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Biological Invasions
Research Article

Phenology and Host Preferences of the Invasive *Pochazia shantungensis* (Chou & Lu, 1977) (Hemiptera: Ricaniidae), a Risk for Agriculture and Forest Areas in the West-Palaearctic Region

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Abstract: Biology of the invasive species *Pochazia shantungensis* (Chou & Lu, 1977), already detected in the Western Palaearctic in 1977, is studied in two areas of Istanbul, Türkiye, on both sides of the Bosphorus. The species overwinters at the egg stage and has two generations per year. The number of host plants identified in this study is 57 (belonging to 31 families). With previous studies, the number of host plant species in Türkiye has reached 58. The main host plants were *Ligustrum lucidum* W. T. Aiton and *Olea europaea* L. Eggs are laid in double rows in the thin twigs of shrubs or trees of one-year old, exceptionally in the main vein on the lower leaf surface of *Magnolia grandiflora* L. The mean number of eggs laid on *L. lucidum* and *O. europaea* were 31.88 and 21.80, respectively. Mean length of egg masses was 17.90 and 15.36 mm and mean twig thickness was 2.21 and 2.20 mm, respectively, on *L. lucidum* and *O. europaea*. *Zelus renardii* (Hemiptera: Reduviidae) was identified as a predator of *P. shantungensis*.

Key words: Ricaniidae, *Zelus renardii*, Host plants, Egg laying, Ligustrum lucidum, Türkiye

Introduction

International trade and climate change facilitate invasive organisms to spread into new regions. In the last decades, Türkiye has been greatly affected by the accidental introduction of several invasive insect species. These include *Leptoglossus occidentalis* (Heidemann) (Heteroptera: Coreidae) (Arslangündoğdu & Hizal 2010), *Cydalima perspectalis* (Walker) (Lepidoptera: Crambidae) (Hizal et al. 2012) and *Dryocosmus kuriphilus* Yasumatsu (Hymenoptera: Cynipidae) (Çetin et al. 2014). A recently added species is *Pochazia shantungensis* (Chou & Lu, 1977). It has been recently recorded as *Ricania shantungensis* Chou & Lou, 1977 in the European part of Istanbul, Türkiye, being also the first record for Europe (Hizal et al. 2019). Later, the species was recorded in France (Bourgoin et al. 2020), Germany (Schrader 2021) and Italy (Stroiński et al. 2022).

Pochazia shantungensis is an invasive species of the planthopper family Ricaniidae Amyot & Audinet-Serville, 1843 (Hemiptera: Fulgoromorpha: Ricaniidae). The family Ricaniidae has a wide distri-

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bution in the world; It includes 442 species belonging to 69 genera (Bourgoin 2022). There are five species recorded in the Western Palaearctic region. *Ricania hedenborgi* Stål, 1865, *R. aylae* Dlabola, 1983 and *R. soraya* Dlabola, 1983 are native species. *Ricania speculum* (Walker, 1851) and *Orosanga japonica* (Melichar, 1898) are invasive species, which have East-Asian origin (Demir 2009, Gjonov 2011, Mazza et al. 2014). Some members of the family Ricaniidae are known to be significant insect pests worldwide in agriculture and forestry (Park & Jung 2021). According to Bourgoin et al. (2020), *P. shantungensis* damages plants thru its feeding sap-sucking action, resulting into accumalation of honeydew secretion that promotes sooty mould development. Additionally, because of the female laying a large number of eggs on the thin twigs of the arboreal trees, sap transmission stops. The distribution of *P. shantungensis* in its native range include China, Korea and Taiwan (Jacobi 1915, Schumacher 1915, Chou & Lu 1977, Yang 1989, Shen 2007, Rahman et al. 2012). In Türkiye (Fig. 1), it has been recorded in the provinces of Istanbul, Kocaeli and Yalova (Hızal et al. 2019, Çetin et al. 2019).

The aims of the present study are to characterise phenology, host plant preferences and egg-laying behaviour on two important host plants in Istanbul, Türkiye, where the pest has been first detected in the Western Palaearctic. In addition, we report a hemipteran species predating on *P. shantungensis*.

Fig. 1. Locations of research areas.

Fig. 2. *Pochazia shantungensis*. **a**. Egg mass on *Ligustrum lucidum* W. T. Aiton. **b.** Nymphs on *Olea europaea* L. **c.** Adults on *Ligustrum lucidum.*

Materials and Methods

Istanbul is located in the north-west part of Türkiye, extending thru both European and Asian sides of the Bosphorus. It has 39 districts. This research was carried out in parks and gardens in five districts where insects were seen: Kadıköy, Üsküdar-Asian side / Beşiktaş, Sarıyer, Şişli-European side (Fig. 1). Field research was conducted between January 2019 and December 2020. The parks and gardens in Kadıköy, Üsküdar, Beşiktaş, Sarıyer and Şişli were visited weekly. Development stages were observed in the Kadıköy and Sarıyer parks and notes were taken (Fig. 2).

Records were taken when a host plant was found with egg masses, nymphs and adults. The leaves, flowers and twigs of difficult to identify plant species were collected. The collected materials were brought to the laboratory in plastic bags. Identification was made by a botanical expert. Twigs containing egg mass were cut from two important host plants (*Ligustrum lucidum*, *Olea europaea*) identified during the fieldwork. These were brought to the laboratory and examined under a stereo microscope. Twig thickness, egg mass length and number of eggs were recorded.

Predators that were found during the field studies to feed with nymphs and adults were brought to the laboratory and identified under a stereomicroscope.

Results

Order Hemiptera Linnaeus, 1758
Suborder Auchenorrhyncha Duméril, 1806
Infraorder Fulgoromorpha Evans, 1946
Superfamily Fulgoroidea Latreille, 1807
Family Ricaniidae Amyot & Audinet-Serville, 1843
Genus *Pochazia* Amyot & Audinet-Serville, 1843

***Pochazia shantungensis* (Chou & Lu, 1977)**

Morphology: Body length – males (N=14): 7.8-9.6 mm (from vertex to tip of genitalia), 14.1-14.6 mm (from vertex to tip fore wings); females (N=12): 8.1-10.8 mm, 14.8-15.6 mm. Females larger than males. General colour dark-brown to black. Vertex, frons, clypeus, rostrum and eyes brown to dark-brown. Ocelli brown. Pronotum and mesonotum black. Thorax black ventrally. Forewing dark-brown to black, with an elliptical white spot on costal margin at about two-thirds from base. Hind wing dark-brown. Detailed morphological descriptions are further given by Rahman et al. (2012) and the last molecular studies were carried out by Zhang et al. (2022).

Biology: Due to the presence of data from two meteorological stations (Kadıköy and Sarıyer, see Table 1), the phenology of the species based on field observations is presented separately for the two working areas (Table 2). This insect overwinters at the egg stage in the research area and has two generations per year. In Kadıköy (Fig. 3), the first-generation nymphs occurred during the second week of May and adults appeared in the fourth week of June. Second-generation eggs are laid the first week of July, with their nymphs appearing in the third week of July. Second-generation adults appeared during the first and second week of September. Next-generation eggs were laid at the beginning of the second week and end of the third week of September.

In Sarıyer (Fig.4), the first-generation nymphs ocurred in the third week of May. Adults appeared in the first week and second week of July. Second-generation eggs were laid in the second and third week of July and their nymphs were observed first during the first and second week of August. Second-generation adults appeared in the last week of September and in the first week of October. Next-generation eggs were laid at the end of the last week of September and at the end of the second week of October.

Host plants: The number of host plants identified in this study comprised 57 species belonging to 31 families. The main host plants were determined as *Ligustrum lucidum*, *Olea europaea*. The laying hosts of *P. shantungensis* adults were also *Liquidambar styraciflua*, *Carpinus betulus*, *Corylus avellana*, *Corylus maxima*, *Calycanthus floridus*, *Lonicera japonica*, *Diospyros lotus, Elaeagnus angustifolia, Elaeagnus pungens, Fagus sylvatica, Quercus robur, Laurus*

Table 1. Kadıköy and Sarıyer meteorological stations monthly average temperature data (2019–2020).

Kadıköy (°C)												
Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019	7.2	7.1	9.9	12.6	19.1	24.3	23.8	24.7	21.4	18.1	16.4	10.3
2020	7.0	8.4	10.3	11.8	17.4	22.5	25.0	25.1	23.4	19.4	12.6	11.4
Sarıyer (°C)												
Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019	6.6	6.2	9.2	10.8	17.9	23.3	23.1	24.1	21.5	17.8	15.7	10.0
2020	6.6	8.0	9.6	10.9	16.4	21.6	24.4	24.7	23.1	19.1	12.4	11.0

Table 2. Dates when the life stages of *Pochazia shantungensis* were first seen.

Year	Stage	Kadıköy	Sarıyer
		First seen date	
2019	Nymphs 1st	08 May	18 May
	Adults	25 Jun	03 Jul
	Eggs	01 Jul	12 Jul
	Nymphs 1st	18 Jul	01 Aug
	Adults	2 Sep	23 Sep
	Eggs (Overwintering stage)	10 Sep	30 sep
2020	Nymphs 1st	11 May	19 May
	Adults	23 Jun	13 Jul
	Eggs	03 Jul	21 Jul
	Nymphs 1st	23 Jul	10 Aug
	Adults	10 Sep	5 Oct
	Eggs (Overwintering stage)	21 Sep	14 Oct

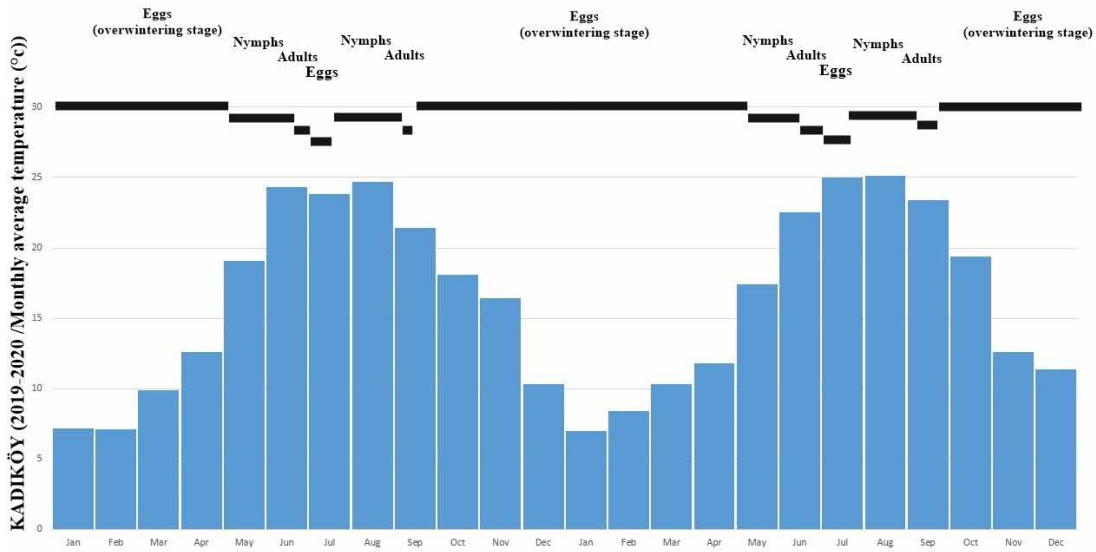

Fig. 3. Phenology of *Pochazia shantungensis* in Kadıköy.

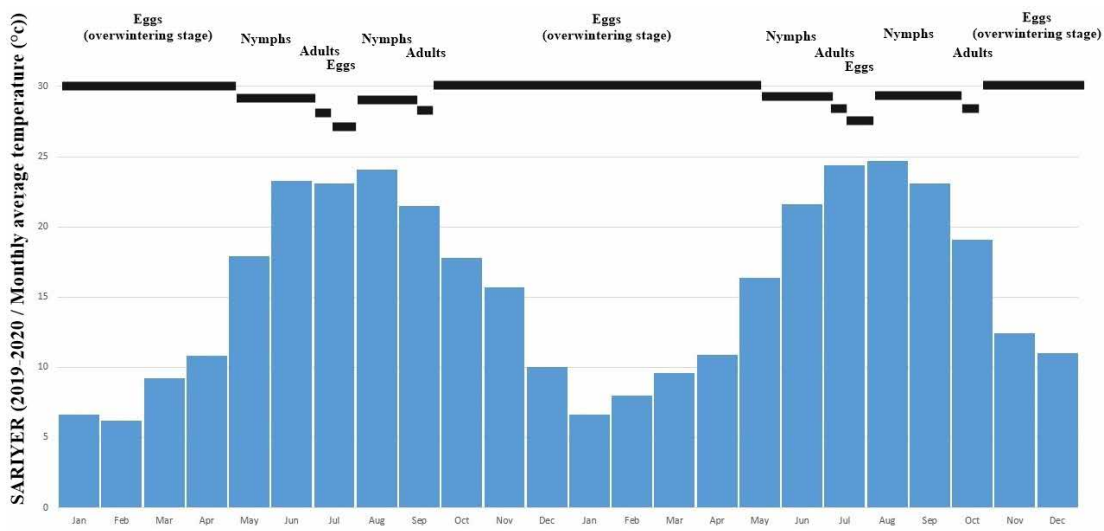

Fig. 4. Phenology of *Pochazia shantungensis* in Sarıyer.

Table 3. Host plants of *Pochazia shantungensis* in Türkiye. Legend: * E: Egg masses, N: Nymph, A: Adult, Host plant preference (●: Low [n: 1-5]; ●●: Medium [n: 6-20]; ●●●:High [n≥21]) (Bold names: new host plant for literature)

Families	Scientific name	Previous studies	Present study*		
			E	N	A
Adoxaceae	***Viburnum opulus*** L.	-	-	●	-
	Viburnum tinus L.	+	-	-	-
Altingiaaceae	*Liquidambar styraciflua* L.	+	●	●	●
Apocynaceae	***Nerium oleander*** L.	-	-	●	●
Araliaceae	***Hedera helix*** L.	-	-	●	●
Berberidaceae	***Berberis aquifolium*** Pursh	-	-	●	●
Betulaceae	***Carpinus betulus*** L.	-	●●	●	●
	Corylus avellana L.	-	●	●	-
	Corylus maxima Mill.	-	●	●	●
Bignoniaceae	***Catalpa bignonioides*** Walter	-	-	●	-
Calycanthaceae	***Calycanthus floridus*** L.	-	●	●	●
Caprifoliaceae	***Lonicera japonica*** Thunb.	-	●	●	-
Celastraceae	*Euonymus japonicus* Thunb.	+	-	●	-
Compositae	***Euryops pectinatus* (L.) Cass.**	-	-	●	-
Ebenaceae	*Diospyros kaki* Thunb.	+	-	●	●
	Diospyros lotus L.	+	●	●	●
Elaeagnaceae	***Elaeagnus angustifolia*** L.	-	●	●	●
	Elaeagnus pungens Thunb.	-	●	●●●	●●
Fagaceae	***Fagus sylvatica*** L.	-	●	●●	●
	Quercus robur L.	-	●	●	●
Juglandaceae	*Juglans regia* L.	+	-	●	●
Lamiaceae	***Vitex agnus-castus*** L.	-	-	●	●
Lauraceae	*Laurus nobilis* L.	+	●●●	●●	●
Leguminosae	***Cercis siliquastrum*** L.	-	-	●	●
	Gleditsia triacanthos L.	-	-	●	●
	Robinia pseudoacacia L.	+	-	●●	●●
Lythraceae	*Lagerstroemia indica* L.	+	-	●	-
	Punica granatum L.	-	●	●	●
Magnoliaceae	***Liriodendron tulipifera*** L.	-	●	●	●
	Magnolia grandiflora L.	+	●●	●	●
Malvaceae	*Hibiscus syriacus* L.	+	-	●●	●
	Tilia tomentosa Moench	-	●	●	●
Moraceae	*Ficus carica* L.	+	-	-	●
	Morus alba L.	+	-	●●	●●●
Myrtaceae	***Acca sellowiana*** (O. Berg) Burret	-	-	●●	●
Oleaceae	***Jasminum officinale*** L.	-	●	●	-
	Ligustrum japonicum Thunb.	+	●	●	●
	Ligustrum lucidum W. T. Aiton	+	●●●	●●●	●●●
	Olea europaea L.	+	●●●	●●●	●●
Pittosporaceae	***Pittosporum tobira*** (Thunb.) W. T. Aiton	-	-	●	-
Platanaceae	***Platanus acerifolia*** (Aiton) Willd.	-	●	●	●
	Platanus orientalis L.	-	●	●	●
Rhamnaceae	*Ziziphus jujuba* MilL.	+	-	●	●

Table 3. Continuation.

Families	Scientific name	Previous studies	Present study*		
			E	N	A
Rosaceae	***Cotoneaster lacteus*** W. W. Sm.	-	●	●	●
	Cydonia oblonga Mill.	-	-	●	●
	Eriobotrya japonica (Thunb.) Lindl.	-	●	●	●
	Malus domestica Borkh.	+	-	●	●
	Malus floribunda Siebold ex Van Houtte	-	-	●	-
	Prunus avium (L.)	-	●	●	●
	***Prunus laurocerasus* L.**	-	-	●	-
	Prunus serrulata Lindl.	-	-	●	-
	Pyracantha coccinea M. Roem.	-	●	●	-
	Rubus vestitus Weihe	-	-	●	-
Rutaceae	***Citrus japonica*** Thunb.	-	●	-	-
Sapindaceae	*Acer campestre* L.	+	●	●	●
	Acer negundo L.	-	●	●	●
	Acer palmatum Thunb.	+	-	●	●
Xanthorrhoeaceae	***Phormium tenax*** J.R.Forst. & G.Forst.	-	-	●●	●●

Table 4. Egg laying characteristics of *Pochazia shantungensis* on two important host plant.

Host Plant	Twig thickness (mm)			Length of eggmass (mm)			No. of egg per eggmass		
	Min.	Max.	Mean±SD	Min.	Max.	Mean±SD	Min.	Max.	Mean±SD
L. lucidum (N: 131)	1.2	3.6	2.21±0.49	6.3	31.2	17.90±5.35	11	54	31.88±10.02
O. europaea (N: 111)	1.3	3.8	2.20±0.44	5.9	34.0	15.36±5.39	10	45	21.80±8.01

Fig. 5. *Pochazia shantungensis.* **a.** Egg rows on *Ligustrum lucidum*. **b.** Egg mass on *Magnolia grandiflora*. **c.** Adults on *Ligustrum lucidum*.

nobilis, *Punica granatum*, *Liriodendron tulipifera, Magnolia grandiflora*, *Tilia tomentosa, Jasminum officinale*, *Ligustrum japonicum*, *Ligustrum lucidum*, *Olea europaea*, *Platanus acerifolia*, *Platanus orientalis*, *Cotoneaster lacteus*, *Eriobotrya japonica*, *Prunus avium, Pyracantha coccinea, Citrus japonica, Acer campestre* and *Acer negundo* (Table 3).

Egg laying characteristics: The female lays its eggs in double rows in hollows it opens on the thin twigs of shrubs or trees (Table 3, Fig. 5a). Exceptionally, it might lay in the main vein on the lower leaf surface of *Magnolia grandiflora* (Fig. 5b). It also covers the egg massess with whitish flaky wax secretions (Fig. 5c).

Fig. 6. *Zelus renardii* on *Ligustrum lucidum.* **a**. Eggs. **b**, **d**. Nymph. **c**, **e**, **f**. Adults.

Females lay eggs on one-year old twigs. The mean number of eggs laid on *L. lucidum* and *O. europaea* were 31.88 and 21.80, mean length of egg masses were 17.90 and 15.36 mm and mean twig thickness were 2.21 and 2.20 mm, respectively (Table 4).

Predator: Predator specimens brought to the laboratory were determined as *Zelus renardii* Kolenati, 1856 (Hemiptera: Heteroptera: Reduviidae) (Fig. 6).

Discussion

The species was originally described in the genus *Ricania* Germar, 1818 (Chou et al. 1985, Shen et al. 2007, Kwon et al. 2017, Hizal et al. 2019, Park & Jung 2020, Kang et al. 2020). Subsequently, it was transferred to the genus *Pochazia* (Rahman et al. 2012, Kim et al. 2015, Bourgoin et al. 2020, Stroiński et al. 2022, Schrader 2021, Zhang et al. 2022). The close species *P. sublimata* (Jacobı, 1915) is likely its synonym (Stroiński & Bourgoin 2022).

In China, *P. shantungensis* has two generations per year (Shen et al. 2007), which coindises with our observations in Türkiye. However, in Korea, one one generation per year has been recorded (Jo et al. 2016).

In previous studies in Türkiye, eight host plants were reported (Hizal et al. 2019, Çetin et al. 2019). In the present study, we report 57 plant species belonging to 31 families, including 38 new host plants to the world literature (Choi et al. 2011, 2012, 2017, Rahman et al. 2012, Kim et al. 2015, Kwon et al. 2017, Stroiński et al. 2022). According to Choi et al. (2017), *Pochazia* species at different developmental stages prefer different host plants depending on environmental factors such as wind and rain. When the oviposition season begins, adults prefer to lay eggs in perennial trees and shrub hosts (Table 3).

As the length between the plant nodes increases, the average number of eggs laid increases. As a result, the length of egg masses also increases. There was no significant difference between the twig thicknesses, in which eggs were placed in *L. lucidum* and *O. europea*. Females lay eggs in one-year old twigs.

The native distribution of the predador *Zelus renardii* is North America (Zhang et al. 2016). The first records of *Z. renardii* from Türkiye were noted from Izmir in 2015 and Istanbul in 2016 (Çerçi & Koçak 2016). *Zelus renardii* is a generalist predator found on several wild and crop plants where it preys on a wide range of insects (Cisneros & Rosenheim 1997, Pinzari et al. 2018). During the field studies in this research, this species was frequently encountered on the host plants.

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