JOURNAL OF INSECT BIODIVERSITY
ISSN: 2147-7612

RESEARCH ARTICLE

Phenotypic variation of *Thaumatomyia notate* (Meigen, 1830) (Diptera; Chloropidae) in East Azerbaijan province - Iran

Samad Khaghaninia[1*] Yaser Gharajedaghi[1] Stepan Kubik[2]

[1]*Department of Plant Protection, Faculty of Agriculture, University of Tabriz, Tabriz, Iran P.O. Box: 51664*
[2]*Department of Zoology and Fisheries, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences, CZ-165 21 Praha 6 - Suchdol, Czech Republic, kubik@af.czu.cz*
**Corresponding author: S. Khaghaninia, E-mail: skhaghaninia@gmail.com*

Abstract: The phenotypic variation of *Thaumatomyia notate* (Meigen, 1830) (Chloropidae) collected from six different regions was studied in the East Azerbaijan province in northwestern Iran during 2009-2012. Eight populations of *Thaumatomyia notata* with different phenotypes were recognized. Environmental parameters such as temperature, elevation and habitat were examined. The results of this study show that colour variation in *T. notata* is caused mostly by seasonal temperature, dark coloration in April to light in July. In addition, variation in some morphological characters such as antenna, ocellar triangle, microchaetotaxy and size as well as diagnostic characters and photos of each variation are provided.

Key words: *Thaumatomyia notata*, colour variation, East Azerbaijan province, Iran.

Introduction

Thaumatomyia notate (Meigen, 1830) belongs to the subfamily Choloropinae (Diptera: Chloropidae) and is a widespread species, known from the Afrotropical, Oriental and Palaearctic Regions (Nartshuk & Andersson, 2013). It differs from other species of the genus *Thaumatomyia* Zenker, 1833 by the following combination of characters: body length 2.5 to 3.5 mm, yellow, with black to reddish stripes on mesonotum; antennal 1st flagellomere mainly black, length equal to width; height of gena narrow, about one third of 1st flagellomere; vertical triangle yellow to black, with two rows of hair-like setulae along lateral margins; vertical setae developed; frons approximately as long as wide; male with one pair of eversible postabdominal vesicles (Nartshuk *et al.* 1988; Nartshuk & Andersson 2013). Adults feed on the nectar of flowers or various other sweet liquids and the larvae are carnivorous, living in roots of grasses and mainly feeding on root aphids (Nartshuk & Andersson 2013).

Intra-specific variation is the potential of one genotype to develop different phenotypes due to environmental changes (Whitman *et al.* 2009). The study of phenotypic plasticity has attracted the interest of many biologists even before Darwin (Bernardo *et al.* 2007; Kunkel 2001). Phenotypic variation in insects is a result of environmental factors (including: biotic factors) such as predatory pressure and abiotic factors such as altitude, diet, humidity, light, oxygen level and temperature (Bernardo *et al.* 2007; Roder *et al.* 2008; Whitman *et al.* 2009; Khaghaninia *et al.* 2011). In most insects, poor-quality diet results in reduced body size. Lower temperatures, increasing altitude, increasing latitude or high humidity can cause darker coloration (Whitman *et al.* 2009). A dark coloration of the cuticle aids absorption of sunshine in cold climates and helps to keep the body temperature at a thermal optimum (May 1984). Nartshuk (2004) reported some dark colour variations of spring specimens of *T. notate* from Tunisia which have been collected from eleven different localities.

In this study, phenotypic diversity (including changes of body size, colour and shape of genitalia) of *T. notata* caused by some environmental factors (temperature, elevation and habitat) was examined.

Material and methods

Adult specimens were collected using standard sweep-netting in open forest, dry and wet grassland habitats in East Azerbaijan province of Iran between April and July of 2009–2012. The specimens were preserved in 75 % ethanol. Male genitalia were cleared in 10% KOH and subsequently permanent slides were prepared. Images were obtained using a microscope (Nikon SMZ 1000) equipped with a camera (Olympus 10μ). The morphological terminology used here follows Merz & Haenni (2000) and Sinclair (2000). The material examined is deposited in the collections of the following institutions:

IMTU: Insect Museum of Tabriz University.

IMCU: Insect Museum of Czech University.

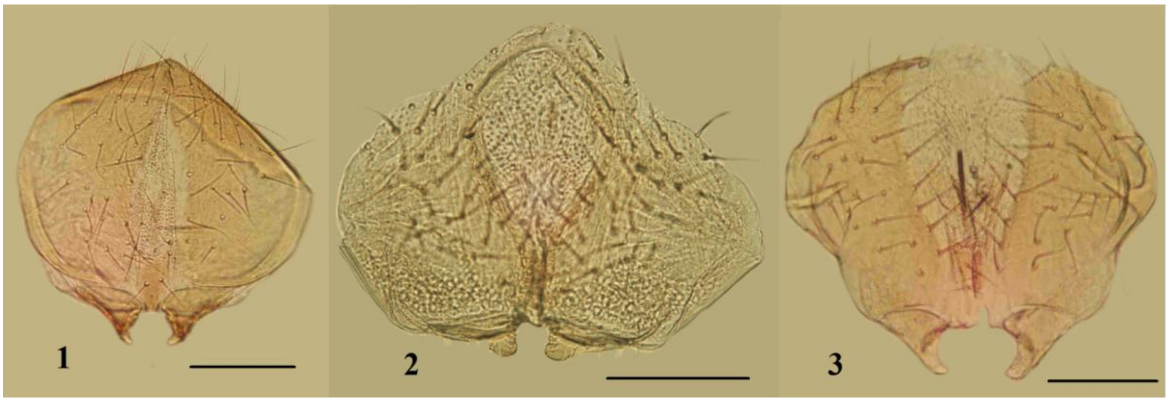
Results

Three species of the genus *Thaumatomyia*, *T. glabra* (Meigen, 1830), *T. notata* and *T. sulcifrons*, were identified from East Azerbaijan province, of which only *T. notata* showed phenotypic variation (Figs. 1-3). In total 70 specimens of *Thaumatomyia notata* from 6 geographic regions and three habitat types were collected (Table 1). These specimens showed 8 main colour pattern variations (Figs. 4-35). The variations of some morphological characteristics are shown in table 2. Seasonal temperature changes in the areas studied are given in table 3. The male and female genitalia of these variations showed no distinct differences (Figs. 36-53).

***Thaumatomyia notata* (Meigen, 1830)** (Figs. 4-35)

Material examined: (27 ♂, 43 ♀ IMTU; 5 ♂, 5 ♀ IMCU).

Variation 1: 1 ♂, 1♀, Maragheh, 37°25' N, 46°25' E, 1790 m a.s.l., 5 July 2010 (grassland habitat); 1 ♂, Chichakli, 38°40' N, 46°31' E, 2150 m a.s.l., 15 June 2011 (forest-grassland habitat); 3 ♂, 2♀, Qaradagh Forests, 38°51' N, 46°52' E, 1770 m a.s.l., 7 July 2012 (forest habitat); 2 ♂, 2 ♀, Kandovan, 37°44' N, 46°19' E, 3000 m a.s.l., 20 June 2012 (grassland habitat), (6 ♂, 12 ♀ IMTU; 1 ♂, 1 ♀ IMCU).



Figures 1-3. Epandrium and surstylus, dorsal view. **1,** *Thaumatomyia glabra* (Meigen, 1830); **2,** *T. notata* (Meigen, 1830); **3,** *T. sulcifrons*.

Variation 2: 5 ♂, Kandovan, 37°44' N, 46°19' E, 3000 m a.s.l., 20 June 2012 (grassland habitat), (5 ♂ IMTU).

Variation 3: 2 ♂, 2 ♀, Chichakli, 38°40' N, 46°31' E, 2150 m a.s.l., 15 June 2011 (forest-grassland habitat); 3 ♂, 5 ♀, Kandovan, 37°44' N, 46°19' E, 3000 m a.s.l., 24 May 2012 (grassland habitat), (4 ♂, 6 ♀ IMTU; 1 ♂, 1 ♀ IMCU).

Variation 4: 1 ♂, 2♀, Qaradagh Forests, 38°51' N, 46°52' E, 1770 m a.s.l., 7 July 2012 (forest habitat); 1 ♂, 1♀, Ajabshir, 37°28' N, 45°46' E, 1400 m a.s.l., 10 July 2012, (grassland habitat); (1 ♂, 2 ♀ IMTU; 1 ♂, 1 ♀ IMCU).

Variation 5: 2 ♂, 3 ♀ Chichakli, 38°40' N, 46°31' E, 2150 m a.s.l., 15 June 2011 (forest-grassland habitat); 2 ♂, 1 ♀, Isperekhan, 37°46' N, 46°24' E, 2500 m a.s.l., 26 April 2010 (grassland habitat) (3 ♂, 3 ♀ IMTU; 1 ♂, 1 ♀ IMCU).

Variation 6: 2 ♀, Isperekhan, 37°46' N, 46°24' E, 2500 m a.s.l., 26 April 2010 (grassland habitat); 4 ♀, Chichakli, 38°40' N, 46°31' E, 2150 m a.s.l., 10 May 2011 (forest-grassland habitat), (5 ♀ IMTU; 1 ♂, 1 ♀ IMCU).

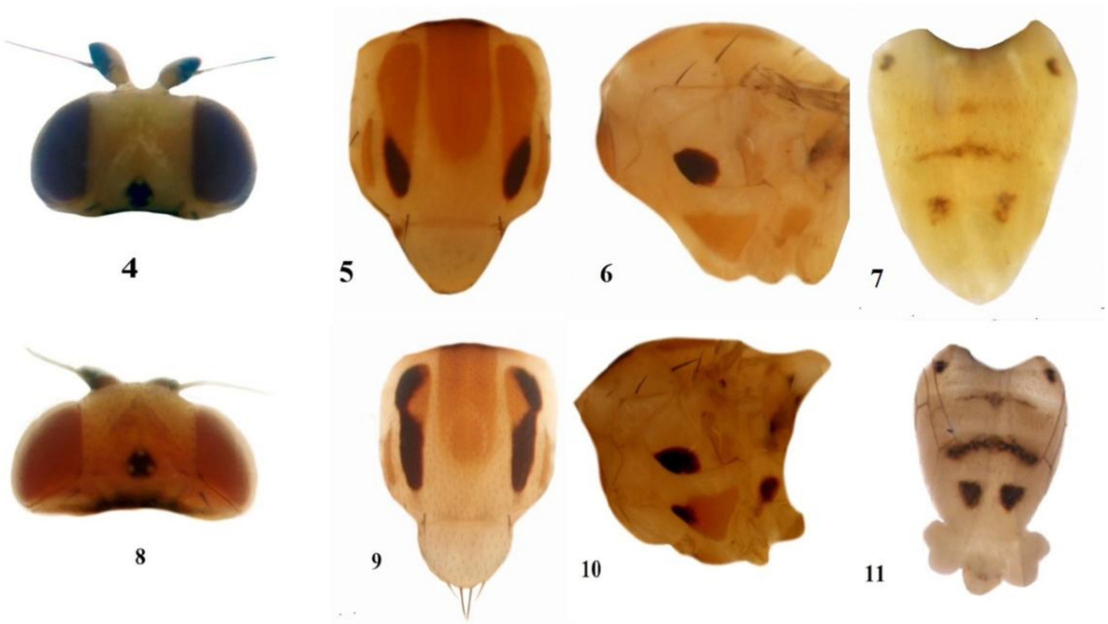
Variation 7: 1 ♂, 4 ♀, Isperekhan, 37°46' N, 46°24' E, 2500 m a.s.l., 26 April 2010 (grassland habitat); 2 ♂, 2 ♀, Chichakli, 38°40' N, 46°31' E, 2150 m a.s.l., 10 May 2011 (forest-grassland habitat), (3 ♂, 6 ♀ IMTU).

Variation 8: 1 ♂, 1♀, Maragheh, 37°25' N, 46°25' E, 1790 m a.s.l., 5 June 2010 (grassland habitat); 1 ♂, Kandovan, 37°44' N, 46°19' E, 3000 m a.s.l., 12 May 2012 (grassland habitat), (2 ♂, 1 ♀ IMTU).

Diagnosis of the variations

Variation 1: Body length 2.5 to 3 mm, light coloration; antennal 1st flagellomere yellow ventrally and brown dorsally; ocellar triangle yellow, with pale hair-like setulae, sometimes with reddish median stripe; scutum mainly with reddish stripes; acrostichal stripe reddish, with pale hair; dorsocentral stripes mainly reddish, black in apical part; alar stripes reddish; anepisternal mark black; katepisternal mark reddish; scutellum pale yellow, with pale hairs; abdominal pattern reduced (Figs. 4-7).

Variation 2: Body length 3 mm, light coloration; antennal 1st flagellomere black; ocellar triangle yellow, with black hairs; scutum mainly with reddish stripes; acrostichal stripe reddish, with black hairs; dorsocentral stripes mainly reddish, black in basal and apical parts; alar stripes reddish; anepisternal mark black; katepisternal mark reddish, with black spot in front corner; scutellum pale yellow, with pale hairs; abdominal pattern reduced (Figs. 8-11).



Figures 4-11. Variation 1: **4,** ocellar triangle (dorsal view); **5,** stripes on notum (dorsal view); **6,** anepisternum and katepisternum (lateral view); **7,** abdomen. Variation 2: **8,** ocellar triangle (dorsal view); **9,** stripes on notum (dorsal view); **10,** anepisternum and katepisternum (lateral view); **11,** abdomen.

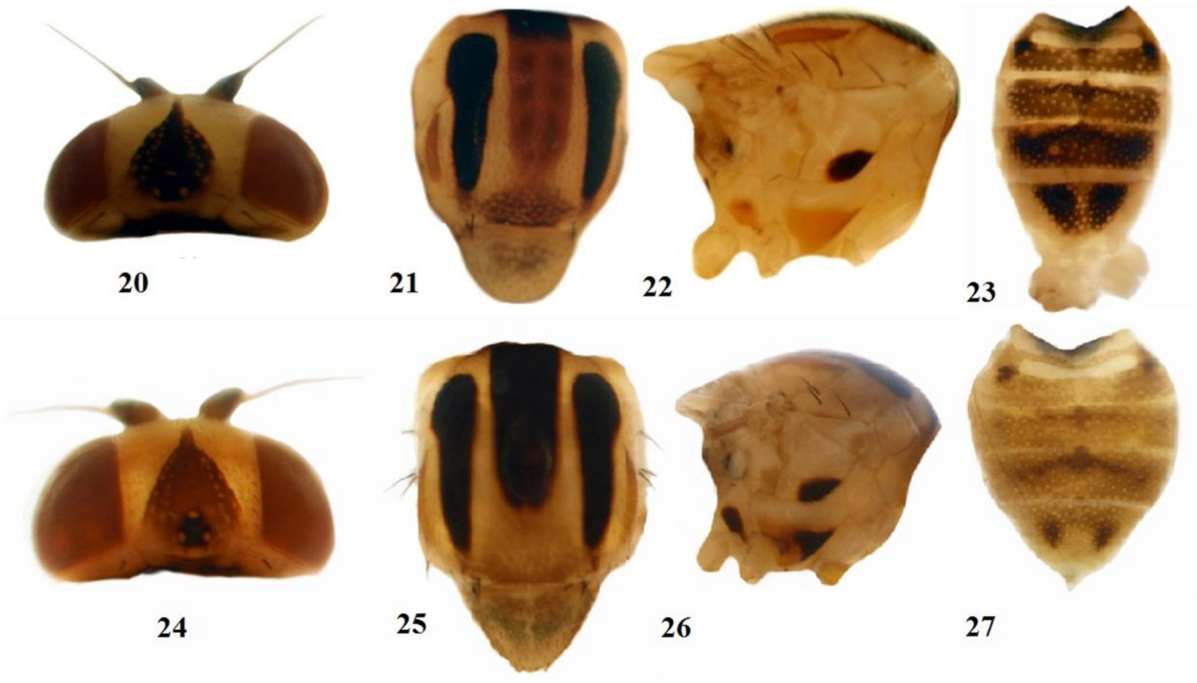
Variation 3: Body length to 3 mm, light coloration; antennal 1st flagellomere black; ocellar triangle yellow, with black hairs, sometimes with reddish median stripe; scutum with black and reddish stripes; acrostichal stripe reddish, with pale hairs; dorsocentral stripes black; alar stripes reddish; anepisternal mark black; katepisternal mark reddish; scutellum pale yellow, with black hairs; abdominal pattern reduced (Figs. 12-15).

Figures 12-19. Variation 3: **12,** ocellar triangle (dorsal view); **13,** stripes on notum (dorsal view); **14,** anepisternum and katepisternum (lateral view); **15,** abdomen. Variation 4: **16,** ocellar triangle (dorsal view); **17,** stripes on notum (dorsal view); **18,** anepisternum and katepisternum (lateral view); **19,** abdomen.

Variation 4: Body length to 3 mm, relatively dark coloration; antennal 1st flagellomere black; ocellar triangle yellow, with black hairs; scutum mainly with black stripes; acrostichal stripe black, with pale hairs; dorsocentral stripes black; alar stripes reddish; anepisternal mark black; katepisternal mark reddish; scutellum pale yellow, with black hairs; abdominal pattern reduced (Figs. 16-19).

Variation 5: Body length to 3 to 3.5 mm, dark coloration; antennal 1st flagellomere black; ocellar triangle black, with pale hairs; all stripes of scutum black, except acrostichal; acrostichal stripe dark red, with pale hairs; anepisternal mark black; katepisternal mark reddish; scutellum with dark pattern and black hairs; abdominal pattern developed (Figs. 20-23).

Variation 6: Body length to 3 to 3.5 mm, dark coloration; antennal 1st flagellomere black; ocellar triangle black, with pale hairs; scutum with black stripes; acrostichal stripe with pale hairs; anepisternal mark black; katepisternal mark blackish in anterior half and reddish in posterior half; scutellum with dark pattern and black hairs; abdominal pattern developed (Figs. 24-27).



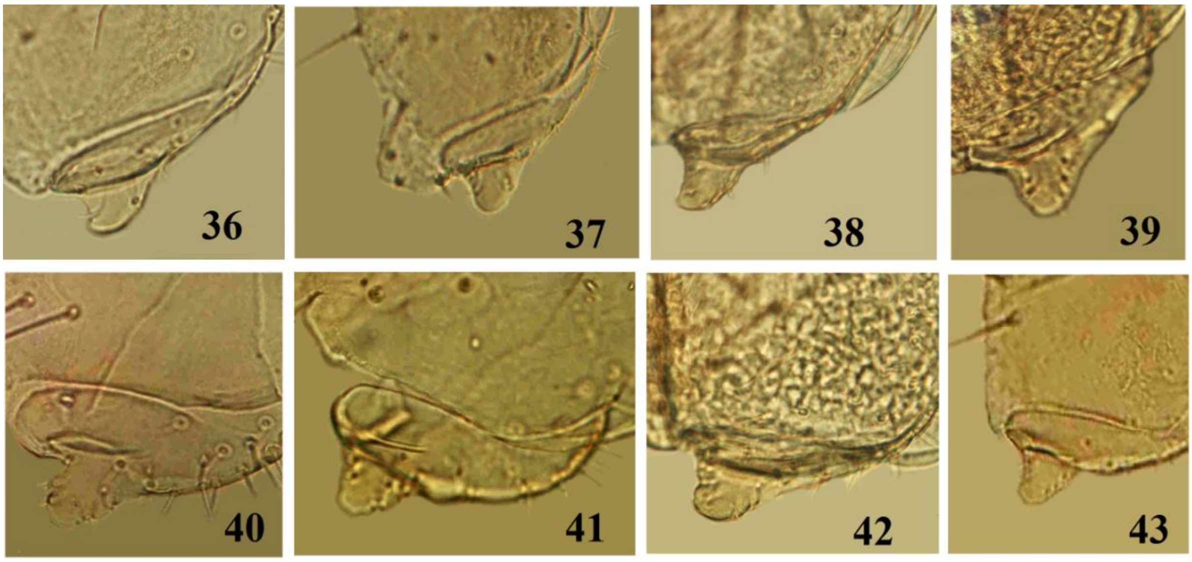
Figures 20-27. Variation 5: **20,** ocellar triangle (dorsal view); **21,** stripes on notum (dorsal view); **22,** anepisternum and katepisternum (lateral view); **23,** abdomen. Variation 6: **24,** ocellar triangle (dorsal view); **25,** stripes on notum (dorsal view); **26,** anepisternum and katepisternum (lateral view); **27,** abdomen.

Variation 7: Body length to 3 to 3.5 mm, dark coloration; antennal 1st flagellomere black; ocellar triangle black, with pale hairs; scutum with black stripes, except median part of acrostical stripe; median part of acrostichal stripe dark red, with pale hairs; anepisternal mark black; katepisternal mark reddish; scutellum with dark pattern and black hairs; abdominal pattern developed (Figs. 28-31).

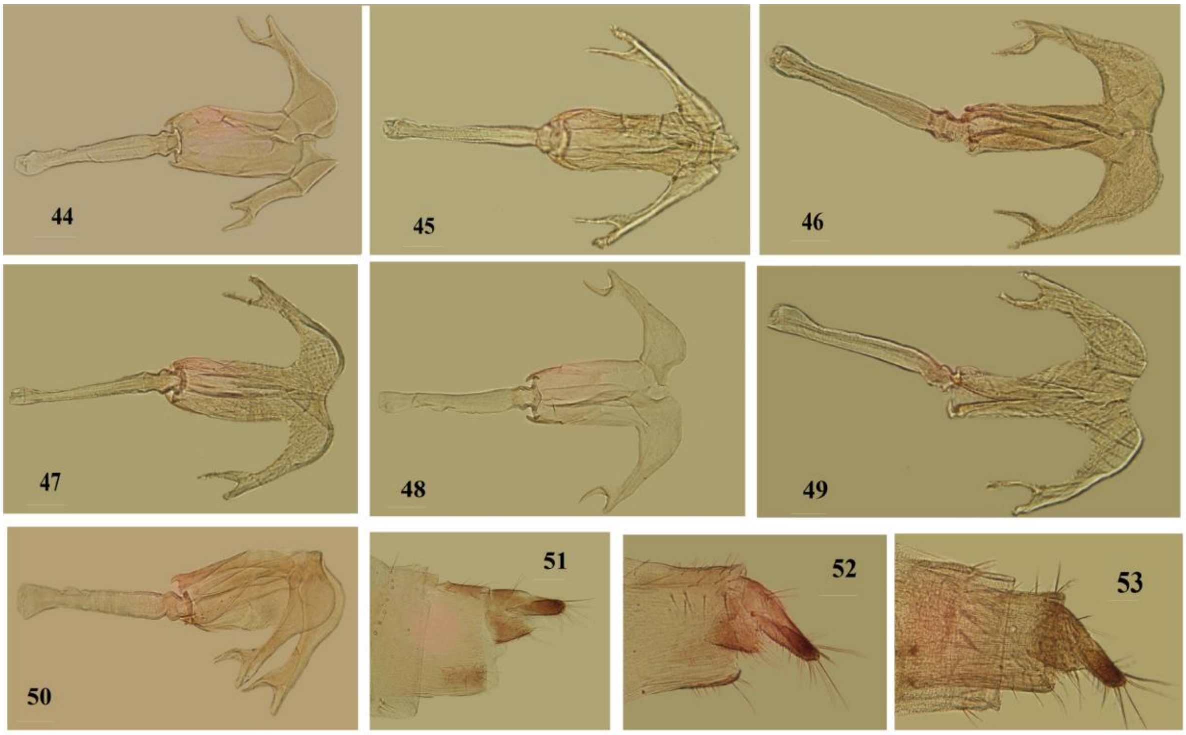
Variation 8: Body length to 3 to 3.5 mm, dark coloration; antennal 1st flagellomere black; ocellar triangle black, with pale hairs; scutum with black stripes and pale hairs;

anepisternal and katepisternal marks black; scutellum with dark pattern and black hairs; abdominal pattern developed (Figs. 32-35).

Figures 28-35. Variation 7: **28,** ocellar triangle (dorsal view); **29,** stripes on notum (dorsal view); **30,** anepisternum and katepisternum (lateral view); **31,** abdomen. Variation 8: **32,** ocellar triangle (dorsal view); **33,** stripes on notum (dorsal view); **34,** anepisternum and katepisternum (lateral view); **35,** abdomen.



Figures 36-43. Surstylus (dorsal view): **36,** variation 1; **37,** variation 2; **38,** variation 3; **39,** variation 4; **40,** variation 5; **41,** variation 6; **42,** variation 7; **43,** variation 8.



Figures 44-53. 44-50, Aedeagus and hypandrium (male, dorsal view): **44,** variation 1; **45,** variation 2; **46,** variation 3; **47,** variation 4; **48,** variation 5; **49,** variation 7; **50,** variation 8; 51-53, ovipositor (female, lateral view): **51,** variation 1; **52,** variation 4; **53,** variation 6.

Discussion

Each population of *T. notata* in this study was different from the other populations, having a different amount of melanisation as well as body pattern. Based on our results, the populations studied were placed into two groups. The first group includes four populations with darker body colour collected during lower temperatures (April to May) and the second group includes four populations with lighter colorations collected during higher temperatures (June to July) (Table 3).

Nartshuk (2004) reported some dark colour variations in spring specimens of *T. notata* from Tunisia which had been collected from 11 different areas. In this study, the group with dark body coloration of *T. notata* (includes variations 5, 6, 7, and 8) were collected from Chichakli, Isperekhan and Maragheh regions at elevations ranging from 1700 m to 2700 m and dry grassland habitats. The group with lighter body coloration of *T. notata* (includes variations 1, 2, 3, and 4) were collected from Ajabshir, Chichakli, Kandovan, Maragheh and Qaradagh forests at elevations ranging from 1300 m to 3000 m and forest habitats from dry to wet grasslands (Table 1).

High altitudes, due to a lower level of oxygen, cold temperatures and high humidity, can cause an increase of melanisation (Bernardo *et al.* 2007; Roder *et al.* 2008; Whitman *et al.* 2009). The studied areas have no temperature differences during summer, but in the beginning of the season (April to May), the temperature differences in lower altitudes in comparison to higher altitudes are very significant (Table 3). Light bodied groups are distributed in all regions at various altitudes. Dark species are not found at lower altitudes. Based on both groups occurring in dry and wet habitats and also the presence of light bodied groups at high altitudes in summer, it seems that high altitudes result in dark forms, while low temperature and other environmental factors such as relative humidity and oxygen level do not seem to have an effect or have a low effect on melanisation of *T. notata*.

An increase of dark pigmentation occur mainly when the flies are exposed to the lower temperature during development, and this is not related to the other abiotic influences like elevation or oxygen level. The darker coloration allows the adult flies to absorb more of the sunshine, and therefore can be more active in low temperature environments.

Table 1. Site description and sampling data of the specimens in the study area.

Variation	Melanisation	locality	Habitats	height (m)	Temperature
1	low	C., K., M., Q.	Dg., Mg., F.	1300-3000	high (15 June to 7 July)
2	low	K.	Mg.	2000-3000	high (20 June)
3	low	C., K.	Dg., Mg.	1700-3000	high (24 May to 15 June)
4	low	A., Q.	Dg., F.	1300- 1900	high (7 to 10 July)
5	high	C., I.	Dg.	1700-2700	low (26 April to 15 June)
6	high	C., I.	Dg.	1700-2700	low (26 April to 10 May)
7	high	C., I.	Dg.	1700-2700	low (26 April to 10 May)
8	high	K., M.	Dg., Mg.	1700-2500	low (12 May to 5 June)

Abbreviations: A) Ajabshir region, C) Chichakli region, Dg) dry grassland, F) forest, K) Kandovan valley, I) Isperekhan region, M) Maragheh region, Mg) wet grassland, Q) Qaradagh forest.

Table 2. Plasticity of some morphological characteristics of variations studied.

Variation	1	2	3	4	5	6	7	8
Body length (mm.)	2/5-3	3	3	3	3-3/5	3-3/5	3-3/5	3-3/5
1st flagellomere	yellowish	black	black	black	black	black	black	black
Vertical triangle	yellow	yellow	yellow	yellow	black	black	black	black
Scutum stripes	reddish	reddish	red-black	blackish	black	black	blackish	black
Scutellum	pale	pale	pale	pale	patterned	patterned	patterned	patterned
Anepisternum	black	black	black	black	black	black	black	black
Katepisternum	reddish	reddish	reddish	reddish	reddish	red-black	red-black	black
Abdominal pattern	reduced	reduced	reduced	reduced	developed	developed	developed	developed

Table 3. The seasonal temperature changes of areas studied at various altitudes.

Areas	April to May (1300-1500 m)	April to May (1500-3000 m)	June to July (1300-1500 m)	June to July (1500-3000 m)
Ajabshir	+9° to +15°	+9° to +1°	+18° to +20°	+16° to +18°
Chichakli	+8° to +15°	+8° to +2°	+ 19° to +22°	+14°to +19°
Kandovan	------	+6° to -2°	------	+12° to +15°
Isperekhan	------	+8° to +1°	------	+15° to +19°
Maragheh	+8° to +13°	+9° to -1°	+18°	+15° to +18°
Qaradagh	------	+7° to +1°	------	+16°to +18°

Acknowledgements

We would like to thank the University of Tabriz for supporting this work. Thanks are also due to section editor Pierfilippo Cerretti (Department of Biology and Biotechnology "Charles Darwin", University of Rome La Sapienza, Rome) and three anonymous reviewers for comments and suggestions that improved the original manuscript.

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Correspondence: Samad Khaghaninia, e-mail*:* skhaghaninia@gmail.com
Received: 20.03.2014 *Accepted*: 22.10.2014 *Published*: 01.11.2014
Cite paper: Khaghaninia S., Gharajedaghi Y. & Kubik S. 2014. Phenotypic variation of *Thaumatomyia notata* (Meigen, 1830) (Diptera; Chloropidae) in East Azerbaijan province- Iran. *Journal of Insect Biodiversity* 2(22): 1–9.
http://dx.doi.org/10.129/jib/2014.2.22 http://www.insectbiodiversity.org