

*This contribution is published  
to honor Dr. Amnon Freidberg,  
a scientist, a colleague and a friend,  
on the occasion of his 75<sup>th</sup> birthday.*

## **Description of a new species of the genus *Rhagoletis* Loew (Diptera: Tephritidae) from Nepal, with a key to species from Central and Southern Asia**

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### **ABSTRACT**

The genus *Rhagoletis* is represented in the Oriental Region by four species known to occur in Nepal. A fifth species, *Rhagoletis freidbergi* n. sp., is described herein. It differs from all known congeners by the colour patterns on the abdominal tergites and wing. A key to known Central and southern Asian species of *Rhagoletis* (from the Caucasus to the Himalayas) is provided. The taxonomic position of “*Rhagoletis bezziana*” Hendel, 1931 is also discussed.

**KEYWORDS:** Diptera, Tephritidae, *Rhagoletis*, Oriental Region, Nepal, biodiversity, identification key, new species, taxonomy.

### **INTRODUCTION**

The genus *Rhagoletis* Loew of the tribe Carpomyini includes 73 valid species from the Holarctic, Oriental and Neotropical Regions (Norrbom *et al.* 1999, with additions). Like other Carpomyini, *Rhagoletis* species breed in fruits, and some of them are economically important pests of apples, cherries, tomatoes, blueberries and walnuts (Boller & Prokopy 1976). The systematics and phylogeny of *Rhagoletis* have been intensively studied for over half a century (Kandybina 1961, 1977; Rohdendorf 1961; Bush 1966; Foote 1981; Norrbom 1989; Hernández-Ortiz 1993; Jenkins 1996; Korneyev & Merz 1997; McPheron & Han 1997; Smith & Bush 1999; Smith *et al.* 2006; Hulbert 2018). Keys for identification of species have been compiled by Foote (1981) for the Americas South of the United States, Bush (1966) and Foote *et al.* (1993) for the USA and Canada, Korneyev and Merz (1997) for Central Asia, Korneyev and Ovchinnikova (2004) for the Asian Far East, Mohamadzade Namin and Rasouljan (2009) for Iran, and Korneyev *et al.* (2017) for Europe, the Caucasus and Middle East. The Oriental species remained mostly unknown except for two species assigned to this genus by Hendel (1931) and Hardy (1964). Recently, Ito (2011) described additional three species and provided a key to the known Oriental *Rhagoletis*. He also noted that *Rhagoletis bezziana* Hendel, 1931 apparently belongs elsewhere.

While studying the Diptera collection of the Steinhardt Museum of Natural History, Israel, a previously undescribed and unnamed species of *Rhagoletis* collected by Dr Amnon Freidberg in Nepal was found and is described here in his honour. A key to the known Central and Southern Asian species of *Rhagoletis* is also provided.

#### MATERIALS AND METHODS

The following acronyms refer to collections housing specimens examined in this study:

- SIZK – I. I. Schmalhausen Institute of Zoology, National Academy of Sciences of Ukraine, Kyiv, Ukraine;  
 SMNHTAU – Steinhardt Museum of Natural History, Tel Aviv, Israel.

Morphological terminology generally follows White *et al.* (1999). Measurements are given in millimetres. The body length of females includes the oviscapae.

The wing and habitus photographs were taken using a Canon PowerShot A640 attached to a Zeiss Stemi C-2000 (SIZK).

#### TAXONOMY

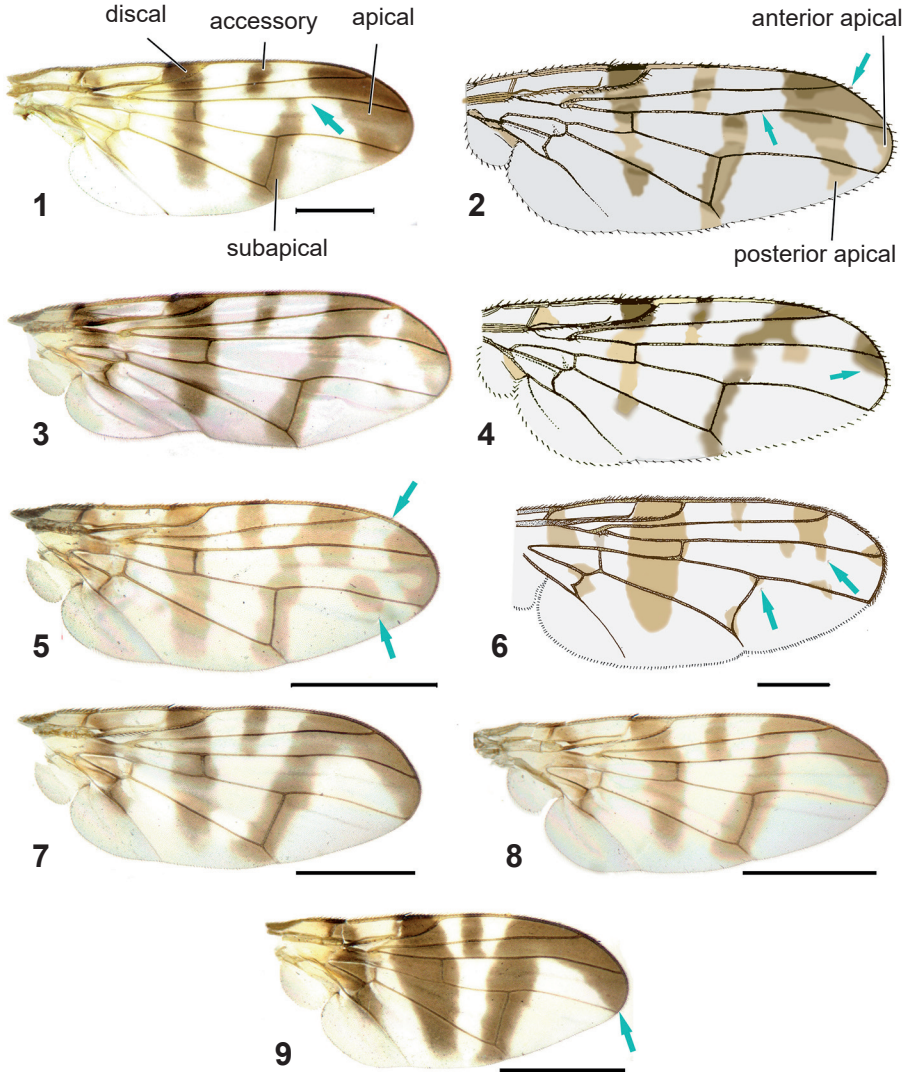
Genus *Rhagoletis* Loew, 1862

#### Key to the species of *Rhagoletis* occurring in the mountains of Central and Southern Asia

(including the Middle East from Iran to Kyrghyzstan and Nepal; Caucasian species are also included in square brackets)

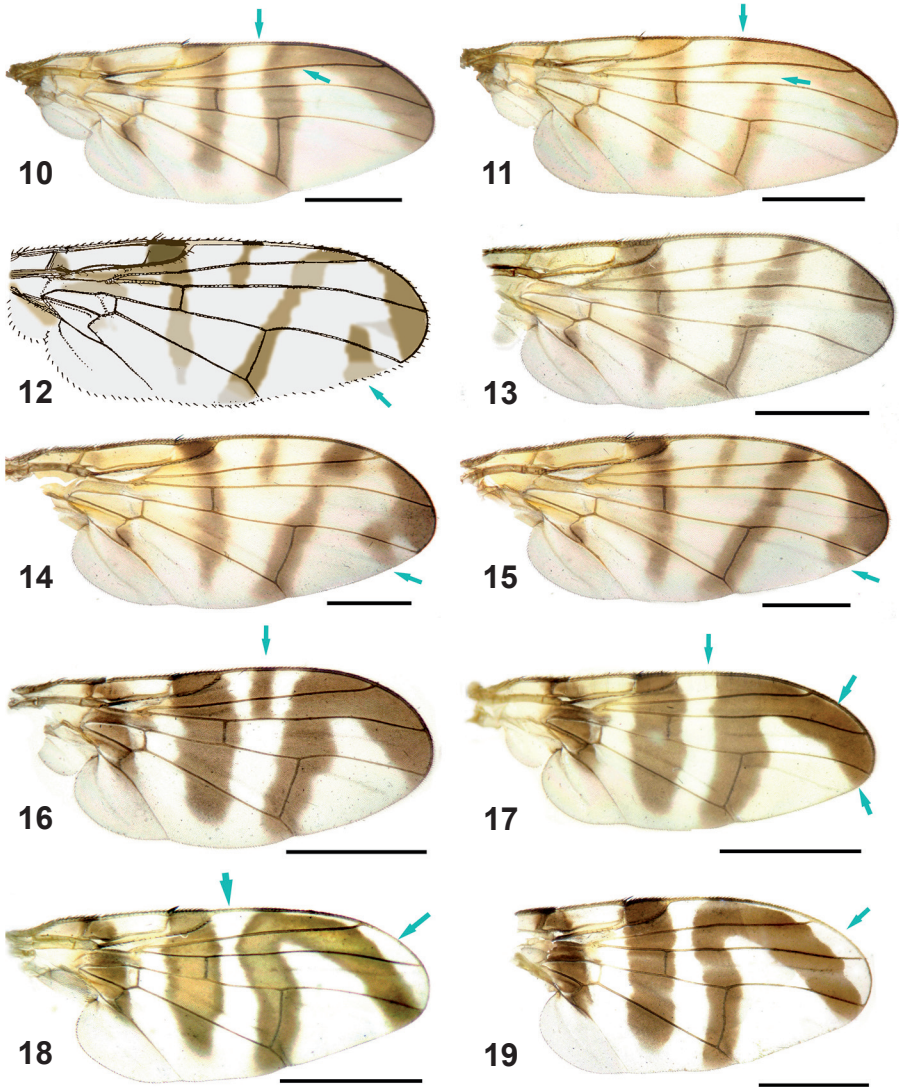
- 1 Ground colour of thorax predominantly yellow (at most scutum, katepisternum, meron, and metatergite with brown or black spots).....2
  - Ground colour of thorax predominantly black (at most postpronotal lobe, scutellum and parts of pleuron yellow)..... 11
- 2 Abdominal tergites mainly black with yellow posterior margins. Wing with complete subapical band connected to anterior apical band (Fig. 7).....
  - ..... [ *R. caucasica* Kandybina & Richter, 1976 ]
  - Abdominal tergites mainly orange, at most with paired black spots. Wing pattern variable.....3
- 3 Thorax shining orange, non-microtrichose. Mediotergite orange-yellow with 2 lateral black spots. Wing with complete subapical band separated from short, spot-like anterior and posterior apical bands (Fig. 5). Abdominal tergites with pair of round submedial spots..... *R. rohdendorfi* Korneyev & Merz, 1997
  - Thorax matt brownish yellow to orange, sparsely microtrichose. Mediotergite, abdominal tergites and wing pattern variable .....4
- 4 Abdominal tergites entirely orange, without black spots.....5
  - Abdominal tergites with dark pattern ..... 10
- 5 Accessory costal band entirely lacking; subapical and apical bands fused (Fig. 10). Mediotergite and oviscapae reddish yellow (at most mediotergite with pair

- of dorsal stripes); oviscape as long as tergites 5–6 combined.....  
 ..... *R. emiliae* Richter, 1976  
 – Accessory costal band present (Figs 11–16), although connected with apical  
 crossband in *R. turanica* (Fig. 11). Other characters variable ..... 6



**Figs 1–9:** *Rhagoletis* wings: (1) *R. meigenii*; (2) *R. nakaoui*; (3) *R. freidbergi* n. sp.; (4) *R. yasudai*; (5) *R. rohdendorfi*; (6) *R. rumpomaculata*; (7) *R. caucasica*; (8) *R. samojlovitshae*; (9) *R. berberidis*. Scale 1 mm. Arrows point to key characters. Figs 2 and 4 redrawn from Ito (2011); Fig. 6, from Hardy (1964), with changes; Fig. 1, from Korneyev *et al.* (2017), with permission.

- 6 Mediotergite and oviscape entirely reddish yellow, the latter as long as tergites 5 and 6 combined. Accessory costal band fused with anterior apical band; subapical band widely separated from anterior apical band in cell  $r_{4+5}$  (Fig. 11) .....  
 ..... *R. turanica* (Rohdendorf, 1961)



**Figs 10–19:** *Rhagoletis* wings: (10) *R. emiliae*; (11) *R. turanica*; (12) *R. quamplurima*; (13–15) *R. alternata* (variation of pattern); (16) *R. almatensis*; (17) *R. flavicincta*; (18) *R. flavigenualis*; (19) *R. batava*. Scale 1 mm. Arrows point to key characters. Fig. 12 redrawn from Ito (2011), with changes; Figs 17–19, from Korneyev *et al.* (2017), with permission.

- Mediotergite at least with pair of black spots or entirely dark. Other characters variable..... 7
- 7 Mediotergite with pair of large black spots separated by medial vitta ..... 8
- Mediotergite entirely black..... 9
- 8 Mesonotum brownish yellow setulose. Oviscape entirely orange. [Wing: Figs 13–15] ..... *R. alternata* (Fallén, 1817)
- Mesonotum black setulose. Oviscape laterally black. [Wing: Fig. 12] .....  
.....*R. quamplurima* Ito, 2011
- 9 Subapical and anterior apical bands broadly connected (Fig. 8). Oviscape mainly orange, as long as tergites 4–6 combined. Accessory costal band isolated from or connected to anterior apical band.....*R. samojlovitshae* (Rohdendorf, 1961)  
[in part, light-coloured females]
- Subapical and anterior apical bands widely separated along vein  $R_{4+5}$  (Fig. 1). Oviscape entirely black, conspicuously shorter than tergites 5 and 6 combined. Accessory costal band always separated from anterior apical band.....  
.....*R. meigenii* (Loew, 1862)
- 10 Abdominal tergites 3–6 in female (unknown in male) with lateral black round spots separated by yellow interspaces much wider than individual spot (Fig. 23). Wing with subapical and anterior apical bands narrowly separated at apex of vein  $R_{2+3}$  (Fig. 3).....*R. freidbergi* n. sp.
- Abdominal tergites 3–5 (and female 6) on anterior halves with transverse dark bars medially separated by yellow interspaces much narrower than dark area .....  
.....*R. samojlovitshae* (Rohdendorf, 1961)  
[in part, specimens with dark spotted abdominal tergites]
- 11 Accessory costal band present (Figs 2, 4, 7, 9), although sometimes fused with subapical and apical bands in *R. nigripes* and *R. berberidis*). Other characters variable ..... 12
- Accessory costal band entirely lacking (Figs 17–19). Subapical and anterior apical bands connected ..... 20
- 12 Femora yellow. Discal band variable..... 13
- Femora black. Distance between discal and subapical bands along vein M narrower than discal band (or at most as wide as) (Figs 9, 16) ..... 18
- 13 Subapical band present, at least on posterior half of wing; crossvein  $dm-cu$  entirely within the dark field; posterior apical band present or absent..... 14
- Subapical, anterior and posterior apical bands incomplete, broken into small separated spots (Fig. 6). Crossvein  $dm-cu$  at most partially covered by dark markings. Abdominal tergites black, sparsely gray microtrichose, with yellow bands along posterior margins ..... *R. rumpomaculata* Hardy, 1964
- 14 Subapical and anterior apical bands connected in cell  $r_{2+3}$  (as in Figs 7, 9) ..... 15
- Subapical and anterior apical bands widely separated in cell  $r_{2+3}$  (Figs 2, 4) ..... 17

- 15 Discal band conspicuously narrower than hyaline interspace between it and subapical band along vein M (Fig. 7). Larger: wing length > 3.7 mm. Associated with *Berberis*..... 16
- Discal band as wide as or wider than hyaline interspace between it and subapical band along vein M (Fig. 16). Smaller: wing length < 3.7 mm. Associated with *Lonicera*..... *R. almatensis* Rohdendorf, 1961
- 16 Female: oviscape very long, at least 4× longer than subcostal cell. Male: proctiger as long as, and surstyli longer than subcostal cell ..... *R. magniterebra* (Rohdendorf, 1961)
- Female: oviscape at most 1.5–2× as long as subcostal cell. Male: proctiger shorter, and surstyli hardly as long as subcostal cell ..... *R. chumsanica* (Rohdendorf, 1961)
- 17 Wing with anterior and posterior apical bands widely connected along costa in cell  $r_{2+3}$ ; but separated from subapical band along vein  $R_{4+5}$  (Fig. 2). Thoracic pleuron anterior and posterior to anterior spiracle widely black. Abdominal tergites mostly black, tergites 2–5 (and female 6) with very narrow, yellowish brown at posterior margin, medially wider, in males tergites also yellow on lateral margin [oviscape characters missing in the original description]..... *R. nakaoui* Ito, 2011
- Wing with anterior apical band reduced to rounded dark spot at tip of vein  $R_{4+5}$ , widely separated from subapical band along costa in cell  $r_{2+3}$  (Fig. 4). Thoracic pleuron anterior and posterior to anterior spiracle widely with yellowish brown dark spots. All abdominal tergites brownish black, tergites 2–5 with wider brownish yellow posterior margin (at least 0.25–0.30 of length); tergite 6 of female widely brownish yellow, with 3 black dots on anterior margin. Oviscape shining black, as long as tergite 6 ..... *R. yasudai* Ito, 2011
- 18 Scutellum entirely black ..... *R. nigripes* Rohdendorf, 1961
- Scutellum mostly yellow ..... 19
- 19 Scutum black with four silvery microtrichose vittae; scutellum entirely yellow, except faint anterior band. Wing with anterior apical band crossing vein M and entering into cell m (as shown on Fig. 16). Larvae in *Lonicera* and cherry fruits ..... *R. cerasi* (Linnaeus, 1758)
- Scutum entirely shining black without microtrichose vittae; anterior margin of scutellum black. Wing with apical crossband touching vein M apex, but not entering into cell m (Fig. 9, arrow). Larvae in *Berberis* seeds ..... [*R. berberidis* Jermy, 1961]
- 20 Anterior apical band entirely contiguous with apical wing margin (Fig. 17). Larvae in *Lonicera* ..... *R. flavicincta* Enderlein, 1934
- Anterior apical band separated from apical wing margin by crescentic marginal hyaline area (Figs 18, 19). Not associated with *Lonicera* ..... 21
- 21 Femora yellow. Associated with *Juniperus* ..... 22
- Femora black. Not associated with *Juniperus* ..... 23

- 22 Posterior surface of head completely yellow, at most with narrow black streaks along sutures. Wing pattern brownish yellow (Fig. 18). Larger: wing length  $\geq 4.0$  mm ..... *R. flavigenualis* Hering, 1958
- Occiput with broad black patch on dorsal third. Wing pattern blackish brown. Smaller: wing length  $\leq 4.0$  mm ..... *R. mongolica* Kandybina, 1972
- 23 Smaller: wing length in male  $< 2.45$  mm (2.0–2.4 mm), in female  $< 2.55$  mm (2.2–2.5 mm). Associated with *Rhamnus* ..... [ *R. bagheera* Richter & Kandybina, 1997 ]
- Larger: wing length in male  $> 2.45$  mm (2.5–3.2 mm), in female  $> 2.55$  mm (2.6–3.2 mm) (Fig. 19). Associated with *Hippophae* ..... *R. batava* Hering, 1958

***Rhagoletis freidbergi* n. sp.**

(Figs 3, 20–24)

**LSID:** urn:lsid:zoobank.org:act:B922E84D-5A2F-4A57-8854-43AC2E740E8F.

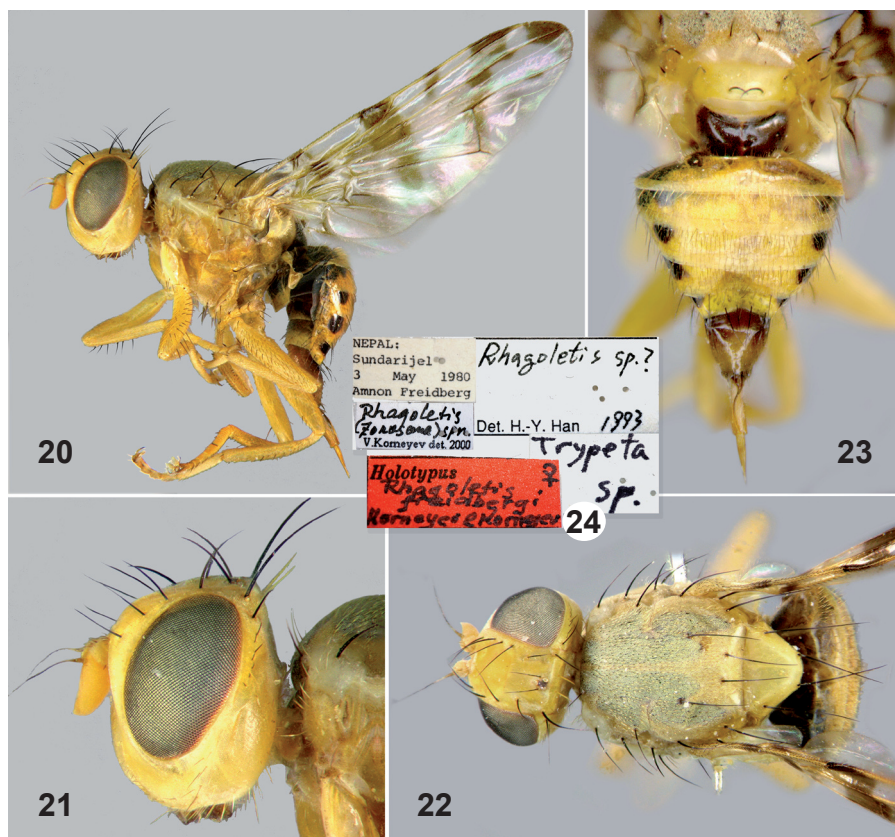
**Etymology:** This species is named in honour of Dr Amnon Freidberg, who collected the type specimen, in recognition of his contributions to the study of fruit flies worldwide.

**Diagnosis:** The new species can be easily separated from other *Rhagoletis* species by the following combination of characters: thorax yellow with yellow microtrichose mesonotum bearing black lyrate pattern; yellow setulae and black setae; abdomen yellow with black syntergite 1+2 and one pair of sublateral spots on tergites 3–6. It is similar to the Old World species *R. alternata*, *R. caucasica*, *R. meigenii*, *R. nakaoui*, *R. rumpomaculata*, *R. rohdendorfi*, *R. samojlovitshae* and *R. yasudai* in having a mostly yellow body and wing pattern with five crossbands (Fig. 3), including sub-basal, discal, accessory costal, subapical, and anterior apical bands (Fig. 1). Differing from the other species as given in the key above.

This species is believed to belong in the group of species associated with *Berberis* spp. (the *meigenii* group *sensu* Kandybina 1977). It fits close to *R. samojlovitshae*, sharing the mostly reddish yellow body colour and first flagellomere apically pointed, differing in having a lyrate black pattern on the mesonotum and abdominal tergites 3–6 with black sublateral spots. In *R. samojlovitshae*, the mesonotum is at most diffusely darkened to brown on the posterior half anterior of the scutum, and the dark spots on the abdominal tergites are subrectangular and submedial, separated by a yellow medial vitta.

**Description: Female.** *Head* (Fig. 21): yellow, with black ocellar triangle; length : height : width ratio = 1:1.3:1.7. Frons parallel sided, 1.5× wider than eye, 1.1× longer than wide, matt yellow, sparsely white microsetulose; frontal plates matt, finely and sparsely yellow microsetulose. Face 1.2× as high as narrowest distance between eyes; with low facial carina and shallow antennal grooves. Flagellomere 1 dorsoapically pointed, twice as long as wide; arista black except basal 0.2, brownish

yellow, micropubescent, longest rays much shorter than arista width at base. Occiput entirely yellow, without dark pattern, silvery microtrichose posterior to medial vertical seta and at margins of genae, sparsely brown setulose at eye level and pale yellow setulose ventrally, with 7–8 supracervical setae on each side. Gena matt yellow, with short brownish yellow genal seta and several setulae posteroventrally,  $0.27\times$  as high as eye and  $0.85\times$  as high as flagellomere 1 length; anteroventrally with 12–13 very short and fine, yellowish peristomal setulae. Mouthparts capitate; palp yellow,  $0.75\times$  as long as flagellomere 1. Frontal, orbital, ocellar, vertical and postocular setae black: 3 frontal setae on left and 4 on right side; 1 reclinate orbital seta; one ocellar seta, half as long as medial vertical seta; lateral vertical seta  $0.75\times$  as long as medial vertical seta; 6–7 postocular setae,  $0.1\text{--}0.2\times$  as long as medial vertical seta. Postocellar and postvertical seta brownish yellow,  $0.3\times$  and  $0.1\times$  as long as medial vertical seta, respectively.



Figs 20–24: *Rhagoletis freidbergi* n. sp., holotype ♀: (20) habitus, left; (21) head, left; (22) head and mesonotum, dorsal; (23) abdomen, dorsal; (24) labels.

*Thorax* (Fig. 22) yellow, with black setae; scutum yellow setulose, densely white microtrichose, with black lyrate pattern partly hidden by microtrichiae; scutellum subshining yellow, non-microtrichose, with 2–3 fine yellowish submarginal setulae on each side; mediotergite entirely black, without median yellow vitta, sparsely whitish microtrichose, subshining, with entirely bare posteromedial spot; 2 pairs of short brown scapular setae; dorsocentral seta aligned with anterior supra-alar seta, acrostichal prescutellar seta strong, at level of intra-alar seta; 2 pairs of scutellar setae, apical one 0.8× as long as basal seta; 1 postpronotal, 2 subequal notopleural, 1 intra-alar, 1 postalar, 1 anepisternal, 1 katepisternal, and 1 anepimeral setae; scutellum slightly convex.

*Legs* yellow, brown setose and setulose, non-thickened; hind femur subapically with 1–3 longer, dark setae on anteroventral and 3–4 longer setulae on anterodorsal surface.

*Wing* pattern as in Fig. 3. Subbasal band pale brown, broken into 3 spots: at humeral crossband, in base of cell br, and at  $Cu_2$  and  $A_1$  junction; discal band broad, entire, reaching from pterostigma to middle of cell cu<sub>1</sub>; accessory costal band present; subapical band complete; anterior apical band narrowly separated from subapical band by hyaline spot at apex of vein  $R_{2+3}$ ; posterior apical band strongly reduced to short brown stump connected to subapical band at vein  $R_{4+5}$  and small dark spot on vein M. Calypters creamy, white ciliate. Haltere yellow.

*Abdomen* (not dissected): tergites shining, yellow (tergites 1–3) or brown (tergites 3–6) setulose and black setose laterally, tergites 5 and 6 also with black setae on posterior margins; syntergite 1+2 mostly black, with yellow posterior margin (note: base of abdomen is full of pitchy-black internal tissue obscuring actual colouration of cuticle); tergites 3–6 sublaterally with round black spots isolated by equally wide yellow interspaces from lateral margins (Fig. 23). Oviscape dorsally convex, pale brown, darkened basally and apically, brown setulose, ventrally 1.5× as long as dorsally, with darkened, Y- or T-shaped desclerotized area ventrally; eversible membrane with dorsal taeniae fused posteriorly; aculeus (not dissected, almost entirely exposed) moderately narrow, in cross section more cylindrical than flattened. Spermathecae not examined.

**Male** unknown.

**Measurements:** Female. Body length, 5.0 mm; wing length, 4.3 mm, costal cell length, 0.9 mm; aculeus length, 0.8 mm; aculeus length / costal cell length, 0.9.

**Holotype:** ♀ “Nepal: Sundarikal [27°48'N 85°25'E] / 3 May 1980 / Amnon Freidberg” (SMNHTAU).

**Host plant:** Unknown.

**Remarks.** This species is morphologically similar to the Central Asian *R. samojloviushae* (Rohdendorf) and apparently belongs in the group of species associated with *Berberis* spp. This group includes *R. berberidis*, *R. caucasica*, *R. chumsanica*, *R. kurentsovi* (Rohdendorf), *R. magniterebra*, *R. meigenii*, *R. rohdendorfi*, *R. samojloviushae*, and corresponds to the *meigenii* group of species recognized by Kandybina (1977) based on larval morphology and “Clade IV” of Hulbert (2018),

a clearly monophyletic cluster supported by both molecular and larval and adult morphological data, as well as by the host-plant association. The included species are mostly specialized for feeding within the seeds rather than fleshy part of the fruit (Kandybina 1977). The adults are also similar in having a usually yellowish body (except *R. berberidis*) and a moderately or (in *R. magniterebra*) very long, narrow, needle-like aculeus as well as a narrow glans on the phallus (see Korneyev & Merz 1997: figs 8–11).

#### DISCUSSION

The species of the genus *Rhagoletis* are most diverse in the Nearctic Region, with certain groups of species occurring in the Neotropical and Palaearctic regions (Rohdendorf 1961; Bush 1966; Kandybina 1977; Jenkins 1996; Smith *et al.* 2006; Hulbert 2018), with local centres of diversity in mountainous areas, especially Central Asia (Korneyev & Merz 1997). In the Oriental Region, only five species are now known, including *R. freidbergi* and the four species described from Nepal by Hardy (1964) and Ito (2011), all from mountainous areas (elevation 1500–3350 m asl), where the climate is similar to Central Asian mountains at lower altitudes, and the flora and fauna are related rather to those of the Palaearctic Region. Nothing is known about their host plants and biology in general, but due to morphological similarity with Central Asian species, they may be associated with *Berberis* or *Rosa* spp. Furthermore, *R. quamplurima* Ito shows strong similarity to, and few rather insufficient differences from the widespread *R. alternata* and quite possibly represents a local population of it.

*Rhagoletis bezziana* Hendel, 1931 (replacement name for *Zonosema dubium* Bezzi, 1913, non Johnson, 1903) from India (Uttar Pradesh, Naini Tal), as has been already noted by Ito (2011), apparently does not belong to *Rhagoletis*. Indeed, it has a narrow wing with a dark spot at the apex of cell *bcu*, which are characters more common for species of the tribe Trypetini rather than for Carpomyini; some species of these tribes can be classified based only on genital characters. This species is not included in the key above.

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