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## Review of the leafhopper genus *Nealiturus* Distant (Hemiptera: Cicadellidae: Deltocephalinae) from Iran

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**ABSTRACT.** Iranian species of the leafhopper genus *Nealiturus* Distant, 1918 (*N. alboflavovittatus* (Lindberg), *N. decemocellatus* (Dlabola); *N. dubiosus* (Matsumura), *N. fenestratus* (Herrich-Schäffer), *N. guttulatus* (Kirschbaum), *N. haematoceps* (Mulsant and Rey), *N. opacipennis* (Lethierry), *N. pulcher* (Haupt); *N. tenellus* (Baker)) are reviewed. Detailed morphological descriptions and illustrations and a key for their identification are provided.

**Key words:** Auchenorrhyncha; Opsiini; taxonomy; *Nealiturus*; *Circulifer*.

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### Introduction

The family Cicadellidae, commonly called leafhoppers, is the largest family of Auchenorrhyncha and can be separated from other Auchenorrhyncha by the presence of one or more rows of spines on the hind tibiae (Viraktamath 2005). The leafhopper subfamily Deltocephalinae has 6683 valid species and 923 genera, placed in 38 tribes (Oman *et al.* 1990; Zahniser and Dietrich 2008, 2010, 2013; Zanol 2008). Deltocephaline species are predominantly found on herbaceous vegetation but they also occur on shrubs and trees (Dai *et al.* 2006). The tribe Opsiini contains 36 genera and 303 species (Oman *et al.* 1990; Zahniser and Dietrich 2013), and has an economic importance because some species in this tribe are vectors of plant pathogens (Young and Frazier 1954). For example, *Nealiturus*

(*Circulifer*) *tenellus* (Baker) is vector of beet curly top, tomato big bud, and 16SrV-16SrIX, and *Nealiturus* (*Circulifer*) *haematoceps* (Mulsant and Rey) vector of sesame phyllody and 16SrV-16SrIX.

The genus *Nealiturus* contains 35 species worldwide (Oman *et al.* 1990; Zahniser and Dietrich 2013). According to Nast (1972), it includes about 20 Palearctic species, of which 9 species occur in Iran. The shape of male genitalia is rather uniform within the genus and the coloration is in many species quite variable (Tishechkin 2007). Therefore, the species discrimination provides many difficulties. They are distinguished from other Opsiini by the following combination of characters: relatively small body size, specimens range in size from 2.2 to 3.8 mm., slender body

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shape, fully developed forewings, subgenital plate with a lateral row of macrosetae, aedeagus bifurcate apically with branches forming semicircles but in the subgenus *Circulifer* nearly complete circle, and ovipositor not protruding far beyond pygofer apex. Records of *Nealiturus* species from Iran are given in Dlabola (1960, 1964, 1972, 1979, 1981, 1987), Metcalf (1967), Kheyri and Alimoradi (1969), Nast (1972), Kheyri (1989), Mirzayans (1995), Karimzadeh *et al.* (1998), Pakarpour *et al.* (2011), Moosavi Mahvelati and Modarres Awal (2011), Pakarpour *et al.* (2014), Abdollahi *et al.* (2015), Pakarpour Rayeni *et al.* (2015; 2016) and Mozaffarian and Wilson (2016). The genus *Nealiturus* has tree subgenera (*Nealiturus*, *Circulifer* and *Alituriscus*) but some authors use *Circulifer* not on subgeneric and use this name on generic level for example in Fauna Europaea. As a result of current study, genus *Nealiturus* is reviewed in Iran for the first time. The characters, habitus, line drawing and key for separation of subgenera and species are given.

### Material and methods

The material of all species except for *Nealiturus (Alituriscus) decemocellatus* was collected by using a standard sweep net and Malaise trap in southern, southeastern and southwestern Iran between 2009 and 2015. Key features of *N. decemocellatus* were taken from the original description (Dlabola 1987). A great variety of crops and other vegetation were sampled. The material was killed in a standard insect killing jar containing ethyl acetate and mounted on triangular points. Both characters of general morphology and of genitalia were used for species identification. To examine the male genitalia, the abdomen was removed and soaked in 10% KOH solution and boiled for a few minutes to clear the pigment. The abdomen was then rinsed in clean water containing a

small amount of glacial acetic acid, rinsed again in pure water, and immersed in glycerin. Finally, the species were identified according to the keys of Oman (1949), Ribaut (1952), Linnavuori (1959), Anufriev and Emeljanov (1988), Emeljanov (1999), and Biedermann and Niedringhaus (2009), or using the original descriptions. The material examined is deposited in the Insect Collection of Jalal Afshar Zoological Museum at University of Tehran (JAZMUT). The morphological terminology follows Oman (1949), Emeljanov (1999) and Zahniser and Dietrich (2013).

### Results

#### Taxonomy

##### Genus: *Nealiturus* Distant 1918.

*Nealiturus* Distant 1918b:63 n. nov.

**Type species:** *Aliturus gardineri* Distant 1908.

**Diagnosis:** Moderately slender, with rounded projecting head and smooth turn of face into vertex. Head subequal to or wider than pronotum. Discal portion of crown glabrous with radial or longitudinal striae. Anterior margin of head shagreen. Frontoclypeus not tumid; texture shagreen. Clypellus parallel-sided or tapering apically; apex following or slightly surpassing normal curve of gena. Lorum subequal to or wider than clypellus near base. Antennal bases near middle or posteroventral (lower) corners of eyes. Antennae short, less than 1.5 x width of head. Antennal ledges absent. Ocelli present, close to eyes on anterior margin of head. Pronotum lateral margin carinate; lateral margin shorter than basal width of eye. Forewing macropterous; appendix restricted to anal margin; with 3 antepical cells; veins not raised; with or without reflexed costal veins; A1-A2 crossvein absent; apical venation not highly reticulate.

Male genitalia: valve articulated with pygofer; with short point of articulation with pygofer. Basolateral membranous

cleft of pygofer present; macrosetae well differentiated into several rows. Subgenital plates free from each other, articulated with valve; macrosetae uniseriate laterally. Style broadly bilobed basally, median anterior lobe pronounced. Basal processes of the aedeagus and connective absent. Aedeagus without basal hinge; shaft divided toward apex in two branches. Anterior arms of connective somewhat divergent, Y-shaped, articulated with aedeagus.

#### Key to the species of *Neoaliturus* in Iran

- 1- Aedeagus shaft apically divided in two branches but without lateral appendages (Fig. 3, e). .....3  
 - Aedeagus shaft in addition to the apical branches with a pair of lateral appendages (Fig. 3, a). .....2
- 2- Apical branches of aedeagus shaft long and distinct, forming a semicircle; appendages slender, directed obliquely basad (Fig. 3, a). .....  
 .....*Neoaliturus alboflavovittatus*  
 - Apical branches of aedeagus shaft rather short, forming a semicircle; appendages sclerotized, spine shaped, directed laterad (Fig. 3, b). .....*Neoaliturus pulcher*
- 3- Gonopore at the base of apical shaft branches (Fig. 3, i); lobes of pygofer without processes (**subgenus *Alituriscus***). .....  
 ....*Neoaliturus (Alituriscus) decemocellatus*  
 - Gonopores at apices of apical shaft branches; pygofer lobes with process situated ventro-posteriorly, running more or less parallel to lobe margin. ....4
- 4- Apical branches of aedeagus shaft forming a common semicircle or arc shorter than semicircle (Fig. 3, c) (**subgenus *Neoaliturus***). .....5  
 - Apical branches of aedeagus shaft forming a nearly full circle (Fig. 3, e) (**subgenus *Circulifer***). .....6
- 5- Process of pygofer lobes short (Fig. 3, j); body black or brown, fore wing of male normally black with several rounded

- hyaline spots; spots fused and forming a band, pronotum black (Fig. 1, c). .....  
 .....*Neoaliturus (Neoaliturus) fenestratus*  
 - Process of pygofer lobes long (Fig. 3, k); body usually brown, anterior part usually lighter than in *fenestratus*, pigmentation on fore wing variable, pronotum often yellow with some black spots (Fig. 1, d). .....  
 .....*Neoaliturus (Neoaliturus) guttulatus*
- 6- Subgenital plates widely truncated (Fig. 2, e, f), body greenish yellow. ....7  
 - Subgenital plates acuminate (Fig. 2, g, h), body color different. ....8
- 7- Subgenital plates with length measured along inner margin greater than width measured at mid-length (Fig. 2, e). .....  
 .....*Neoaliturus (Circulifer) dubiosus*  
 - Subgenital plates with length measured along inner margin equal to or less than width measured at mid-length (Fig. 2, f). ...  
 .....*Neoaliturus (Circulifer) tenellus*
- 8- Base color greenish grey, fore wing with variable coloration (Fig. 1, g), hind margin of abdominal sternite VII in female concave with reddish brown edged incision and with median denticle (Fig. 4, g). .....  
 .....*Neoaliturus (Circulifer) haematoceps*  
 - Body color from green to yellowish green, fore wing without dark spots (Fig. 1, h), hind margin of abdominal sternite VII in female more or less concave, not reddish brown (Fig. 4, h). .....  
 .....*Neoaliturus (Circulifer) opacipennis*

#### *Neoaliturus alboflavovittatus* (Lindberg 1954)

**Material examined: Kerman Province:** Bam, Baravat, 2♂♂, 26.ix.2010, swept on weeds in palm orchard; Jiroft, Karim Abad village, 1♂, 1♀, collected via light trap in potato field, 14.iii.2011., **Khuzestan Province:** Ahvaz, 1♂, 2♀♀, swept on weeds in Shahid Chamran University of Ahvaz, 13.iii.2014; Dezful, 3♂♂, 1♀, swept on weeds in citrus orchards, 14.iii.2014, Leg.: F. Pakarpour Rayeni (JAZMUT).

**Description.** Size 4.1-4.5 mm; head and pronotum yellowish brown with some dark dots, forewing darker than head and pronotum with characteristic light spots, veins dark (Fig. 1, a).

**Male genitalia.** Subgenital plates acuminate, outer margin slightly concave (Fig. 2, a). Basal part of aedeagus shaft with pair of appendages. Apical branches of aedeagus shaft rather long, forming semicircle. Appendages distinctly shorter, directed obliquely basad (Fig. 3, a).

**Female genitalia.** Hind margin of abdominal sternite VII undulated and in the middle with wide incision and two dark spots (Fig. 4, a).

**Distribution in Iran:** Kerman and Khuzestan Provinces (Pakarpour Rayeni *et al.* 2015; 2016; Mozaffarian and Wilson 2016).

**General Distribution:** Canary Islands and Iran.

#### *Neoliturus pulcher* (Haupt 1927)

**Material examined: Khuzestan Province:** Ahvaz, 4♂♂, 5♀♀, swept on weeds in palm orchards, 07.ix.2014; Dezful, 3♂♂, 7♀♀, collected with Malaise trap, 27.vii.2015, leg.: Farzad Pakarpour Rayeni (JAZMUT).

**Description.** Size 3.8-4.4 mm; body color light, stramineous, yellow or green, head wider than pronotum, crown glabrous and shagreen, forewing pale, greenish yellow with some pigmentation (Fig. 1, b).

**Male genitalia.** Subgenital plates in male acuminate (Fig. 2, b); Basal part of aedeagus shaft with pair of appendages. Apical branches of aedeagus shaft more or less short and forming semicircle; Appendages sclerotized and dark, directed laterad (Fig. 3, b).

**Female genitalia.** Hind margin of abdominal sternite VII undulated and in the middle with short obtuse bifide process (Fig. 4, b).

**Distribution in Iran:** Azarbaijan-e-Sharghi, Hormozgan, Kerman, Khuzestan, Sistan-o Baluchestan and Tehran Provinces (Dlabola 1960; 1972; 1981; Nast 1972; Mirzayans 1995; Pakarpour Rayeni *et al.* 2015; 2016; Mozaffarian and Wilson 2016).

**General Distribution:** Russia (European part), Georgia, Iran, Israel, Kazakhstan, Saudi Arabia, Tajikistan.

#### *Neoliturus (Alituriscus) decemocellatus* (Dlabola 1987)

**Description.** See Dlabola (1987): 311, Figs. 76-81.

**Distribution in Iran:** North of Iran, Taleghan (Dlabola 1987; Pakarpour Rayeni *et al.* 2015; Mozaffarian and Wilson 2016).

**General Distribution:** Iran.

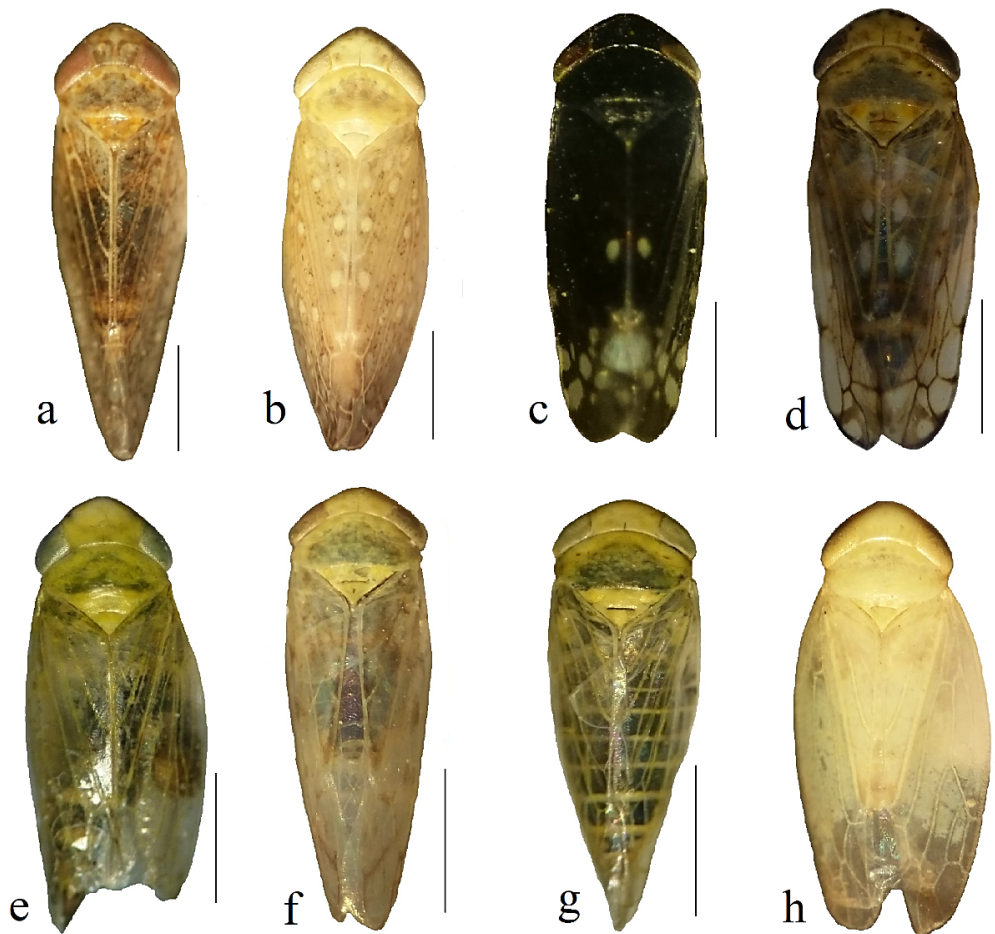
#### *Neoliturus (Neoliturus) fenestratus* (Herrich-Schäffer 1834)

**Material examined: Kerman Province:** Rayen, 1♂, 11.vii.2010; **Khuzestan Province:** Ahvaz, 1♂, 13.iii.2014; Dezful, 1♂, 1♀, 14.iii.2014; Bagh-e-Malek, 2♂♂, 09.ix.2014; Dezful, 1♂, 12.ix.2014; Bagh-e-Malek, 1♂, 15.v.2015. Leg.: F. Pakarpour Rayeni (JAZMUT).

**Description.** Size 2.8-3.4 mm; head and pronotum matte black, crown shorter than pronotum and apically rounded, forewing metallic black with several rounded hyaline spots apically, spots fused and forming transverse preapical band (Fig. 1, c).

**Male genitalia.** Subgenital plates in male acuminate, outer margin slightly concave (Fig. 2, c); pygofer process short with sharp apical appendix (Fig. 3, j); apical branches of aedeagus shaft forming semicircle (Fig. 3, c).

**Female genitalia.** Hind margin of abdominal sternite VII undulated, without dark coloration (Fig. 4, c).



**Figure 1.** Habitus figures of Iranian *Neoaliturus* Distant: **a.** *N. alboflavovittatus* (Lindberg) (Jiroft); **b.** *N. pulcher* (Haupt) (Ahvaz); **c.** *N. fenestratus* (Herrich-Schäffer) (Rayen); **d.** *N. guttulatus* (Kirschbaum) (Dezful); **e.** *N. dubiosus* (Matsumura) (Ahvaz); **f.** *N. tenellus* (Baker) (Dezful); **g.** *N. haematoceps* (Mulsant and Rey) (Zarand); **h.** *N. opacipennis* (Lethierry) (Dezful). (scale bar = 1mm).

**Distribution in Iran:** Alborz, Azarbaijan-e-Sharghi, Kerman, Khorasan-e-Razavi; Khuzestan and Tehran Provinces (Dlabola 1960; 1972; 1981; Mirzayans 1995; Pakarpour Rayeni *et al.* 2015; 2016; Mozaffarian and Wilson 2016).

**General Distribution:** Eastern Palaearctic, Western Palaearctic.

*Neoaliturus* (*Neoaliturus*) *guttulatus* (Kirschbaum 1868)

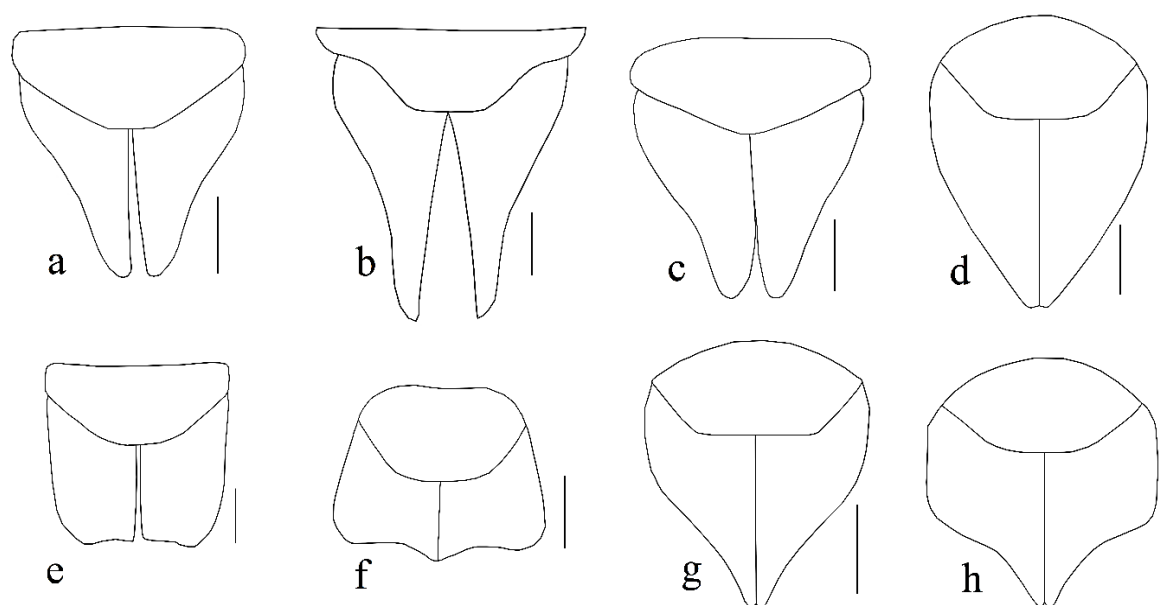
**Syn.:** *Neoaliturus transversalis* (Puton 1881)

**Material examined:** Khuzestan Province: Dezful, 2♂♂, 5♀♀, swept on weeds in citrus

orchards, 14.iii.2014, leg.: Farzad Pakarpour Rayeni (JAZMUT).

**Description.** Size 2.8-3.3 mm; head and pronotum greenish yellow, anterior margin of crown with some black dots, pronotum with dark spots near crown, scutellum with a pair of triangular faint spots; forewing pale with variable pigmentation (Fig. 1, d).

**Male genitalia.** Subgenital plates in male acuminate, outer margin not concave (Fig. 2, d); pygofer process long and gradually tapering towards apex (Fig. 3, k); apical branches of aedeagus shaft forming semicircle (Fig. 3, d).



**Figure 2.** Subgenital plates in male (ventral view) in Iranian *Neoliturus* Distant: **a.** *N. alboflavovittatus* (Lindberg) (Jiroft); **b.** *N. pulcher* (Haupt) (Ahvaz); **c.** *N. fenestratus* (Herrich-Schäffer) (Rayen); **d.** *N. guttulatus* (Kirschbaum) (Dezful); **e.** *N. dubiosus* (Matsumura) (Ahvaz); **f.** *N. tenellus* (Baker) (Dezful); **g.** *N. haematoceps* (Mulsant and Rey) (Zarand); **h.** *N. opacipennis* (Lethierry) (Dezful). (scale bar = 1mm).

**Female genitalia.** Hind margin of abdominal sternite VII with a wide incision (Fig. 4, d).

**Distribution in Iran:** Chaharmahal-o Bakhtiari, Isfahan, Kerman, Khuzestan and Khorasan-e-Razavi Provinces (Dlabola 1972; Pakarpour Rayeni *et al.* 2015; 2016; Mozaffarian and Wilson 2016).

**General Distribution:** Palaearctic and Oriental.

***Neoliturus (Circulifer) dubiosus* (Matsumura 1908)**

**Material examined: Khuzestan Province:** Ahvaz, 1♂, 3♀♀, swept on weeds in palm orchards, 07.ix.2014; Bagh-e-Malek, 3♂♂, 5♀♀, collected with Malaise trap, 28.vii.2015, leg.: F. Pakarpour Rayeni (JAZMUT).

**Description.** Size 2.8-3.2 mm; crown dull yellow usually paler than pronotum and more or less produced, pronotum weakly sordid gray, scutellum usually unicolor more or less like color of crown or slightly

darker; forewing without any spots or patterns (Fig. 1, e).

**Male genitalia.** Subgenital plates of male quadrilateral with length measured along inner margin greater than width measured at midpoint of length (Fig. 2, e). Apical branches of aedeagus shaft forming nearly full circle (Fig. 3, e).

**Female genitalia.** Hind margin of abdominal sternite VII more or less U shaped with very deep incision, with median denticle (Fig. 4, e).

**Distribution in Iran:** Isfahan, Khuzestan and Tehran Provinces (Mirzayans 1995; Pakarpour Rayeni *et al.* 2015; 2016; Mozaffarian and Wilson 2016).

**General Distribution:** West Sahara, Algeria, Bulgaria, Russia, France, India, Israel, Italy, Kazakhstan, Libya, Morocco, Romania, Saudi Arabia, Spain, Tajikistan, Tunisia, Turkey.

***Neoaliturus (Circulifer) tenellus* (Baker 1896)**

**Material examined:** **Kerman Province:** Bahramjerd village, 6♂♂, 11♀♀, 08.iii.2010; Dalfard, 6♂♂, 9♀♀, 13.iii.2010; Bam, Tahrud village, 19.iii.2010; **Khuzestan Province:** Dezful, 14♂♂, 22♀♀, 14.iii.2014; Bagh-e-Malek, 22♂♂, 16.iii.2014; Bagh-e-Malek, 30♂♂, 09.ix.2014; Dezful, 55♂♂, 12.ix.2014; Ahvaz, 13♂♂, 18♀♀, 26.iv.2015; Dezful, 11♂♂, 30♀♀, 27.iv.2015; Bagh-e-Malek, 8♂♂, 11♀♀, 15.v.2015; Ahvaz, 45♂♂, 25.vii.2015; Dezful, 5♂♂, 12♀♀, 27.vii.2015; Bagh-e-Malek, 24♂♂, 28.vii.2015. Leg.: F. Pakarpour Rayeni (JAZMUT).

**Description.** Size 2.8-3.5 mm; color variable, unmarked yellow, greenish yellow or sordid green, crown slightly produced, rounded at apex; forewing without any spots (Fig. 1, f).

**Male genitalia.** Subgenital plates of male quadrilateral, with length measured along inner margin equal to or less than width measured at midlength; each plate with a small pointed apex (Fig. 2, f); Apical branches of aedeagus shaft forming nearly full circle (Fig. 3, f).

**Female genitalia.** Hind margin of abdominal sternite VII with deep U shaped incision, usually without median denticle (Fig. 4, f).

**Distribution in Iran:** Fars, Isfahan, Kerman, Khuzestan, Lorestan, Sistan-o Baluchestan and Tehran Provinces (Dlabola 1960; 1964; 1972; 1981; Nast 1972; Mirzayans 1995; Pakarpour Rayeni *et al.* 2015; 2016; Mozaffarian and Wilson 2016).

**General Distribution:** Nearctic, Palaearctic.

***Neoaliturus (Circulifer) haematoceps* (Mulsant and Rey 1855)**

**Material examined:** **Kerman Province:** Rafsanjan, 18♂♂, 23♀♀, 12.v.2010; Anar, 5♂♂, 7♀♀, 12.v.2010; Zarand, 9♂♂, 12♀♀, 10.viii.2010; **Khuzestan Province:** Dezful, 1♂, 6♀♀, 14.Mar.2014; Ahvaz, 3♂♂, 11♀♀, 07.Sep.2014; Bagh-e-Malek, 5♂♂, 6♀♀, 28.Jul.2015. Leg.: F. Pakarpour Rayeni (JAZMUT).

**Description.** Size 2.5-3.6 mm; base color greenish grey, crown and pronotum with variable color, anterior margin of pronotum frequently broadly paler; forewings translucent with veins contrasting yellow, veins not dark (Fig. 1, g).

**Male genitalia.** Subgenital plates of male acuminate, outer margin apically concave (Fig. 2, g); Apical branches of aedeagus shaft forming nearly full circle (Fig. 3, g).

**Female genitalia.** Hind margin of abdominal sternite VII concave with reddish brown edged incision and with median denticle (Fig. 4, g).

**Distribution in Iran:** Alborz, Azarbaijan-e-Gharbi, Fars, Hormozgan, Isfahan, Kerman, Kermanshah, Khorasan-e-Razavi, Khuzestan, Kohkiluyeh and Boirahmad, Kordestan, Qom, Sistan-o Baluchestan and Tehran Provinces (Nast 1972; Dlabola 1981; Mirzayans 1995; Pakarpour Rayeni *et al.* 2015; 2016; Mozaffarian and Wilson 2016).

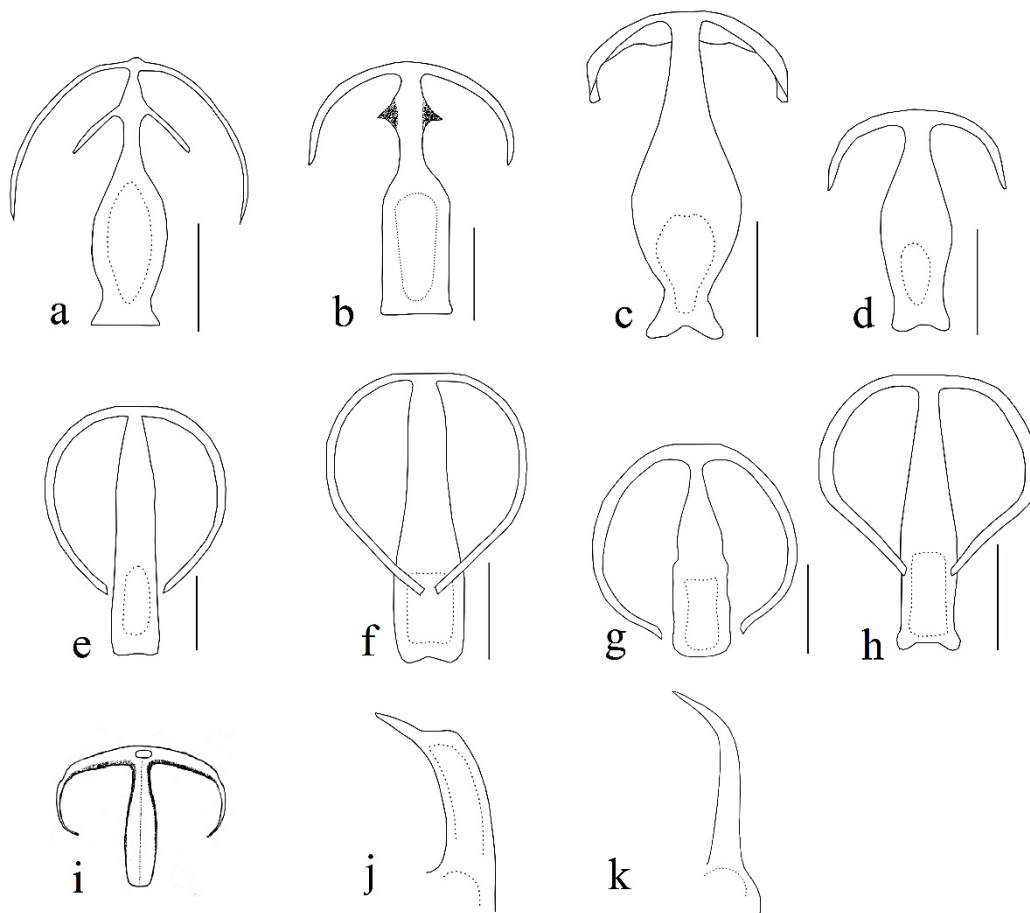
**General Distribution:** Eastern and Western Palaearctic.

***Neoaliturus (Circulifer) opacipennis* (Lethierry 1876)**

**Material examined:** **Khuzestan Province:** Dezful, 4♂♂, 10♀♀, swept on weeds in citrus orchards, 14.Mar.2014, leg.: Farzad Pakarpour Rayeni (JAZMUT).

**Description.** Size 2.3-3.3 mm; body color variable, most often green or yellowish green, crown most commonly unmarked green or yellow, pronotum dull gray, anterior margin of pronotum frequently broadly paler; forewings most commonly hyaline with greenish or yellowish reflections; abdominal dorsum usually dark with caudal margins of terga narrowly paler (Fig. 1, h).

**Male genitalia.** Subgenital plates of male acuminate, outer margin apically very strongly concave (Fig. 2, h); apical branches of aedeagus shaft forming nearly full circle (Fig. 3, h).



**Figure 3.** Aedeagus (dorsal view) in Iranian *Neoaliturus* Distant: **a.** *N. alboflavovittatus* (Lindberg) (Jiroft); **b.** *N. pulcher* (Haupt) (Ahvaz); **c.** *N. fenestratus* (Herrich-Schäffer) (Rayen); **d.** *N. guttulatus* (Kirschbaum) (Dezful); **e.** *N. dubiosus* (Matsumura) (Ahvaz); **f.** *N. tenellus* (Baker) (Dezful); **g.** *N. haematoceps* (Mulsant and Rey) (Zarand); **h.** *N. opacipennis* (Lethierry) (Dezful); **i.** *N. decemocellatus* (Dlabola) (after Dlabola, 1987); process of pygofer (lateral view); **j.** *N. fenestratus* (Herrich-Schäffer) (Rayen); **k.** *N. guttulatus* (Kirschbaum) (Dezful). (scale bar = 0.1mm).

**Female genitalia.** Hind margin of abdominal sternite VII slightly concave, with median denticle (Fig. 4, h).

**Distribution in Iran:** Azarbaijan-e-Sharghi, Chaharmahal-o Bakhtiari, Golestan, Isfahan, Kerman, Khorasan-e-Razavi, Khorasan-e-Shomali, Khuzestan, Mazandaran, Qazvin, Sistan-o Baluchestan and Zanzan Provinces (Dlabola 1960; 1972; Pakarpour Rayeni *et al.* 2015; 2016; Mozaffarian and Wilson 2016).

**General Distribution:** Eastern and Western Palearctic.

## Discussion

The current study provides diagnostic species identification tools to be used for future investigations of species of the genus *Neoaliturus* in Iran and adjacent areas. The genus *Neoaliturus* is one of the most complicated ones in Deltocephalinae, and many taxonomical and phylogenetical problems are unresolved or resolved in different ways by different authors. For example, Tishechkin (2007) analysed male calling signals for the separation of different biological species of *Neoaliturus* gr.

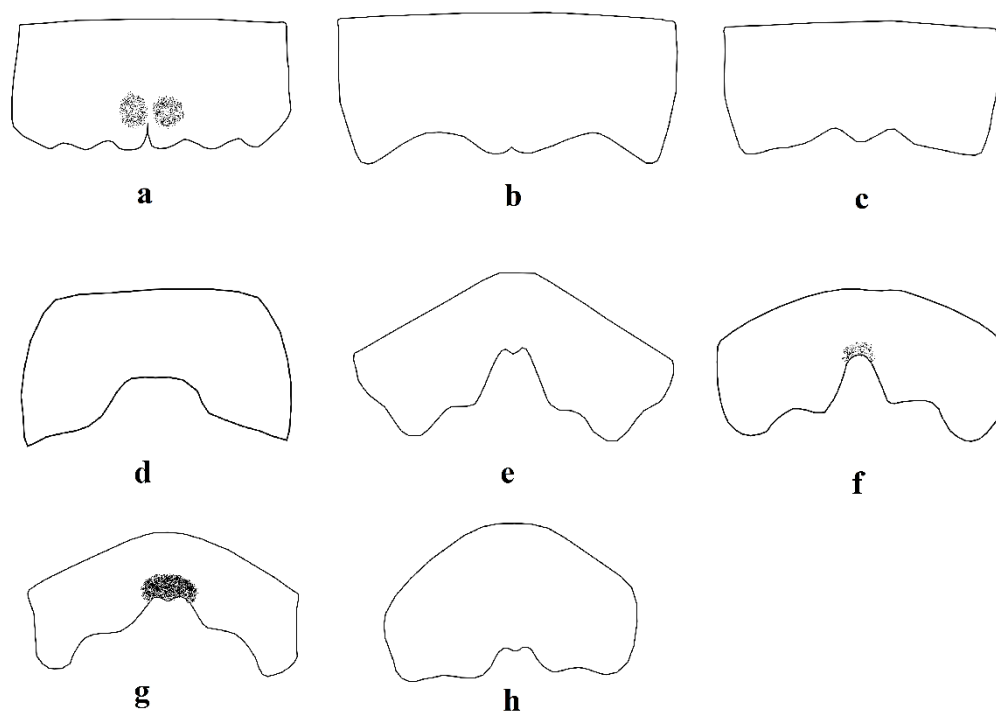


*fenestratus* and then he carried out a comparative investigation of their coloration and the structure of male genitalia in aim to find taxonomic characters for the identification of his material. Nevertheless, it is clear that the problem of taxonomic status of different species of the genus *Nealiturus* has not been solved conclusively and it can be resolved only with the aid of molecular methods, possibly also including ecological data and host plants, and based on many populations from different regions and habitats. Therefore, at this time a key for the discrimination of species should be completed by remarks which discuss these difficulties. The following cases reveal such difficulties.

In the original description of *Nealiturus pulcher* (Haupt), distinct dark markings on head, pronotum and wings are described and figured (in the male and in one of the two females; the other one displays a lighter coloration with less distinct markings). The latter fits more or less with the figure in this study (Fig. 1, b). In addition, in the original description, there is no figure of the aedeagus, but only of the genital plates. On the pregenital sternite of the female, Haupt mentions that the hind margin is shallowly concave in an obtuse angle, in the middle with short obtuse bifide process as mentioned and figured in the present paper (Fig. 4, b). But Linnavouri (1962) figured *Nealiturus pulchellus* Hpt. as endemic for Israel which could be a misspelling and may refer to *pulcher*. In this case there are two different interpretations of this species, as Linnavouri's figure (of *pulchellus*) displays a clearly different aedeagus shape (without shaft appendages) than Emeljanov (for *pulcher*). It is necessary to mention that the key of Emeljanov has been used for the identification of the current material, so it is better to name the taxon *Nealiturus pulcher* Hpt. *sensu* Emeljanov.

The two taxa *Nealiturus fenestratus* (Herrich-Schäffer, 1834) and *N. guttulatus* (Kirschbaum, 1868) were in the past often considered synonyms. The only rather constant difference between both species consists in the different shape of the pygofer process (Fig. 3, j and k), even if also in this character there is some slight variability. The coloration is in both taxa highly variable. Tishechkin (2007) found in Russia a lighter coloration in *guttulatus* than in *fenestratus*. Apparently there is also some seasonal variability with light specimens occurring rather in the winter and black ones rather in summer. Thus, the coloration is no reliable character for species discrimination between these two taxa. However, in the material from Iran, the *guttulatus* specimens had a lighter coloration than *fenestratus*. The taxon *Nealiturus transversalis* (Puton 1881) is regarded by some authors as a valid species. Above all, it is mentioned in Mozaffarian and Wilson 2016 for the Iranian fauna. This taxon is characterized by a white transverse band on the (black) forewings. Dlabola (1957) considers it a good species and mentions, that it displays a long pygofer process as in *N. guttulatus*. Thus, it should be synonymous to this taxon.

The *Circulifer haematoceps* group constitutes the main problem among the taxa treated in the current study. The division in the two taxa *haematoceps* and *opacipennis* is only a provisional solution. Maybe it is better to speak about the *haematoceps* complex and the *opacipennis* complex (Klein and Raccah 1991). Both taxa are interpreted by different authors in different ways. The problem is due to the uniformity of male genital characters on the one side and high variability in size, coloration and shape of female pregenital sternite on the other.



**Figure 4.** Hind margin of VII abdominal sternite of female (ventral view) in Iranian *Nealiturus* Distant, **a.** *N. alboflavovittatus* (Lindberg) (Jiroft); **b.** *N. pulcher* (Haupt) (Ahvaz); **c.** *N. fenestratus* (Herrich-Schäffer) (Bagh-e-Malek); **d.** *N. guttulatus* (Kirschbaum) (Dezful); **e.** *N. dubiosus* (Matsumura) (Ahvaz); **f.** *N. tenellus* (Baker) (Dezful); **g.** *N. haematoceps* (Mulsant and Rey) (Zarand); **h.** *N. opacipennis* (Lethierry) (Dezful).

This variability (possibly there is also some seasonal variability with many taxa hibernating in the adult stage) can be interpreted as well as a high number of closely related different taxa, and in fact many subspecies, forms and varieties were described in the past in correspondence to these different habitus forms (for example Ribaut 1952). The name *haematoceps* which means “with blood (coloured) head” probably refers to a taxon with distinct red colour on head and other parts of the body, living in the Mediterranean area on *Cistus* spp. It is clear, that the problem presently must remain unresolved and it can be resolved only with the aid of molecular and/or bioacoustic methods. It is necessary to mention that the use of the taxon names may be in contrast to that one of other authors and to explain the reasons.

At the end, the present study is the first taxonomic work on the genus *Nealiturus* in

Iran. Future faunal research, as well as studies on the host plant associations is necessary for species discrimination. As Tishechkin (2007) mentions, species of this group feed mainly on Asteraceae but usually it is impossible to establish an association with specific plants with certainty. So, in the future the sampling should focus on collecting larval instars and the plants where they are feeding. This approach gives us much reliable data for accurate identification. Finally, it seems that the general problem of the high variability in this genus is increased by possible seasonal variability.

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## References

- Abdollahi, T., Jalali Zand, A.R., Mozaffarian, F. and Wilson, M. 2015. A faunistic study on the leafhoppers of Northwestern Iran (Hemiptera, Cicadellidae). *Zookeys*, 496, 27–51. DOI: <https://doi.org/10.3897/zookeys.496.9059>
- Anufriev, G.A. and Emeljanov, A.F. 1988. Suborder Cicadinea (Auchenorrhyncha)-cicadas. pp: 12–496, In: Lera, P. A. (Ed.), *Key to the Identification of Insects of the Far East USSR*. Vol. 2 Homoptera and Heteroptera. Leningrad, Nauka Publishing House, 496 pp.
- Baker, C.F. 1896. The North American species of *Gnathodus*. *Canadian Entomologist*, 28: 35–42.
- Biedermann, R. and Niedringhaus, R. 2009. The plant and Leafhoppers of Germany, Identification key to all species. Wilhelm Brüggemann GmbH, Bremen, 409 pp.
- Dai, W., Zhang, Y., Viraktamath, C.A. and Webb, M.D. 2006. Two new Asian Scaphytopiini leafhoppers (Hemiptera: Cicadellidae: Deltocephalinae) with description of a new genus. *Zootaxa*, 1309: 37–44.
- Distant, W.L. 1908. Rhynchota, IV. Homoptera and appendix (Pt.). In: Bingham, C.T. (Ed.), *The fauna of British India, including Ceylon and Burma*, London, Taylor & Francis, 501 pp.
- Distant, W.L. 1918. Rhynchota, VII. Homoptera: appendix. Heteroptera: addenda. In: Shipely, A.E. & Marshall, G.A.K. (Eds.), *The fauna of British India including Ceylon and Burma*, London, Taylor & Francis, 210 pp.
- Dlabola, J. 1957a. Die Zikaden Afghanistans nach den Ergebnissen der von Herrn Klapperich in der Jahren 1952–1953 nach Afghanistan unternommenen Expedition. *Mitteilungen der Münchner Entomologischen Gesellschaft*, 1957: 265–303.
- Dlabola, J. 1960. Iranische Zikaden (Homoptera: Auchenorrhyncha). (Ergebnisse der entomologischen Reisen Willy Richter, Stuttgart, in Iran, 1954 und 1956, N: 31). *Stuttgarter Beiträge zur Naturkunde*, 41: 1–24.
- Dlabola, J. 1964. Die Zikaden Afghanistans (Homoptera, Auchenorrhyncha), II. Ergebnisse der Sammelreisen von Dr. H. G. Amsel, G. Ebert, Dr. Erichson, J. Klapperich und Dr. K. Lindberg. *Mitteilungen der Münchner Entomologischen Gesellschaft*, 54: 237–255.
- Dlabola, J. 1972. Beiträge zur Kenntnis der Fauna Afghanistans. Homoptera Auchenorrhyncha. *Acta Musei Moraviae Scientiae Biologicae*, 16–17: 189–248.
- Dlabola, J. 1979. Neue Zikaden aus Anatolien, Iran und aus südeuropäischen Ländern (Homoptera: Auchenorrhyncha). *Acta Zoologica Academiae Scientiarum Hungaricae*, 21 (3–4): 235–257.
- Dlabola, J. 1981. Ergebnisse der tschechoslowakisch-iranischen entomologischen Expeditionen nach dem Iran (Mit Angaben über einige Sammelresultate in Anatolien) (1970 und 1973) (Homoptera, Auchenorrhyncha). II Teil. *Acta Musei Nationalis Pragae*, 40: 127–311.
- Dlabola, J. 1987. Neue ostmediterrane und iranische Zikadenarten. *Acta Entomologica Bohemoslovaca*, 84: 295–312.
- Emeljanov A.F. 1999. A key to genera of the subfamily Deltocephalinae s.l. (Homoptera, Cicadellidae) from Kazakhstan, Middle Asia, and Mongolia, with description of new genera and subgenera. *Entomological Review*, 79: 547–562.
- Haupt, H. 1927. Homoptera Palestinae I. Bulletin. The Zionist Organisation. Institute of Agriculture and Natural History. *Agricultural Experiment Station Tel-Aviv Palestine*, 8: 5–43.
- Herrich-Schäffer, G.A.W. 1834. *Jassus punctifrons*, *Jassus histrionicus*, *Jassus strigipes*, *Jassus 4-notatus*, *Jassus striola*, *Jassus fenestratus*, *Jassus punctatus*. *Deutschlands Insecten*, 122: 1–6.
- Karimzadeh, J., Kharrazi Pakdel, A. and Kheyri, M. 1998. Leafhopper (Homoptera: Auchenorrhyncha) fauna of sugar beet fields in Isfahan province. Proceedings of 12<sup>th</sup> Iranian Plant Protection Congress, 23–27 August 1998, University of Tehran, Karaj, Vol. I. Pests, p. 69.
- Kheyri, M. 1989. An inventory of pests attacking sugar-beet in Iran. *Applied Entomology and Phytopathology*, 56 (1&2): 75–91.

- Kheyri, M. and Alimoradi, I. 1969. *The leafhoppers of Sugarbeet in Iran and their role in curly-top virus disease*. Sugarbeet Seed Institute, Karaj, 54 pp.
- Kirschbaum, C.L. 1868. Die Cicadinen der gegend von Wiesbaden und Frankfurt A. M. Nebst einer anzahl neuer oder Schwer zu unterscheidender arten aus anderen Gegenden Europa's Tabellarisch Beschrieben. *Jahrbuch des Nassauer Vereins fur Naturkunde im herzogthum Nassau*, 21-2: 1-202.
- Klein, M. and Raccah, B. 1991. Separation of two leafhopper population of the *Circulifer haematoceps* complex on different host plants in Israel. *Phytoparasitica*, 19: 153-155.
- Lethierry, L.F. 1876. Homopteres nouveaux d'Europe et des contrees voisines. *Annales de la Societe entomologique de Belgique*, 19: 5-17.
- Lindberg, H. 1954. Hemiptera Insularum Canariensium. Systematic, Okologie und Verbreitung der Kanarischen Heteropteren und Cicaden. *Commentationes Biologicae, Societas Scientiarum Fennica*, 14 (1): 1-304.
- Linnavuori, R. 1959. Revision of the Neotropical Deltocephalinae and some related subfamilies (Homoptera). *Annales Zoologici Societatis Zoologicae Botanicae Fennicae 'Vanamo'*, 20: 1-370.
- Linnavuori, R. 1962. Hemiptera of Israel. *Annales Zoologici Societatis Zoologicae Botanicae Fennicae "Vanamo"*, 24 (3): 1-108.
- Matsumura, S. 1908. Neue Cicadinen aus Europa und Mittelmeergebiet. *Journal of the College of Science, Imperial University of Tokyo*, 23 (6): 1-46.
- Metcalf, Z.P. 1962-1968. *General Catalog of the Homoptera*. U.S. Department of Agriculture, Agriculture Research Service, 6, Cicadelloidea. [Part 1: Tettigellidae, 730 pp (1965); Part 2: Hylicidae, 18 pp (1962); Part 3: Gyponidae, 299 pp (1962); Part 4: Ledridae, 147 pp (1962); Part 5: Ulopidae, 101 pp (1962); Part 6: Evancanthidae, 63 pp (1963); Part 7: Nirvanidae, 35 pp (1963); Part 8: Aphrodidae, 268 pp (1963); Part 9: Hecalidae, 123 pp (1963); Part 10: Euscelidae, Section 1, 1-1077; Section 2, 1078-2074; Section 3, 2075-2695 (1967); Part 11: Coelidiidae, 182 pp (1964); Part 12: Eurymelidae, 43 pp (1965); Part 13: Macropsidae, 261 pp (1966); Part 14: Agallidae, 173 pp (1966); Part 15: Iassidae, 229 pp (1966); Part 16: Idioceridae, 237 pp (1966); Part 17: Cicadellidae, 1513 pp. (1968)].
- Mirzayans, H. 1995. *Insects of Iran, The list of Homoptera: Auchenorrhyncha in the Insect Collection of plant Pests and Diseases Research Institute*. Ministry of Agriculture, Agricultural Research, Iran, 63 pp.
- Moosavi Mahvelati N. and Modarres Awal, M. 2011. Faunistic study of Auchenorrhyncha in sugar beet fields of Mashhad and Chenaran. *Journal of Plant Protection*, 25 (3): 275-266.
- Mozaffarian, F. and Wilson, M.R. 2016. A checklist of the leafhoppers of Iran (Hemiptera: Auchenorrhyncha: Cicadellidae). *Zootaxa*, 4062 (1): 1-63. DOI: <http://doi.org/10.11646/zootaxa.4062.1.1>
- Mulsant, M.E. and Rey, C. 1855. Description de quelques Hemipteres- Homopteres nouveaux ou peu connus. *Annales de la Societe inneeenne de Lyon*, 2 (2): 197-249.
- Nast, J. 1972. *Palaeartic Auchenorrhyncha (Homoptera) An annotated check list*. Polish Scientific Publishers, Warsaw, Poland, 550 pp.
- Oman, P.W. 1949. The Nearctic leafhoppers (Homoptera: Cicadellidae). A generic classification and check list. *Memoirs of the Entomological Society of Washington*, 3: 1-253.
- Oman, P.W., Knight, W.J. and Nielson, M.W. 1990. *Leafhoppers (Cicadellidae): a bibliography, generic check-list and index to the world literature 1956-1985*. CAB International Institute of Entomology, Wallingford, UK. 368 pp.
- Pakarpour, F., Nozari, J and Hosseinaveh, V. 2011. A faunistic study of the Iranian leafhoppers (Hemiptera: Cicadellidae): Kerman province. *Proceedings of 2nd Iranian Pest Management Conference*, 14-15 September 2011, Shahid Bahonar University of Kerman, pp. 371-411.
- Pakarpour, F., Nozari, J., Hosseinaveh, V. and Almasi, A. 2014a. Morphological study on a leafhopper genus *Neoliturus* Distant, 1918 (Hemiptera, Cicadellidae) by associating

- molecular methods to confirm identification, with the first record species of Cicadellidae for Iranian leafhoppers fauna. Proceedings of 21th congress of Iranian Plant Protection 23–26 August 2014, University of Urmia, Vol. I. Pests, p. 752.
- Pakarpour Rayeni, F., Nozari, J. and Seraj, A.A. 2015. A checklist of Iranian Deltocephalinae (Hemiptera: Cicadellidae). *Iranian Journal of Animal Biosystematics*, 11(2): 121–148.
- Pakarpour Rayeni, F., Seraj, A.A. and Nozari, J. 2016. Contributions to the leafhoppers (Auchenorrhyncha: Cicadellidae) of Khuzestan, southwest of Iran. *Journal of Insect Biodiversity and Systematics*, 2(2): 229–257.
- Puton, A. 1881. Enumeration des Hemipteres recoltés en Syrie par M. Abeille de Pemin avec la description de especes nouvelles. *Mitteilungen der Schweizerischen entomologischen Gesellschaft*, 6: 119–129.
- Ribaut, H. 1952. *Homopteres Auchenorrhynques, II (Jassidae)*, Faune de France, 57. Paul Lechevalier, Paris, France, 474 pp. (in France).
- Tishechkin, D.Y. 2007. Review of *Nealiturus* gr. *fenestratus* (Herrich-Schäffer, 1834) (Homoptera: Cicadellidae) of the fauna of Russia. *Russian Entomological Journal*, 16(4): 415–424.
- Viraktamath, C. A. 2005. Key to the subfamilies and tribes of leafhoppers (Hemiptera: Cicadellidae) of the Indian subcontinent. *Bionotes*, 7: 20–24.
- Young, D.A. and Frazier, N.W. 1954. A study of the leafhopper genus *Circulifer* Zakhvatkin (Homoptera, Cicadellidae). *Hilgardia. A Journal of Agricultural Science published by the California Agricultural Experiment Station*, 23:25–52.
- Zahniser, J.N. and Dietrich, C.H. 2008. Phylogeny of the leafhopper subfamily Deltocephalinae (Insecta: Auchenorrhyncha: Cicadellidae) and related subfamilies based on morphology. *Systematics and Biodiversity*, 6 (1): 1–24. DOI: <http://dx.doi.org/10.1017/S1477200007002617>
- Zahniser, J.N. and Dietrich, C.H. 2010. Phylogeny of the leafhopper subfamily Deltocephalinae (Hemiptera: Cicadellidae) based on molecular and morphological data with a revised family group classification. *Systematic Entomology*, 35 (3): 489–511. DOI: <http://dx.doi.org/10.1111/j.13653113.2010.00522.x>
- Zahniser, J.N. and Dietrich, C.H. 2013. A review of the tribes of Deltocephalinae (Hemiptera: Auchenorrhyncha: Cicadellidae). *European Journal of Taxonomy*, 45: 1–211. DOI: <http://dx.doi.org/10.5852/ejt.2013.45>
- Zanol, K.M.R. 2008. Catalogue of the Neotropical Deltocephalinae (Hemiptera: Cicadellidae). Part III – Tribe Athysanini. *Acta Biológica Paranaense*, 37: 1–104.

## مرور زنجرک‌های جنس *Neoliturus* Distant (Hemiptera: Cicadellidae: Deltocephalinae) در ایران

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**چکیده:** در این پژوهش، زنجرک‌های جنس *Neoliturus* Distant 1918 در ایران شامل: *N. decemocellatus* (Dlabola)، *N. alboflavovittatus* (Lindberg)، *N. guttulatus*، *N. fenestratus* (Herrich-Schäffer)، *dubiosus* (Matsumura) (Kirschbaum)، *N. opacipennis*، *N. haematoceps* (Mulsant and Rey)، *N. tenellus* (Baker) و *N. pulcher* (Haupt) (Lethierry)، مورد مطالعه قرار گرفته‌اند. ویژگی‌های شکل‌شناسی هر یک از گونه‌ها به همراه تصاویر و ترسیم‌های اصلی و کلید شناسایی ارائه شده است.

**واژگان کلیدی:** Auchenorrhyncha؛ Opsiini؛ تاکسونومی؛ *Neoliturus*؛ *Circulifer*.