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The brown lacewings (Neuroptera, Hemerobiidae) of northwestern Turkey with new records, their spatio-temporal distribution and harbouring plants

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ABSTRACT. The brown lacewings (Neuroptera, Hemerobiidae) of northwestern Turkey with new records, their spatio-temporal distribution and harbouring plants. The occurrence and spatio-temporal distribution of brown lacewing species (Neuroptera, Hemerobiidae) in Bursa province, northwestern Turkey, was investigated during 1999-2011. A total of 852 brown lacewing specimens of 20 species, including the genera of *Hemerobius, Megalomus, Micromus, Sympherobius,* and *Wesmaelius* were collected. Of these, 12 species were new records for northwestern Turkey while *Sympherobius klapaleki* is a new record for the Neuroptera fauna of Turkey. The most widespread species were *Hemerobius handschini* and *Sympherobius pygmaeus* with percent dominance values of 42.00 and 15.96%, respectively. *Wesmaelius subnebulosus* was the earliest emerging hemerobiid species and had the longest flight activity lasting from March to October. The species of southern origin characterized by the Mediterranean elements constituted 55% of the hemerobiid fauna and prevailed over the species of northern origin that belong to the Siberian centres. The total number of hemerobiid species reached a peak in July with captures of 15 species per month. There were 11, 13, 18 and 5 hemerobiid species occurring at altitudes between 1–500, 501–1000, 1001–1500 and 1500–2000 m, respectively. In addition, plant species harbouring hemerobiids are given for each species, and their association with the hemerobiid fauna is discussed.

KEYWORDS. Bursa; host plants; Insecta; phenology; vertical distribution.

Hemerobiidae is the third largest family of the order Neuroptera containing approximately 600 species worldwide (Oswald 2004; Farahi *et al.* 2009). Members of this family are commonly known as brown lacewings. Brown lacewings can be distinguished from the green lacewings (Chrysopidae) by their usual colouring and wing venation with forked costal cross veins shorter than in Chrysopidae (Monserrat 1990).

Unlike many adult green lacewings such as *Chrysoperla*, which feeds only on nectar and pollen, both larval and adult stages of brown lacewings are predacious. Most brown lacewings are aphidophagous predators, and they usually have a narrow host range compared with green lacewings. However, they can be more effective at low aphid densities than green lacewings because their adults do not need to feed on honeydew to lay eggs. The low temperature thresholds of brown lacewings also give them a survival advantage during cold spells and frosts in temperate climates (Neuenschwander *et al*. 1975).

Studies on the Hemerobiidae fauna of Turkey were first initiated by the European entomologists who made important contributions to the knowledge of the Neuroptera fauna of Turkey (Aspöck & Aspöck 1966, 1969a; Popov 1977a; Aspöck *et al*. 1980; Monserrat & Hölzel 1987). Nevertheless, Hemerobiidae fauna in many regions has been largely neglected or inadequately examined in the vast lands of Anatolia. Turkish researchers conducted surveys primarily to determine the entire Neuroptera fauna rather than to focus merely on a specific family (Sengonca 1979; Düzgünes *et al.* 1981; Kiyak & Özdikmen 1993; Canbulat 2002; Ari & Kiyak 2003; Canbulat & Özsaraç 2004; Canbulat & Kiyak 2005).

The Turkish Hemerobiidae includes 31 described species (Aspöck & Aspöck 1969a; Canbulat & Kiyak 2005). There are rare species reported only from one locality or region. Some species may be restricted geographically and/or ecologically to a small region in a province. For many Turkish provinces, no data are available on the presence of hemerobiids, their habitats and biology.

No detailed study has been conducted on the Hemerobiidae fauna in the Bursa province of northwestern Turkey so far, although the distributional maps of species of Neuroptera in Turkey, drawn by Aspöck *et al.* (1980), showed the occurrence of 9 hemerobiid species in this province. However, the authors failed to provide localities where they captured these hemerobiid specimens. Their counts are believed to underestimate the number of extant hemerobiid species as far as the diversity of natural and agricultural ecosystems in Bursa province are concerned.

Bursa province belongs to the Mediterranean zoogeographical subregion, which mainly supports the Mediterranean faunal elements. The presence of Mount Uludag (2,543 m) and other high altitude mountains in this province also provides a suitable environment for species of northern origin. The occurrence of individual hemerobiid species in a

geographical region is determined not only by climatic conditions, but also by the character of habitat and vegetation. There is little published information on the host plants of hemerobiid species (Aspöck *et al.* 1980; New 1989; Monserrat & Marin 1996). Monserrat & Marin (1996) provide a detailed review on plants harbouring hemerobiid species in Europe, but similar data are very limited in Turkey.

The objectives of this study were to find out the species composition of brown lacewing species as well as their adult phenology, harbouring plants and spatio-temporal distribution in natural and man-altered habitats in Bursa province. In addition, the hemerobiid species were classified into zoogeographical categories on the basis of origin.

MATERIAL AND METHODS

A survey of brown lacewing adults was carried out during 2004–2011 in Bursa province located between 39–41° N and 28–30° E in northwestern Turkey. Additionally, brown lacewing species collected within the framework of other studies during 1999–2003 were reported.

Specimens were collected from 72 localities in 15 counties of the Bursa province (Fig. 1). Localities were numbered and given in parenthesis in the annotated list. The ecosystem diversity and altitudinal variation were taken into account when localities were chosen. Altitudes, route tracks, and directions were recorded using a manual GPS device (Magellan Sportrak Pro GPS, Thales Navigation, CA, U.S.A.). Details of the 72 collecting sites, in each county, are as follows: **Keles.** 1: Kocayayla, 1200 m; 2: Kendir plateau, 1305 m; 3: Kendir plateau- Besikci district, 1460 m; 4: Epceler, 1280 m; 5: Pinarcik, 1055 m. **Osmangazi.** 6: Karaislah, 1 km N, 925 m; 7: Bagli picnic area, 1200 m; 8: Bagli, 1 km NE, 1100 m; 9: Sogukpinar, 1 km NW, 1060 m; 10: Sogukpinar, 1 km SE, 1000 m; 11: Sogukpinar-Golcuk, 1200 m; 12: Sogukpinar, 2 km NE, 1300 m; 13: Sogukpinar-Ketenlik plateau, 1430 m 14: Uludag National Park (UNP)-Oteller, 1935 m; 15: UMP-Sarialan, 1600 m; 16: UMP-Kirazliyayla, 1500 m; 17: UNP-Karabelen, 1300 m; 18: Kirazli, 4 km N, 1250; 19: Kirazli, 875 m; 20: Huseyinalan, 1 km E, 970 m; 21: Huseyinalan, west entry, 1005 m; 22: Yigitali, 600 m. **Kestel.** 23: Nuzhetiye, 555 m; 24: Derekizik, 2 km N, 300 m; 25: Osmaniye, picnic area, 515 m; 25: Alacam, 1 km N, 775 m; 27: Alacam, 100 m S, 1030 m; 28: Alacam, 1 km S, 1110 m; 29: Aksu, 2 km SE, 480 m; 30: Sayfiye, 1 km W, 830 m. **Inegol.** 31: Ciftlikkoy, 100 m SW, 875 m; 32: Ciftlikkoy, 500 m W, 905 m; 33: Ciftlikkoy-Merzukiye Mahallesi, 1 km E, 930 m; 34: Kirankoy 2 km W, 1150 m; 35: Kirankoy, 3 km W, 1230 m. **Yenisehir.** 36: Subasi, 500 m NW, 240 m; 37: Selimiye, 100 m W, 280 m. **Iznik.** 38: Hisardere 3 km SW, 580 m; 39: Hisardere, 2 km SE, 625 m; 40: Upper Sansarak canyon; 41: Sagirhisar Mahallesi, 2 km SW, 755 m; 42: Sagirhisar Mahallesi, 775 m. **Orhangazi.** 43: Hamzali, 2 km E, 435 m. **Gemlik.** 44: Gemlik-Central town, 15 m; 45: Karacaali, 500 m N, 80 m; 46: Hamidiye, 2 km W, 460 m; 47: Findicak, 480 m; 48: Findicak, 4 km NW, 515 m; 49: Findicak, 7 km NW, 725 m. **Gursu.** 50: Hasankoy, 4 km N, 150 m; 51: Ericek, 500 m E, 715 m. **Mudanya.** 52: Bademli, 185 m. **Nilufer.** 53: Hasanaga, 6 km SW, 375 m; 54: Uludag University Gorukle campus (U.U.G.K.), Yoncalik, 55 m; 55: U.U.G.K., forest, 125 m; 56: Kayapa inlet, 180 m; 57: Kurucesme, 3 km NW, 380 m; 58: Maksempinar, 2 km NE, 400 m; 59: Doganci, 3 km S, 350 m. **Orhaneli.** 60: Goktepe, 3 km NW, 725 m; 61: Erenler, 6 km NE, 425 m; 62: Sadagi canyon, 1 km NE, 445 m; 63: Sadagi canyon, 450 m; 64: Orhaneli, 4 km S, 750 m; 65: Kadikoy, 1 km E, 910 m; 66: Mahaller, 2 km E, 970 m; 67: Mahaller, 3 km SE, 990 m. **Harmancik.** 68: Harmancik, 11 km NW, 1010 m. **Buyukorhan.** 69: Buyukorhan, 300 m NE, 800 m; 70: Armutcuk, 2 km E, 700 m. **Mustafakemalpasa.** 71: Korekem, 2 km E, 475 m; 72: Sogutalan, 3 km W, 300 m.

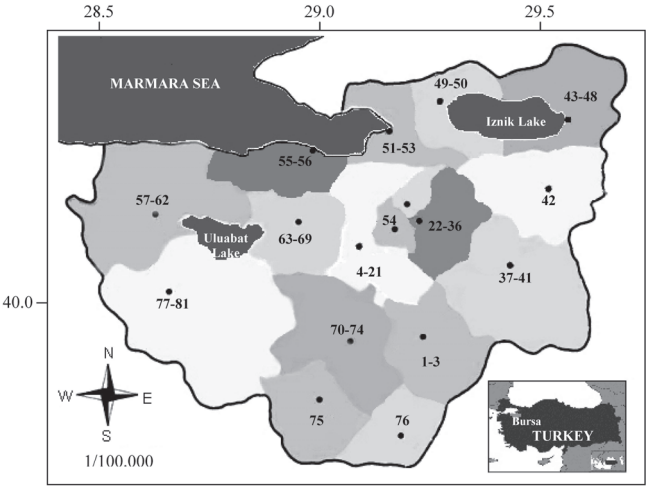


Fig. 1. Map of Bursa, northwestern Turkey. Numbers within counties indicate the specific localities where the hemerobiid species were collected. Keles: 1–3; Osmangazi: 4–21; Kestel: 22–36; Inegöl: 37–41; Yenisehir: 42; Iznik: 43–48; Orhangazi: 49–50; Gemlik: 51–53; Gürsu: 54; Mudanya: 55–56; Karacabey: 57–62; Nilüfer: 63–69; Orhaneli: 70–74; Harmancik: 75; Büyükorhan: 76; Mustafakemalpasa: 77–81.

Each hemerobiid specimen was collected with a sweep net from its harbouring plant. Live insect specimens were identified immediately after capture. If specimens could not be identified in the field, they were brought back to laboratory alive and killed with ethyl acetate (Neuenschwander 1984). All the hemerobiid specimens were pinned with their wings spread, then dried and preserved in the Plant Protection Department collection of the Faculty of Agriculture at Uludag University. Species were identified using the identification keys of Aspöck *et al.* (1980). Species identification was also confirmed by the examination of the genitalia (Klimaszewski & Kevan 1985).

The main zoogeographical categories proposed by Popov & Letardi (2010) were used for arrangement of hemerobiid species in groups according to their origin. Detailed information on the distribution of widespread hemerobiid species, the first and last record dates and the number of males and females caught during each season according to years and localities was provided. Plants harbouring the collected specimens were recorded. In addition, the local and worldwide distribution of the identified species was included.

RESULTS

During the thirteen year survey in Bursa, northwestern Turkey, a total of 852 hemerobiid specimens belonging to 20 species were collected. Of these species, 13 species are new records for Bursa province, while 12 species are new for northwestern Turkey. One species, *Sympherobius klapaleki* (Zeleny), is recorded from Turkey for the first time (Table I). The total number of localities, where these species were captured, is presented in Table I.

Table I. List of hemerobiid adults collected during 1999-2011 in Bursa, Turkey, with percent dominance values and total number of localities where each species were recorded.

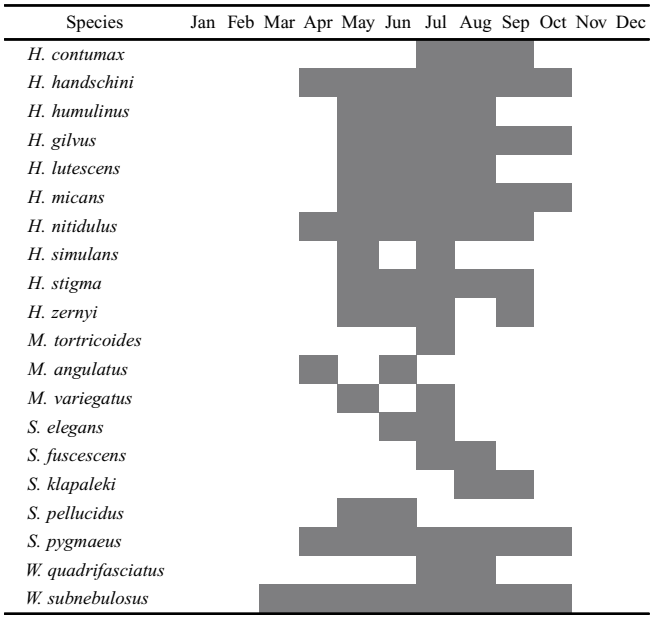
Species	Female	Male	Total	Percent dominance values (%)	Number of localities
Hemerobius contumax	18	1	19	2.23	5
H. handschini	295	63	358	42.00	42
*H. humulinus**	14	5	19	2.23	10
H. gilvus	31	11	42	4.92	13
*H. lutescens***	9	3	12	1.40	10
H. micans	50	3	53	6.22	19
*H. nitidulus***	48	20	68	7.98	27
*H. simulans***	3	–	3	0.35	2
*H. stigma***	32	1	33	3.87	13
H. zernyi	8	4	12	1.40	8
Megalomus tortricoides	–	2	2	0.23	1
*Micromus angulatus***	1	3	4	0.46	2
*M. variegatus***	6	6	12	1.40	3
*Sympherobius elegans***	5	–	5	0.58	2
*S. fuscescens***	3	–	3	0.35	2
*S. klapaleki****	3	–	3	0.35	2
*S. pellucidus***	5	–	5	0.58	4
S. pygmaeus	10	36	136	15.96	35
*Wesmaelius quadrifasciatus***	2	2	4	0.46	1
W. subnebulosus	40	21	61	7.15	29

*First record for Bursa; **First record for northwestern Turkey; ***First record for Turkey.

The phenology of hemerobiid species was monitored at monthly intervals from January to December (Table II). *Wesmaelius subnebulosus* (Stephens) was the earliest emerging hemerobiid species and had the longest flight activity lasting from March to October. Four species emerged in April and most species began to appear in May (Table II). The total number of hemerobiid species reached a peak in July with captures of 15 species per month. The flight activity of some species such as *Megolamus tortricoides* Rambur was primarily confined to a short period during the summer.

The altitudinal distribution and harbouring plants of brown lacewing species collected from Bursa province is summarized in Table III. There were 11, 12, 18 and 5 brown lacewing species occurring at altitudes between 1–500, 501–1000, 1001–1500 and 1501–2000 m, respectively. Only two of these species were captured below an altitude of 100 m. Among all brown lacewing species, *Hemerobius handschini* Tjeder, *W. subnebulosus,* and *Hemerobius micans* Olivier showed the greatest environmental tolerance in terms of altitudinal distribution and host plant preference. In contrast to *Wesmaelius quadrifasciatus* Reuter living at high altitude, *Micromus angulatus* (Stephens) inhabits low elevation meadows.

Table II. Adult phenology of hemerobiid species for monthly periods in Bursa, Turkey.



Some hemerobiid species (*e.g.*, *H. micans*) were found in mixed stands of deciduous and coniferous trees while other species (*e.g.*, *M. angulatus*) preferred certain host plants such as *Medicago sativa* L. (Table III). The zoogeographical categories of brown lacewing species according to their origin based on the classification of Popov & Letardi (2010) are shown in Table IV. Zoogeographically, all species were arboreal. Among all hemerobiid species, the Holomediterranean elements were the most representative followed by the Siberian, Siberian-Nearctic, Central European-Mediterranean, and Pontomediterranean elements, respectively.

Below an annotated list of hemerobiid species is provided, including the number and sex of the specimens, their distribution, extreme dates of adult flights, harbouring plants, and zoogeographical categories. Localities, where rare species were collected, are also listed.

Hemerobius contumax Tjeder, 1932

Material: 2004; 13.VIII, 2 F (14); 18.IX, 1 F (9); 2005; 26.VII, 3 F (14), 1 F (16); 30.VII, 3 F (27), 1 M, 2 F (28); 6.VIII, 3 F (16); 29.VIII, 1 F (16), 2007; 16.VII, 1 F (14), 2011; 18.VIII, 1 F (16).

Distribution in Turkey: Northern and southern Anatolia (unspecified locality) (Aspöck *et al.* 1980), Konya (Kahraman 2008).

Distribution in the world: Austria, Andorra, Bulgaria, Switzerland, Czech Republic, Germany, Denmark, Spain, France, Liechtenstein, Great Britain, Greece, Hungary, Croatia, Italy, Norway, Netherlands, Poland, Romania, Swe-

Table III. Altitudinal distribution and harbouring plants of hemerobiid species in Bursa, Turkey.

Species	Altitude (m)	Harbouring plants
Hemerobius contumax	1050–1935	*Abies bornmuelleriana, Fagus orientalis, Quercus cerris*
H. handschini	80–1935	*Abies bornmuelleriana, Corylus spp., Pinus brutia, Pinus nigra, Pinus sylvestris, Quercus cerris*
H. humulinus	460–1050	*Corylus sp., Pinus nigra, Pinus sylvestris, Quercus cerris*
H. gilvus	350–1280	*Corylus sp., Pinus nigra, Pinus sylvestris, Quercus cerris*
H. lutescens	445–1500	*Quercus cerris*
H. micans	300–1935	*Abies bornmuelleriana, Corylus avellana, Fagus orientalis, Juglans regia, Pinus brutia, Pinus nigra, Pinus sylvestris, Prunus avium, Quercus cerris*
H. nitidulus	435–1500	*Pinus brutia, Pinus nigra, Pinus sylvestris, Quercus cerris*
H. simulans	1050–1430	*Pinus nigra*
H. stigma	300–1500	*Abies bornmuelleriana, Pinus brutia, Pinus nigra, Pinus sylvestris, Quercus cerris*
H. zernyi	180–1100	*Pinus nigra, Quercus cerris*
Megalomus tortricoides	1345	*Pinus nigra*
Micromus angulatus	60–555	*Medicago sativa*
M. variegatus	1030–1200	*Fragaria vesca, Pinus nigra, Quercus cerris*
Sympherobius elegans	725–1200	*Pinus nigra*
S. fuscescens	725–1430	*Pinus nigra, Pinus sylvestris*
S. klapaleki	1200–1305	*Pinus nigra*
S. pellucidus	1030–1345	*Pinus nigra*
S. pygmaeus	180–1280	*Ficus carica, Phillyrea latifolia, Pinus brutia, Pinus nigra, Pinus sylvestris, Prunus persica, Quercus cerris*
Wesmaelius quadrifasciatus	1935	*Abies bornmuelleriana*
W. subnebulosus	125–1935	*Abies bornmuelleriana, Fagus orientalis, Olea europaea, Pinus bratia, Pinus nigra, Pinus sylvestris, Prunus avium, Prunus cerasifera, Quercus cerris*

Table IV. Zoogeographical categories of hemerobiid species occurring in Bursa, Turkey according to their origin based on Popov & Letardi (2010).

Categories	Number of species	Percentage (%)
Central European-Mediterranean	2	10
Holomediterranean	8	40
Pontomediterranean	1	5
Siberian	5	25
Siberian-Nearctic	4	20

den, Finland, Slovenia, Ukraine, the former Yugoslavia (Aspöck *et al.* 1980).

Host plants: *Abies bornmuelleriana* Mattf.*, Fagus orientalis* Lipsky.*, Quercus cerris* L.

Zoogeographical category: Central European-Mediterranean.

Hemerobius handschini Tjeder, 1957

Material: This species was the most widespread and abundant species in Bursa province and collected in 42 of the 72 localities. Of the 358 adults caught, 295 were females and 63 were males (Table I). Adults were first caught in sweep nets on 15 April in Hasanaga, Nilufer county at 375 m on *Pinus brutia* Ten. The latest date for collecting adults was 16 October in Yigitali, Osmangazi county at 600 m on the same host plant.

Distribution in Turkey: Central and southern Anatolia (unspecified locality) (Aspöck *et al.* 1980; Aspöck & Aspöck 1969a); Antalya, Isparta, Denizli (Canbulat & Kiyak 2005)

Distribution in the world: Austria, Bulgaria, Switzerland, Czech Republic, Germany, Spain, France, Greece, Hungary, Croatia, Italy, Portugal, Poland, Romania, Slovenia, Ukraine, the former Yugoslavia (Aspöck *et al.* 1980).

Host plants: *Pinus brutia*, *P. nigra* L., *P. sylvestris* L., *Quercus cerris*, *A. bornmuelleriana* and *Corylus* spp.

Zoogeographical category: Holomediterranean (expansive northwards).

Hemerobius humulinus Linnaeus, 1758

Material*:* 2005; 14. V, 1 F (30); 16.VI, 2 F (71); 21.VI, 1 M (26), 1 F (27); 25.VI, 1 M (21); 27.VI, 1 M,1 F (31), 1 F (33); 12. VII, 1 F (25), 1 F (27); 11.VIII, 1 F (40); 23.VIII, 1 F (60); 2006: 14.V, 1 M(26); 24.VIII, 1 F (26); 2008; 22.V, 1 F (30); 2009; 17.VII, 1 F (25), 2010; 18.VI, 1 M (26), 2011; 10. VIII, 1 F (60).

Distribution in Turkey: Northern Anatolia (unspecified locality) (Aspöck *et al.* 1980).

Distribution in the world: Austria, Albania, Belgium, Belarus, Bulgaria, Bosnia-Herzegovina, Switzerland, Czech Republic, Germany, Denmark, Spain, Estonia, France, Liechtenstein, Great Britain, Greece, Hungary, Croatia, Italy, Ireland, Luxembourg, Lithuania, Latvia, Moldova, Norway, Netherlands, Portugal, Poland, Romania, Russia, Sweden, Finland, Slovenia, Ukraine, the former Yugoslavia, Georgia, Armenia, N-Anatolia, NW-Iran; Kazakhstan, Turkmenistan, Tajikistan, Kyrgyzstan, Siberia, Sakhalin, Kamtschatka, Mongolia, China, Korea, Japan, Alaska, the Azores, Canada, USA, Mexico, Guatemala (Aspöck *et al.* 1980).

Host plants: *Quercus cerris*, *Corylus* spp.*, Pinus* spp.

Zoogeographical category: Siberian-Nearctic.

Hemerobius gilvus Stein, 1863

Material: 2004; 26.VIII, 1 F (8),1 M (21); 2.IX, 1 M (5);18, IX, 2 F (12); 25.IX, 2 F (39);10.X, 1 F (59), 2005; 14.V, 1 M (30); 17.V, 4 F (31); 24.V, 2 F (39), 2 M (40); 7.VI, 1 F (4), 3 M, 3 F (11); 21. VI, 2 F (30); 27.VI, 3 F (31); 30.VIII, 1 F (32); 10.IX, 1 M(12); 2006; 23.VII, 1 F (32); 29.VIII, 1 M, 2 F (11); 16. IX, 1 F (39), 1 F (40); 1.X, 1 F (60); 2007; 15.V, 2 F (39), 2008; 16.VI, 1 F (4), 2011; 12.IX, 1 M (5).

Distribution in Turkey: Gaziantep, Ankara, Tokat, Samsun, Konya and Isparta (Aspöck & Aspöck 1969a; Canbulat & Kiyak 2005).

Distribution in the world: Western Europe, Italy, Spain (Aspöck and Aspöck 1969b; Aspöck *et al*. 1980; Monserrat 1980; Badano & Letardi 2010).

Host plants: Adults were usually collected on *Q. cerris* but some were also found on *Corylus* spp. and *Pinus* spp. (Table III).

Zoogeographical category: Holomediterranean (expansive northwards).

Hemerobius lutescens Fabricius, 1793

Material: 2004; 13.VIII, 1 F (16); 2.IX, 1 M (10), 2005; 16.VI, 1 F (71); 21.VI, 1 F (26); 1 M (30); 27.VI, 1 F (31); 30.VI, 1 F (62); 9. VII, 1 F (13); 12.VII, 1 F (25); 3.VIII, 1 F (60), 2007; 11.IX, 1 M (10), 2010; 1. VII, 1 F (13).

Distribution in Turkey: Tokat.

Distribution in the world: Western Europe, the UK, Italy (Killington 1936; Aspöck *et al*. 1980; Badano & Letardi 2010).

Host plant: All adults were collected from *Q. cerris.*

Zoogeographical category: Siberian.

Hemerobius micans Olivier, 1792

Material: 2004; 24.V, 1 F (40); 18.IX, 1 M (9); 2005:7.VI, 1 F (11), 12.VI, 1 F (19); 16.VI, 1 F (71); 18.VI, 1 F (51); 21.VI, 1 F (24), 2 F (27), 1 F (30); 25.VI, 1 F (8), 2 F (19); 7.VI,11 F (31), 2 F (32), 1 F (33); 30.VI, 3 F (30), 1 F (65); 9.VII, 1 F (13); 12.VII, 4 F (25); 26.VII, 1 M, 2 F (14); 30.VII, 1 F(26), 3 F (30); 6.VIII, 1 F (14); 30.VIII, 1 F (34); 8.IX, 1 F (62); 2006: 29.VIII, 1 F (14), 1.X, 1 F(60); 2007; 2.VII, 1 F (13); 19.VII, 1 F (26); 2009; 26.VII, 1 M, 1 F (14); 2010; 15.VI, 1 F (51).

Distribution in Turkey: Northeastern Anatolia (Aspöck *et al*. 1980), Isparta (Canbulat & Kiyak 2005), Ardahan and Kars (Ari *et al.* 2008).

Distribution in the world: Austria, Albania, Armenia, Belgium, Bulgaria, Bosnia and Herzegovina, Croatia, Czechoslovakia, Denmark, England, Finland, France, Georgia, Germany, Greece, Holland, Hungary, Ireland, Italy, northern Iran, Latvia, Liechtenstein, Luxembourg, Macedonia, Moldova, Norway, Poland, Romania, Russia, Slovenia, Sweden, Switzerland, Ukraine, the former Yugoslavia (Aspöck *et al*. 1980, 2001; Monserrat 1990; Aspöck & Hölzel 1996).

Host plants: Adults were found on *A. bornmuelleriana, Pinus* spp. and deciduous trees (Table III).

Zoogeographical category: Central European–Mediterranean.

Hemerobius nitidulus Fabricius, 1777

Material*:* This widespread species was captured in 27 localities in Bursa. Of the 68 adults caught, 48 were females and 20 were males (Table I). Adults were first detected on *Pinus nigra* on 20 April at locality 6 and last captured on 28 September at localities 17 and 20.

Distribution in Turkey: Central Anatolia and western Black Sea (Aspöck *et al*. 1980), Antalya, Aydin, Burdur, Denizli, and Mugla (Canbulat & Kiyak 2005), Ardahan and Kars (Ari *et al.* 2008).

Distribution in the world*:* Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechoslovakia, Denmark, England, Estonia, The Fareast, Finland, France, Germany, Greece, Holland, Ireland, Latvia, Liechtenstein, Luxembourg, Hungary, Mongolia, Moldova, Norway, Poland, Romania, Russia, Siberia, Solvenia, Spain, Sweden, Switzerland, Ukraine, and the former Yugoslavia (Aspöck *et al*. 1980, 2001).

Host plants: Most adults were found on *Pinus* spp. but four females and one male were collected on *Q. cerris* (Table III).

Zoogeographical category: Siberian.

Hemerobius simulans Walker, 1853

Material: 2005; 14.V, 1 F (27); 9.VII. 1 F (13), 2008; 3.V, 1 F (27).

Distribution in Turkey: Bolu.

Distribution in the world: Europe, Alaska, Canada, Norway (Greve 1967; Aspöck *et al.* 1980; Kevan & Klimaszewski 1987).

Host plant: *P. nigra*.

Zoogeographical category: Siberian–Nearctic.

Hemerobius stigma Stephens, 1836

Material: 2004; 25.IX, 1 F (39); 2005: 14.V, 2 F (27); 16.V, 1 F (53); 10.VI, 1 F (60); 12.VI, 2 F (19); 16.VI, 1 F (72); 21.VI. 1 F (26), 1 F (27); 25.VI, 1 F (8), 1 F (21); 2.VII, 3 F (40); 9.VII, 1 F (12), 1 M, 3 F (13); 26.VII, 3 F (16); 30.VII, 2 F (28); 11.VIII, 2 F (40), 1 F (41); 2006; 16.IX, 2 F (40), 2009; 05.V, 1 F (53); 2011; 11.VI. 1 F (26), 15.VII, 1 F (28).

Distribution in Turkey: Northern Anatolia (Aspöck *et al*. 1980), Bolu, Ardahan and Kars (Ari *et al.* 2008).

Distribution in the world: Austria, Bulgaria, Canada, Canary Islands, Croatia, Cyprus, Czechoslovakia, Denmark, England, Estonia, Finland, France, Germany, Holland, Hungary, Ireland, Japan, Kazakhstan, Latvia, Liechtenstein, Luxembourg, Mongolia, Moldova, Morocco, Norway, Poland, Portugal, Romania, Russia, Siberia, Slovenia, Spain, Sweden, Switzerland, Ukraine, the Azores, the USA, and the former Yugoslavia (Aspöck *et al*. 1980, 2001; Aspöck and Hölzel 1996).

Host plants: One adult was collected on *Q. cerris,* three adults were found on *A. bornmuelleriana* and the rest were captured on *Pinus* spp. (Table III).

Zoogeographical category: Siberian-Nearctic.

Hemerobius zernyi Esben-Petersen, 1935

Material: 2004; 18.V, 1 F (9); 24.V, 2 F (39); 18.IX, 1 M (8) 2005; 13.V, 1 M (56); 21.V, 1 M (61), 27.VI, 2 F (31); 30.VI, 1 F (65); 12.VII, 1 F (27) 2007; 10.V, 1 M (61), 2010; 09.IX, 1 M (8).

Distribution in Turkey: Adiyaman, Ankara, Osmaniye, Konya, Isparta and Denizli (Aspöck and Aspöck 1969a; Sengonca 1979; Aspöck *et al.* 1980; Canbulat & Kiyak 2005).

Distribution in the world: Anatolia, Balkan Peninsula (Popov & Letardi 2010).

Host plant: One adult was found on *P. nigra*, and the rest on *Q. cerris*.

Zoogeographical category: Pontomediterranean (Anatolian).

Megalomus tortricoides Rambur, 1842

Material: 2005; 7.VI, 1 M (27) 2010; 16.VI, 1 M (27).

Distribution in Turkey: Central and northern Anatolia (Aspöck and Aspöck 1969a; Aspöck *et al*. 1980), Antalya, Burdur, Isparta and Denizli (Canbulat & Kiyak 2005).

Distribution in the world: Central and southern Europe (Letardi & Migliaccio 2002).

Host plant: *Pinus nigra*.

Zoogeographical category: Holomediterranean (expansive northwards).

Micromus angulatus (Stephens, 1836)

Material: 2004; 21.VI, 1 M,1 F (54); 2005; 20.IV, 1 M (23), 2009; 12.IV, 1 M (23)

Distribution in Turkey: Isparta (Canbulat & Kiyak 2005).

Distribution in the world: Europe, North America, northern Asia (Eremenko 1984; Khloptseva 1991; Kozlova 2009; Vela *et al.* 2012).

Host plant: Adults were found on *Medicago sativa.*

Zoogeographical category: Siberian-Nearctic.

Micromus variegatus (Fabricius, 1793)

Material: 1999: 24.VII, 1 F (11); 2001: 8.VII, 1 M, 1 F (8), 2005; 14.V, 4 M, 4 F (27), 2011; 30.VI, 1 M (8).

Distribution in Turkey: Anatolia (Aspöck *et al*. 1980).

Distribution in the world: British Isles and Western Europe, France, Canada, Iran, Japan, the former Soviet Union (Killington 1936*;* Agekyan 1973*;* Aspöck *et al*. 1980; Klimazewski & Kevan 1988; Messelink *et al*. 2012).

Host plants: Adults were collected from *Fragaria vesca* L.*, P. nigra* and *Q.cerris.*

Zoogeographical category: Siberian.

Sympherobius elegans Stephens, 1836

Material: 2005; 12.VI, 2 F (1); 18.VI, 1 F (51); 26.VII, 1 F (1), 2009; 5.VI, 1 F (51).

Distribution in Turkey: Burdur and Konya (Monserrat & Hölzel 1987; Canbulat & Kiyak 2005).

Distribution in the world: United Kingdom, Austria, Belgium, Bulgaria, Czech Republic, France, Germany, Holland, Hungary, Italy, Luxembourg, Malta, Russia, Slovakia, Spain, Norway (Aspöck *et al.* 1980; Monserrat 1990).

Host plant: *P. nigra*

Zoogeographical category: Holomediterranean (expansive northwards).

Sympherobius fuscescens (Wallengren, 1863)

Material: 2005; 2.VII, 1 F (40); 6.VIII, 1 F (13), 2010; 27.VII, 1 F (40).

Distribution in Turkey: Northeastern Anatolia (Aspöck *et al*. 1980) and Ardahan (Ari *et al.* 2008).

Distribution in the world: Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, England, Estonia, Finland, France, Germany, Holland, Italy, Japan, Kazakhstan, Liechtenstein, Latvia, Mongolia, Norway, Poland, Romania, Russia, Siberia, Slovenia, Spain, Switzerland, Sweden, Ukraine, and the former Yugoslavia (Aspöck *et al*. 1980, 2001; Aspöck & Hölzel 1996).

Host plants: *P. nigra* and *P. sylvestris*

Zoogeographical category: Siberian.

Sympherobius klapaleki (Zeleny, 1983)

Material: 2004; 18.IX, 1 F (7); 26.VIII, 1 F (2); 2007; 15.VIII, 1 F (2).

Distribution in the world: Austria, Britain, Bulgaria, Czech Republic, Germany, Italy, Poland, Romania, Spain, Switzerland (Aspöck *et al*. 1980).

Host plant: *P.nigra*

Zoogeographical category: Holomediterranean (expansive northwards).

Sympherobius pellucidus (Walker, 1853)

Material: 2005; 14.V, 1 F (27); 7.VI, 1 F (4), 1 F (12), 2006, 7.VI, 1 F (11), 2009; 13.VI, 1 F (4).

Distribution in Turkey: Northern Anatolia (unspecified locality) (Aspöck *et al.* 1980)

Distribution in the world: Western Europe, the UK, Hungary, Poland (Aspöck *et al*. 1980; Barnard *et al.* 1986; Czechowska 2002).

Host plant: *P. nigra*

Zoogeographical category: Holomediterranean (expansive northwards).

Sympherobius pygmaeus (Rambur, 1842)

Material: This species was the second most widespread species. It was collected in 35 localities. A total of 136 adults, 100 females and 36 males, were captured (Table I). First adults were detected on 18 April at locality 9 while last adults were found on 24 October at locality 56.

Distribution in Turkey: Antalya, Burdur, Denizli, Kirsehir, Kahramanmaras (12 km north of Sarikaya) (Sengonca 1979; Canbulat & Özsaraç 2004; Canbulat & Kiyak 2005).

Distribution in the world: France, Greece, Hungary, Israel, Iran, Italy, Spain (Bodenheimer & Neumark 1955; Aspöck *et al*. 1980; Sadeghi *et al.* 2007; Bayram 2008).

Host plants: Shrubs, conifers and deciduous trees (Table III).

Zoogeographical category: Holomediterranean (expansive northwards).

Wesmaelius quadrifasciatus (Reuter, 1894)

Material: 2004; 13.VIII, 1 M (14); 2005:26.VII, 1 M,1 F (14); 2011; 11.VIII, 1 F (14)

Distribution in Turkey: Northeastern Anatolia (Aspöck *et al*. 1980), Ardahan (Ari *et al.* 2008).

Distribution in the world: Austria, Belarus, Czechoslovakia, Denmark, England, Estonia, Finland, France, Germany, Greece, Holland, Hungary, Italy, Latvia, Liechtenstein, Mongolia, Norway, Poland, Romania, Russia, Siberia, Slovenia,

Spain, Sweden, Switzerland, Ukraine, and the former Yugoslavia, (Aspöck *et al*. 1980, 2001; Aspöck & Hölzel 1996).

Host plant: *A. bornmuelleriana*

Zoogeographical category: Siberian.

***Wesmaelius subnebulosus* (Stephens, 1836)**

Material: This eurytopic species was the third most widespread species in Bursa. It was found particularly on deciduous trees in 29 localities. Adults had the earliest emergence time among all hemerobiids, with first record on 15 March at locality 55. The adult flight activity lasted until 23 October at locality 56. Of the 61 collected adults, 40 were females and 21 were males.

Distribution in Turkey: Bursa (Uludag), Izmir (Semikler, Odemis), Kahramanmaras (12 km north of Kahramanmaras; Sarikaya), Kirsehir, Mersin (Aslankoy), Central Anatolia (Aspöck & Aspöck 1969a; Monserrat & Hölzel 1987; Sengonca 1979; Canbulat & Özsaraç 2004).

Distribution in the world: Europe, North America and northern Africa (Aspöck *et al*. 1980).

Host plants: Deciduous trees, *A. bornmuelleriana, Pinus* spp. and *Olea europaea* (Table III).

Zoogeographical category: Holomediterranean (expansive northwards).

DISCUSSION

During the course of the study, a total of 20 brown lacewing species were captured of which one (*Sympherobius klapaleki*) is a new record for Turkey. There are also 12 new records for the Neuroptera fauna of northwestern Turkey (Table I). This study confirmed the presence of seven out of the nine hemerobiid species reported by Aspöck *et al.* (1980) in Bursa province. Two of the previously recorded species, *Hemerobius pini* Stephens *1836* and *Wesmaelius ravus* (Withycombe, 1923), were not found during this survey. They may be very rare or already extinct.

The genus *Hemerobius* has a cosmopolitan distribution with more than 220 species occurring in Africa, Asia, Australia, Europe, North and South America (Monserrat 1990). Within *Hemerobius*, *H. handschini* was the most predominant and widespread species. Other species of *Hemerobius*, ranked in order of descending abundance from common to rare, were *H. nitidulus, H. micans, H. gilvus, H. stigma*, *H. humulinus*, *H. lutescens*, *H. contumax*, *H. zernyi*, and *H. simulans*, respectively (Table I).

Aspöck *et al.* (2001) pointed out the general occurrence of *H. handshini* and *H. gilvus* across the Anatolia, while they noted restricted distribution of *H. micans* and *H. stigma* populations in northern Anatolia. On the other hand, Canbulat & Kiyak (2005) also found the above-mentioned species of *Hemerobius*, except for *H. stigma,* in southwestern Anatolia, but they only captured a single female of *H. micans* and *H. gilvus* at one locality in the Isparta province. Apparently, some *Hemerobius* species were either rare or localized. Adults of *H. simulans* were rarely found and only three females of this species were collected at two localities (Table I). It was interesting to record this Siberian-Nearctic species in Mt. Uludag, suggesting a close relationship to the Balkan fauna (Popov & Letardi 2010). On the other hand, some species such as *H. humulinus* showed localized distribution probably related to their dependency on main prey. For example, *H. humulinus* occurs mainly in the apple orchards in France owing to the localized abundance of aphids and European red mite (Principi & Canard 1984).

As far as the harbouring plants of *Hemerobius* are concerned, some species like *H. handshini* were confined to conifers while other species such as *H. micans, H. lutescens* and *H. zernyi* showed preference for deciduous trees. The species *H. simulans, M. tortricoides, S. elegans, S. fuscescens, S. klapaleki,* and *S. pellucidus* were only found on conifers such as pine trees. Similarly, *W. quadrifasciatus* was a conifer specialist on fir trees. Populations of *H. handshini* were commonly found on *Pinus* spp. but seven specimens of this species were collected from *Q. cerris*. It is unclear whether these captures represent wind-drifted material as suggested by Greve (1969). Many species typical for coniferous trees and many other species typical for deciduous trees were found in Bursa province on both groups of trees. *Hemerobius contumax* was mainly collected from the conifer *A. bornmuelleriana* but also found in small numbers on broad-leaved deciduous trees including beech and oak. *Hemerobius nitidulus* and *H. stigma* had strong preference to *Pinus* spp. although they were recorded on other conifer and deciduous trees. In addition, *W. subnebulosus*, *H. humulinus, H. gilvus,* and *S. pygmaeus* were generalist, eurytopic hemerobiid species occurring both on conifer and broad-leaf trees.

Species of *Micromus* are important predators of a number of economically important pests such as aphids, whiteflies and mealybugs (Khloptseva 1991). They have a worldwide distribution thanks to their ability to survive in low temperatures. In contrast, this genus shows limited distribution in Turkey. In previous studies, only a single female specimen of *Micromus angulatus* was found in the Isparta Province (Canbulat & Kiyak 2005). The second species of *Micromus* found in Bursa, *M. variegatus*, has a wider distribution across northeastern Anatolia than the other species (Aspöck & Aspöck 1969a).

Micromus angulatus lives on low vegetation such as grass and herbs (Hölzel & Wieser 1999), but Monserrat (1978) added that they can also move into shrubs and deciduous trees. In Bursa, specimens of *M. angulatus* were only observed on *Medicago sativa* as reported in Spain by Xavier *et al.* (2005). On the other hand, specimens of *M. variegatus* were collected on *Q. cerris* and especially on trees of *P. nigra*, which were surrounded by the vegetation mainly composed of *F. vesca*.

Increasing altitude and latitude may affect the distribution of Neuroptera species (Kovanci & Kovanci 2007). In terms of the upper limits of habitats for hemerobiid species in northwestern Turkey, *M. angulatus* adults were caught at a maximum altitude of 555 m, whereas *M. variegatus* adults were recorded just above an altitude of 1000 m (Table III).

This finding is in agreement with Popov (1986) who reported that the upper limits of habitats for *M. variegatus* in Bulgaria may reach to an altitude of 900 m. Similarly, Aspöck *et al.* (1980) found *M. angulatus* adults up to an altitude of 1000 m in central Europe.

Among all the species of *Sympherobius* recorded in this study, *S. pygmaeus* was the only common and widespread species, while the other species were found to be rare (Table I). *Sympherobius pygmaeus* was first recorded as a mealybug predator by Sengonca (1979) in the citrus groves of Kahramanmaras, southern Turkey. Later, Türkyilmaz (1984) also observed the feeding and foraging behaviour of the predator *S. pygmaeus* on *Planococcus citri* (Risso) in Antalya. In Europe, *Sympherobius* feeds on aphids and European red mite in apple orchards (Principi & Canard 1984). Hence, the widespread presence of *S. pygmaeus* in Bursa province is promising for future biocontrol studies.

Adults of *S. pygmaeus* were collected from shrubs, conifers and deciduous trees, although Killington (1936) and Séméria & Berland (1988) indicated that this species may be entirely confined to oaks. Our findings confirm the presence of *S. pygmaeus* on deciduous and coniferous trees as previously reported by several authors (Sengonca 1979; Popov 1977b, 1986, 1991; Monserrat 1986; Díaz-Aranda *et al.* 1986). Díaz-Aranda & Monserrat (1988) also found *S. pygmaeus* on *Olea europaea*.

Other species of *Sympherobius* were confined to *Pinus*. *Sympherobius klapaleki* was a new record for Turkey and the specimens were collected on *P. nigra* at an altitude of 1200 and 1305 m for the first time (Table III). However, Díaz-Aranda *et al.* (1986) noted *Q. pyrenaica* as a host plant for *S. klapaleki*. In addition, Popov (1986) captured adults of this species at an altitude of 700 m. *Sympherobius elegans* and *S. pellucidus* were collected on *P. nigra*, but they were absent on deciduous trees despite the findings by previous studies (Killington 1936; Séméria & Berland 1988; Popov 1991). *Pinus nigra, P. sylvestris* and *P. pinaster* were recorded as potential hosts for *S. elegans* in Norway, Bulgaria, and Spain, respectively (Greve 1968; Popov 1977b; Monserrat 1978; Monserrrat & Díaz-Aranda 1987).

When the vertical distribution of hemerobiid species was examined, the total number of species showed an increasing trend up to an altitude of 1500 m. The highest number of species occurred between 1000–1500 m altitude with 18 species recorded along this gradient (Table III). As compared with the Hemerobiidae fauna of Bulgaria (Popov 1986), 10 out of 12 species existing both in northwestern Turkey and Bulgaria share the same altitudinal range between 1000–1500 m.

When the habitat altitudes of 12 species were compared with those from Bulgaria, the habitats of 6 species living in northwestern Turkey had higher maximum altitude values than did the same species in Bulgaria while all species, except for *M. variegatus*, in Bulgaria had lower minimum altitude values. However, Aspöck *et al.* (1980) provided higher upper limits for habitats in Mediterranean countries than those in central Europe. Besides, the current records of *M. angulatus* in northwestern Turkey at altitudinal ranges between 60–550 m are not in line with the findings of Aspöck *et al.* (1980) in central Europe, where the authors captured the same species up to an altitude of 1000 m.

Adult phenology of brown lacewing species for monthly periods from January to December is presented in Table II. Our results are in general agreement with the findings of Aspöck *et al.* (1980), except for *H. stigma* and *M. angulatus*. Both species were expected to be constantly present during the whole year because they overwinter in the adult stage. However, adults of *M. angulatus* were only found in June while those of *H. stigma* were caught between May-September. The limited distribution of these species during the year may have stemmed from their low populations. Unlike *H. stigma*, *W. subnebulosus* adults were ubiquitous and active from March to October. The high abundance of this eurytopic species may be due to its high reproductive capacity and affinity to urban land use in addition to feeding habits with a wide variety of prey ranging from aphids to psyllids.

Cold adapted or psychrophilic species such as *H. simulans* inhabit only in the mountains, while *H. zernyi* prefers to live in warm and dry habitats of Anatolia. Based on the zoogeographical analysis, the species of southern origin characterized by the Mediterranean elements constituted 55% of the Hemerobiidae fauna of northwestern Turkey and prevailed over the species of northern origin that belong to the Siberian centres (Table IV). This finding is in contrast with the zoogeographical categorization of the Bulgarian Hemerobiidae fauna, where the species of northern origin prevail, with percent dominance values of 71% (Popov 1986).

Previous studies on the Turkish Hemerobiidae fauna at the provincial level were only conducted in southwestern Anatolia (Canbulat & Kiyak 2005). These studies have reported a total of 10, 6, 5, 4, 1 and 1 species in Isparta, Denizli, Burdur, Antalya, Aydin and Mugla provinces, respectively. When Bursa's brown lacewing fauna is compared with that of other Turkish provinces, the presence of 22 species in this region may be considered as a fairly good indicator of its rich biodiversity. The number of species is likely to increase if additional localities and areas unreachable by road can be searched in more detail.

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