0.02mm and similar to a bean surrounded with a light corona by the side close to the inner tip with thick light brown corona convex in shape tends to inner side at the middle of the acoustic system. The edge toward the leg is covered with chitin plate makes the tips of the acoustic system looks like a cutting edge surrounded in accurate chitin long hairs. The inner hole of the system is stick like. The front side of the system lies in the leg and is small circular opening. (*Pic.*18A, B).

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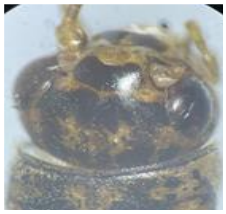
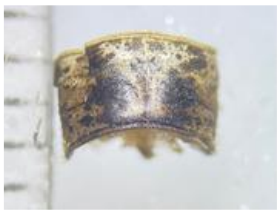
Pic (10): *Eumodicogryllus bordigalensis*



Pic (11): The Head

Pic (12): The Antenna

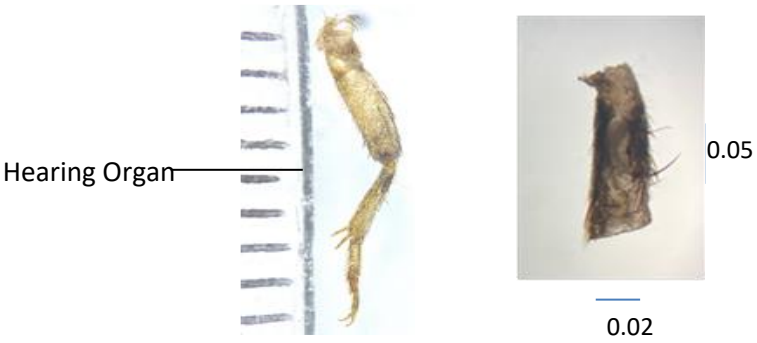


Pic (13): Pronotum Plate

Pic (14): The Forewing **Pic (15) : The Hind Wing**

Pic (16): The Hinder Tibia

Pic (17): The Abdomen



Pic(18A):Location of the hearing Organ in the Front legs,B: Internal anatomy of the Hearing organ

3- *Gryllus bimaculatus* (DeGeer, 1773) Description

The General Description: It is dark black. The male is 40 mm while the female is 44 mm, (*Pic.*19).

The Head: the head is oval, small, and black. Its length is 3 mm and its width is 6 mm. the eyes are circular and lie at the sides in form small ditches and dense a little bit, (*Pic.*20).

The Antenna: The antennas are linear, thin, dark brown, covered with soft dense hair, divided, and long. The base is cup like and the root is tube like short. The whips consist of cylinder like knots and symmetrical in size, *(Pic21*)

Pronotum Plate: The Pronotum plate is 5 mm in length and 8 mm in width. It is a rectangular. It consists of soft hair at the tip of the zigzag front plate, (*Pic.*22).

The Forewing: It is 19 mm in length and reaches the end edge of the abdomen. In the male, the linear veins are straight and close in parallel to the outer edge. There is a spot in form of coleoptile square plate at the base of the wing and other spot is circular at the last third of the wing. Then, the wing is appeared to be like a net and seems to be two-dotted wing. In female, the wing is triangle with two outer and inner edges equals size with a scar with top like at the inner edge with in parallel veins in form of straps in diagonal to the linear axel of the wing. The second half is in parallel to the external edge with veins like a net, (*Pic.23*).

The Hind Wing: It is transparent, thin, and longer than the body. It stretches to the end of the body in form of a tail with total length 30 mm. the linear veins are clear and dark brown. The longitude veins are light brown thin with two strap, one of which is brown and in parallel to the front tip and the second is at the middle of the wing, (*Pic.*24).

The Hinder Tibia: It is 31 mm in length, the femur is calendric in form and wide. The leg is thin and carries six pairs of thorns. The spurs are four and lie at the end of the leg. The wrist consists of two pieces, the first of which is big with six pairs of small thorns. There is a big thorn between the two pieces. The second piece carries at the end two claws with no pad, (*Pic.*25).

The Abdomen: the abdomen, in males, is 22 mm while it is, in females, 31 mm in length. The abdomen in females ends with the reproduction system. In females also an egging membrane 17 mm in length, straight, and needle like. It is parted from the end. The anal antennas are 8 mm in length,

The Hearing Organ for both types: the hearing organ is a pair of holes similar to elliptical drums. It lies at the base of front tibia. It is white. Its length is 0. 2 mm and its width is 0.02 mm and similar to a bean surrounded with a light corona by the side close to the inner tip with thick light brown corona convex in shape tends to inner side. The edge close to the leg is covered with chitin plate makes the acoustic edge the form of a cutting edge with surrounded in accurate chitin long hairs. The outer hole of the system is thicker than the thorns close to the inner tip. The inner hole of the acoustic system is stick like. The front side of the system lies in the leg and is small circular opening, (*Pic.26A,B,C*).

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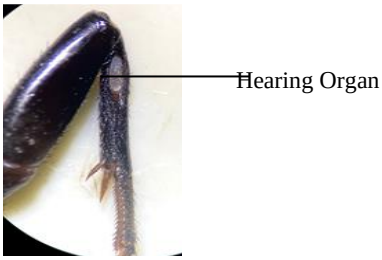
Pic (19) : *Gryllus bimaculatus*

Pic (24) : **The Hind Wing**

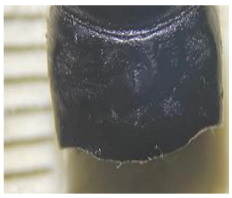
Pic (25) : The Hinder Tibia

Pic (20) : **The Head**



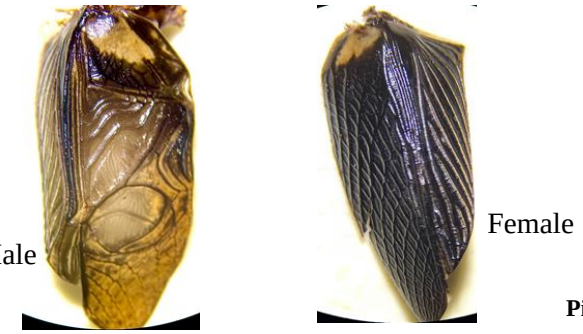
Pic (26): Location of the hearing Organ in the Front legs

Pic (21) : The Antenna

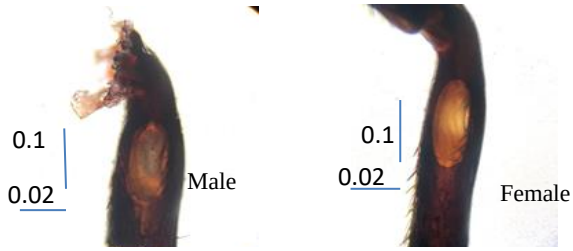


Pic (22) : **Pronotum Plate**

Pic (26B) : **Internal anatomy of the hearing Organ in the mal and femal from the front**



Pic (23) : The Forewing



Pic (26C) : **Internal anatomy of the hearing Organ in the Male and female from the back**

4- *Neoconocephalus troips* (Linnaeus , 1758)

The General Description: The body is 62 mm and yellowish brown> Its antenna are long. Its hinder tibias are long and tall. (*Pic27.*).

The Head: the head is 12 mm and conical. The middle protrusion is like a sharp tip at the head between the antennas. The complex eyes' position is on the head sides. They are dark brown. The simple eyes' position is between the antenna near the abdomen. They are white. (*Pic28.*).

The Antenna: The antennas are conical and bog. The root is cylinder like. The whip is tubal and long, (*Pic29.*).

Pronotum: It is a rectangular flat plate and 8 mm in length and 4 mm in width. At the centre is middle light brown stitch. There are two short thin black straps. The lateral two stitches are dark brown with semi-circular edge. (*Pic30*).

The Hinder Tibia: the hinder tibia is 52 mm in length. The leg is long with a high that carries number of thorns. The wrist consists of three parts and ends with a pair claws. (*Pic.31*).

The Forewing: the forewing is a thick wing 51 mm in length and 9 mm in width. It is yellowish brown with black spots. The tips are straight with circular tops and sharp tips, (*Pic32.*).

The Hind Wing: the hind wing is more than 47 mm in length and 20 mm in width and in form of transparent with longitude dark brown veins which are clear and straight. Their edges are zigzag and have circular. (*Pic 33.*).

The Abdomen: the abdomen is short 24 mm in length and 4 mm in width. It is cylinder like in shape with egg laying member 14 mm in length which is sword like with sharp tips. The anus horns are short and wide at the base and get thinner upward. There are three pairs of valves at the back side of the abdomen covered with soft and dense hairs. (*Pic34*).

The Hearing Organ : the hearing Organ is a pair of holes similar to elliptical drums. It lies at the base of front tibia. Its length is 0.07mm and its width is 0.04 mm. It resembles a rectangular narrow crack get lower from the outer part of the front tibia. This lowness is similar to acoustic drum and lacks the protrusions at the external tips therefore, it looks like a non-concave shape tends to inner side. The back shape is apparent and looks like a long groove moves into the inner side and withdrawn into the outer part. The drum is transparent. (*Pic35A,B*).

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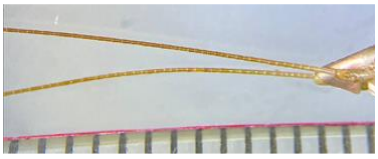
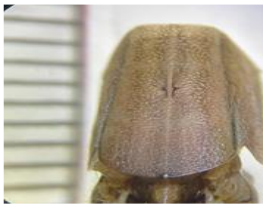
Pic (27) : ***Neoconocephalus troips***

Pic (28) : The Head



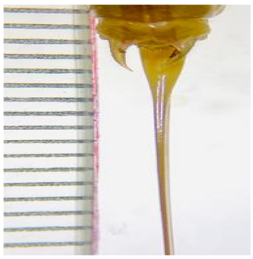
Pic (29) : The Antenna



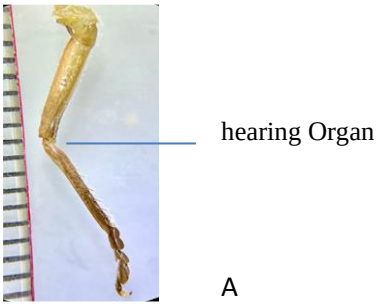
Pic (30) : Pronotum Pic (31) : The Hinder Tibia

Pic (32): The Forewing

Pic (33): The Hind Wing



Pic (34) :The end of abdomen in females



Pic (35)A: Location of the hearing Organ in the Front legs, B Internal anatomy of the hearing Organ

5- *Neoconocephalus robustus* (Scudder , 1863)

The General Description: It is green, 64 mm in length. The antennas are longer than the body, the hinder tibias are characterise by being strong and long. The female is distinguish by long egg membrane. (*Pic.36*).

The Head: the head is 7 mm in length, long, and conical similar to a protrusion with round top stretched in between the antennas. The complex eyes lie at the both sides of the head and they are dark brown with black strap, (*Pic.*37).

Pronotum: It is 8 mm in length and 5 mm in width. Its colour is light green and the middle stitch is stretched from the end of the head to the end of the pronotum with cross stitch at the hinder part. The end part is semi-circular, (*Pic.* 38).

The Forewing: the forewing is a leather in 48 mm length and 5 mm width. It is sword like. The top of the wing contains a transparent part lies in the tips and longitude veins which are clear and straight and a parallel veins which are dense. (*Pic.39)*.

The Hind Wing: the hind wing is more than 47 mm in length and 20 mm in width and in form of transparent with longitude dark brown veins which are clear and straight. Their edges are zigzag and have circular. (*Pic40.*).

The Hinder Tibia: the hinder tibia is 51 mm in length. The leg is long with a high that carries number of thorns. The wrist consists of four parts and ends with a pair claws. (*Pic.41*).

The Abdomen: the abdomen is short 21 mm. It contains in the males 9 rings and short anus antennas. The abdomen valve is crescent like tends to the inner side in angular shape. The female has 37 mm abdomen ends with 21 mm sword like egg membrane, which is green. (*Pic*.42,43).

The Hearing Organ: the hearing Organ is a pair of holes similar to elliptical drums. It lies at the base of front tibia. Its length is 0.07 mm and its width is mm. It resembles a rectangular narrow crack get lower from the outer part of the front tibia. This lowness is similar to acoustic drum and lacks the protrusions at the external tips therefore, it looks like a non-concave shape tends to inner side. The back shape is apparent and looks like a long groove moves into the inner side and withdrawn into the outer part. The drum is transparent(*Pic44A,B*).

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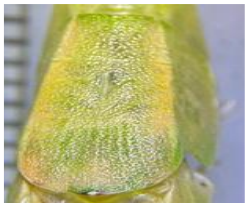
Pic (36): ***Neoconocephalus robustus***

Pic (37) : The Hea



Pic (38) : Pronotum

Pic (39) : **The Forewing**

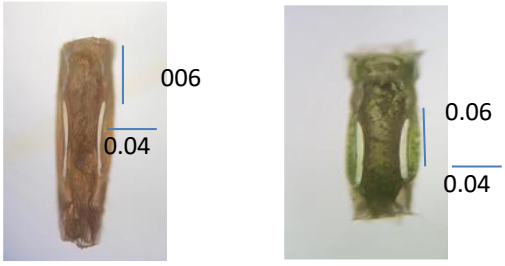
Pic (40) : The Hind Wing

Pic (41): The Hinder Tibia

Pic (42) : The Abdomen, The end of abdomen in females

Pic (43) : :The end of abdomen in males

Pic (44)A: Location of the hearing Organ in the Front legs



Pic (44) B , Internal anatomy of the hearing Organ in the Male and female

Discussion

Based on the phenotypic and anatomical characteristics and the shape and cavity of the hearing organ of adult insects, and through the study, the authors found a difference in the shape and cavity of the hearing organ, between the recorded species, which can be adopted as a taxonomic characteristic to determine the species within one genus or between different genera.

In the Gryllidae family, there was slight variation between the shapes of the hearing organs between species within one genus, with differences between genders, males and females within one species. The hearing apparatus consists of two oval-shaped membranes, one of which is in the front part of the leg, which is the anterior tympanic membrane, and the second is in the back part of the leg. The leg (posterior tympanic membrane) has unequal sizes, in contrast to the hearing organs of the Tettigoniidae family. It has equal sizes and is in the form of a narrow, elongated rod-like slit. Similarities were found between species belonging to the Tettigoniidae family and between males and females of one species.

With similarity in the location of the hearing organ between Gryllidae and Tettigoniidae in the front leg, the description of these recorded species agreed with what was described by (**8 , 10**).

Conclusion

Species of this active flying order have tympanic-type hearing organs.The location of the hearing organ was identical for species of the same order.Variation was also found in the shape and size of the ear opening between species.

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