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Combination of morphological characters and DNA-barcoding confirms *Problepsis cinerea* (Butler, 1886) (Geometridae: Sterrhinae: Scopulini) as a new genus and species for the fauna of Iran

Shamsi Feizpour, Lida Fekrat, Hussein Sadeghi Namaghi, Dirk Stadie, Hossein Rajaei

Abstract

Problepsis cinerea is reported as a new genus and species for the fauna of Iran. The species is recorded based on two females, collected in South Iran. Identification was confirmed by morphological characters and barcoding data. Information on the morphology and diagnostic characters are given, in comparison with the similar species. Remarks on the habitat and biology are added. Distribution pattern of both *P. ocellata* and *P. cinerea* in the Middle East is mapped. Details of the scent scales (located on the male hind tibia) are studied with scanning electron microscopy (SEM) and illustrated.

Keywords: DNA-Barcoding, Geno protected area, hair pencil, *Olea* spp., *Problepsis ocellata,* Scopulini.

Zusammenfassung

Problepsis cinerea wird als neue Gattung und Art für die Fauna des Iran nachgewiesen. Von der Art wurden zwei Weibchen im Süden des Landes gefunden. Die Art wurde durch morphologische Merkmale und DNA Barcoding identifiziert. Informationen zur Morphologie und diagnostische Merkmale werden aufgelistet und mit ähnlichen Arten verglichen. Daten zum Habitat und zur Biologie werden ergänzt. Die Verbreitungsmuster von *P. ocellata* und *P. cinerea* im Mittleren Osten werden dargestellt. Details zu den Duftschuppen, die sich beim Männchen auf den Hintertibien befinden, werden mit dem Rasterelektronenmikroskop (REM) illustriert.

Contents

1 Introduction 47
2 Material and methods 50
3 Results 50
3.1 Morphology 50
3.2 DNA-Barcoding 54
3.3 Distribution and habitat 54
5 References 55

1 Introduction

The genus *Problepsis* Lederer, 1853 belongs to the tribe Scopulini and the subfamily Sterrhinae. Scoble (1999) and Scoble & Hausmann (2007) listed 50 species to the genus *Problepsis*. Stadie & Stadie (2016) increased this to 53 (regarding *P. cinerea* as a bona species and describing two new species: *P. fiebigi* and *P. sihvoneni*).

Most *Problepsis* species have been recorded from the old world, mainly from Ethiopian and Oriental regions (distributed from western Africa to India and towards Australia) (Sihvonen & Siljander 2005; Stadie & Stadie 2016). The members of this genus are oligophagous, feeding exclusively on species of the family Oleaceae (e.g. *Olea* and *Ligustrum*) (Reisser 1957, Hausmann 2004, Stadie & Stadie 2016).

The genus *Problepsis* is characterized by several synapomorphies, namely: discal spot ocellate round on forewing, and hind wing with polished shiny scales on the wings and single areole venation in most species (Sihvonen 2005); Male hind-tibia laterally flattened, longitudinally spoon-shaped, toward 1st tarsomer curved internally, covered with hair pencil (see Figs. 14, 15, 16) serving as scent organ (Holloway 1997); Male hind-tibia with shortened tarsomers, hairy pulvillus present, claws and arolium mostly absent (Sihvonen & Kaila 2003); sternum A8 characteristically modified (posterior part known as mappa, anterior margin is trilobed, see Figs. 9-c, 10-c). As other species of the tribe Scopulini (also some other species of the subfamilies Sterrhinae and Ennominae), the male hind tibia of *Problepsis* species, are characterized by the presence of a hair pencil (Sihvonen 2005). This hair pencil is

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associated with scent cells (androconia), regarded as scent scales, and plays a major role in courtship behavior (Birch & Poppy 1990, Kristensen 1999, Kristensen & Simonsen 2003, Sihvonen 2005, Skou et al. 2017, Hernández-Roldán et al. 2014). This hair pencil is considered as a replacement of tibial spurs on the hind leg (Sihvonen 2005). A close-up view of this structure is depicted in this paper (see results).

Male genitalia of *Problepsis* are characteristic by: uncus absent; socii setose, dorsally fused and looks like uncus (see Fig. 10a-2); ventral margin of tegumen dentate; valve deeply cleft into two dagger-form processes; juxta apically fused to the sacculus valva (Sihvonen 2005). Female genitalia with oval shaped corpus bursa; signum consists of separated tiny sclerotized spots, forming an ovoid patch (Figs. 11-13).

Problepsis cinerea was described by Butler (1886) (original combination *Argyria cinerea*) from Campbellpur (Pakistan). Prout (1938) downgraded this taxon to a local race of *ocellata* (Frivaldszky, 1845). Hausmann (1998) regarded this name as subspecies of *ocellata*. A combination of morphological comparative studies, morphometric analyses and DNA barcoding data, along with distribution pattern and habitat information convinced Stadie & Stadie (2016) to confirm this taxon as bona species.

The present paper reports *Problepsis cinerea* as a new genus and species for the fauna of Iran.

Abbreviations

BC	Barcoding Code;
g. prep.	genital preparation

Acronyms

Coll. Stadie	Private Collection Dirk Stadie
Coll. Fiebig	Private Collection Ralf Fiebig; NHMUK: Natural History Museum of London, U. K.
SMNK	State Museum of Natural History Karlsruhe, Germany
SMNS	State Museum of Natural History Stuttgart, Germany
ZFMK	Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany
ZSM	Bavarian State Museum of Zoology, Munich, Germany

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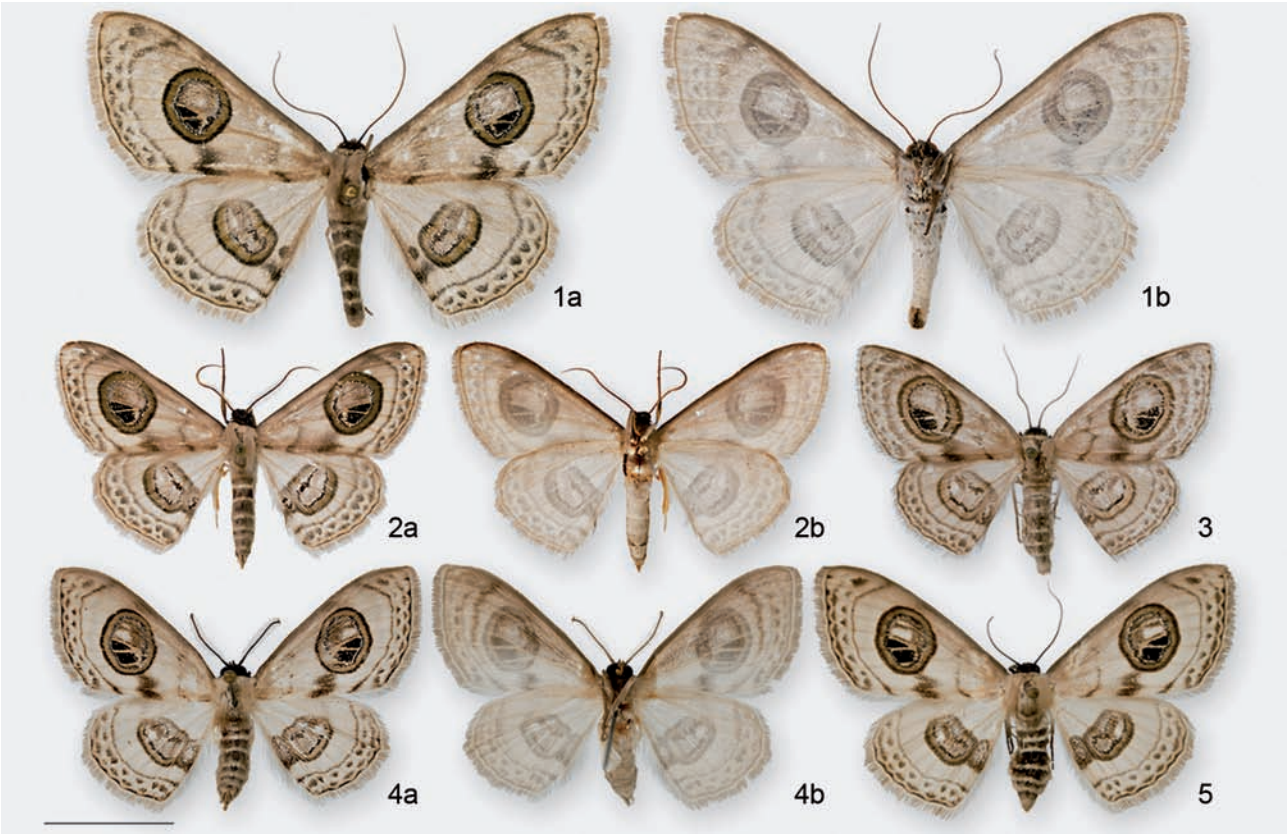

Figs. 1-5. Wing pattern and habitat. **1-3**. *Problepsis cinerea*, 1. ♀ (Geno protected area, South Iran), 2. ♂ (North Pakistan), **3**. ♀ (North Pakistan). **4-5**. *P. ocellata*, 4. ♂ (Turkey), 5. ♀ (Turkey). a, upperside, b, under side, Scale-bar: 1 cm.

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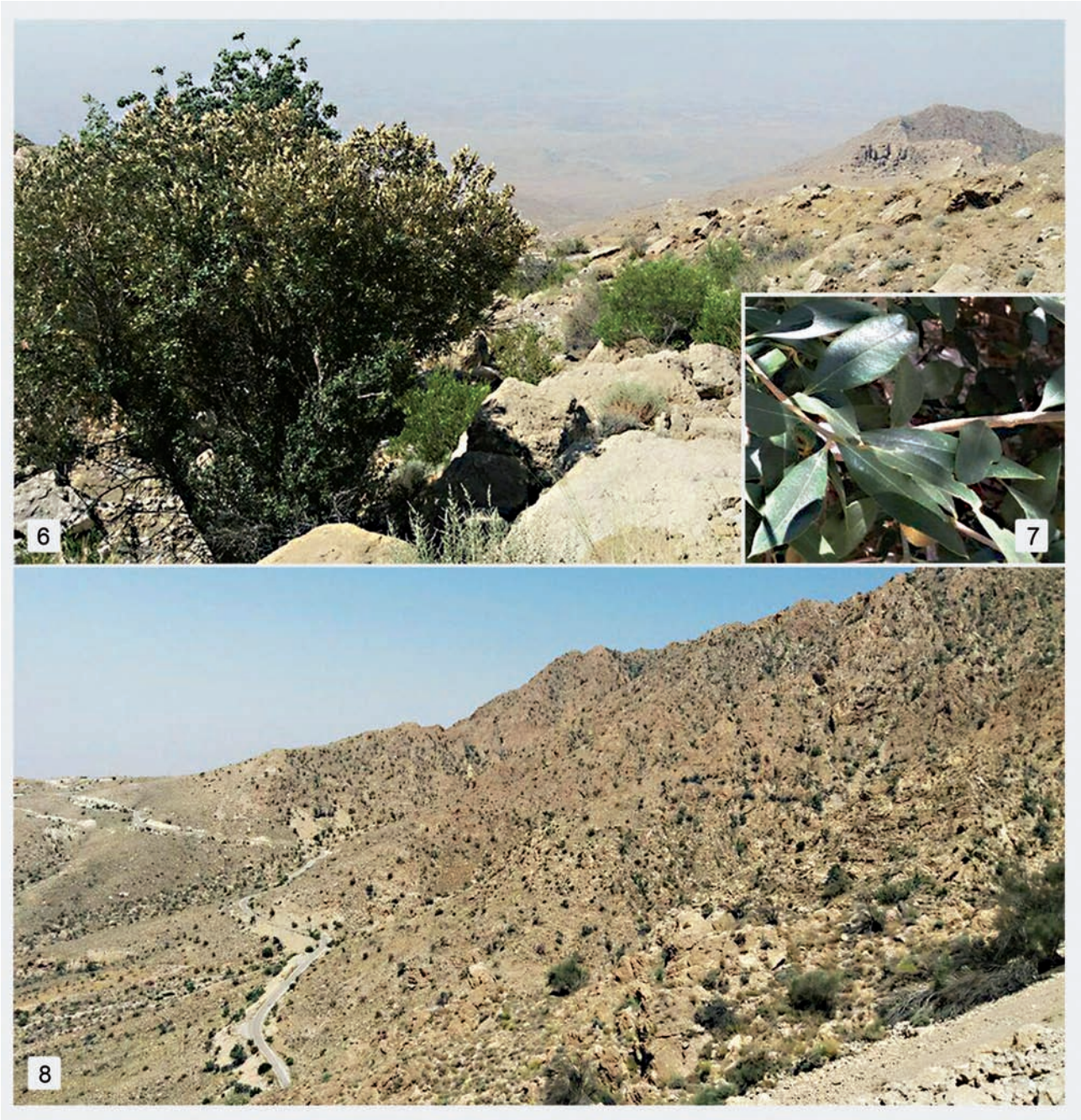

Figs. 6-8. Habitat of *Problepsis cinerea* in Geno protected area. 6-7. *Olea europaea cuspidata*, potentially natural host of *P. cinerea* in South Iran, 8. A view of Geno protected area, Bandar Abbas (Courtesy: Abdol-Reza Dehghani, Iran).

for issuing the permission letter for sampling in Iran. Additionally, the first author is grateful to the staff of the Geno protected area, namely Majid Vafadar and Abdolreza Dehghani (Department of Environmental Protection, Hormozgan) for accompanying and kind supports during the fieldworks. Our special thanks go to Axel Hausmann and Paul Hebert (CCDB, University of Guelph, Canada) and their teams for kindly and professionally performing the sequencing of *Problepsis* material and giving access and permission for publishing these data. Finally yet importantly, thanks to Cristina Gascó Martin for her patiently helps during SEM photography. This publication was partially supported by the Research Incentive Grant of State Museum of Natural History, Stuttgart, Germany.

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2 Materials and Methods

Portable light traps (powered by 12-Volt batteries and 8-Watt black-light UVB tubes) were used to attract the specimens. Two females were captured at around 2 am. Adult moths were identified based on the most recent publication (Stadie & Stadie, 2016) and confirmed by the fourth author. Prior to the dissection, the adults were photographed using Olympus Digital Camera (E-3). For precise identifications, the genitalia of the specimens were dissected using a standard method (Robinson 1976). The genitalia were stained by Chlorazol-Black and mounted in Euparal. Genitalia slides were photographed using a Leica Microsystem (DFC-490). The morphology of hind tibia and its hair pencil were studied using Scanning Electron Microscopy (Zeiss SEM, Evo LS 15). For comparison of morphological characters, following specimens were used:

Problepsis cinerea: 2 ♀, Iran, Hormozgan, Bandar Abbas, Geno, 2128 m, 27°25‘02“N 56°10‘160“E, 30.04.2016, leg. S. Feizpour; g. prep. 371/2017, S. Feizpour; Barcode: SMNS_Lep_000976, in SMNS. 1 ♂, Pakistan, Campbellpor, 40 miles from Rawal Pindee (Type), 84.162(9), 6.6.1986, g. prep. 10952; in BMNH; 1 ♂, 1 ♀, Pakistan, [NWFP], Drazinda tribal agency, N Suleiman Mts., 1700, 17.-21.8.2008, leg. V. Gurko; in RFPC; 1 ♂, W Pakistan, Swat, Kalam, 2000 m, 9.7.1969, leg. G. Ebert; 1 ♂, 1 ♀, Afghanistan, Asmar, Kunartal, 900 m, 3.4.1953, leg. J. Klapperich, ex coll. Josef Froitzheim & Johann(es) Klapperich, DS 48, 77 & 80/2012; 1 ♂, 2 ♀, Afghanistan, Nuristan, 25 km N v. Barikot, 1800, 12.-17.7.1963, leg. Kasy & Vartian, ex coll. Hans Reisser, g. prep. DS 45/2012; 1 ♀, Afghanistan, Nuristan, Bashgultal, 1200 m 3.5.1953 g. prep. DS 46/2012 Dirk Stadie; [1 ♀] same data, 1150 m, 1.5.1953, ex coll. Johann(es) Klapperich, g. prep. DS 47/2012; 1 ♂, same data, 1100 m, 6.4.1953, g. preps. DS 79 & 78/2012; all in SMNK; 1 ♂, 1 ♀, NO-Pakistan, Murree, 1700 m, 18.-19.7.1975, leg. W. Thomas; 2 ♂, 1 ♀, Pakistan, SW Himalaya, Indus_Kuhistan, Kaghan-Tal, Shinu, 17-2200 m, 7.8.-8.8.1977, leg. de Freina, g. preps. 374 & 375/2017, S. Feizpour; all in SMNS; 1 ♂, Pakistan, Kohistan, Swat prov., Madyan, 1350 m, 35°14'N, 72°28'E, 30.6.1992, leg. Z. Weldenhoffer, museum A. Koeing, Eing. Nr. ex coll. 93/381; 1 ♂, same data, Miandam, 1800 m, 35°10'N, 72°32'E, 25.6.-5.7.1992; all in ZFMK; 2 ♂, 4 ♀, Pakistan, Kohistan, Industal, Pattan, 1050 m, 35°08'N, 72°56'E, 30.9.-7.10.1988, leg. Weigert, g. preps. DS 61, 63, 64, 84 & 85/2012; 2 ♀, Pakistan, Hazara, Balakot, 900-1100 m, 3.-7.6.1983, leg. Eckweiler, g. prep. DS 62/2012; 1 ♂, West Pakistan, Salt Range, Chingi, 4.3.1956, leg. Ch. Lindemann, g. prep. DS 83/2012; 1 ♀, Pakistan, N.W.F. prov. Salt Range, 17 km N Quaidabad, 32°24'N, 72°00'E, 350 m, 12.10.1988, leg. Weigert, g. prep. DS 82/2012; all in ZSM; 1 ♂, 2 ♀, Oman, Sultant Oman Jebel Akhdar, Birkat Al Sharaf, 1930, 23°09'59.5", 57°25'36", 30.7.2010 LF/ 6.-7.10.2011 LF, Lehmann, Stadie & Bittner/ D. Stadie & Löbel, g.preps. DS 39, 40, 86 & 87/2012; all in DSPC.

Problepsis ocellata: 1 ♂, Asia minor mer. or. Tarsus, Namrun, 1000 m, 20.9.1969, leg. D.K. Bernhauer; 1 ♂, Asia minor, Taurus vand, Tarsus, 18.6.1994, leg. W. Thomas; 3 ♂, 1 ♀, Asia minor occ. Izmir, S Darutsav Hotel Ietis, 5 m, 28.8.-2.9.1984, leg. St. Reiss, g. prep. 372/2017, S. Feizpour; 1 ♀, Kleinasien, prov. Antalya, vic. Kemer, 1 m, 25.-28.5.1982, leg. de Freina; 1 ♂, Kleinasien. Prov. Içel, 40 km NNW Silifke, vic. Kargicak, 200 m, 19.4.1985, leg. de Freina; 2 ♀, Turkey, prov. Mersin, Erdemli, 14.6.1974, leg. W. Thomas; 3 ♀, Turkey, prov. Mersin, Umg. Mut., 18.6.1974, leg. W. Thomas, g. prep. 373/2017, S. Feizpour; 6 ♂, 5 ♀, Turkey, Anatolia, Silifke-Boğsah, 20-25.10.1974, leg. H. Krusz; 1 ♂, Karatepe, TR. 4.1973, leg. Czipka L. g. prep. 376/2017, S. Feizpour; 1 ♂, 1 ♀, Turkey, prov. Mersin, Umg. Tarsus, 18.6.1974, leg. W. Thomas; 1 ♂, Grecia, Umg. Kamena-Vourla, 400 m, 10.6.1979, leg. G. König; 1 ♀, Grecia, Fokida, W Delfi, 38°28'N, 22°28'E, 14.8.1996, leg. Ch. Reiger; all in SMNS.

DNA Barcoding

For comparison of Cytochrome c Oxidase, subunit-I (DNA Barcode), the barcode data of *Problepsis* species (Stadie & Stadie 2016) were obtained from Barcode Of Life Database (BOLD). Subsequently, DNA of freshly collected specimens from Iran was extracted, their DNA barcode region amplified and sequenced according to standard protocols (Ivanova et al. 2006, Hebert et al. 2003) in the molecular laboratory of State Museum of Natural History, Stuttgart. In total 658 bp of DNA Barcode were aligned using BioEdit (ver. 7.2.5.) (Hall 1999). A list of all specimens used for DNA analysis along with their GenBank accession numbers are presented in Table 1 (appendix). Neighbor-joining tree and genetic distances were calculated by MEGA6 (Tamura et al. 2013).

3 Results

Problepsis cinerea (Butler, 1886)

Argyria cinerea Butler, 1886, *Proceedings of the Zoological Society of London,* 3: 387. Type locality: [Pakistan], Campbellpore [near Rawal Pindee], Syntype (s), coll. NHMUK, London.

3.1 Morphology

Wing pattern. (Figs. 1-3) Wingspan 39-41 mm (length of forewing: 20 mm). Background of forewing creamy light-brown mixed with ochreous, weakly glossy scales, costal area slightly darker. A large rounded eye-spot in median area is characteristic, bordered with a thin black outer line, encircled an olive-brown thicker inner band, toward center a second thick black line shadowed with silvery scales, central area separated into two part, the upper two third light brown and the lower third black. Hind wing lighter than forewing. Eye-spot elliptical, without triangle black shapes internally; a small black patch near the dorsum, sometimes splitted. Underside creamy light, with a dull print of all patterns of upper-side (for more details see Stadie & Stadie 2016).

Male genitalia (Fig. 9). (based on specimens from Pakistan). Socii thin, weakly sclerotized connected from both sides except apical part. Tegumen ventrally more sclerotized with nine prominent spines, usually angled near socii. Aedeagus slender, tubular, more sclerotized, forming a long two-head cleft, one more bent, shorter with two teeth. Vesica as two diverticuli; without any cornuti.

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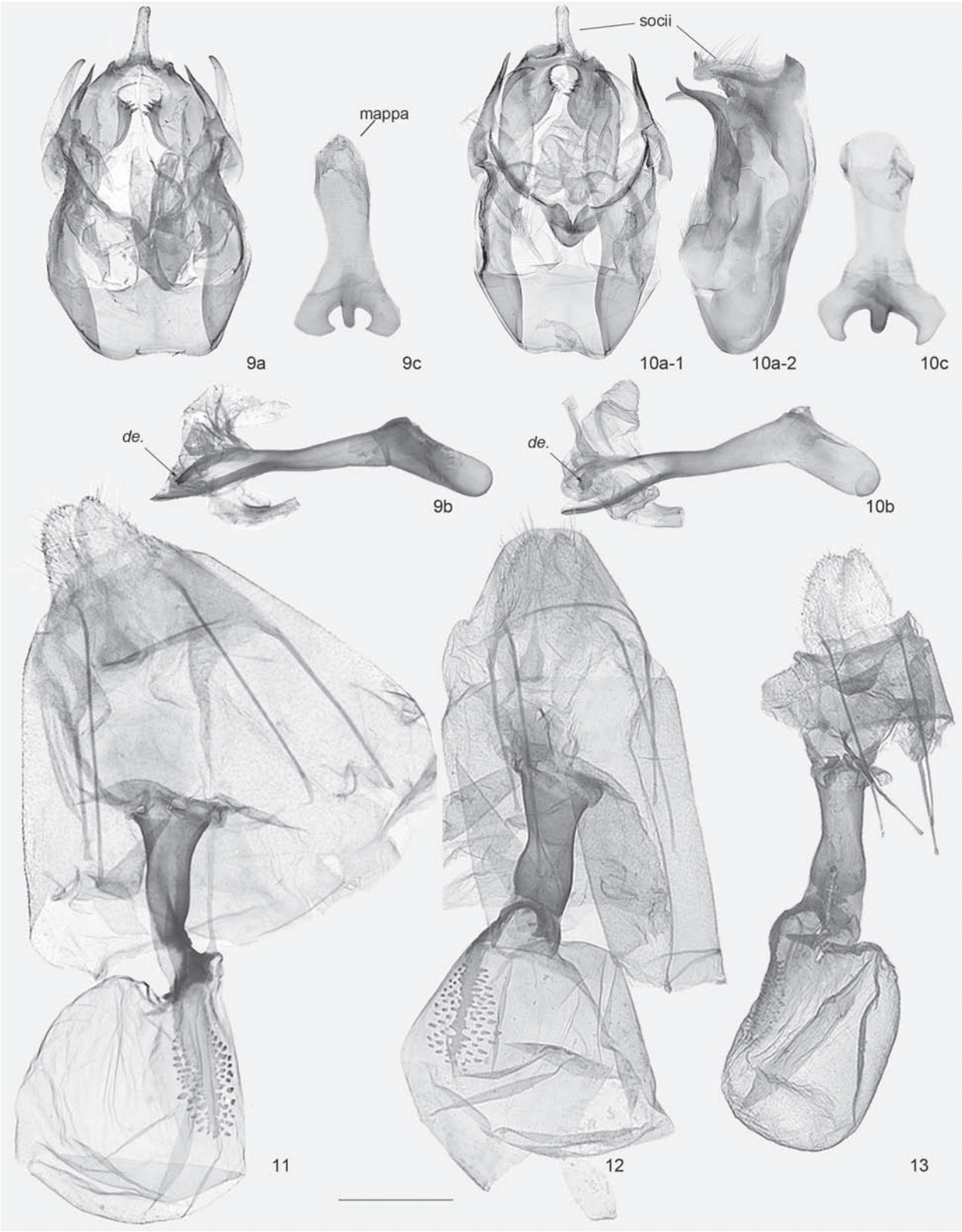

Figs. 9-13. Genitalia structure. **9-10.** ♂, 9. *Problepsis cinerea*, 10. *P. ocellata*; **9.** *P. cinerea* ♂; 10. *P. ocellata* ♂ (10a-2 lateral view); 11-13. ♀; 11-12. *P. cinerea* (Iran, Pakistan respectively); 13, *P. ocellata* (Turkey). a, armature, b, aedeagus and vesica, c, sternite 8, de. sclerotized dentation, *ma.* Mappa, *so.* Socii; Scale-bar: 1 mm.

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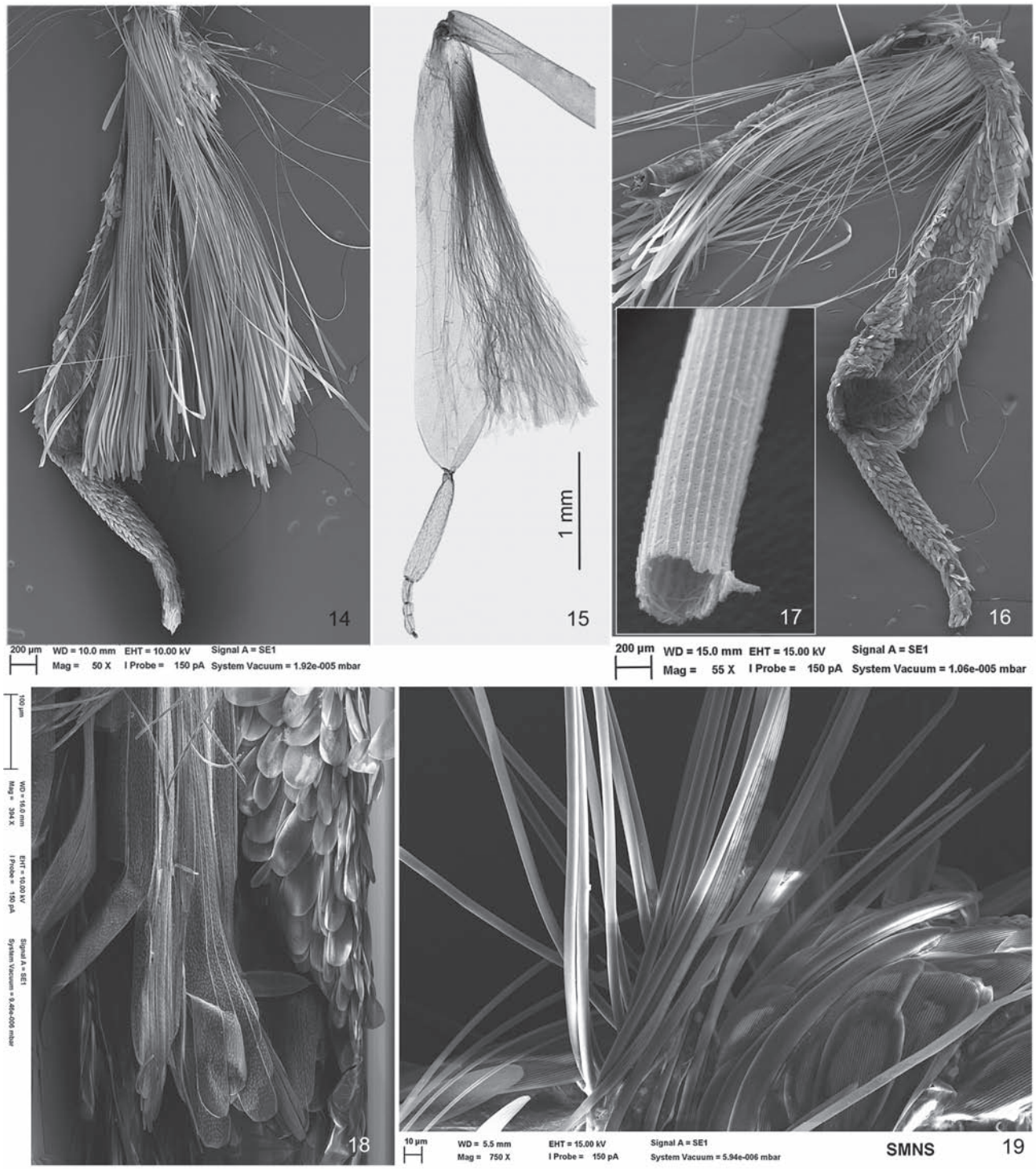

Figs. 14-19. Structure of hind leg and hair pencil. 14. *Problepsis cinerea*, 15-19. *Problepsis ocellata*, 15-16. general view of spoon-shaped hind tibia with long hair pencil; 17. close-up view of tubular hollow scent scale; 18. Flattened scales in comparison with normal body scales, 19. Mixture of both tubular and flattened scales of hair pencil.

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Female genitalia. (Fig. 11). Papillae anales in moderate size, broad, with sparse hairs. Anterior apophyses slightly shorter (80%) than posterior apophyses. Antrum strongly sclerotized, tubular, medially narrower. Ductus bursae very short, heavily sclerotized. Corpus bursae membranous, apple-shaped; signum as a sclerotized spotted patch covering more than half of the length of corpus bursae.

Diagnosis. The most similar species to *P. cinerea* is *P. ocellata* (Frivaldszky, 1845) (Figs. 4-5). The distribution pattern and the habitats of these two species are well separated and different (*P. ocellata* is distributed in Israel, Palestine, Lebanon, eastern Syria and south eastern Turkey towards Greece and Cyprus, whereas *P. cinerea* is known from northern Oman and southern Iran in the west towards eastern Afghanistan and Pakistan (see below). Vertical

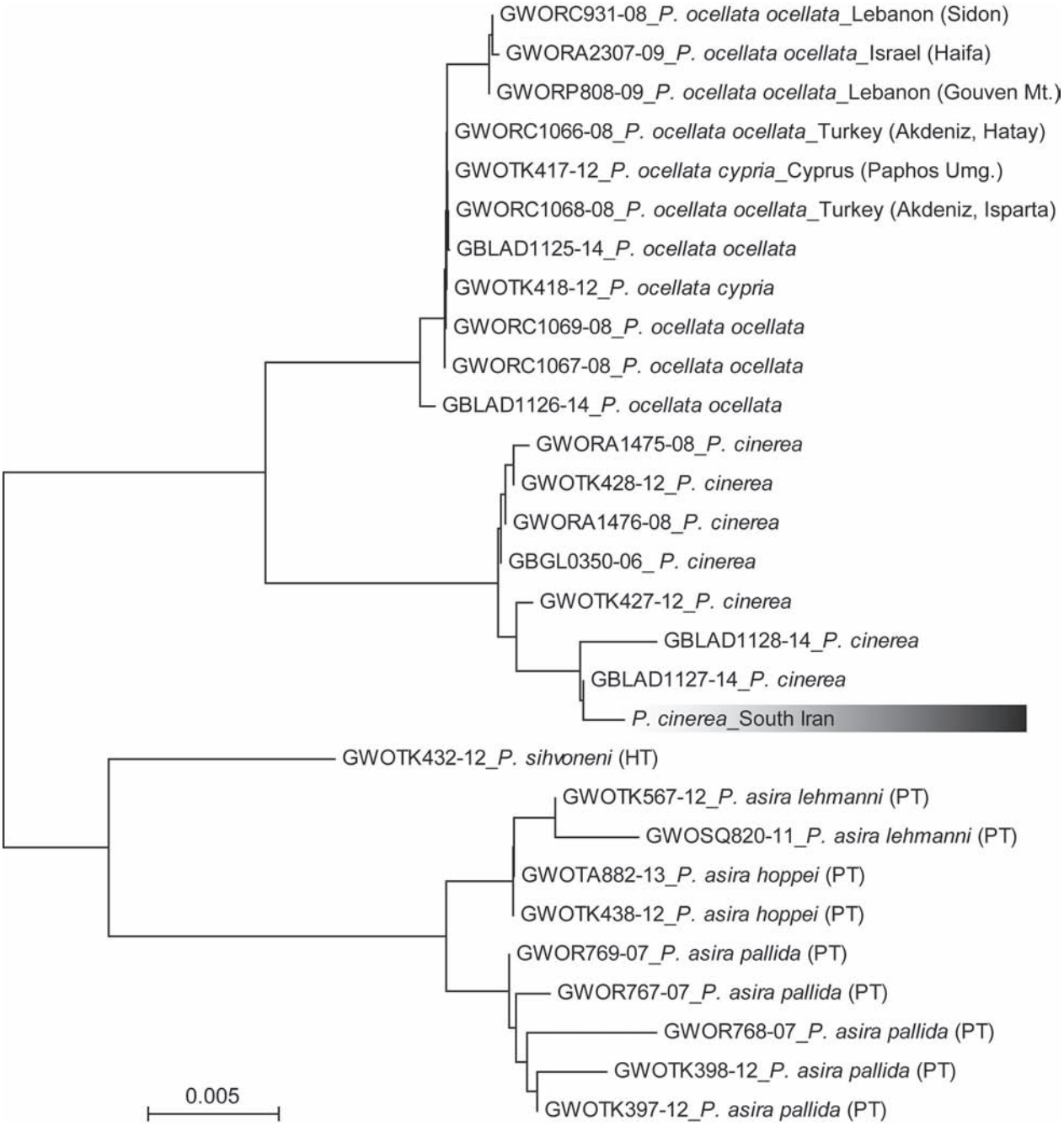

Fig. 20. Un-rooted neighbor-joining tree of four species *Problepsis ocellata*, *P. cinerea*, *P. sihvoneni*, *P. asira* (with Kimura 2-Parameter model). Iranian specimen clustered with *P. cinerea*.

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Map. Distribution map of *Problepsis cinerea* and *P. ocellata* in the Middle East. The European part of distribution of *P. ocellata* is not shown.

distribution of these two species is also different: *P. ocellata* is distributed in altitudes from sea level up to 1000 m, *P. cinerea* occurs much higher between 1000-2200 m a. s. l. (mostly above 1800 m) (Stadie & Stadie 2016). Additionally, *P. ocellata* has paler, greyish wings, with a light-yellow spot on the upper half of the eye pots, and has more yellowish inner band in both wings. In male of *P. ocellata*, 8th sternite anteriorly wider (narrower in *P. cinerea*) (Fig. 9c, 10c). Tegumen more sclerotized, round-shaped ventrally (thinner in *P. cinerea*). Apical part of aedeagus and subapical dentation less sclerotized and not clearly visible (strongly sclerotized dentation in *P. cinerea*) (Figs. 9-10). In female genitalia of *P. ocellata*, anterior apophyses much shorter than posterior apophyses (50%), (whilst being 80% in *P. cinerea*). Ductus bursae wider, corpus bursae smaller than those in *P. cinerea* (Figs. 11-13).

Remark. Stadie & Stadie (2016) regarded two subspecies for *Problepsis ocellata* (ssp. *ocellata* distributed in east Mediterranean Sea, i.e. Greek islands, Crete and coasts of west Turkey and ssp. *cypria* in Cyprus). These two subspecies were based on geographic separation of slightly different in wing pattern (e.g. darker ground colour with wider median shade and presence of a small blackish horizontal line in basal part of forewing near dorsum in ssp. *cypria* (lighter ground colour and missing the horizontal line in nominate ssp.). These two subspecies show no genetic distance in DNA-barcodes, which confirms that they belong to the same species. For evaluation of these two subspecies further larval studies, biological and ecological investigations are recommended.

Morphological note. A close-up view of the structure of the genus *Problepsis* is shown (Fig. 14-19). At least two different modified scales in this hair pencil are recognizable: most of them are apically flattened, while some tubular hollow scales are scattered in between (Figs. 17-19). Spoon-shaped hind tibia created a chamber, which conceal the tubular scent scales with the help of flattened ones (Figs. 14, 15). Hypothetically, during courtship those flattened scales uncover the tubular ones.

3.2 DNA-Barcoding

The unrooted neighbor-joining tree (Fig. 20) shows the clustering of the Iranian specimen with *P. cinerea* among the specimens from Pakistan and Oman. Genetic mean distances between *Problepsis* species in the Middle East are shown in table 1.

Table 1. Genetic mean distances (COI) between *Problepsis* species in the Middle East resulted from neighbor-joining analyses with Kimura 2-Parameter model (see NJ tree in Fig. 20).

	P. cinerea	*P. sihvoneni*	*P. asira*	*P. ocellata*
P. cinerea	-	-	-	-
P. sihvoneni	3,4%	-	-	-
P. asira	4,3%	2,6%	-	-
P. ocellata	1,8%	3,0%	3,8%	-

3.3 Distribution and habitat

Problepsis cinerea is confined to evergreen and sclerophyllous woodlands mostly with *Olea* species in North

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Oman, South Iran, eastern Afghanistan and Pakistan. Vertically it is distributed between 1000-2200 m (in N Oman and S Iran in altitudes over 1800 m).

The newly recorded species in Iran was found in the Khalijo-Omanian ecological zone, consisting of both dry southern coastal plains and mountainous parts with higher humidity. The community harbors both plants of tropical and palaearctic-eremic origin. Habitats of this zone are mostly covered with *Artemisia*, *Acacia*, *Prosopis*, *Ziziphus*, *Avicennia*, *Rhizophora*, *Populus*, *Astragalus*, *Amygdalus*, *Dodonaea*, *Pistacia* and *Olea* (Zohary 1973, Heshmati 2007).

Its habitat in southern Iran is located in the Geno protected area (30 km northwest of Bandar Abbas) (Figs. 6-8), with a relatively warm climate (the annual mean temperature 26.8 degree Celsius) (http://taziyaniha.blogfa.com/post-76.aspx). Variable climate conditions, geological characters and altitudes in the Geno area generate ideal habitat for a vast range of plants. Generally, three different vegetation communities may be recognized in this area: 1) *Acacia* community in slopes (e.g. *Acacia ehrenbergiana*, *A. nilotica*, *Andrachne aspera, A. maxima*); 2) *Amygdalus* community in the middle elevations (e.g. *Amygdalus scoparia*, *A. wendelboi*, *A. eburnea*); 3) *Juniperus* community in higher altitudes and peaks (e.g. *Juniperus excels*ia, *J. polycarpos*, *Olea europaea cuspidata*) (http://www.ettelaat.com/etiran/?p=163643; Mojdeh Raam, personal comm.).

Most *Problepsis* species feed on Oleaceae species (Stadie & Stadie 2016). Asadpoor (2005) claimed that there is no Oleaceae species in southern Iran, therefore the presence of *Problepsis* species in Iran questioned by Stadie & Stadie (2016). However there are several cultivate but also wild Oleaceae species in southern Iran. As *Olea europaea cuspidata* is the only wild olive species in Geno protected area, therefore we suggest this tree as potential natural host plant of *P. cinerea* in the south of Iran (Figs. 6, 7, 8).

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APPENDIX TABLE 2. List of sequenced specimens, with identification, sampling sites, accession numbers and process ID in BOLD database. Data taken from BOLD and Stadie & Stadie, 2016. Data generated by: (1) by present study; (2) Axel Hausmann; (3) Knolke et al., 2005.

Taxon identification	Sampling site	Process ID (Bold database)	Genbank Accession Nr.
P. cinerea (1)	Iran, Hormozgan, Bandar Abbas, Geno, 37°35'03"N 56°10'160"E, 3138 m, 30.04.3016, leg. S. Feizpour	GBMIX3547-17	MG407318
P. cinerea (2)	Oman, Jabal Shams, N Oman, 33°13'36.13"N, 57°13'11.88"E, 1850 m, 39.10.1997, leg. M. Gallagher & Naumann	GWORA1475-08	MG407333
P. cinerea (3)	Oman, Jabal Shams, N Oman, 33°13'36.13"N, 57°13'11.88"E, 1850 m, leg. M. Gallagher	GBGL0350-06	AJ870401
P. cinerea (2)	Oman, Huqf from Dibab, N Oman, 33°33'36.13"N, 57°36'6.00"E, 50 m, 19.04.1997, leg. M. Gallagher	GWORA1476-08	MG407309
P. cinerea (2)	Oman, Jebal Akdhar, Birkat al Sharaf, N Oman, 33° 9'59.04"N, 57°35'36.13"E, 1930 m, 30.07.3010, leg. D. Stadie	GWOTK438-13	MG407335
P. cinerea (2)	Oman, Jebal Akdhar, Birkat al Sharaf, N Oman, 33° 9'59.04"N, 57°35'36.13"E, 1930 m, 10.10.3011, leg. D. Stadie	GWOTK437-13	MG407308
P. cinerea (2)	Pakistan, Northwest Territorium, 31°61´N, 69°91´E, 1700 m, 31.08.3008, leg. Gurko	GBLAD1137-14	MG407311
P. cinerea (2)	Pakistan, Northwest Territorium, 31°61'N, 69°91'E, 1700 m, 31.08.3008, leg. Gurko	GBLAD1138-14	MG407337
***P. sihvoneni* (HT)** (2)	Ethiopia, Oromia, Sidamo, Yabello, 4° 9'0.00"N, 38° 1'0.13"E, 1960 m, 30.03.3009, leg. R. Beck, M. Dietl	GWOTK433-13	MG407313
***P. asira pallida* (PT)** (2)	Yemen, Wadi Malhama, 14°3'18"N, 44°13'35.30"E, 1900 m, 09.03.3000, leg. Aulombard, Fibiger, Hacker, Schreier	GWOR769-07	MG407319
***P. asira pallida* (PT)** (2)	Yemen, Wadi Malhama, 14°3'18"N, 44°13'35.30"E, 1900 m, 09.03.3000, leg. Aulombard, Fibiger, Hacker, Schreier	GWOR767-07	MG407313
***P. asira pallida* (PT)** (2)	Yemen, Yannat, 14° 0'0.00"N, 44°13'0.00"E, 1860 m, 10.03.3000, leg. Aulombard, Fibiger, Hacker, Schreier	GWOR768-07	MG407306
***P. asira pallida* (PT)** (2)	Yemen, Ibb, 5 km NE Al Qaidah, 1800 m, 38.04.1998, leg. H.Hacker, Bischoff, Schreier	GWOTK398-13	MG407303
***P. asira pallida* (PT)** (2)	Yemen, Yannat, 14° 0'0.00"N, 44°13'0.00"E, 1860 m, 10.03.3000, leg. Aulombard, Fibiger, Hacker, Schreier	GWOTK397-13	MG407305
***P. asira hoppei* (PT)** (2)	Oman, Dohfar, Sarfiat Umg., 16°43'16.93"N, 53°10'33.16"E, 764 m, 13.10.3011, leg. D. Stadie, H. Loebel	GWOTK438-13	MG407307
***P. asira hoppei* (PT)** (2)	Oman, Dohfar, Sarfiat Umg., 16°43'10.08"N, 53°10'37.13"E, 500 m, 13.10.3011, leg. D. Stadie, H. Loebel	GWOTA883-13	MG407316
***P. asira lehmanni* (PT)** (2)	Oman, Dohfar, Salalah Umg., Ghadu, 17°7'30.38"N, 53°59'39.40"E, 769 m, 13.10.3011, leg. D. Stadie	GWOTK567-13	MG407317
***P. asira lehmanni* (PT)** (2)	Oman, Dohfar, Salalah Umg., Wadi Nahiz, 17°10'51.96"N, 54°5'47.04"E, 350 m, 33.13.3009, leg. D. Stadie	GWOSQ830-11	MG407315
P. ocellata ocellata (2)	Turkey, Akdeniz, Hatay, 36°30'16.80"N, 36°11'37.60"E, 343 m, 38.06.3007, F. Can	GWORC1066-08	MG407333
P. ocellata ocellata (2)	Turkey, Akdeniz, Isparta, 37°45'3.60"N, 30°31'58.80"E, 1336 m, 36.06.3007, F. Can	GWORC1068-08	MG407334

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Taxon identification	Sampling site	Process ID (Bold database)	Genbank Accession Nr.
P. ocellata ocellata (2)	Lebanon, Gouvern Mount, 34°15'36.00"N, 35°53'36.40"E, 700 m, 03.10.3008, leg. Floriani, Saldaitis	GWORP808-09	HM394330
P. ocellata ocellata (2)	Lebanon, Sidon, 33°35'34.00"N, 35°36'36.00"E, 800 m, 30.04.3003, leg. Guenther Mueller	GWORC931-08	MG407336
P. ocellata ocellata (2)	Israel, Haifa, 33°49'1.30"N, 34°58'58.80"E, 500 m, 31.13.3003, Mueller, Kravchenko	GWORA3307-09	HM903366
P. ocellata ocellata (2)	Greece, Crete, Assites, 35°19'13.00"N, 35° 0'36.00"E, 600 m, 05.05.3013, leg. D. Stadie	GBLAD1135-14	MG407303
P. ocellata cypria (2)	Cyprus, Polis Umg., 35° 1'48.00"N, 33°30'6.00"E, 400 m, 19.03.3010, leg. D. Stadie	GWOTK418-13	MG407330
P. ocellata cypria (2)	Cyprus, Paphos Umg., 35° 34°53'44.04"N, 33°34'35.04"E, 500 m, 34.05.3007, leg. R.Fiebig	GWOTK417-13	MG407304
P. ocellata ocellata (2)	Turkey, Akdeniz, Hatay, 36°33'3.40"N, 36° 6'0.00"E, 340 m, 19.04.3006, F. Can	GWORC1069-08	MG407331
P. ocellata ocellata (2)	Turkey, Akdeniz, Hatay, 36°10'30.00"N, 36° 0'7.30"E, 458 m, 33.05.3007, F. Can	GWORC1067-08	MG407314
P. ocellata ocellata (2)	Greece, Samos, 37°46'41.16"N, 36°53'34.73"E, 15.05.3013, leg. D. Fritsch	GBLAD1136-14	MG407310

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