Morphological Identification of Dragonflies Naiads (Odonata: Anisoptera) From Temporary Ponds in Basrah Province, South of Iraq

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Abstract

Dragonfly naiads of the Anisoptera species were collected from shallow ponds in Basrah Province, South of Iraq, between December 2017 and November 2018. The specimens were identified based on their morphological features, with special attention to the structure of the mandibles. A total of eight species were recorded, which included Anax parthenope from the Aeshnidae family, and seven species from the Libellulidae family: *Crocothemis erythraea*, *C. servilia*, *Diplacodes trivialis*, *Orthetrum sabina*, and *Selysiothemis nigra*. Naiads of two species, *Diplacodes lefebveri* and *Sympetrum striolatium*, were also observed in the study region for the first time.

Key words: Dragonflies, taxonomy, morphology, nymph, endemic species, Iraq.

Introduction

The worldwide diversity of Odonates from one place to another makes them a good indicator of healthy ecosystems at different ecological levels, ranging from local to continental (Boudot and Kalkman, 2015), Iraq is among the countries with the most relatively low diversity, due to the harsh environment, especially in the Basrah Province in the south of Iraq (Khalaf and Zayed, 2009) . A global attention of Odonata were received because of their distinctive environmental role as voracious

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predators used in the biological control of harmful aquatic organisms, and their naiads adapted to live in a variety habitat of freshwater ecosystem including shallow ponds, marshes and streams as well they represent desirable prey for many fish and waterfowl (Corbet, 1999).

The known number of Odonates species reached 5950 belonging to 625 genera and 30 families (Dijkstra and Kalkman, 2012), where the Suborder Anisoptera (dragonflies) subdivided into 12 extant families (Corbet and Brooks, 2008; Dijkstra and Kalkman, 2012), but the larva stage (naiads) of most odonates species still not identified, however Corbet (2002) found that the molt approximately 8 to 17 times, with various number of instars within and between Odonata species, the final instar represents the end of the aquatic stage of odonates life cycle which extends between 1 to 4 years depending on the species and the geographical region. The emergence process of naiads happens when the last instar of naiads leaves behind the exuvia and transfers to adult stage (Dijkstra & Lewington, 2006).

Many taxonomic keys for identifying Odonata species focus on naiads of the species of Libellulidae family, including species found in our region, as in the following: Dumont (1999), Nesemann *et al.* (2011) and De Gabriele (2013).

De Foneska (2000) provided a simple identification key to determine the differences in the morphological features between naiads of several odonates species, he stated that they have a special structural features of respiratory organs which were mainly separated between naiads of the two Suborders: Anisoptera (Dragonflies) and Zygoptera (Damselflies), in addition to specific characteristics (e.g., labial structure, number and arrangement of body spines, shape of the abdomen and anal pyramid).

In Iraq, very few studies shed light on Odonata adults and naiads particular in the aquatic environment of the southern part, such as: Ali *et al.* (2002), Al-Onan (2018), Darweesh (2018) Ahmed and Kareem (2019), Ahmed (2020) and Ahmed and Kareem (2020 a and b).

This study aimed to document fauna of Anisoptera naiad's species (Order: Odanata) in Basrah Province- South of Iraq, by using specific taxonomical features supported with drawings.

Materials and methods

Samples of naiads were obtained from temporary shallow ponds of Basrah Province from December 2017 to November 2018. Three selected ponds with depths ranged between 35-50cm, were represented the main stations for sampling, which located in Abu Al-Kassib district (30 25 45.1"N 47 55 52.1"E), Al-Hartha district (30 39 5.47"N 47 42 34.32"E) and Al-Madina district (30 55 51.7"N 47 14 29.6"E), as well as three other temporary stations in the Garmat Ali Campus 56 86.61"N 47 75 37.15"E, Basrah City Center 30 32 13.70"N 47 43 40.99"E and in Al-Huta region 30 63 17.29"N 47 76 91.75"E. Individuals of dragonflies nymphs were collected according to the methods of Usinger (1974) and Lamelas-Lo´pez, *et al.* (2017), with some modification when necessary due to the ecological difference between the samples regions.

Specimens of 800 naiads in different life stages, were collected using sieve with 22cm in diameter and mesh size of 1 x 1 mm; the sieve was pulling under water for a distance of 25 to 50 cm, then raised quickly with a slight shaking to get rid of excess water, naiads were lifted from the sieve using a brush. Some specimens were preserving in 70% alcohol for further examinations, While the other naiads were chosen in the later stages and kept alive in a suitable container with aerated water and some aquatic plants to complete their final larval stages.

We determined the final instar of naiads when the length of wings buds reached the segments between 4, 6, or 7 of the abdomens depending on Odonata species; the selected naiads were rearing until emergence to adults, to study the identification characteristics of each species.

Morphometric measurements have been studied using Dissecting and Compound Microscopes to diagnose some specific features; a ruler nearest 0.1mm were used to take the measurements. Drowning was made to illustrate the specific

details by Camera Lucida and photographed by Camera (Huawei Mate 9 Leica Dual). Identification features were followed according to the taxonomical keys of: Carchini (1983), Dumont (1991), Hawking and Theischinger (1999), DE Forsake (2000), Cham (2007), Nesemann *et al*. (2011) and De Gabriele (2013).

Results

The nymphs (naiads) of eight Anisoptera species that have been recorded from Basrah are belong to the two families Aeshnidae and Libellulidae. The general identification features of the body were showed in Figure 1.

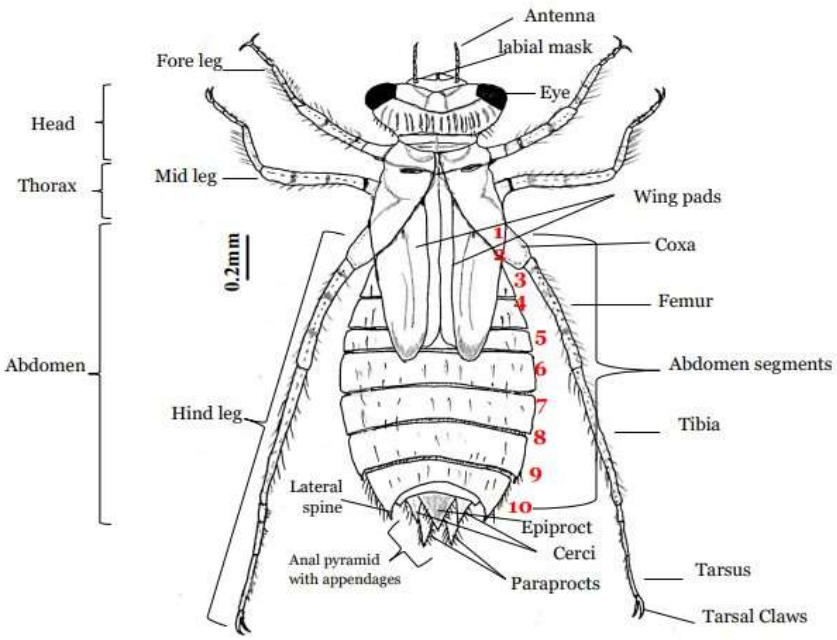

Figure 1: General morphological features of an Anisoptera naiads (*Crocothemis servilia*)

Remarks

Long or Short and robust body consist of ten cylindrical segments (S1-10 from base to apex), hairy or less hairy; semicircular, square or triangle head, lateral or semi lateral large complex eyes; labium variable in size and shape, flat or concave; hind legs may equal or extend beyond abdominal end; elongated flat or rounded broad abdomen with or without mid-dorsal and lateral spines; five long or short anal appendages.

Key for morphological identification of the final instar of Anisoptera naiads

1-Body length between 45- 50mm; flat prementum without setae, anner edge of labium palp is slightly serrated, mid lobe has a medial slit called (Cleft); short wing buds exceed apex of S4 abdominal segment, elongated abdomen; hind legs do not exceed the eighth abdominal segment..... **Family: Aeshnidae** 2

1'-Body length less than 25 mm; Prementum and palpal lobes of labium (lower lip) spoon-shaped or concave and has bristles; wing buds exceed of S6; Short semi-ovate abdomen; the hind legs extend beyond apex of the anal appendages.....**Family: Libellulidae**.....3

2- Semi-circular head, lateral-dorsal eye longer than wide; short Straight lateral spines on the S7 - S9; Epiproct plate with truncated apex.....***Anax parthenope***

3-No mid dorsal spines; short lateral spines on S8- S9 4

3'- Mid dorsal spines in some abdominal segments.....7

4- Medium size body ≥19 mm; wing buds reached the base of S6; tibia equipped with a dense row of long hairs; very short lateral spines.....***Crocothemis***....5

4'- Body length less than 15 mm; wing buds reached ¾ of S7; tibia equipped with a row of long and scattered hairs; hind leg exceeds the anal appendages.....***Diplacods***.....6

5- Body length 14-16 mm, dark brown color; dark bands on the legs, length of the hind legs exceeds anal appendages at approximately the apex of tibia .....***Crocothemis erythraea***

5'- Body length between 17.5-19 mm, light brown color, length of the hind leg exceeds the apex of anal appendages at approximately the second segment of tars.....***Crocothemis servilia***

6- Body length 12.5-14 mm, dark brown color or blackish and speckled; mid lobe of the lower lip studded with needle hairs.....***Diplacodes lefebvrei***

6'- Body length 12-14 mm, light brown color; mid lobe of the lower lip without styloid hairs.....***Diplacodes trivialis***

7- Body length more than 19 mm, covered with dense hairs; rectangular head; wing buds reached the base of S7; mid dorsal spines in S4–S7 ....***Orthetrum sabina***

7'- mid dorsal spines on S4- S8; long lateral spines on the S9 abdominal segment.....8

8- Body length between 14-18 mm, brown or pale olive color with dark brown spots; Semi-oval head covered with scattered hairs, elongated longitudinally eyes; wing buds exceed the apex of S6; straight lateral

spines on S9 shorter than the post anal plates. ....***Selysiothemis nigra***

8'- Body length between 17-18 mm, yellowish brown color with two rows of black spots and brown blotches; Semi rectangular head, anterior-lateral eyes; wing buds reached the base of S6; curved lateral spines on S9 longer than or equal to the anal plates. .....***Sympetrum striolatium***

The two families and an eight species were illustrated as follows:

1- Family: Aeshnidae

Common name: Darner dragonflies

Commonly collected in vegetation along the edges of lakes and ponds.

Naiads (about 80 individuals) of one species of this family was recorded only in St.1 of Basrah Province during the period from Dec.2017 to June 2018; two individuals reached the final instar were identified as follow:

1- *Anax parthenope* naiad (Selys, 1839) (Plate 1)

General shape: cylindrical body, elongated and robust, brown or olive, total length 45-50mm.

Head: semi-circular, as an average 6 mm in length and 8.5 mm in width; large eyes, flattened dorsally and laterally with straight posterior edges and antenna 7- segmented.

Mouthparts: Mandibles enlarged with sharply, curved and pointed black molars**;** labium long with flat prementum, in average 10 mm long, labial palps with two hooks, the inner one-pointed black top, slightly curved inward, the outer one labial

palp long and mobile with a sharp pointed tip, middle edge covered with a thin black strip like a brush, a deep median slit with a groove called (cleft).

Thorax: Narrow cylindrical, bears two pairs of short wing buds, exceed top S4 abdominal segment; thin cylindrical legs, femur and tibia elongated with rows of short pin bristles, tarsi of three segments ends with terminal claw bears two hooks and hind leg extend to S8 abdominal segment.

Abdomen: Semi oval in shape, very long, bearing lateral spine of S7- 9, anal pyramid elongated consist of: epiprocts semi rectangular with a broad top, pair of cerci equal ⅓ length of paraprocts which triangular elongated ends of sharp terminal with black spines.

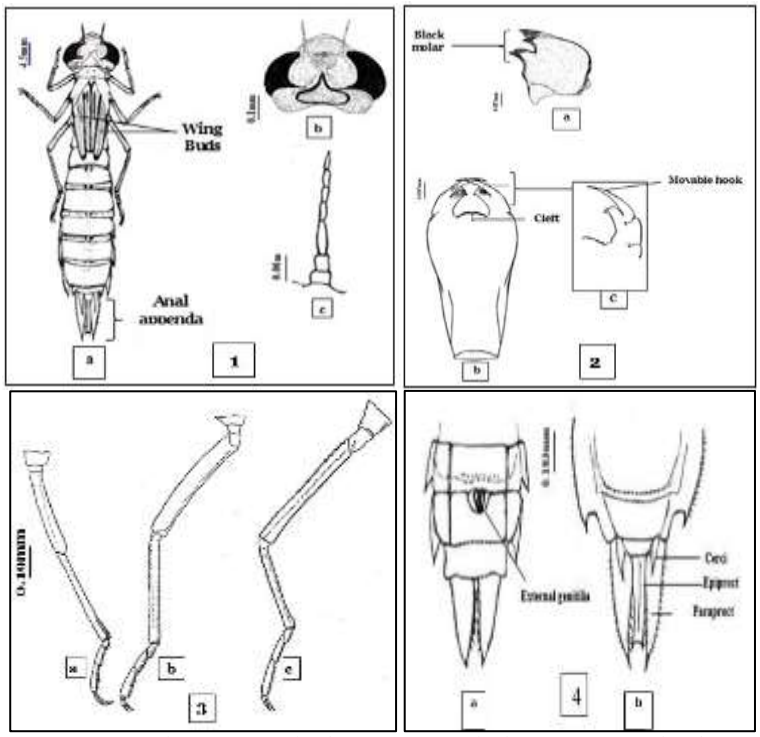

Plate 1: *Anax parthenope* naiad, 1- General shape: a- Body, b- Head, c- Antenna; 2- Parts of the mouth: a- Mandible, b- Labium, c- Enlarged part for movable hook; 3- Legs: a-Fore, b- Mid, c- Hind; 4- Anal appendages: a- Dorsal view, b- Ventral view.

2- Family: Libellulidae

Common name: Skimmer dragonflies

Usually found: In ponds lakes swamps marshes and ditches (slow moving water).

Naiads of seven species of this family were recorded in the three stations of Basrah Province during the period from Dec.2017 to Nov. 2018, and they identified as follow:

1- *Crocothemis erythraea* (Brulle, 1832) (Plate 2)

General shape: Semi- cylindrical or oval body, reddish-brown, total length 14-16 mm, covered with a small number of tough hairs.

Head: semi-rectangular, in average 4 mm in length and 5 mm in width, rounded eyes, large and projecting laterally prominent, antennae of 7 jointed segments ends with terminal pointed apex.

Mouth parts: Mandibles enlarged with two black molars of pointed tips, Prementum with 2 rows of 14 setae each (8 long and 6 short); labial palp with 10-11 long setae with small movable hook on the tip and blotched with dark brown spots.

Thorax: cylindrical, narrow and short, bears two pairs of wing buds, extend to base of S7 abdominal segment; legs: longer and slenderer, femur straight, bearing long and medium-density hairs with dark markers, hind legs exceed abdomen end.

Abdomen: broad oval shaped, tapers between S9 and S10, short lateral spine on S8-9 with red pointed apex; anal pyramid surrounded by black bristles, Epiproct equal ¼ length of paraprocts, cerci equal about half shorter than them.

2- *Crocothemis servilia* naiad (Drury, 1773) (plate 3)

General shape: Semi cylindrical body, yellowish-brown, total length 18- 20mm.

Head: Semi square head, eyes protruding laterally big whitish with a darker lower region, 7-jointed antenna segments, 3-6 filiform, tapering apically.

Mouth parts: Mandibles enlarged with an irregular margin and sharply pointed molars, labium spoon-shaped, prementum

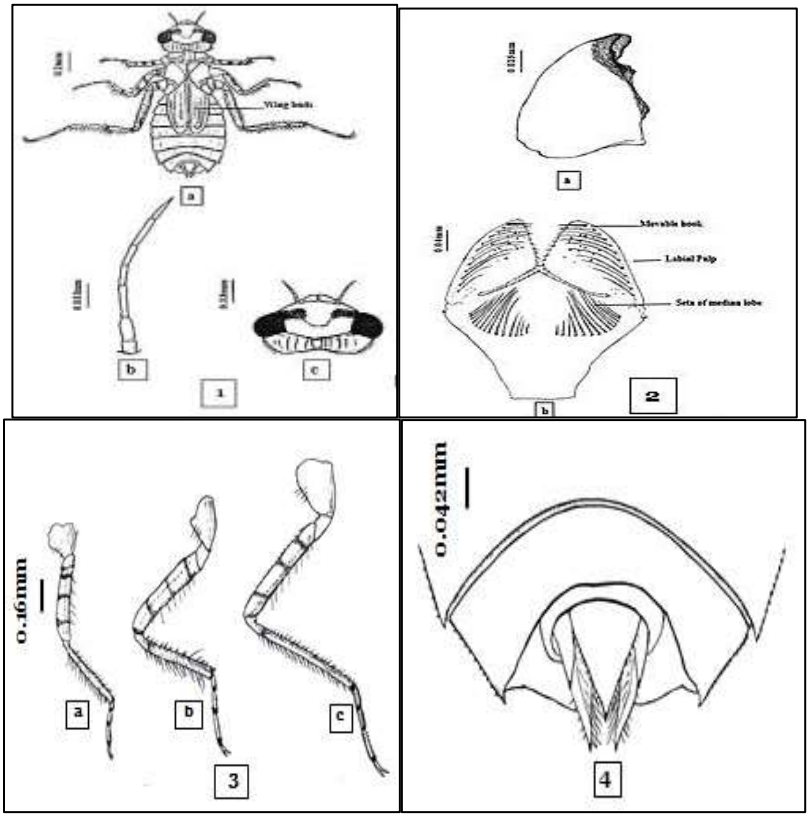

Plate 2: *Crocothemis erythraea* naiad, 1- General shape: a- Body, b- Antenna, c- Head; 2- Parts of the mouth: a- Mandible, b- Labium, c- Enlarged part for movable hook; 3- Legs: a- fore, b- mid, c- hind; 4- Dorsal view of anal appendages.

convex with 13+13 to 15+15 premental setae, palp setae 10+10 to 11+11, median lobe of labium studded with setae, distal margin of palps crenate, each crenation bearing setae.

Thorax- Cylindrical thorax, wing sheaths extend to base of S7 abdomen segment; legs slender quadridentate setae on the tip of tibia with dark bands
on femur, tibia and dark spots on tarsi.

Abdomen: Semi oval in shape, Abdominal segment 10 sunken into segment 9, mid-dorsal abdominal spines absent; lateral spines on S8-9 short, those on S9 not more than 1/4 of the length of that segment; anal pyramid not distinctly protruding, epiprocts and paraprocts inlaid with rows of setae on sides.

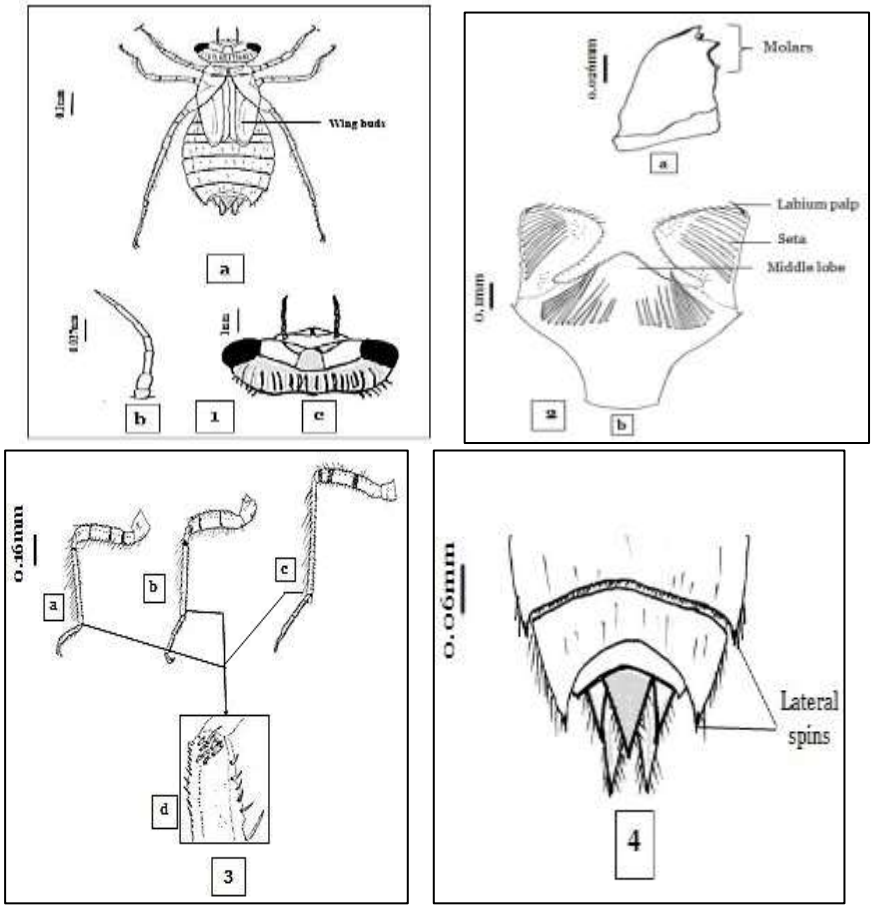

Plate 3: *Crocothemis servilia* naiad, 1- General shape: a- Body, b- Antenna, c-Head; 2- Mouth parts: a- Mandible, b- Labium, 3- Legs: a- Fore, b-Mid, c-Hind, d- enlarged part of the tibia; 4- Anal appendages.

4- *Diplacodes lefebvrei* naiad (Rambur, 1842) (Plate 4)

General shape of the body: Cylindrical dark reddish brown, total length 12-14 mm.

Head: Semi-triangular, anterior–lateral eyes.

Mouth parts: Mandibles enlarged with molars of pointed margin; spoon- shaped labium, premental setae 14 + 14 (8 long and 6 short), palps setae 10 + 10, movable hook with a brown terminal tip, median lobe of labium studded with setae.

Thorax: cylindrical, bearing two pairs of wing buds of unequal length, reaching approximately ¾ of S7 abdomen segment.

Abdomen: Broad oval, dark reddish-brown, bearing straight and short lateral spines on two sides of S8-9 equal ¼ of their length, outer margin studded with thick hairs, anal pyramid surrounded by long scattered hairs, epiprocts funnel-shaped, equal more than ½ of its paraprocts length.

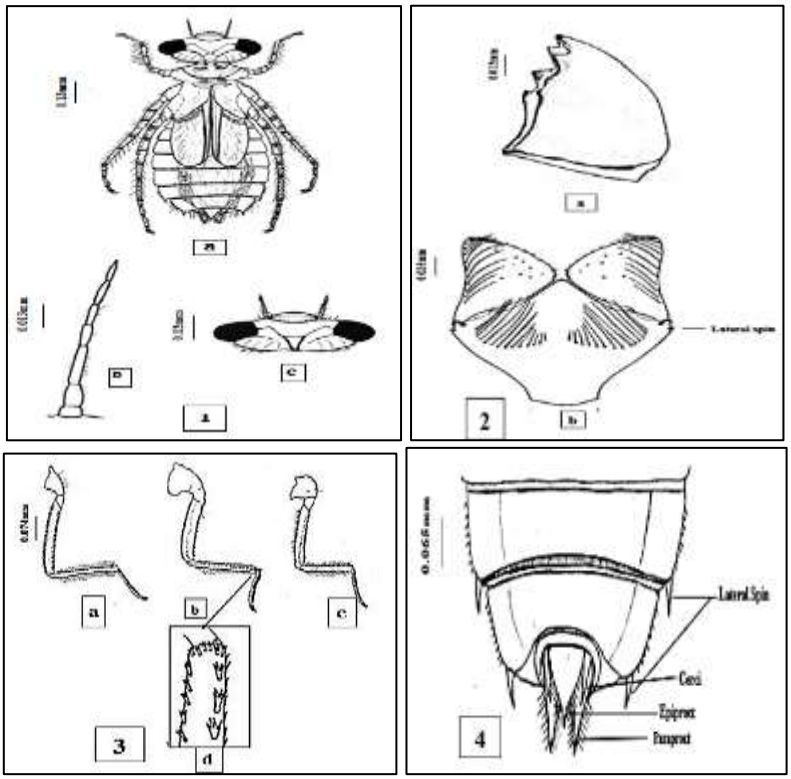

Plate 4: *Diplacodes lefebvrei* naiad, 1- General shape: a- Body, b- antenna, c-Head; 2- Parts of the mouth: a- Mandible, b- Labium, 3- Legs: a-Hind, b- Mid, c- Fore, d- enlarged part of tibia; 4- Anal appendages.

5- *Diplacodes trivialis* naiad (Rambur, 1842) (Plate 5)

General shape: Semi oval body, brownish yellow, total length 11-14mm.

Head: Broadly semi rectangular with curved back edges head, laterally protruding eyes.

Mouth parts: Mandibles enlarged with molars of pointed margin, labium and labial palps spoon-shaped, premental setae 14 + 14, palps setae 10 + 11, median lobe of labium without setae.
Thorax: Cylindrical; wing buds extend to the middle of S7 abdomen segment; legs slender spotted with dark bands, tarsi of hind legs embayed with rows of tridentate setae.
Abdomen: oval in shape; lateral spines on S8-9 straight and short with lengths equal 1/3 of their segment's length; anal pyramid distinctly protruding, tips of epiproct, paraprocts and cerci ends with reddish black spins.

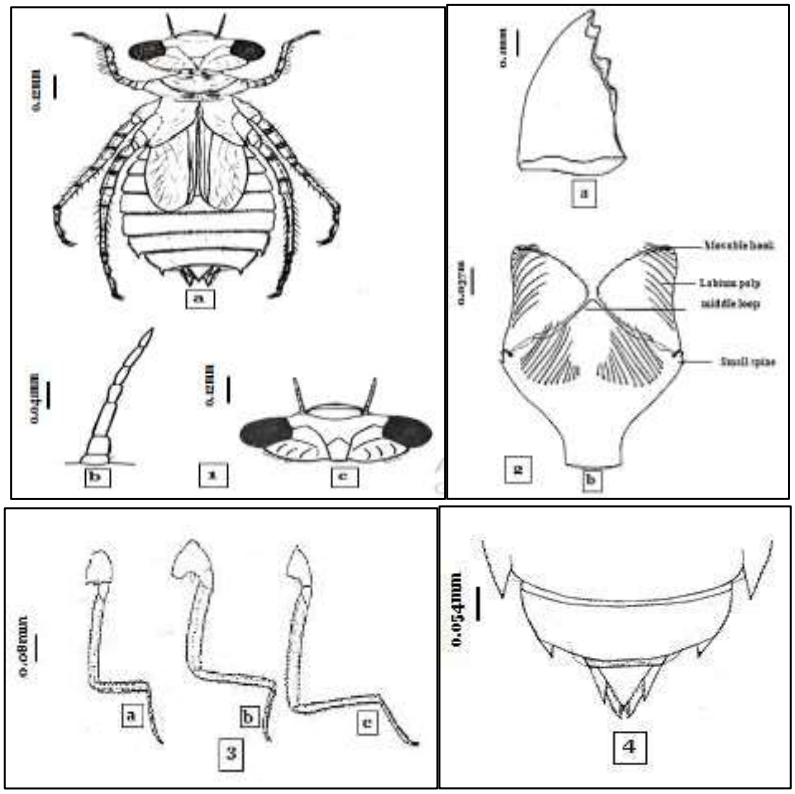

Plate 5: *Diplacodes trivialis* naiad, 1- General shape: a- Body, b- Antenna, c- Head; 2- Parts of the mouth: a- Mandible, b- Labium; 3- Legs: a- Fore, b- Mid, c- Hind; 4- Anal appendages.

6- *Orthetrum sabina* naiad (Drury,1793) (Plate 6)

General body: Semi oval-cylindrical, hairy, brown or olive, total length 17-22 mm.

Head: Semi rectangular, small protruding frontal –lateral eyes.

Mouth parts: Mandibles descend into a black curve with irregular pointed margin of molars; premental setae 3 +3 long and two irregular rows of 17+16 short setae, labial palps setae 8+8; distal margin of palps formed beak-like crenation, two spiniform setae present near the base of the palps.

Thorax: Cylindrical, narrow and short, covered with dense bristles, bearing two pairs of wing buds with prominent veins of length reach to the base of S7 abdomen segment; legs yellow-brown, short and sturdy, with rows of long and scattered bristles.

Abdomen: Broad, oval in shape, strongly curved dorsally, covered with irregular thick hairs, short and broad triangular spines prominent on S4-7 abdominal segments, very short lateral spines on the sides of S8- 9 abdominal segments, anal pyramid is conical, elongated, and hairy yellow-brown with tapered ends, length of epiprocts equal ¾ length of paraprocts.

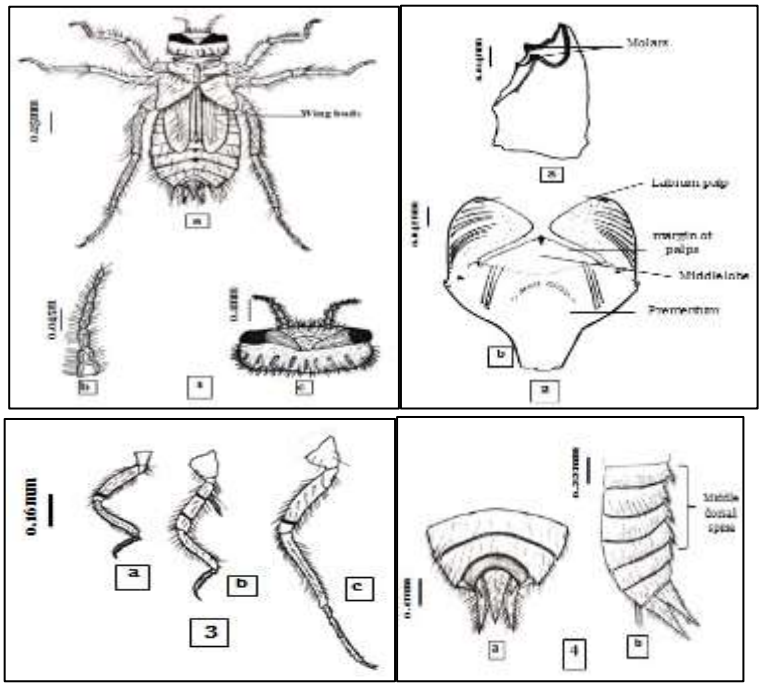

Plate 6: *Orthetrum sabina* naiad, 1- General shape: a- Body, b- antenna, c- Head; 2- Parts of the mouth: a- Mandible, b- Labium; 3- Legs: a- Fore, b- Mid, c- Hind; 4- Anal appendages: a- Lateral view, b- Dorsal view.

7-*Selysiothemis nigra* naiad (Vander Linden, 1825) (Plate 7)

General shape: semi-oval body, brown or pale olive with dark brown spots, total length 14-18mm.
Head: semi-triangular, anterior- lateral eyes longitudinally elongated
Mouth parts: Mandibles enlarge with irregular and dark pointed molars, some with sharply tip; spoon- shaped labium with small spines in each side, premental setae 14 + 14 (8 long and 6 short), palps setae 11 + 11 with movable hooks.
Thorax: broad cylindrical, bears two pairs of wing buds with different length exceeds the end of S6 abdominal segment, legs cylindrical with dark brown lines or markers.
Abdomen: oval, light brown, prominent spines on the S5-8 with different sizes, covered with dense bristles. Small and thin spine on S5, large spines on S6- 8, with pointed ends strongly curved towards the end of the abdomen; lateral spines of S8- 9 very large and studded with short spines, spine of S8 straight and extends to the length of S9 abdomen segment, while spine of S9 large and curved inward, extending to ¾ of the length of the anal appendages, epiprocts funnel- shaped with pointed tip, more than ½ length of the anal pyramid and long triangular paraprocts with pointed tips surrounded by protruding rows of long bristles.

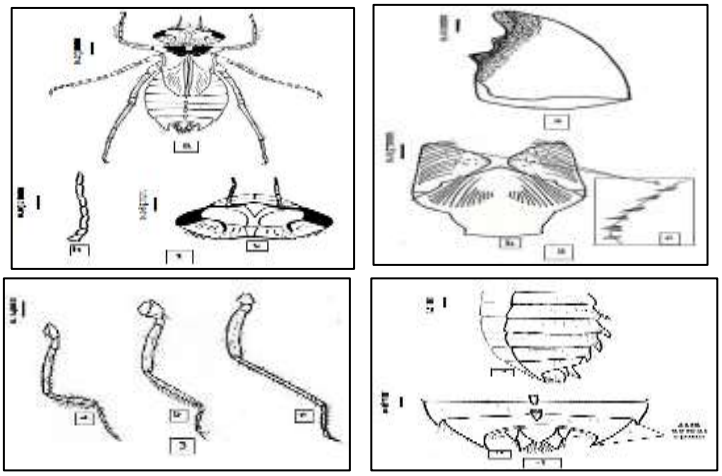

Plate 7: *Selysiothemis nigra* naiad, 1- General shape: a- Body, b- Antenna, c- Head; 2- Mouth parts: a- Mandible, b- Labium, c- Enlarged rim part of the interior of the labial palps, 3- Legs: a- Fore, b- Mid, c- Hind; 4- Abdomen and anal appendages: a- Lateral view, b- Dorsal view.

8- *Sympetrum striolatium* naiad (Charpentier, 1840) (Plate 8)

General shape: Semi cylindrical- oval body, yellowish-brown with two rows of black spots and brown blotches, total length 17-18mm.

Head: semi-oblonged, rounded eyes protruding laterally, antennae of seven segments with fine bristles.

Mouth parts: Mandibles enlarge with zigzag margin of pointed tips, spoon- shaped labium with small spines in each side, premental setae 12 + 12 (7 long and 5 short), labial palps 10+10 long setae with movable hook, median lobe studded with single needle setae regularly distributed.

Thorax: cylindrical brown, bearing two pairs of wing buds reaching to the end of S6 abdominal segment; legs long cylindrical with brown marks and long bristles concentrated on the outer edge of tibia apex, with four- branched terminal bristles, hind legs extend to the end of abdomen.

Abdomen: Dark brown striped with distinct black marks, mid-dorsal abdominal spines in S4- 9, spine of S4 relics and cuts, spine in S5 small and thin, spines of S6 and S7 largest with tapering end up to the middle of the smallest spine S8; lateral spines of S8-9 very long and slightly curved inward, reaching the end of anal pyramid; small cerci, epiprocts funnel-like with pointed tip, equal ½ length of paraprocts, surrounded by rows of long hairs.

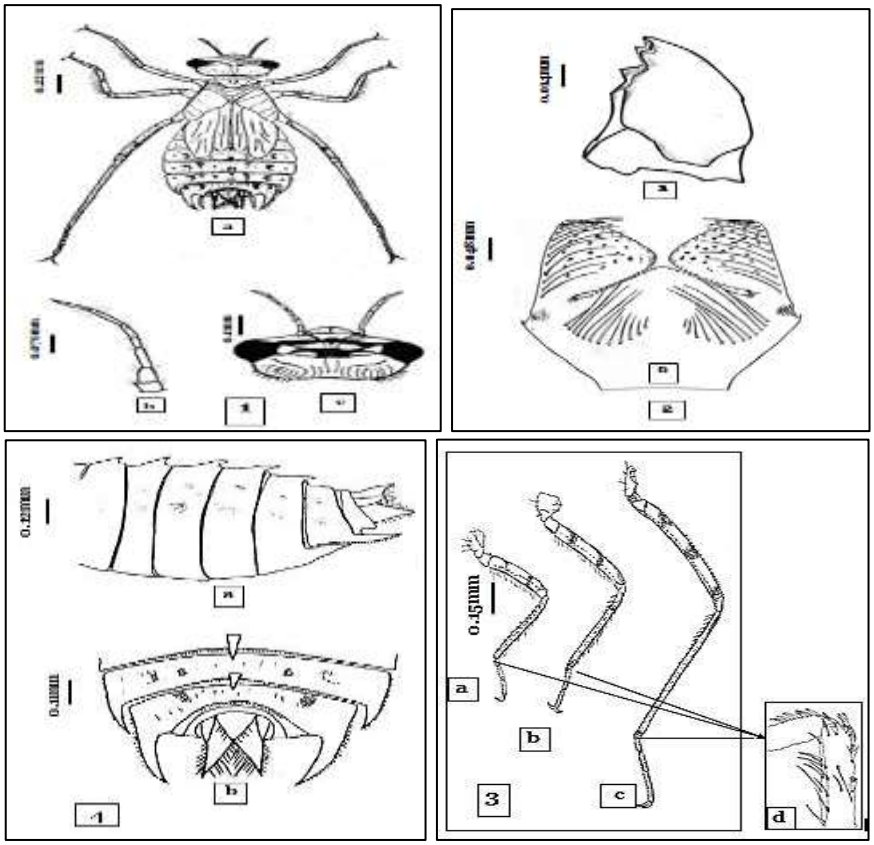

Plate 8: *Sympetrum striolatium* naiad,1- General shape: a- Body, b- Antenna, c- Head; 2- Mouth parts: a- Mandible, b- Labium, 3-Legs: a- Fore, b- Mid, c- Hind, d- Enlarged part of the apex of the tibia; 4- Abdomen and anal appendages: a- Lateral view, b- Dorsal view.

Discussion

Naiads of Anisoptera (Dragonfly) species, were characterized by unique morphological structures, which contributed to the accurate identification of species at the suborder and family levels and the isolation of genera.

As Fleck *et al.* (2008) mention that the species of Libellulidae are more diversity and distribution than other Odonata families; we encountered many difficulties to obtain the

final instar of naiads for each species because they quickly emergence to an adult insects when the environmental conditions were suitable; our study based on many features for naiads identified includes: shape and size of the body, labium mask shape, arrangement and characteristics of the setae on the inner surface of the labial palps, presence or absence of spines in the mid-dorsal abdominal spines and the lateral spines, in addition to the measurements of the relative size of anal plates to each other, also head parts have been used to identified suborders, genera, or species.

In the Libellulidae family, we observed distinct variations in the head shape and size among the naiads of Crocothemis, Orthetrum, and Selysiothemis. Additionally, there were clear differences in the structure of the mandibles among all the studied species, which could be considered as a reliable identification characteristic for distinguishing between different taxonomic orders. Kumar (1973) confirmed that when he described the naiads of the Zygoptera species, in addition to the other features.

We utilized the final stage before emergence, in line with Brooks and Cham (2009), who stressed the significance of the final instar in species-level identification of Odonata.

Finally, specimens of naiads were collected from ponds in different regions of Basrah province in significant numbers. The obtained species could be considered endemic to the Odonata group in Iraq.

Conclusion

Naiads of eight Anisoptera species (Order: Odonata) belonging to two families were recorded for the first time in Basrah Province -South of Iraq. The species were identified by using morphological features, where most of the studied characteristics of the naiads in our study were matched with the used taxonomic keys including Aeshnidae of one species *Anax parthenope*, and Libellulidae of seven species *Crocothemis erythraea*, *C. servilia*, *Diplacodes trivialis*, *Orthetrum sabina*, *Selysiothemis nigra* with a special record of *Diplacodes lefebveri* and *Sympetrum striolatium*.

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التشخيص المظهري لحوريات الرعاشات متباينة الاجنحة (Odonata: Anisoptera) من البرك المؤقتة في محافظة البصرة، جنوب العراق

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المستخلص

جمعت حوريات الرعاشات من رتيبة متباينة الاجنحة (Odonata: Anisoptera) من البرك الضحلة لمناطق مختلفة من محافظة البصرة–جنوب العراق للفترة من كانون الثاني 2017 إلى تشرين الثاني 2018، وشخصت الأنواع اعتمادا على الصفات المظهرية مع إضافة صفة شكل الفكوك العليا، اذ تم تسجيل ووصف ثمانية أنواع شملت النوع *Anax parthenope* الذي ينتمي إلى عائلة Aeshnidae وسبعة أنواع من عائلة Libellulidae وهي *Crocothemis erythraea* و *C. servilia* و *Diplacodes trivialis* و *Orthetrum sabina* و *Selysiothemis nigra* والنوعين *Diplacodes lefebveri* و *Sympetrum striolatium* تم تسجيلها من هذه المنطقة لأول مرة.

الكلمات المفتاحية: الرعاشات الكبيرة، التصنيف، المظهري، الحوريات، أنواع متوطنة، العراق.

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