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Morphological description of three species of diving beetles (Dytiscidae: Coleoptera) Recorded in Thi Qar governorate, Southern Iraq

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Abstract
In this study, three species of predatory diving beetles belonging to the suborder: Adephaga (Family: Dytiscidae) were recorded in Thi Qar Governorate, southern Iraq. Six districts of the aforementioned governorate were selected for the purpose of collecting adult-stage insects of water beetles. The results showed the discovery of 98 samples of the species *Hyphoporus solieri*, 82 samples of the species *Laccophilus minutus* and 180 samples of the species *Hydroporus planus*.

Keywords: Predatory diving beetles, Adephaga, Dytiscidae

Introduction

Predatory diving beetles or water beetles are aquatic insects of varying sizes ranging from 1 to 50 mm in length (Ribera *et al*., 2008) [30]. They belong to the family Dytiscidae of the suborder Adephaga, which is the largest family of the order Coleoptera, with 4300 species described. They are cosmopolitan in distribution (Travnicek *et al*., 2012; Libonatti *et al*., 2013; Nilsson, 2013; Lupi *et al*., 2014) [32, 20, 22, 26], as they are found on most continents except Antarctica (Segura *et al*., 2012) [31]. They can be found in freshwater ecosystems such as lakes, streams, springs, wet rock surfaces, ponds, swamps, and stagnant waters. They include blind species that live in springs, artesian wells, and caves. A few species are found in tropical regions (Travnieek *et al*., 2012; Ribera *et al*., 2008) [30]. Their mouthparts are gnawing, with sharp, sickle-shaped upper jaws that grasp prey and penetrate the body wall to inject a milky digestive fluid that helps kill the prey and initiate the digestion process (Usinger, 1956) [33]. The most important feature of the Dytiscidae family is the mutation of the first three carpal segments of the male's forelegs into so-called adhesive discs or adhesive hairs that enable the males to cling to the smooth dorsal surface of the females during mating (Miller, 2003) [23]. Both adults and larvae are strong predators, feeding on a variety of animal prey such as insect larvae, aquatic crustaceans, small insects, dead fish fragments, zooplankton, tadpoles, immature mosquito stages, and other prey (Lundkvist, *et al*., 2003; Aditya and Saha, 2006) [21, 3]. Some species of the family have medical importance as they are good predators that are important in the biological control of mosquitoes (Chandra *et al*., 2008; Tara *et al*., 2011) [12]. Among the studies that dealt with the family of diving beetles Dytiscidae in Iraq, the study of Abdul-Karim (1978) [1] and a study conducted by Ali (1978 a & b) [5, 6] in which he identified 55 species of the family Dytiscidae. Abdul-Karim (1987) [2] conducted a study on aquatic beetles in which he recorded 24 species of that family. Hassan *et al*. (2000) [16] conducted a study in which he showed the presence of aquatic diving beetles with algae in Basra governorate. Al-Shammary (2014) [9] conducted a study on aquatic beetles from the Dytiscidae family. Karim (2015) [18] conducted a study on the types of predatory insects and their presence in the aquatic environment of some areas of Basra Governorate. Through this study, he identified eight types of predatory aquatic insects, four of which belong to the diving beetle family. Khalaf, *et al*. (2017) [19] studied the presence and biodiversity of aquatic insects in three aquatic ecosystems in southern Iraq, including diving beetles. Alak (2017) [4] conducted a diagnostic and environmental study of some species of the aquatic Coleoptera order, Dytiscidae family. Al-Onaan (2018) [7] conducted a study that included the diagnosis of some aquatic insects, six of which belong to the diving beetle family.

The aim of this study was to phenotypically diagnosis the adult insect stage of three species of diving beetles (family: Dytiscidae) that were found in 6 districts in Thi Qar Governorate, southern Iraq.

Materials and Methods

The current study was conducted in 6 districts of Thi Qar Governorate, one of the governorates of southern Iraq, which is 366 km south of the capital, Baghdad. The districts are (Qalaat Sukkar, Al-Rifai, Al-Shatra, Al-Nasiriyah, Al-Jibayish, and Souq Al-Shuyukh). Samples were collected using sieves and aquatic insect fishing nets (dipping net) prepared for this purpose. The caught insects were kept in bottles containing 70% ethyl alcohol until they were brought to the laboratory for examination and diagnosis. A number of taxonomic keys were used for diagnosis, including (Abdul Karim, 1978; Friday, 1988; Bidarzani, 1994; Alak, 2017; Hamada, 2018) [1, 14,, 4, 15]. The examination used a stereo microscope (2x/4x progressive zoom) with two lenses, and a light compound microscope. The images were taken using a digital camera equipped with a 7-inch display screen with a resolution of 16 MP.

Results

360 insects of water beetles belonging to the family Dytiscidae were found, distributed into three species. The following is a morphological description of each species:

1-*Hyphoporus solieri* (Aubé, 1838)

Number of specimens examined: 98 (37 males, 61 female)

Description: A small to medium-sized aquatic beetle with an elongated, streamlined, oval-shaped body, usually about 4-4.7 mm long. It is usually yellowish-brown in color with a metallic sheen, especially on the elytra, which contains distinctive longitudinal line markings. The abdomen is black with a yellow border to the elytra that appears from below and is wider near the edges of the thoracic sterns. The mouthparts, legs and antennae appear reddish-brown. The tarsal segments 1-3 in the fore and middle legs of the male are expanded. The claws in the distal tarsal segments of all legs are simple and equal in length.

Head: Oval in shape, brown in color with dark areas especially on its dorsal surface, where there are black lines on the clypeus and a black stripe extends on its posterior edge. The head bears a pair of brown filiform antennae consisting of 11 segments that gradually darken towards the tip starting from the seventh or eighth segment. A pair of maxillary palps consisting of four segments, the largest of which is the terminal one, and a pair of labial palps also consisting of three segments can be observed. (Fig 1).

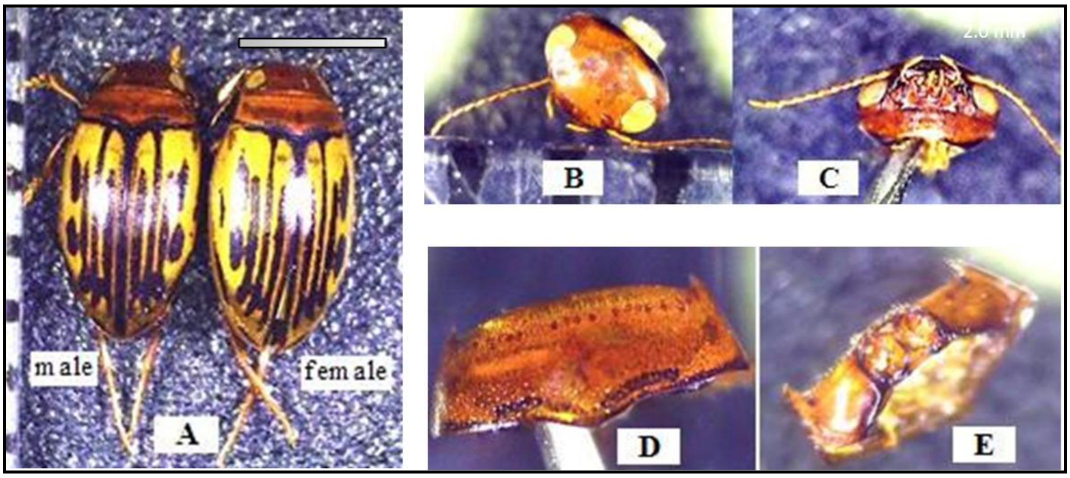


Fig 1: *Hyphoporus solieri* A-male & female. B-Dorsal & C-ventral (view of the head). D-Dorsal view of the Pronotum. E-prothorax sternum.

Thorax: The dorsal plate (Pronotum) is reddish-brown, near its anterior margin is a row of black circular pits, and a narrow black stripe is observed confined to the middle near the posterior margin, with a protrusion in its center extending backwards and is bordered by a thin basal black stripe. The prosternum is small, almost circular in shape, dark in color, bearing a slightly elevated sternal protrusion and on its sides two coxal cavities, The abdominal sternal of the mesothorax and metathorax are black in color and The sternum of the metathorax is large and appears funnel-shaped which is confined between the two posterior coxal plates. Its surface is covered with pits of various sizes. and from the middle the posterior sternal process appears in the form of a cavity or depression with two slightly raised edges from behind, ending with its connection to the two posterior coxal plates from below. (Fig 2:A).

Legs: All legs in this species appear reddish brown in color, the front and middle are similar in shape and structure and almost equal in size, the tarsus in them consists of four segments, and the first three tarsal segments in the front and middle legs of males are characterized by being covered with hairs that help in adhesion, and the terminal segment of the tarsus ends with two equal claws. The hind legs are longer than the fore and middle pairs, and are thin and their parts are elongated. The coxal plate is semicircular and ends with a small coxal projection. The tarsus in hind legs consists of five segments, the first of which is the largest in size, then the segments gradually decrease in size until reaching the fifth, smaller, terminal segment, which ends with two equal claws. All the tarsal segments bear long yellow hairs on the sides. (Fig 2).

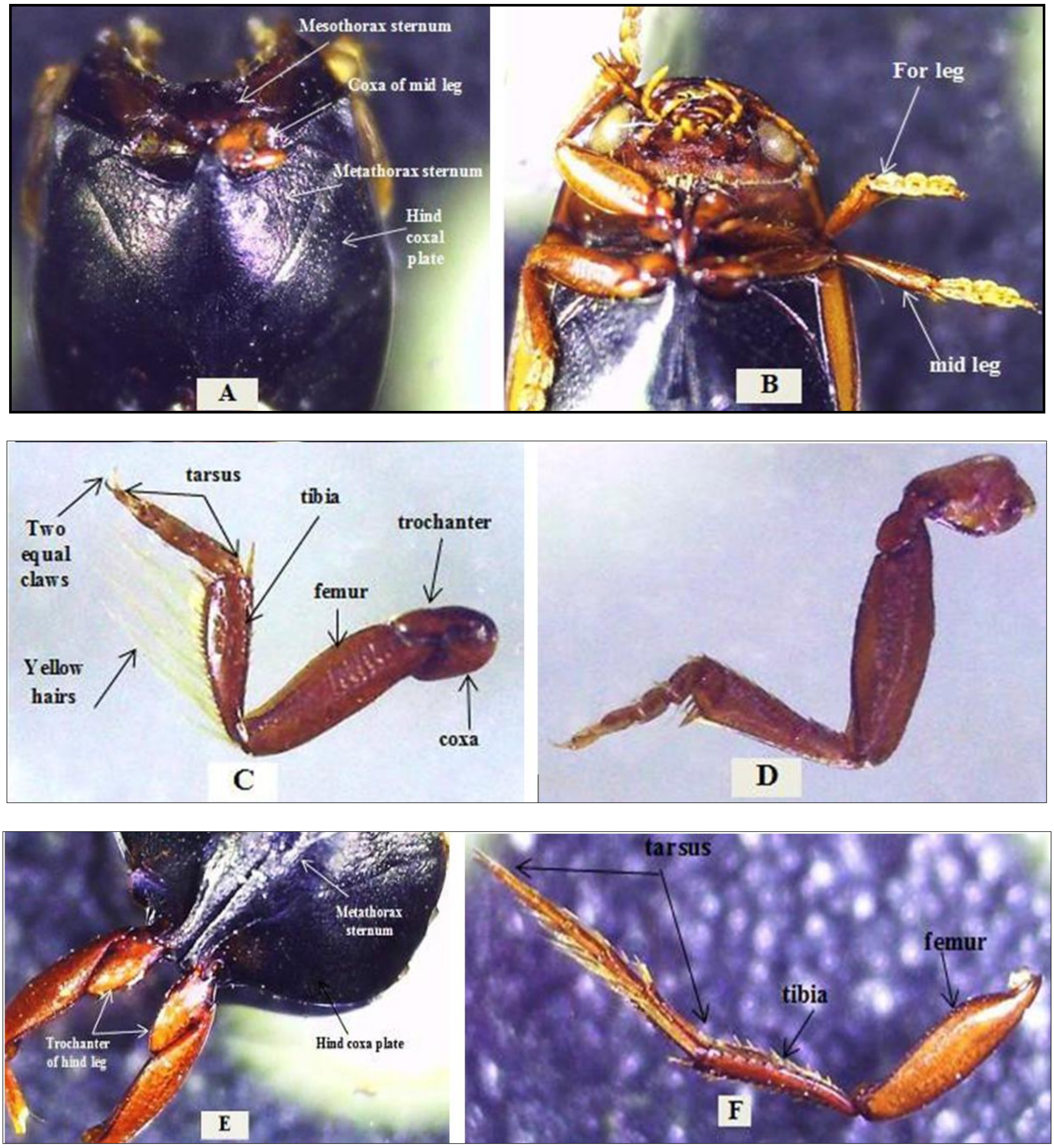


Fig 2: *Hyphoporus solieri* A-Ventral view of the second and third thoracic segments. B-The two front pairs of male legs. C-Fore-leg in female. D-Mid-leg in female. E-Hind leg plate. F-Hind leg.

Wings: The fore wing (elytra) is yellowish-brown, about 3.5 mm long. On its dorsal surface and on each part of it appear four distinctive black broad lines, the third of which is the longest, its beginning is connected to the upper fore wing edge and its end tends towards the outer lateral edge in the last quarter of the wing. A narrow black stripe frames the wing. The inner surface of the wing appears pale and the lines are not clear, especially in the upper half of it. (Fig 3). The hind wing (membranous) is folded under the elytra when at rest and is 2.5 mm long. When opened in flight, it is about 4.5 mm long and shows the same veining pattern as in members of the Dytiscidae family. The costal vein (C) and directly below it the subcostal vein (Sc) extend parallel to the anterior margin to approximately the end of the first third of the outer wing margin. Then the radial vein (R) appears clearly below the subcostal vein and extends beyond the middle to connect to the median vein (M) by a transverse vein (r-m). Under the median vein lies the cubitus vein (Cu), which is thick and extends from the base of the wing and branches into two branches: (Cu1), at the end of which there is a closed wing cell, and (Cu2), which is thin and unclear and lacks the branching usually found in the rest of the species of the Dytiscidae family. Then there are the posterior (anal) veins (A) Anal, which are four veins (A1, A2, A3, A4). The first posterior vein A1 is connected to the cubitus vein by a transverse vein, which is cu-a1, while the second posterior vein A2 is divided into two veins: 1stA2, which merges with the first posterior vein A1 and they form a closed triangular cell, and 2ndA2. The third posterior vein A3 is thick and continues towards the inner edge of the wing, and finally the fourth posterior vein A4 is weak and is located on the inner edge parallel to the base of the wing. Two dark membranous folds are also observed behind the transverse vein r-m in the part close to the outer distal tip of the wing. (Fig 4).

Fig 3: Elytra of *Hyphoporus solieri* A-Dorsal view B-Ventral view

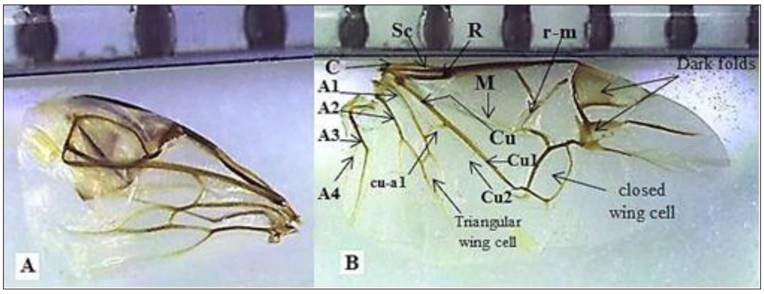


Fig 4: Membranous wing in *Hyphoporus solieri* A-At rest B-In case of flight

Abdomen: The abdomen consists of eight black targa on the dorsal side, the first four of which are approximately equal in size, then decrease in size towards the back. They are covered by the elytra when the beetle is at rest. The eighth striation is narrow, oval, darker in color and covered with dense black hairs. Eight pairs of spiracles can be seen, one pair on either side of each dorsal striation of the abdominal segments. On the ventral side, six black abdominal sterna can be distinguished, with small pit-like holes spread across their surfaces. The first sternum is narrow and is completely divided in front by the posterior coxal. The second and third are the largest and merge together so that it is difficult to distinguish the dividing line between them. The last three sterna in the male overlap each other and rise slightly upwards. (Fig 5).

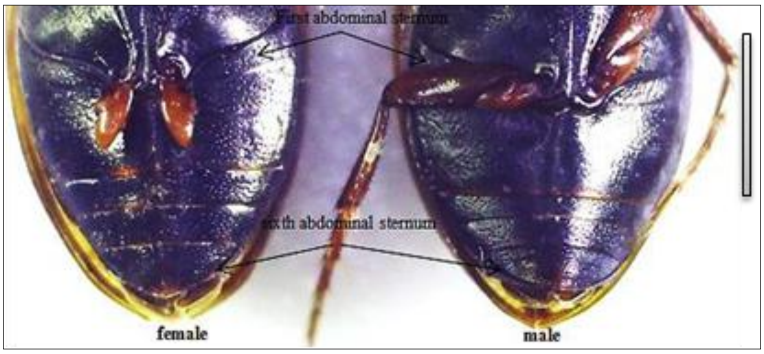


Fig 5: Abdominal sterna of *Hyphoporus solieri*

2-*Laccophilus minutus* (Linnaeus, 175)
Number of specimens examined: 82 (45 males, 37 female)

Description: The length of the whole species ranges from 4.0 to 4.6 mm, the body is oval, the head and abdomen are pale brown, with dark areas but no distinctive markings, the antennae and palps are pale and their distal apical parts are dark, the elytra is light brown with dark longitudinal markings which may be extended and thus give the beetle a bicolored appearance, the ventral surface is pale to dark brown, sometimes appearing reddish, the legs are dark reddish brown entirely. Males can be identified by the expanded basal parts of the anterior tarsus.

Head: Compressed disc-shaped, light brown with a yellowish tinge, the clypeus is small and sloping downward, ending with the forehead, which is smooth, its posterior end is light brown, the compound eyes are large, black, circular, located in the middle of the head on the sides. The antennae are threadlike, yellow, consisting of 11 equal-sized segments. The maxillary palps consist of four yellow segments, and the labial palps consist of three segments. (Fig 6).

Thorax: The dorsal plate (Pronotum) is pale yellowish-brown. Its surface is smooth and not perforated, except on the anterior and lateral margins, where fine, scattered, irregular, finely carved holes can be distinguished. Its anterior margin is slightly arched, its posterior margin sinuous, and projects strongly backwards from its middle. The ventral sternum of the prothorax is small, slightly raised upwards, and a distinct lance late sternal process projects backwards from its middle, on the lower sides of which lie the coxal cavities of the fore-legs. The sterna on the ventral side of the mesothorax and metathorax segments appears smooth and pale brown, the sternal process of the posterior sternum being pointed at its apex. (Fig 6).

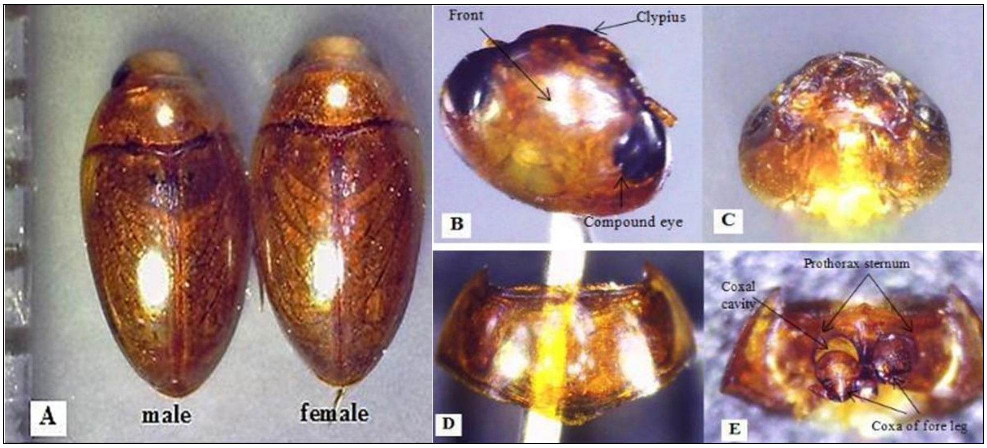


Fig 6: *Laccophilus minutus* A-male & female. B-Dorsal & C-ventral (view of the head). D-Dorsal view of the Pronotum. E-prothorax sternum.

Legs: The legs are dark reddish brown in colour, with the tip being darker. The front pair is the smallest. The tarsus consists of five segments, the first being the largest, then the segments gradually decrease in size until reaching the last segment, which is narrow and elongated and ends with two equal claws. The middle leg is similar to the foreleg in shape and structure, and is slightly larger in size. The hind legs are larger in size and consist of a large coxal plate that is directly connected to the metathorax sternum. All the tarsal segments of the hind leg bear long yellow hairs. (Fig 7).

Fig 7: *Laccophilus minutus*. A-fore leg in male. B-fore leg in female. C-mid leg. D-hind leg.

Wings: The forewing (elytra) is about 3.5 mm long, light yellowish brown in colour and transparent enough to show the membranous wing folded underneath when not in flight. It is characterized by markings in the form of longitudinal lines intersecting with small transverse lines in an irregular manner to form a net-like pattern which is clearly visible on examination. The outer edge is folded downwards to form a pocket extending from the middle of the anterior end of the wing to just before its posterior (apical) end, while the inner edge is surrounded by a narrow dark brown stripe. The membranous wing is triangular in shape, about 4.5 mm long. When opened in flight, the costal vein (C) is dark brown in colour. There is a dark brown spot in the middle of the wing. At the end of the cubitus vein (cu1) there is an oblong cell. (Fig 8).

Fig 8: Wings in *Laccophilus minutus*. A-ventral view of elytra. B-dorsal view of elytra.

C-membranous wing

Abdomen: The dorsal side of the abdomen consists of eight dorsal targa, the first six of which are dark brown in the middle and the edges are brown. The eighth targum is triangular and divided into two parts separated by a median line. The abdomen contains eight spiracles. The ventral side consists of six sterna, the first of which is divided by the coxal cavity protrusion. The first four are almost yellowish brown in color, while the fifth and sixth sterna are almost dark brown. (Fig 9).

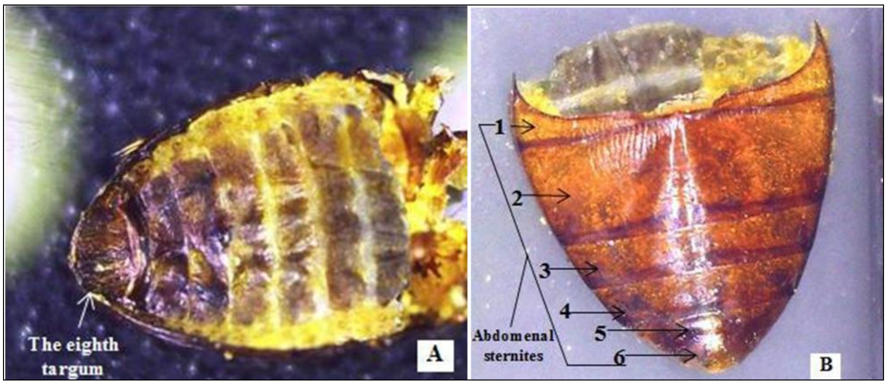


Fig 9: Abdomen in *Laccophilus minutus*. A-dorsal view (targa). B-ventral view (sterna).

3-*Hydroporus planus* (Fabricius, 1782)

Number of specimens examined: 180 (74 males, 106 female):

Description: Small to medium-sized aquatic beetles, 4.5 to 5 mm long, oval in shape, sometimes widened laterally, head and dorsal plate (Pronotum) black, elytra pale brown with a distinctive yellow patch, lateral margins usually narrowly pale, antennae and legs reddish brown.

These beetles are characterized by the presence of dense downy hairs covering both body surfaces (dorsal and ventral), the density and distribution of which varies with respect to different body regions. The fore and middle tarsus consists of four parts or appears so because the fourth part is very small and hidden between the lobes of the third part.

Head: The head is small, oval, completely black with slightly lighter areas on the dorsal side near the middle of the posterior edge. The eyes are black, lateral and flat. The antennae are filiform, consisting of 11 segments, reddish-brown, segments 1 to 4 are lighter in color, segments 5 to 11 are slightly expanded, bead-like, and are more prominent in males. On the ventral side of the head, a pair of maxillary palps and a pair of labial palps consisting of 3 segments can be seen, reddish-brown in color, the terminal segment is light in color. The surface of the head is covered with black hair, concentrated in the middle half, and is denser on the ventral surface than the dorsal surface. (Fig 10:A,B,C).

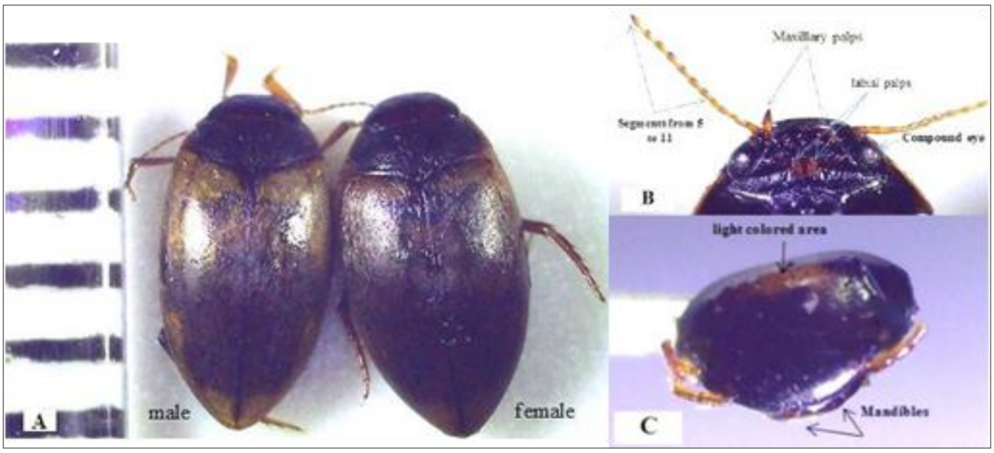
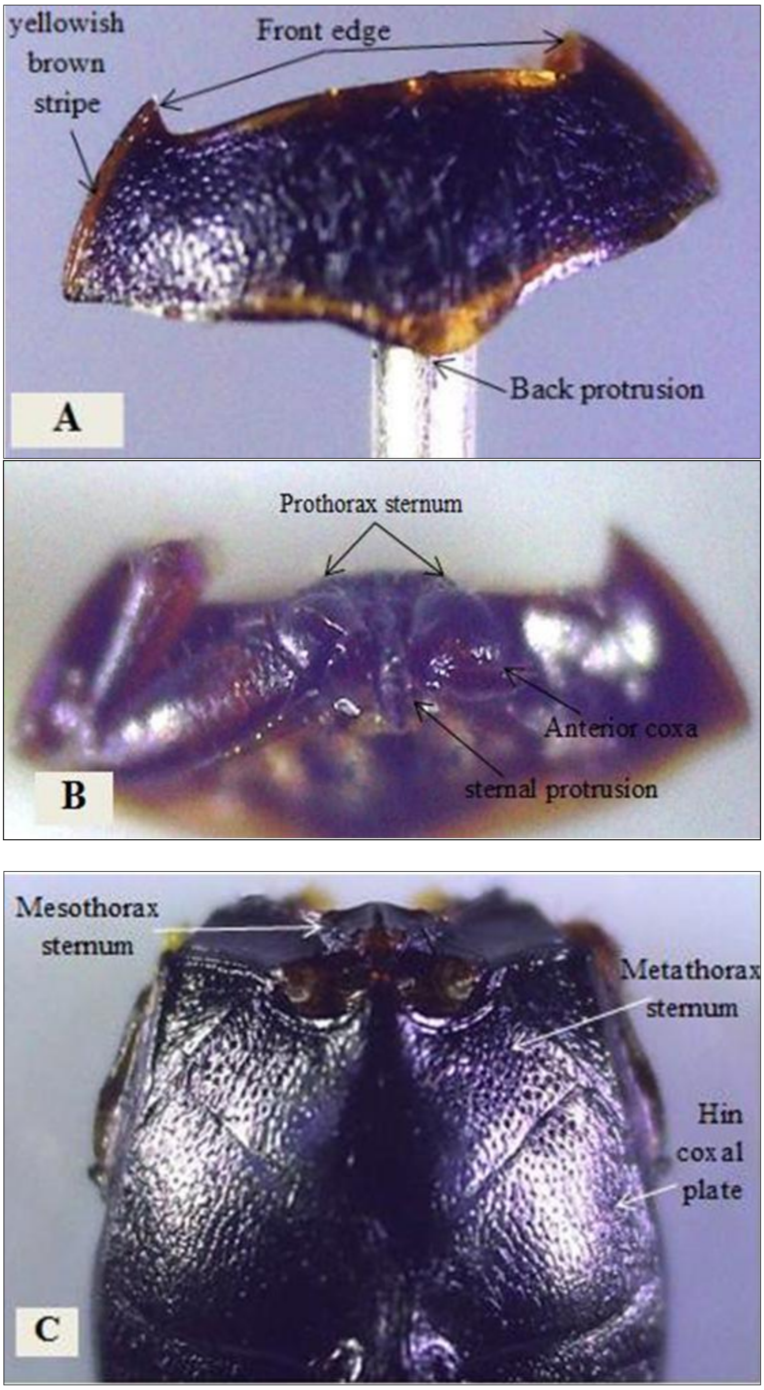


Fig 10: *Hydroporus planus* A-(male & female) B-ventral view of the head C-Dorsal view of the head

Thorax: The dorsal plate (Pronotum) is completely black, surrounded by a narrow light brown to yellow stripe. Its surface is covered with dense, dark grey to black downy hair. Its posterior edge is zigzag on both sides, and in the middle there is a protrusion extending backwards. From the ventral side, the sternum of prothorax can be seen. It is small and completely black, with a slightly curved, scalpel-shaped sternal protrusion extending backwards. The second thoracic sternum is small, narrow, black, and ends at the bottom with two coxal cavities between which is a small sternal protrusion. As for the posterior sternum, it is wide and slightly raised in the middle, its posterior edges are straight, and it is black, covered with short black hair that emerges from cavities and pits that are widely spread on the surface of the sternum. (Fig 11:A,B.C).

Legs: The forelegs and middle legs are similar in shape and structure, as they show a spherical coxa connected to a small oval shaped trochanter, which in turn is connected to the femur, on whose surfaces hairs are spread, then the tibia, which is covered with hairs and spines more densely than the femur. Then, tarsus consists of 4 parts, the first of which is the largest in size, the second and third are equal, while the last, terminal part is elongated and less wide than the rest of the parts and ends with two equal claws. All parts of the tarsus bear hairs and small spines. The coxal plate of the hind leg is broad and black in colour, connected above to the posterior thoracic ridge and covered with hair, most densely seen in the space between the two posterior coxal processes. The tarsus in hind leg consists of five parts, the first of which is the longest and largest, then the parts gradually decrease in size until reaching the terminal and final part, which bears two equal claws. All the tarsal segments bear spines and hairs of different shapes and sizes. (Fig 11:D,E,).



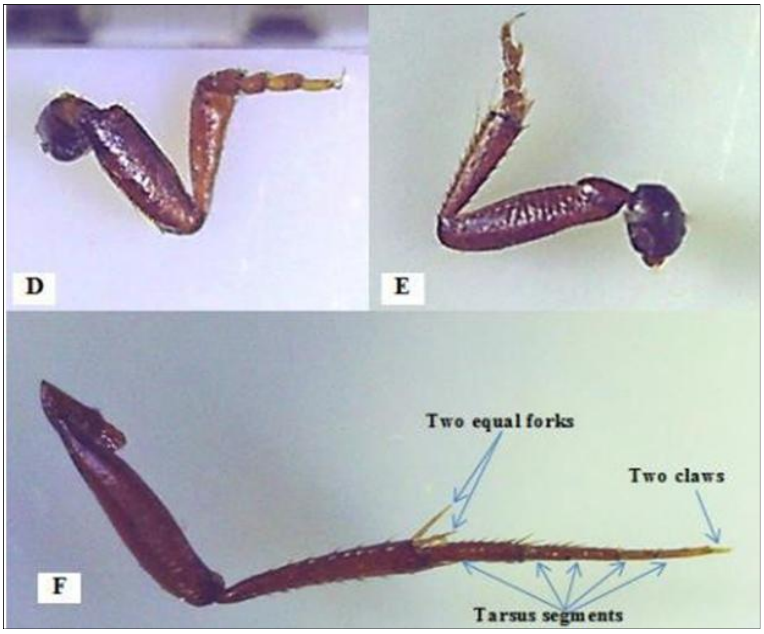


Fig 11: Thorax in *Hydroporus planus* A-Pronotum. B-Prothorax sternum C-Meso & metathorax sterna D-Fore leg E-Mid leg F-Hind leg

Wings: Wings: The forewing (Elytra) is less than 4 mm long and is mostly brown in colour with a yellow patch or spots forming distinctive patterns. The anterior quarter of the elytra is pale, while the rest of the area is dark with pale spots that can be seen with the naked eye. The dorsal surface of the elytra is completely covered with dense, grayish downy hairs extending to the lower lateral margins of the anterior half, which are in the form of a marginal fold extending from the outer corner of the base of the elytra to approximately the middle of the wing. Fig (13:A).

Abdomen: The abdomen consists dorsally of 8 black targa, the first of which is narrow, the second and third are the largest, then the dorsal targa gradually decrease in size until reaching the eighth sternum, which is the smallest, and bears dense black hairs. There is also a pair of spiracles on the sides of each dorsal targa. From the ventral side, six black sterna can be seen, all of which bear long gray to black hairs that emerge from cavities or holes widely present on the surfaces of the sterna and are densely concentrated in the middle. It is also noted that it is more widespread on the fifth and sixth sterna. The first sternum is narrow and thin and is divided into two parts by the two posterior coxal. The posterior edge of the second sternum has a median inward curvature. The third sternum is the largest, and the posterior end of the sixth and last sternum is triangular (Fig 13:B,C).

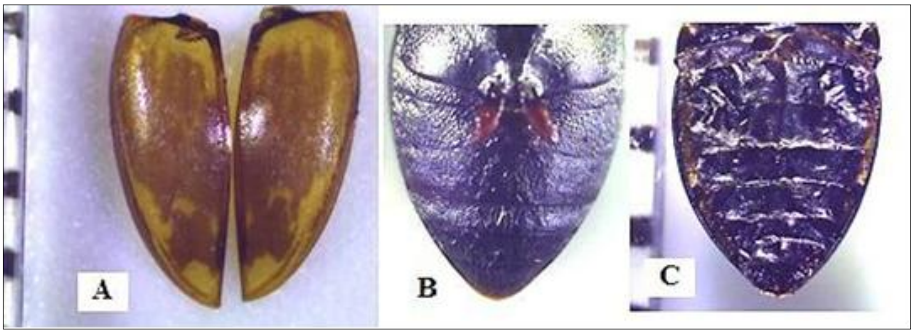


Fig 13: A-Elytra in *Hydroporus planus*. B-Abdominal sterna. C-Abdominal targa.

Discussion

General morphological characters were used to distinguish between the three species recorded in this study, which belong to the family Dytiscidae. Two of them belong to the subfamily Hydroporinae, namely the species *Hyphoporus solieri* and *Hydroporus planus* and the third species, *Laccophilus minutus*, belongs to the subfamily Laccophilinae **(**Foster & Friday, 2011).

The species *Hyphoporus solieri* was first recorded in Iraq by Abdul-Karim (1978) [1] and was also recorded in Al-Saffar and Augul (2021) [8]. It has a wide distribution spanning the Palearctic regions, with records from southern Europe, parts of North Africa, and the eastern regions. Its presence has been recorded from Iran to the Arabian Peninsula and Egypt. This distribution indicates that H. solieri inhabits a variety of aquatic habitats (Nilsson and Hájek, 2021).

The species *Laccophilus minutus* is widely distributed worldwide, covering all continents, except Antarctica, and its original habitat is reported to be in Europe (Nilsson, 2015) [27]. (Biström *et al*. 2015) [10] indicated that this species is found in North Africa, as it has been recorded in Morocco, Algeria, Tunisia and Libya. (Ramadan and Ramadan, 2021) [29] also recorded its appearance in Jordan. It was first recorded in Iraq by (Abdul Karim, 1978) [1] then (Carl, 1989) [11] and recorded it by (Alak, 2017) [4] in a diagnostic study of some species of the Dytiscidae family. It was also recorded in the study of (Al-Saffar and Akoul, 2021) in the southern marshlands.

The species *Hydroporus planus* was first recorded in Iraq by Abdul-Rassoul *et al*. (1987) [2]. It is widely distributed in the Palearctic, being known on three continents (Asia, Africa and Europe) and in more than 40 countries from the United Kingdom to China, It is especially common in western, central and northern Europe (Nilsson, 2001, 2003; Jäch, 2004) [17]. Duff (2012) [24, 25, 13] reported that this species is widespread throughout England and Wales, with scattered populations in Scotland and Ireland. It is particularly abundant in low-lying areas with stable freshwater bodies.

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