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Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775 in Iran (Zygaenidae). Part VIII: Bionomics of high-mountain species in the Alborz Mountains and adjacent areas (introduction; *Z. speciosa*, *Z. cacuminum*)

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Abstract. This is the first of three articles on the burnet moths (*Zygaena* Fabricius, 1775) of the oreal biome in northern Iran. The species of the northern mountain ranges inhabit biotopes in the cushion zone around and above the tree line between 2,650 m and 4,000 m above sea level. Four species are endemic to the Alborz (*Zygaena speciosa* Reiss, 1937, *Z. cacuminum* Christoph, 1877, *Z. ecki* Christoph, 1882) and adjacent areas in Azerbaijan (*Z. christa* Reiss & Schulte, 1967). Populations of a more widely distributed species – *Zygaena carniolica* (Scopoli, 1763) – also occur in the same vertical zone. However, these populations are separated from those of lower regions by a gap of nearly 500 m. Moreover, they possess very characteristic phenotypic and biological adaptations and are well distinguishable. For the first time, *Zygaena speciosa* is recorded from regions outside of the Alam-Kuh area (type locality), i.e. in four localities located in the provinces of Gilan, Mazandaran and Tehran. Data on the bionomics of *Z. speciosa* are provided for the first time; all preimaginal stages are figured. In 2005, 2006 and 2007, cocoons and half and fully grown larvae were found at Kuh-e Tochal (north of Tehran) at an altitude of 3,400–3,700 m. The larvae feed on *Semenovia tragioides* (Boiss.) Manden, a white-flowered Apiaceae. The results of an ab ovo culture (2005–2007) are presented. In 2006, two new and well-distinguished populations were found on Kuh-e Samamus (near Ramsar) and on a pass named Gardeneh-ye Tondrokosch (Tonekabon S). Moths and larvae of the more eastern populations are significantly different from those occurring further west. Larvae at Kuh-e Samamus feed on three distinct Apiaceae (*Trachydium eriocarpum* Born. & Gauba, *T. depressum* (Bois.) Bois. and a further, undetermined species that probably belongs either to the genus *Peucedanum* or to *Semenovia*). Smaller larvae that were collected in the wild (on Kuh-e Tochal and on Kuh-e Samamus) and all larvae from this ab ovo culture over-wintered for a second time. Presumably this is not an artefact but a general strategy of this high-mountain species. Hitherto, the closely related *Zygaena cacuminum* was known only from its type locality, but in 2005 it was discovered at two sites on Kuh-e Shahvar, around 25 km as the crow flies from the Kuh-e Gawkoshan in the Shahkuh range.

Zusammenfassung. Beitrag zur Kenntnis des Genus *Zygaena* Fabricius, 1775 im Iran (Lepidoptera: Zygaenidae). Part VIII: Bionomie der Hochgebirgsarten des Elbursgebirges und anschließender Regionen (Einführung; *Z. speciosa*, *Z. cacuminum*). – Bei der vorliegenden Arbeit handelt sich um den ersten von drei geplanten Artikeln über die Rotzygaenenarten (*Zygaena* Fabricius, 1775) des orealen Lebensraums im Nordiran. Die nördlichen Hochgebirgsarten besiedeln Lebensräume der Dornpolsterstufe im Bereich der oberen Baumgrenze und höher zwischen 2.650 m und 4.000 m Höhe. Vier Hochgebirgsarten sind Endemismen des Elbursgebirges (*Zygaena speciosa* Reiss, 1937, *Z. cacuminum* Christoph, 1877, *Z. ecki* Christoph, 1882) und der anschließenden Regionen Azarbaidjans (*Z. christa* Reiss & Schulte, 1967). Die weiter verbreitete *Zygaena carniolica* (Scopoli, 1763) kommt in der gleichen Höhenstufe vor. Diese Vorkommen sind von *carmiolica*-Populationen tieferer Lagen durch eine Lücke von fast 500 Höhenmetern getrennt. Auffällige habituelle und präimaginalbiologische Unterschiede sind gut entwickelt. *Zygaena speciosa* wird erstmals außerhalb ihrer Typenlokalität im Alam-Kuh-Gebiet gemeldet. Inzwischen konnte die Art an fünf Fundstellen in den Provinzen Gilan, Mazandaran und Teheran nachgewiesen werden. Die Biologie von *Z. speciosa* wird erstmals beschrieben, alle präimaginalbiologischen Stadien werden abgebildet. Raupen und Kokons konnten 2005, 2006 und 2007 nördlich Teheran am Kuh-e Tochal zwischen 3.400 und 3.700 m Höhe gefunden werden. Die Raupen leben hier an der Apiaceae *Semenovia tragioides* (Boiss.) Manden. Die Ergebnisse einer ab-ovo-Zucht (2005–2007) werden vorgestellt. 2006 wurden zwei weitere, wohldifferenzierte Populationen am Kuh-e Samamus bei Ramsar und am Gardaneh-ye Tondrokosch (südlich Tonekabon) gefunden. Falter und Raupen sind von den östlichen Populationen deutlich verschieden. Interssanterweise sind die Raupen der östlichen Vorkommen, deren Falter stark melanistisch sind (Alam-Kuh, Kuh-e Tochal, Dizin-Shemshak) weniger stark verdunkelt, als die Raupen der westlichen Populationen, deren Variabilität im Imaginalphenotyp keine verdunkelten Hinterflügel beinhaltet. Die Raupen am Kuh-e Samamus leben an drei verschiedenen Apiaceae-Arten (*Trachydium eriocarpum* Born. & Gauba, *T. depressum* (Boiss.) Boiss.) und einer weiteren, nicht näher bestimmbaren

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Apiaceae (wahrscheinlich *Peucedanum* sp. oder *Semenovia* sp.). Im Freiland gefundene kleine Raupen (sowohl vom Kuh-e Tochal als auch vom Kuh-e Samamus) sowie alle Raupen der ab-ovo-Zucht überwinterten ein zweites Mal. Es wird vermutet, daß dies eine generelle Strategie dieser Hochgebirgsart darstellt. *Zygaena cacuminum*, bislang nur von der Typenlokalität bekannt, wird erstmals vom Kuh-e Shavar, einem Gebirgsstock ca. 25 km Luftlinie vom Shahkuh entfernt, gemeldet.

در ایران (لپیدوپترا: زیگنیده) قسمت هشتم: اطلاعات زیست شناختی گونه های *Zygaena* Fabricius, 1775 مقاله ای در مورد ساکن ارتفاعات البرز و مناطق همجوار (مقدمه: *Zygaena cacuminum* Christoph, 1877, *Zygaena speciosa* Reiss, 1937: خلاصه) ساکن بیوم اورنال در ایران مورد بحث قرار گرفته *Zygaena* Fabricius, 1775 در این مقاله شب پره های "زیگنا" اند، گونه هایی که در بیوتوپهای رشته کوههای شمالی ایران در منطقه ی بوته زار از حدود خط رویش درختان به بالا، بین 2650 و 4000 متر از سطح دریا زندگی میکنند. چهار گونه از این گونه ها در منطقه ی البرز و آذربایجان آندمیک هستند: در البرز *Zygaena speciosa* Reiss, 1937، *Z. cacuminum* Christoph, 1877، *Z. ecki* Christoph, 1882 و در مناطق همجوار ، شب پره ای که در منطقه ی وسیعی *Z. carniolica* (Scopoli, 1763) آذربایجان *Z. christa* Reiss & Schulte, 1967 انتشار دارد، درهمان محیط و همان ارتفاع از سطح دریا زندگی می کند که آندمیکهای نامبرده نیز می زیند. البته محل این جمعیتهای جداست و نیز از نظر ارتفاع، دیگر جمعیتها در ارتفاع *Z. carniolica* (Scopoli, 1763) ساکن مناطق مرتفع از سایر جمعیتهای کمتری (حد اقل حدود 500 متر پایینتر) هستند. علاوه بر این، خصوصیات فنوتیپی و انطباق بیولوژیکی شان آنها را به وضوح از هم متمایز می نماید. در این مقاله برای اولین بار *Z. speciosa* Reiss, 1937 (یعنی علم از محلی غیر از تایپ-لوکالیته ی اصلی اش کوه) گزارش می شود. در ضمن نمونه های این گونه از پنج نقطه ی دیگر در استانهای گیلان، مازندران و تهران نیز کشف گردید. در اینجا اطلاعات مربوط به بیونومی کامل *Z. speciosa* Reiss, 1937 برای اولین بار ارائه و تمام مراحل تکاملی این شب پره تشریح میگردد. در سالهای 2005، 2006 و 2007 م. پیله، لارو نیمه بالغ و بالغ در کوه توچال در شمال تهران در ارتفاع 3400 الی 3700 متری پیدا شد. لاروها از گیاه *Semenovia tragioides* (Boiss.), Manden که یک Apiaceae با گلهای سفید است تغذیه میکنند. نتایج پرورش آزمایشگاهی این شب پره از مرحله ی تخم (سالهای 2005 الی 2007 م.) در اینجا گزارش می شود. در سال 2006 م. دو جمعیت جدید کاملا" متمایز در کوه سماموس (نزدیک رامسر) و گردنه ی تندروکش (در جنوب تنکابن) پیدا شدند. پروانه و لارو این جمعیت ها به وضوح از جمعیت های شرقی تر متفاوتند. لاروهای کوه سماموس از سه گونه ی مختلف Apiaceae تغذیه می کنند: *T. depressum* (Boiss.), Boiss.، و یک Apiaceae غیر قابل شناسایی، *Trachydium eriocarpum* Born. & Gauba یا *Semenovia* sp. پیدا شدند. پروانه و لارو احتمالا" گونه ی *Peucedanum* sp. چه لاروهای کوچکی که در طبیعت (در کوههای توچال و سماموس) پیدا شدند و چه آنهایی که در آزمایشگاه از مرحله ی تخم پرورش یافته اند، همه دو بار به خواب زمستانی رفتند. به نظر می رسد که این پدیده آرتیفکت نبوده بلکه استراتژی کلی برای این گونه ی ساکن کوهستانهای مرتفع باشد.

Introduction to the series

The series "Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775, in Iran" began in 2000 in *Linneana Belgica*, in which seven parts were published. With the tragic death of its editor, Ronny Leestmans (26.vii.1942–8.xii.2006), the journal ceased to be published. We dedicate the present article to him in memory and recognition of all his support and help during that time.

Fortunately the editorial committee of *Nota lepidopterologica* kindly offered to continue the series in an equivalent presentation. Short summary of the first seven parts will help the reader to get acquainted with the work accomplished so far.

Part 1 (Hofmann 2000a). This is a general chapter presenting the entomological exploration of the fauna of Iran and the development of our knowledge on the indigenous *Zygaena* species. A check-list with distribution based on provinces is provided. The systematic part begins with *Z. seitzi, Z. nocturna*, and *Z. manlia*. New records are provided for Fars, Boyer Ahmad-va-Kohgiluyeh, Markazi, Kuh-e Sorkh, Birjand and the mountains south-west of Kashan. The biology of all three species is described. Based on intensive fieldwork, the nocturnal activity of *Z. nocturna* is confirmed and its relationship to *Z. seitzi* is discussed. A new subspecies of *Z. manlia* (ssp. *piti*) is described from the provinces of Hamadan and Lorestan.

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Part 2 (Hofmann 2000b) discusses populations hitherto referred to *Z. rubricollis*. New locality records are given for Yazd, Hamadan, Kerman, and Fars. The biology of *Z. rubricollis kermanensis* – to be transferred in a forthcoming article as a subspecies of *Z. qashqai* – is described. The most melanistic *Zygaena* population is described as *Z. rubricollis ginnereissi*. Today the status of this taxon is under discussion as a valid species (Keil 2003c).

Part 3 (Hofmann 2000c) discusses the distribution and zoogeography of *Z. haematina*. Its biology is also described and figured. With J. Klir as co-author, a new subspecies is named from Lorestan (ssp. *lorestanensis*).

Part 4 (Hofmann (2000d) provides the descriptions of two new subspecies of *Z. haematina* from Darreh Kamaran (ssp. *aurora*) and from the isolated mountain range of Kuhha-ye Quorud (ssp. *fusca*), the latter having been raised to species level by Keil (2003a, 2003d) and Efetov (2004: 40) (without any explanations). The complete biology of *Z. cacuminum* is also described and figured.

Part 5 (Hofmann & Tremewan 2001) deals with the polymorphism of *Z. tamara* and its distribution, for which new records are given for several provinces. Its biology is also described and figured.

Part 6 (Hofmann & Tremewan 2003) raises or reinstates *Zygaena nocturna, Z. aisha*, and *Z. fredi* as well-defined biospecies. The behaviour of the nocturnal *Z. nocturna* is treated and compared with that of *Z. seitzi*, which is strictly diurnal. A new subspecies of *Z. nocturna* is described from the vicinity of Eqlid (Esfahan) and its biology is also described and figured (ssp. *meinekei*). *Zygaena aisha* with predominant nocturnal activity and a very significant larval phenotype is distinguished as a distinct biospecies from *Z. manlia*. From the vicinity of Semirom, *Z. fredi syntopica* and the dichromatic *Z. rubricollis tenhageni* are described. The complete biology of the latter is described and figured.

Part 7 (Hofmann & Tremewan 2005) treats the *Zygaena* fauna of the highest mountain in the Zagros range – the Zarde Kuh. In addition to new distribution records for *Z. seitzi* and *Z. cambysea*, a new biospecies is described from this region (*Z. bakhtiyari*). From the nearby Kamaran valley a unique subspecies of *Z. cambysea* with red, orange, and yellow phenotypes is described (ssp. *kamarana*).

The high-mountain endemics

The *Zygaena* fauna of Iran is characterised by a high percentage of species that occur exclusively in the Alborz or Zagros mountains or in adjacent areas (Tab. 1).
Four *Zygaena* species are endemic to the northern mountain ranges south of the Caspian Sea, between Azerbaijan and the eastern Alborz. While *Zygaena speciosa* Reiss, *Z. cacuminum* Christoph, and *Z. ecki* Christoph, are known only from the Alborz range, *Z. christa* Reiss & Schulte, is restricted to Azerbaijan in the neighbourhood of Dugijan (NE Marand). All four species are restricted to high-mountain areas above

Tab. 1. Altitudinal distribution of the high-mountain *Zygaena* species of Iran. – Northerly and southerly distributed species are listed according to the average of their altitudinal appearance, indicating their ecological and altitudinal main centres. [1] Only personal records are taken into account as in former times the altitudes were often given for too large an area or were often estimated, incorrect or unreliable. [2] Every record is counted here as one date, e.g. when a site was cited as 2,900–3,000 m, the arithmetic mean of 2,950 m is taken into account. In obtaining an *average*, every single mean was counted and divided by the numbers of sites. [3] The new records and a new taxon will be published in a separate publication. [4] The highest record is from the literature (Reiss 1938). [5] There are specimens from a few more localities with reliable data recorded by other collectors; the altitudes mentioned on the labels are within the same zone. [6] Only the very distinct high-mountain populations of this species are taken into account. [7] The second biotope was discovered in 2006 on Sultan Zanjir Dagh (Tabriz NNW).

species		Number of sites[1]	Lowest and highest record	Average[2]	Vertical span	Endemic to	Latitudinal limitation
Northern mountain ranges	***Z. speciosa***	5[3]	3,270–4,000[4] m	3,484 m	730 m	Alborz	36°50' – 35°52'
	Z. cacuminum	3	2,900–3,720 m	3,328 m	820 m	Alborz	36°37' – 36°32'
	Z. carn. transiens	10[5]	2,650–3,800[6] m	3,307 m	820 m	Alborz	36°50' – 35°44'
	Z. ecki	4[5]	2,650–3,720 m	3,146 m	1.070 m	Alborz	36°37' – 35°55'
	Z. christa	2[7]	3,050–3,150 m	3,100 m	100 m	Azerbaijan	38°35' – 38°32'
Southern mountain ranges	***Z. fusca***	2	2,900–3,200 m	3,025 m	300 m	Kuhhaye Qorud	33°27' – 32°53'
	Z. haematina	24[5]	2,350–3,500 m	2,768 m	1.150 m	Zagros	37°59' – 29°37'
	Z. aisha	3	2,400–3,100 m	2,856 m	700 m	Kerman	29°09' – 29°01'
	Z. bakhtiyari	1	2,800–3,100 m	2,950 m	300 m	Zagros	32°08'

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the tree line between 2,600 and 4,000 m altitude. Surprisingly, the same zone is inhabited by very distinctive and relatively uniform populations of *Zygaena carniolica* (Scopoli, 1763), an extremely widespread species that ranges from southern Spain to the Altai mountains, with many populations in the Mediterranean region representing extraordinary subspecies. Several subspecies are described from northern Iran, all of them belonging to the same ecotype that is found only in the cushion zone above and around the tree line. This ecotype of *Z. carniolica* (with a white spot 6, reduced or lost abdominal cingulum, darkened larval phenotype and dark pupal exuviae) is found in several localities where it is syntopic with *Z. ecki*. It is distributed from the Kuh-e Samamus region south of Ramsar to the Kendevan and Demavand region and extends further east to the Shah-Kuh mountain range. The other three species were hitherto known only from their type-localities although a second subspecies of *Z. speciosa* was described. However, this nominal taxon is derived from a population occurring in the same valley just about 2–3 km further south and higher up than the nominotypical form.

Further south in Iran, in the more eremic Zagros, in the Kuhha-ye Quorud and in the higher areas of the Kerman region, a few more species have predominantly settled in this altitudinal zone (Tab. 1): *Zygaena haematina* Kollar (and *Z. fusca* Hofmann), *Z. aisha* Naumann & Naumann, and *Z. bakhtiyari* Hofmann & Tremewan. While the species from the Alborz and adjacent areas (*Z. speciosa, Z. cacuminum, Z. ecki, Z. christa* and *Z. carniolica transiens* Staudinger) are easily recognised as oreal faunal elements, the categorisation of the other four species remains unsatisfactory. They are probably xeromontane species although their ecological niches are not easily recognisable. Their lower occurrence is contrary to expectations, as they inhabit more southerly regions. This may be due to lack of investigations but could also be a feature of this ecological group because in the eremic regions the rainfall decreases at higher altitudes and that makes the biotopes suboptimal from a certain level upward. However, it must be emphasised that in the Zagros range and in the province of Kerman the regions between 3,300 and 4.000 m altitude are poor and only very locally explored (Hofmann 2000a).

While biological data and colour plates (Tab. 2) of all preimaginal stages are available for *Z. haematina* (Hofmann 2000c, 2000d), *Z. cacuminum* (Hofmann 2000d), *Z. aisha* (Hofmann & Tremewan 2003), and *Z. carniolica transiens* Staudinger (as *demavendi* Holik; Tremewan 1976, 1977), nothing was hitherto known about *Z. speciosa* and only the cocoon of *Z. bakhtiyari* is figured (Hofmann & Tremewan 2005). Data for *Z. ecki* and *Z. fusca* are unpublished and for *Z. christa* they are incomplete (Naumann 1985; Karami et al. 1999b). Regarding Tab. 2, with reference to the aspect of the growth of knowledge, one becomes aware how successful fieldwork has been since 1997 when the "new cooperation" started. This network lead to the foundation of the Association Lepidoptera Iranica (A.L.I.) project (Hofmann & Trusch 2006). During the coming years it should be possible to close the remaining gaps by successfully rearing *Z. christa* or finding the unknown preimaginal stages of *Z. bakhtiyari*.

As expected, the species with the most extensive range – vertically and horizontally – and relatively low distribution has the highest number of accompanying *Zygaena*

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Tab. 2. Available biological data on the high-mountain *Zygaena* species of Iran. – Explanation of notes: [1] In 2005 B. Mollet and A. Hofmann found this species east of the type locality at Kuh-e Shahvar kucek and Kuhe Shahvar bozorg. Furthermore, there is an unconfirmed record from "Kuh-e Aladagh, Shogan" (vide J. Mooser). [2] There are specimens from a few more localities with reliable data recorded by other collectors; the altitudes mentioned on the labels are within the same zone. Together with *Z. cacuminum*, this species was also found at Kuh-e Shahvar kucek and Kuh-e Shahvar bozorg. Moreover, there is an unconfirmed record from "Kuh-e Bozqush, Siyah-Chaman" (vide J. Mooser). [3] Hitherto unpublished.

species		Number of loc. to 1965	Number of loc. 1965-80	Number of loc. 2007	Data available for:				Authors
					Egg	Larva	Cocoon	Ethology	
Northern mountain ranges	***Z. speciosa***	1	1	5	2007	2007	2007	1937, 2007	Reiss 1937a, 1937b, 1938
	Z. cacuminum	1	1	3[1]	2000	2000	2000	2000	Hofmann 2000c
	Z. carn. transiens	4	5	16	1976	1976, 2007	1976, 2007	1976, 2007	Tremewan 1976, 1977
	Z. ecki	2	3	5[2]	2007	2007	2007	1977	Tremewan 1977
	Z. christa	0	1	2[3]	1985, 2007	1985, 2007	–	1985, 2007	Naumann 1985
Southern mountain ranges	***Z. fusca***	0	0	2	2007	2007	2007	2000, 2007	Hofmann 2000d, Keil 2003d
	Z. bakhtiyari	0	0	1	–	–	2005	2005	Hofmann & Tremewan 2005
	Z. aisha	0	1	3	2003	2003	2003	2003	Hofmann & Tremewan 2003
	Z. haematina	2	3	24	2000	2000	2000	2000	Hofmann 2000c, 2000d

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Tab. 3. The high-mountain *Zygaena* species of Iran (vertically listed) and their syntopy (●), with accompanying oreal, arboreal and eremic species (horizontally listed) in the Alborz (A), the Zagros (Z) and/or in the mountains of the areas around Kerman (K). Only in the Alborz is there more than one high-mountain species at one site. While *Z. speciosa* and *Z. cacuminum* are syntopic only with other oreal species, *Z. carniolica transiens* and *Z. ecki* occur with species of a lower vertical distribution, viz. *Z. cambysea, Z. haberhaueri* and *Z. rosinae*. In the Zagros range and in Kerman, no syntopy of high-mountain species with other high-mountain species is observed. Here they are predominantly syntopic with species of the eremic biome.

		Oreal species of Alborz and adjacent areas					**High-mountain species of Zagros and Kerman**				**Syntopic non-high-mountain species of Alborz (A), Zagros (Z), Kerman (K)**											
		speciosa Reiss, 1937	*cacuminum* Christoph, 1877	*carniolica* Scopoli, 1763	*ecki* Christoph, 1882	*christa* Reiss & Schulte, 1967	*fusca* Hofmann 2000	*bakhtiyari* Hofmann & Tremewan, 2005	*aisha* Naumann & Naumann, 1980	*haematina* Kollar, 1849	*haberhaueri* Lederer, 1870 A	*rosinae* Korb, 1903 AZ	*cambysea* Lederer, 1870 AZ	*tamara* Christoph, 1889 AZ	*seitzi* Reiss, 1938 Z	*nocturna* Ebert, 1974 Z	*escalerai* Poujade, 1900 Z	*manlia* Lederer, 1870 Z	*fredi* Reiss, 1938 ZK	*chirazica* Reiss, 1938 ZK	*sengana* Holik & Sheljuzhko, 1956 K	*ginnereissi* Hofmann, 2000 K
Oreal species of Alborz and adjacent areas	***Z. speciosa***	–		●																		
	Z. cacuminum		–	●	●																	
	Z. carn. transiens	●	●	–	●						●	●	●									
	Z. ecki		●	●	–						●	●	●									
	Z. christa					–					?			?								
High-mountain species of Zagros and Kerman	***Z. fusca***						–											?		?		
	Z. haematina							–				●	●	●	●	●	●	●	●	●		
	Z. aisha								–										●	●	●	●
	Z. bakhtiyari									–			●		●				●	●		

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species. *Zygaena haematina* is recorded from 24 localities situated between Hakkari (Turkey) and Dasht-e Arjan (Iran, Fars) and within this range it is syntopic with nine species. *Zygaena aisha* inhabits biotopes together with *Z. ?rubricollis ginnereissi, Z. chirazica* and *Z. sengana* while *Z. haematina* and *Z. bakhtiyari* are syntopic with several arboreal species, e.g. *Z. chirazica, Z. fredi, Z. tamara, Z. cambysea, Z. manlia, Z. nocturna*. No syntopy is observed for *Z. fusca* and *Z. christa*. Syntopy with other oreal *Zygaena* species can only be confirmed for the Alborz species. *Zygaena cacuminum* is accompanied on Shah-Kuh and Kuh-e Shahvar by *Z. ecki* and *Z. carniolica*. *Zygaena speciosa* is found in all its localities flying together with *Z. carniolica* (Tab. 3) .

In the present paper and two others, forthcoming, new data on the biology and distribution of these high-mountain species will be presented, beginning here with *Zygaena speciosa* and *Z. cacuminum*.

Abbreviations

CAHO	Collection Axel Hofmann, Breisach-Hochstetten, Germany.
CCMN	Collection Clas M. Naumann, now in ZFMK, Bonn.
CFDM	Collection Franz Daniel, München (Munich), now in CMWM.
CMWM	Museum Thomas J. Witt, München, Germany, assigned to Zoologische Staatssammlung München.
ZFMK	Zoologisches Forschungsmuseum A. Koenig, Bonn, Germany.

Zygaena speciosa Reiss, 1937

"*Zygaena* (*Peristygia*) *speciosa* n. spec." Reiss, 1937a: 466, figs a2, b2, c2. Type locality: "Persia s., Elburs mts. s., Tacht i Suleiman, Hecarčal-Tal, 28–3200 m" (acc. label of "Type ♂"). (see distribution map, loc. no. 3).

„*Zyg.* (*Peristygia*) *speciosa* Reiß var. *suleimanicola* n. var." Reiss 1938: 165. Type locality: "Persia sept., Elburs mts. c. s., Tacht i Suleiman, Särdab Tal (Hećerčam), 4200 m" (acc. label of "Type ♂"). (see distribution map, loc. no. 4).

The original description of *Z. speciosa* was based on 16♂, 6♀ collected by E. Pfeiffer on "3–7.VII.36". The "Type ♂" and "Type ♀" are figured in monochrome and recorded as being deposited in coll. F. Daniel/München. Both specimens together with the paratypes (also from coll. Reiss) are now in coll. T. Witt/München. Single paratypes are in coll. C. M. Naumann (now Zoologisches Forschungsmuseum Bonn) and coll A. Hofmann.

The original description of *Z. speciosa* var. *suleimanicola* was based on 125♂, 42♀ collected by E. Pfeiffer & W. Forster on "20.VII.37". Type series in coll. T. Witt/ München via coll. F. Daniel/München. Paratypes in several collections (coll. C. M. Naumann, now Zoologisches Forschungsmuseum Bonn, coll. A. Hofmann etc.). Synonymised by Hofmann & Tremewan (1996).

Reiss (1937a, 1938) has provided detailed descriptions of the moths of both taxa; they were collected in a north-facing valley called *Sardab* (cold water) valley, south-east of

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the highest point in this area, the Alam Kuh (4,850 m). The type localities are about three kilometres from each other as the crow flies. While the nominotypical form is found at 3,000 m altitude, just after passing *Tange Golu* (narrow gorges), var. *suleimanicola* was discovered above the high valley of Hezarchal, from where a pass (Hezercham) leads to the southern side. In between these two localities (3,700 m), Clas Naumann and Gerry Tremewan collected a total of four specimens on 28.vii.1997 in the high valley of Hezarchal (Figs 4–5) thus documenting that gene flow occurs between the populations. All specimens from this area are melanistic with darkened hindwings and reduced spots on the forewings. They are purely five spotted without any trace of a spot 6. While nearly 50% of the moths from higher up (4,200 m) have spot 4 reduced or even lost, the phenotypes from below 1,000 m show slightly more pronounced forewing spots. Apart from that, no significant differences are found, which is why Hofmann & Tremewan (1996) and Karami et al. (1999a) placed *suleimanicola* Reiss, in synonymy with *Z. speciosa*.

The discovery of the preimaginal stages of *Zygaena speciosa* at Kuh-e Tochal

Until 2005, nothing was known about the preimaginal biology of this species. Reiss (1937a) refers to E. Pfeiffer who speculated one of the several *Astragalus* spp. present to be the larval host-plant. The following year, E. Pfeiffer and W. Forster observed moths being attracted to a *Thymus* sp.; nectaring moths and copulae were seen on this plant and these collectors considered this to be the host-plant. From then on, this information was cited in the literature (Holik 1938; Hofmann & Tremewan 1996; Karami et al. 1999a). The last authors mention the observation of a dead larva "in July 1980 at the type locality in the immediate vicinity of an unidentified species of *Thymus* (CMN)". Further efforts in finding the moths or preimaginal stages failed in 1999 and 2000 by C. M. Naumann, and on 16 July 1999 by B. Mollet and A. Hofmann.

In 2005 we were in Iran for a three-month tour. At the beginning of August at the end of our tour we were visited by our Iranian colleague Ahmad Karbalaye who showed us his interesting collection of Zygaenidae from the last few years. This collection included a couple of *Z. speciosa* collected around the last teleski station (3,740 m) on Kuh-e Tochal (3,964 m) close to Tehran, a new locality for *Z. speciosa* and situated on the south side of the Alborz (see distribution map, loc. no. 6). This valuable information – thanks to Ahmad Karbalaye – motivated us to search for the proverbial needle in the haystack. Without any idea of the exact biotope, we first searched for meadows containing thyme plants around the station between 3,700 and 3,800 m altitude. However, field experiences with the closely related *Z. cacuminum* some years before (Hofmann 2000d) reminded us to be critical with such unconfirmed speculations. Like *Z. cacuminum*, *Z. speciosa* belongs to a species-group that lives exclusively on *Eryngium* spp. or on other Apiaceae. But no *Eryngium* or any other Apiaceae were found. On the top of the mountain and near the station there were still small snow-fields at the beginning of August, a strong wind was blowing and when the sun was hidden behind clouds it immediately became cool. Only

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a few high-mountain butterflies were observed, *Melitaea saxatilis* (Christoph), *Colias sagartia* Lederer, *Polyommatus* (*Agrodiaetus*) *posthumus* (Christoph). In the afternoon one hour before the last telecabin left to go down to the ground station at 1,800 m, on the other side of a scree of rock debris and moving stones, an interesting south-west-facing biotope (Fig. 10) east of the telecabin station was discovered with plenty of *Onobrychis cornuta* cushions, several Gramineae spp., a *Thymus* sp. smelling of mint, and pinkish-flowering thistles. As the whole area, including this site, was overgrazed, but not too strongly because of its steepness and the poor vegetation, the shepherds and their sheep never remained here very long. However, as some *Z. carniolica* were flying, we stayed here longer. Suddenly a black moth in clumsy flight was observed just a few metres away from the orbit of the net. For a moment we were unable to chase it because of the strong winds, but of course, we would not be telling this story if the moth had not found its way into the net – a large perfect female of *Z. speciosa*. It was the only one, but it did not need too much self-discipline to keep it alive for laying eggs, although it was so fresh that it was unclear whether it had already mated. In spite of our scepticism we put it into a small plastic box. And then, while making a small temporary camp, whitish-flowering Apiaceae, similar to *Trachydium eriocarpum* (the host-plant of *Z. cacuminum*), were found among the stones (Figs 11–14). Now we knew that we were at the very exact locality and immediately started to turn over stones expecting to find cocoons or larvae. After more than one hour of work on unstable slopes without any further success, we had to leave the biotope hoping to get the last telecabin coming down. It was already very late and the prospect of walking back 15 km or more and 2,000 m down in cool winds made us hurry. Just at this moment – with all the luggage hanging on her back and arms – Tabassom reported the discovery of a "black larva with yellow spots". No doubt, this must be the fully grown larva of *Z. speciosa*, sitting fully exposed in the late afternoon sun on the west side of a warmed-up big stone close to one of the Apiaceae plants. Forgetting the time we took several photos (Figs 11–14), not forgetting to press some plants for exact determination. The moment we wanted to start we realised that the female was just starting to lay eggs. We couldn't put it in the dark rucksack, as it needed the evening sun. Fortunately, thanks to the telecabin guardian, we were able to find accomodation at a nearby hotel that was exceptionaly open. The next day, before returning to Tehran, we went again to the biotope. Nothing was flying nor were any other larvae found. However, a cocoon was discovered under a stone of medium size (12 × 7 × 5 cm), thus completing the bionomics of *Z. speciosa* with a minimal number of records: one female, one fully grown larva, one cocoon and one batch of eggs together with the pressed unknown host-plant. With the awareness of having had an entomological highlight we left Kuh-e Tochal on August 4, 2005. However, the price we paid was high. It was the very last day in the wild on this tour and our driver, with all the larvae from three months' fieldwork in the car, forgot this day for half an hour his job that he had done so carefully during the long tour. On the Tochal base plateau the car stood exposed in the full mid-day sun and heated up on the inside to more than 70°C. Over 1,400 *Zygaena* larvae – the majority already just before diapause – cooked and died. It needed weeks to revitalise from this shock and two years to write this article.

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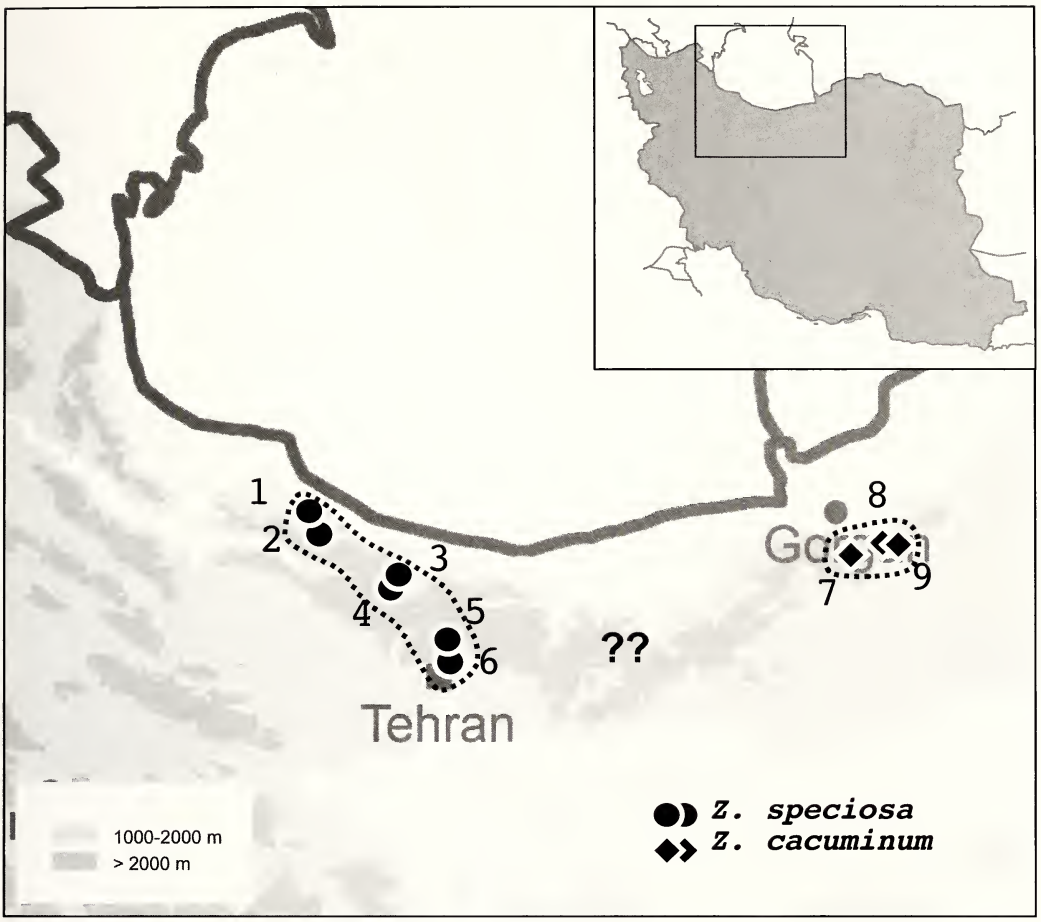

Map. Records and areals of the two oreal *Zygaena* (*Mesembrynus*) species in northern Iran. While *Z. speciosa* (loc. 1–6) is known from central and western Alborz, the closely related *Z. cacuminum* is only recorded from Shah Kuh (loc. 7) and Kuh-e Shahvar (loc. 8, 9) S of Gorgan. Numbers of localities: **1** Kuh-e Samamus, **2** Gardaneh-ye Tondrokosh, **3** Hezarchal (type locality of *Z. speciosa*), **4** Hezercham (type locality of *Z. speciosa suleimanicola*), **5** Dizin-Shemshak, **6** Tochal. – Distances between the most peripheral populations of *Z. speciosa* are 140 km, those of *Z. cacuminum* are only 30 km. Absence of records between Tehran and Gorgan (270 km) is assumed to be an artefact due to lack of fieldwork. The mountains in this region are not so high, but east of Demavend (vicinity of Lac Taar) and north-east of Semnan they reach altitudes above 3,500 m.

Zygaena speciosa at Dizin-Shemshak (province Tehran), 3,500–3,800 m (Figs 7–8)

In the vicinity of the pass between Dizin and Shemshak, A. Karbalaye had already collected, in 2001, some burnet moths including *Z. carniolica* and a couple of *Z. speciosa* (labelled: "M. Dezen, 3.800 m, 5.8.2001"; (see distribution map, loc. no. 5). The following year but more than one month earlier, W. ten Hagen found a single female here at the top of the teleski station ("Tehran N, Elburs, NE Dizin, 3550 m, 2.7.2002"). Until these discoveries, *Z. speciosa* was known only from its type locality.

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The phenotype of this population differs slightly from the nominotypical form and is more similar to moths from Kuh-e Tochal, as one would expect. While all moths from the area around Dizin are also melanistic, but with the hindwings slightly more red scaled and the forewings tending to being six spotted, the population from Kuh-e Tochal is phenotypically between the darkened 5-spotted populations of Alam-Kuh (100 % five-spotted) and that from Dizin-Shemshak (here two moths are six spotted, the other two have spot 6 vestigial).

We visited this locality at the end of July 2003 and 2005 without any success. However, with the newly acquired information about the larval host-plant (from Kuh-e Tochal), a westerly facing site where the same Apiaceae occurred (as with the biotopes at Kuh-e Tochal) was visited on July 10, 2006 on the south side of this ridge (3,500–3,600 m). The flight period was already coming to an end, as only one female, two vacated cocoons (under stones) and one batch of eggs (under a stone, Fig. 8) were found on this date. One week later, 1♀ and 1 worn ♂ were observed at the same locality. The male was attracted to a virgin female of *Z. speciosa* from Kuh-e Tochal (e. p.).

Zygaena speciosa at Kuh-e Samamus (province Gilan), 3,350–3,600 m (Figs 26–31, 34–45)

This new locality from 3,350 m up to the summit (3,620 m) of Kuh-e Samamus (Tonekabon SW) on June 25, 2006 (see distribution map, loc. no. 1) was discovered by Alireza Naderi (Karaj). The description of this well-separated and easily distinguishable new subspecies will follow in another paper. Five days later, A. Hofmann and A. Naderi visited the biotope at 3,400 m altitude. In spite of very bad weather conditions (fog, rain, subsequently a cold wind, temperature falling to 8°C), the preimaginal stages and four moths (sitting inactive on stones) were found. In addition to more than a dozen cocoons that were already vacated (some with the pupal exuviae still protruding), nine with living pupae inside were found and taken with us. All were hidden, spun under predominantly flat stones of a size somewhat bigger than those from Kuh-e Tochal. Only three cocoons were spun under stones of medium size that could be taken with us. Moreover, we found seven larvae (one fully grown, six fairly small, 10 and 12 mm) hidden under stones or just coming out to warm up when the sun came through for a short moment. A third visit (July 6, 2006, A. Hofmann & T. Kia Hofmann) had to be cancelled as the weather was extremely bad. Further successful

Figs 1–6. Iran, Alborz, Alam-Kuh region, type locality of *Zygaena speciosa*. **1.** Many trials to rediscover the species failed because the weather conditions can be "very suboptimal" even in July and August; Bernard Mollet putting our luggage on a mule near Tange Golu, 15.vii.1999. **2.** On the way to the Hecarchal valley, 15.vii.1999. **3.** Our camp site near the narrow gorges (Tange Golu); here we had three days rain, wind and storm. **4.** Fresh snowfall in the Hecarchal valley at the site where we expected to find the biotopes, 16. vii. 1999. **5.** A good locality with plenty of host-plants was discovered in 2006. Although it was sunny and mild at the beginning of August, not a single specimen could be found (Note. Fig. 4 shows the same site just 3 weeks earlier). **6.** Clas Naumann and Gerry Tremewan had more luck when they visited Alam Kuh in 1997; four fresh specimens were found on 28.vii.1997 (Fig. 6, photo by C. M. Naumann.).

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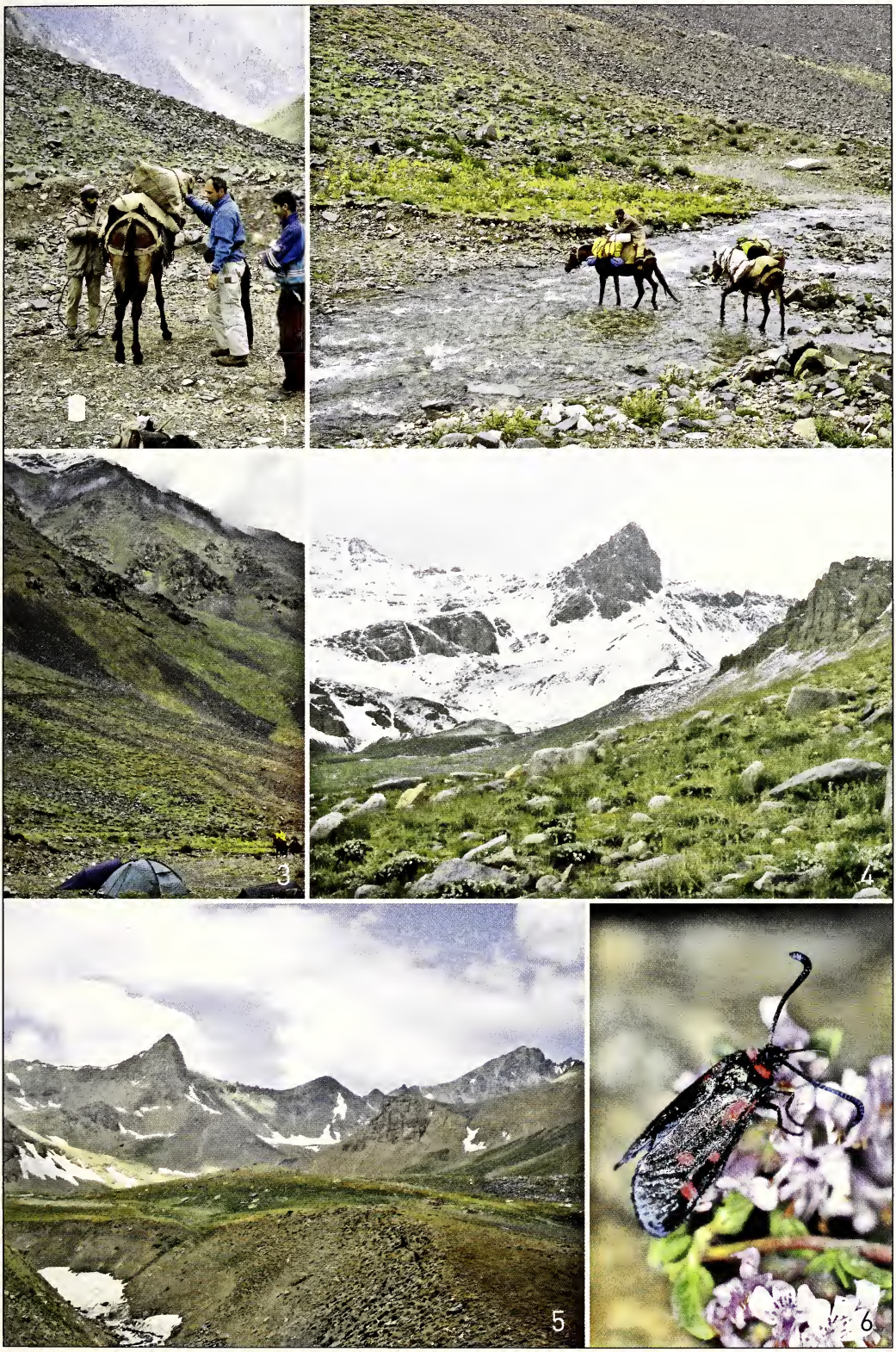

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observations and collections were possible on the fourth visit (July 15, 2006, A. Hofmann) when *Zygaena speciosa* was common on this date and accompanied by masses of *Z. carniolica*.

Zygaena speciosa at Gardaneh-ye Tondrokosh (Zarout) (province Mazandaran) 3,270–3,350 m

While crossing the Alborz range (14.vii.2006) on a bad trail between Qazvin and the Caspian Sea, we stopped at the highest pass named Gardaneh-ye Tondrokosh (ca 3,250 m) and climbed to the nearby summit of the mountain. Here another population of *Z. speciosa* (see distribution map, loc. no. 2) was found syntopic with *Z. carniolica*. This population inhabits a west- to north-west-facing biotope and in good weather one can see the Kuh-e Samamus that is around 20 km distance as the crow flies. Like the population from the latter locality, it is not melanistic on the hindwings, as in the eastern populations from the type locality, from Dizin-Shemshak and from Kuh-e Tochal. Therefore it will be referred to the new subspecies from Kuh-e Samamus in a forthcoming paper. A white-flowering, undetermined Apiaceae, probably a *Semenovia* sp., grows in the biotope and must be the host-plant as no other Apiaceae was present. While *Z. carniolica* was visiting the flowers of an *Acantholimon* sp. and *Thymus* sp. in the late afternoon, all moths of *Z. speciosa* were observed flying very quickly and therefore they were difficult to collect.

Description of an ab ovo culture (2005–2007) and the preimaginal stages (Kuh-e Tochal)

(Figs 15–25, 32–33)

The above-mentioned female from Kuh-e Tochal laid 70 eggs that were deposited in three batches, all on the same day (August 3, 2005). As it was disturbed several times by moving and walking, the eggs were not deposited in regular batches.

Ovum. The eggs are relatively large, bigger than that of *Z. tamara* (reared at the same time). Usual whitish cream colour tinged with orange-brown. Yolk sack bigger than in *Z. tamara*.

Figs 7–13. Iran, Alborz, new records of *Z. speciosa* from Dizin-Shemshak and Tochal. **7–8.** Between Dizin and Shemshak. In spite of the fact that *Semenovia tragioides* – one of the larval host plants – is not very common on this extremely steep biotope, one batch of eggs was found on the underside of a stone, 10.vii.2006. **9–13.** Kuh-e Tochal, province Tehran, observations in the wild. **9.** Before starting to feed, the larvae first come out and warm up on warmed stones or expose themselves to the sun, 28.vi.2006. **10.** Typical *Z. speciosa* biotope in the boulder scree zone close to snowfields at 3,650 m altitude, with flowering *Onobrychis cornuta* bushes at the end of the larval phase, 28.vi.2006. **11.** At the end of June the host-plant sets its first seeds. When it is sunny the half- or fully-grown larvae crawl out from under the stones and preferably eat the last fresh buds (note larva sitting on right stem), 28.vi.2006. **12–13.** About one-third of the adult larvae that we found in the field were parasitised by Chalcididae or Tachinidae, Kuh-e Tochal, 3.viii.2005.

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Eggs were deposited in two or three layers. In the heat of Tehran the embryos developed very quickly and emerged after six days (August 9, 2005). Before emergence, the eggs changed in colour and became greyish (darker than in *Z. tamara*). In 2006, one batch of eggs was found in the wild at a site near Dizin – Shemshak (Tehran). It was deposited in two layers on the underside of a stone (similar behaviour to that of *Z. cacuminum*), the batch being of medium size and placed directly beneath the host-plant. It consisted of 19 (11+8) eggs (Fig. 8).

From the F1 generation (derived from the female from Tochal) two subsequent cultures (F2) were reared in 2007 when successful pairings were obtained (May 21 and 27, 2007).

In CV070521,1 (= first "Copula-Versuch" [copulation trial] on May 21, 2007) the copula (Fig. 15) took place at 14h00 and remained till 13h00 of the next day. The same afternoon the female laid five batches of eggs, deposited in two to three layers, some slightly irregular.

In CV070527,3 (= third "Copula-Versuch" on May 27, 2007) the copulating pair was found at 16h00 and had already separated by the next morning at about 10h00. However, the same day the female laid three batches of eggs within three hours. The first batch (slightly irregular) consisted of 43 eggs. The second was deposited in three layers and comprised 29 eggs (15+12+3), the third in a double layer (Fig. 16) consisted of 33 eggs (22+11).

All in all, six batches of eggs were laid in captivity on the underside of the wooden construction of the box, the female sitting with the dorsum downwards. Only one batch was laid on the underside of a leaf of *Eryngium planum* (L.) (Apiaceae).

While in Iran, the egg phase lasted only 6 days, but the cultures in Germany needed 8 to 9 days. This is one day shorter than *Z. tamara* or *Z. nocturna* under the same conditions. In all cases, all batches were fertile. Infertility or partial infertility (of single eggs) was not observed.

Larva. On the day of hatching, the L1 larvae ate parts of their egg shells and then sat close together before starting, after 24 hours, to accept the several Apiaceae plants that they were offered, e.g. *Seseli libanotis* (L.) Koch, *Eryngium planum* Linnaeus, and *Pastinaca sativa* Linnaeus. The freshly emerged L1 larva is already pigmented and

Figs 14–27. Preimaginal stages of *Z. speciosa* from Kuh-e Tochal and Kuh-e Samamus. **14.** The white-flowering larval host-plant, *S. tragioides*, mostly grows between unstable stones, Kuh-e Tochal, province Tehran, 28.vi.2006. **15–25.** Breeding *Z. speciosa* in captivity (2005–2007). **15–16.** After two years the first moths (F1) emerged in spring 2007. A successful copula was obtained on 21 May 2007; the next day the ♀ laid three batches of eggs (F2) arranged in 2 and 3 layers. **17–18.** Already the pre-diapause larvae – here in the L3 – have the typical aposematic pattern; however, the black coloration is slightly less developed, 31.viii.2005. **19–20.** Diapausing larvae (L4D), 14.ii.2006. **21.** Half-grown larva in the postdiapause instar (L5). **22.** Cocoon with pupal exuviae, e.o., Kuh-e Tochal. **23–24.** The yellow spots of the fully grown larvae (here from the ab ovo culture of 2005) are bright and obviously contrasting, thus giving the larvae a strong aposematic pattern, 7.v.2007. **25.** Lateral pattern of the fully grown larvae; well visible are the areas of ground colour on the verrucae, 30.vi.2006. **26–27.** All cocoons were spun on the underside of stones; some places had such excellent microclimatic conditions that even 2 cocoons were spun close to each other, Kuh-e Samamus, 30.vi.2006.

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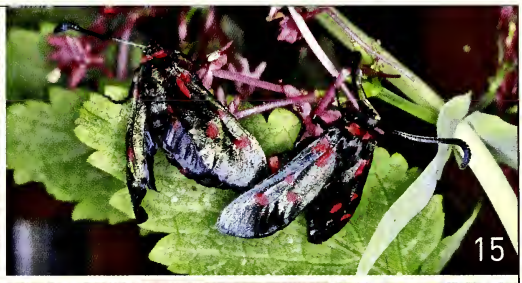
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looks greyish. Two pronounced brown lines (one on each side of the lighter greyish white dorsum) are visible; the ground colour is also dominated laterally by brownish darkened pigmentation interrupted by the lighter verrucae. Ventrally the ground colour is whitish grey; the crochets of the abdominal prolegs are dark brown to black. White setae long, dark setae short. At the end of L1 (after 7–9 days in Iran), the typical pattern of the fully grown larva is already visible. However, the coloration is not so strong and black as in the postdiapause stages – it is more dirty brownish in L1. This means that the larva of *Z. speciosa* is darkened from the beginning onwards, whereas typical eremic or arboreal *Zygaena* species in Iran have a green or creamy-white coloration before diapause and obviously change their pattern successively after diapause. This observation fits well with those of other oreal species, e.g. *Z. cacuminum*, a characteristic that must be interpreted as an adaptation to high-mountain climates. Even in August, when the young larvae hatch, the temperatures at night can fall close to 0°C and bad weather conditions with rain and storms can last for days. In the L2 stage the pigment coloration changes more from brownish to black and becomes extended dorsally so that the lighter grey ground colour remains only as a narrow dorsal line. 10 yellow-white dorso-subdorsal spots (DSS) are now present from the 2nd thoracic to the 8th abdominal segment. The larvae now preferred *Pastinaca sativa,* less so *Seseli libanotis* and only a few feeding marks were noted on *Eryngium planum* or *E. giganteum.* In captivity the larvae fed well and grew quickly. The L3 larva (5 mm, Figs 17–18) exhibits nearly the same pattern as that found in the fully grown larvae; only the spots become more accentuated and the yellow DSS are more brilliant. The majority of larvae had already entered diapause by the end of June; single individuals underwent a further moult (L4) and went on feeding till the end of August. After the first year, i.e. in the autumn, 51 larvae had entered diapause (L4D, L5D, Figs 19, 20) when the contrasting coloration was reduced; the ground colour became light brownish while the black pigmentation was medium brown and the yellow dorso-subdorsal spots were weaker. The loss of larvae was low and only a few died during diapause. The following spring (end of March), the larvae (4 mm) were taken into a warm room and subjected to greater humidity. After 10 days the larvae moulted (L5, partly L6). Under the same conditions, larvae of other *Zygaena* species moulted much quicker: *Z. cambysea* (3 days), *Z. manlia* (3), *Z. tamara* (5), *Z. christa* (5). After moulting, the *Z. speciosa* larvae regained their predominant black coloration with the yellow spots less pronounced in the beginning (later becoming more significant). Some larvae died but the majority fed well and grew. However, all larvae fed for just one instar (6–7 mm) and after 4 weeks they all entered diapause for a second time (L6D, partly L7D).

Figs 28–31. Biotopes, host-plants and preimaginal stages of *Zygaena speciosa* from Kuh-e Samamus (SW Ramsar). **28.** In the lower parts of Kuh-e Samamus there are dense forests followed by subalpine meadows from 2,300 m altitude upwards. The prostrate *Juniperus sabina* L. (2,300–2,600 m) is characteristic of the transition zone to the treeless highest regions (2,700–3,620 m). **29.** The trail to the pass (3,350 m) was partly destroyed in 2006 so that one had to walk from 2,650 m upwards. **30.** Freshly emerged ♀ of *Z. speciosa* warming up on a limestone rock, 30.vi.2006. **31.** Flowering plants of a pinkish-flowered *Thymus* sp. were preferably visited for nectaring when the sun was shining, 15.vii.2006.

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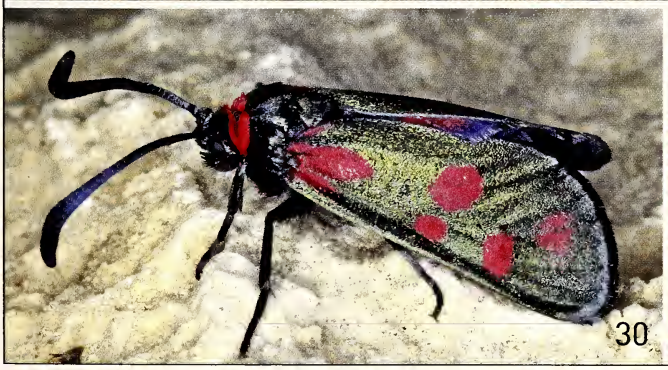
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Quite remarkable was the feeding behaviour of the post-diapause larvae. The main activity was observed during the afternoon. At dusk and during the night the larvae hide themselves under leaves or sit inactive under papers. This observation was confirmed after the following diapause in 2007. Thirty-five larvae were overwintering (2006 to 2007); after moulting at the end of March 2007, many larvae died (probably because of an application of the active substance fipronil ["Frontline"] on the house dog as prevention against ticks). Only a dozen larvae that were taken into the room some weeks later survived and all of these developed well.

After two further moults (L10, partly L11) the first larva became fully grown (Figs 23–25, 32–35) at the beginning of May 2007. The fully grown larva has a light bluish-grey ground colour although this is strongly reduced. The intersegmental regions are only visible when the larva stretches by moving. On the dorsum the ground colour is reduced to a narrow zigzag band by the two expanded black dorsal spots. Posteriorly, the dorsal line is broader on every segment; anteriorly it is very thin (Fig. 23). The large anterior dorsal spot (ADS) is connected to the posterior dorsal spot (PDS) on both sides (dorsally and ventrally) and even the areas surrounding the verrucae or dorsal warts (D1+D2; terminology after Tremewan 1985: 91; Hofmann 2003: 77) are dark-pigmented, only the bases of the setae are lighter. In the same way the subdorsal verrucae (SD) are also ring-shaped surrounded by one large black spot that is formed by the anterior subdorsal spot (ASS) and by the posterior subdorsal spot (PSS). Only the tops of the verrucae are of the ground colour. The immediate surrounding of the spiracle at the lower end of the connected subdorsal spot is also lighter. Further ventrally, the dark pigmentation becomes more brownish-black. The next verruca under the spiracle – the upper lateral verruca (L1) – is in the same way surrounded and even further ventrally the L2 verruca is darkened. Ten large, bright yellow, dorso-subdorsal spots (DSS) of oval shape contrast strongly although the first and the last are reduced. Retractile first thoracic segment, abdominal prolegs and anal prolegs light greenish-yellow. White setae long, predominant on the abdominal segments. Black setae present on the first and second thoracic segment and on the last abdominal segment short, rather stiff.

Cocoon. Half a dozen cocoons were found in the wild on the Kuh-e Tochal on August 4, 2005 (1), 2006 (4) and July 31, 2007 (1). Moreover, remnants of cocoons from former years were noted. Eight cocoons resulted from larvae found on June 28, 2006. From the ab ovo cultures that began in 2005, nine cocoons were spun on the underside

Figs 32–35. Comparison of final instar larvae collected in the wild at Kuh-e Tochal (**32–33**) and Kuh-e Samamus (**34–35**). All larvae from Kuh-e Tochal exhibit a mediodorsal band of ground colour, while the larvae from Kuh-e Samamus are generally darker and especially this band is narrower or even absent. **36–38.** Kuh-e Samamus, biotope and fieldwork. **36.** Optimal weather conditions with full sun on the *Z. speciosa* biotope, while clouds from the Caspian Sea hang lower down in the valleys, 15.vii.2006. **37.** Two weeks earlier we had been here twice under very different conditions, but fog, rain and cold temperatures did not prevent us from searching for larvae and cocoons under stones; Alireza Naderi in "warm" clothes, 30.vi.2006. **38.** 2♂ of *Z. speciosa* crawled out from their hiding places under stones immediately when the sun came out for a few minutes, but sat inactively when it became cloudy again, 30.vi.2006.

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of the lid of the box and under stones between May 4–12, 2007. At Kuh-e Samamus 25 cocoons were found and four resulted from larvae.
The cocons are slightly wrinkled, semi-ovoid, extremely fragile (cannot be removed from stones without destroying its base). Colour variable, from whitish to brownish or golden and with metallic sheen. Weakly developed ribs occasionally visible posteriorly. Pupal exuviae are mid- to dark brown. Exuviae from ab ovo cultures darker than those found in the wild. Cocoon from 2007, found at 3,400 m, differing in browner, more golden coloration and in lighter brown exuviae.
All cocoons in the wild were spun under stones of medium size and situated not far from the host-plant. Not a single one was found exposed or spun on vegetation. From the cocoons obtained from larvae found in the wild at the end of June 2006, the moths emerged after 14 days in Iran (first female e.p.: July 12, 2006), while the cocoon phase in Germany lasted two days longer. The first male and female emerged from cocoons obtained from the ab ovo culture after 16 days (May 20 and 21, 2007). Three more males and three females emerged up until May 28, 2007.

Infraspecific differences in preimaginal and imaginal phenotypes

The moths of both western populations (Kuh-e Samamus, Gardaneh-ye Tondrokosh) are not melanistic. They are smaller than the melanistic populations from Alam-Kuh and Kuh-e Tochal. Consequently, the larvae and cocoons do not reach the same size. In the last and penultimate instars the larvae from Kuh-e Samamus (Figs 34–35) are clearly darker than those from Kuh-e Tochal (Figs 32–33). The ground-coloured mediodorsal band is narrower or can even be lost, thus giving the larva a completely black dorsum. The pigmentation subdorsally and laterally is stronger, too. The most darkened larvae are reminiscent of a larva of a *Parnassius* sp. (Fig. 43). The extension of the dark pigmentation can be a subspecific adaptation to the extreme weather conditions so close to the Caspian Sea where, at the time of the final larval development, the periods of fog, cold wet winds and little sunshine can be normal. On four trips to this locality between the end of June and mid July we had rain, wind and very low temperatures on three occasions (Fig. 37). But when the sun came through, the larvae immediately started climbing up the plants, warming up and feeding. In contrast to the larval phenotype, the imaginal phenotype is not melanistic. Probably the conditions some weeks later during the flight period of the moths are more stable on average and/or the lower altitude of

Figs 39–45. Kuh-e Samamus, larvae of *Z. speciosa* on different host-plants and syntopic *Z. carniolica*, 30.vi.2006. **39–40.** The majority of the fully grown larvae of *Z. speciosa* were found on the yellow-flowered *Trachydium depressum*. **41.** Two larvae feeding on one plant of the whitish-flowered *Trachydium eriocarpum*, also a host-plant. **42.** A third, unidentified Apiaceae on which larvae were found feeding. **43.** Fully grown larvae – especially when partly hidden – resemble larvae of *Parnassius* species, 30.vi. 2006. **44–45.** *Zygaena carniolica* accompanies *Z. speciosa* in all its known localities. The moths of *Z. carniolica* prefer to nectar on the globe-like flowers of a second *Thymus* sp. that is growing in this area.

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the biotopes (3,270–3,400 m; compared with those from Tochal, 3,500–3,800 m and Alam Kuh, 3,200–4,000 m) allows enough activities for nectaring and reproduction so that no melanistic adaptation has evolved to absorb more solar radiation. Not a single melanistic form was found here although around 150 moths were observed, while all the moths from Alam-Kuh, Kuh-e Tochal, and Dizin-Shemshak (ca. 200 specimens) are melanistic.

Further field observations and larval host-plants

At Kuh-e Tochal larvae were found during the early afternoon under small stones or at the base of plants of *Semenovia tragioides* (Boiss.) Manden (det. H. Akhani), a very characteristically smelling, white-flowering Apiaceae. At the end of June 2006 the host-plant was not in flower; the flowering stems, however, were protruding. The first larva that was found on August 3, 2005 was parasitised by a species of Chalcididae. On June 28, 2006, more than a dozen larvae were found; of these, nine were fully grown, while five were of medium size or even smaller and some of the latter were entering diapause for a second time. Just before the appearance of the moths, two more larvae of medium size were found on July 19, 2006; both went into a second diapause, thus confirming the above observations. The same was observed with larvae from Kuh-e Samamus. Of nine larvae, only one made a cocoon the same year, three went into diapause and the rest died or were parasitised. Based on these observations, one can assume that two over-wintering periods are the general strategy of this high-mountain species, as all larvae from the ab ovo culture also went into a second diapause.
Host-plants used by larvae exhibit a characteristic look: as the larvae feed on the flowering stems, the latter are bent over or they are without umbels, as the larvae preferably eat these parts. Because of this behaviour, the plants on which the larvae feed look different and acquire a cushion-like form.
The temperature at this altitude falls very quickly when clouds or fog that emanate from the Caspian Sea prevent direct sunshine. The activity of the moths is more or less restricted to the warmest time of the day, i.e. between 11.00 and 15.00 h. The few observed and freshly emerged females had a heavy flight, but two males were observed to fly very quickly; one female was seen nectaring on thyme.

At Kuh-e Samamus the biotopes have a west- to north-west-facing aspect. In contrast to Kuh-e Tochal and the pass between Dizin-Shemshak, the larvae here feed on three different Apiaceae with a slight preference for the yellow-flowering Apiaceae. Feeding larvae were found on *Trachydium eriocarpum* Born. & Gauba (white-flowering), *Trachydium depressum* (Bois.) Bois. (yellow-flowering) and another Apiaceae (probably *Peucedanum* sp. or *Semenovia* sp.) (all det. H. Akhani / Tehran). However, the definitive determination needs confirmation as the plants were just flowering and no seeds could be found.
The plants do not grow as high as those on Kuh-e Tochal but are somewhat prostrate or close to the ground.

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Around midday the moths were observed visiting the 'polsters' or cushions of two different *Thymus* spp. and nectaring at their flowers; some were active on one polster for more than 10 minutes and crawling from one flower to the next. During periods when the wind abates and the sun is fully shining, the moths immediately come out and warm up on the sun-exposed sides of stones. We observed this behaviour even at low temperatures of 12–13°C at the beginning of the flight period (June 30, 2006). During the main period (mid July to beginning of August), the moths can immediately appear in abundance and begin to fly when it becomes sunny and less windy for a moment in the habitat. But when the sun is hidden or the wind is too strong, they land or fall down to the ground and crawl under stones. The flight is steady and calm, 20–30 cm above the ground when it is windless; then they are probably searching for nectar plants or the males for females. But males were regularly observed flying 1–5 m high and very quickly, especially when crossing the saddle of the mountain ridge.
Two virgin females from Kuh-e Tochal (ex larvae) were placed in gauze-covered boxes for checking their attractiveness to the males of the population at Kuh-e Samamus. At one single stop, eight males arrived and tried to reach the females, their valvae opened and ready for mating.

From both localities, parasitoids (Hymenoptera and Diptera) were obtained from larvae collected in the wild. A complete list with all known parasitoids will be published later.

Biotope(s). On Kuh-e Tochal four biotopes inhabited by *Z. speciosa* were discovered between 2005 and 2007, all of them situated on the south side of the mountain. The maximum distance from each other is around 3 km; the lowest is situated at 3,390 m, the highest at 3,680 m altitude. In all these sites the larval host-plant *Semenovia tragioides* is common and flowering at the time of appearance of the moths. The sub-populations are only weakly isolated by areas where the larval host-plant does not grow. However, each site is visible from one habitat to the next and there are no isolating barriers between them. Consequently, the population exhibits a typical metapopulation structure. All sites are very steep, westerly facing biotopes with moving stones (scree) and abundant *Semenovia tragioides*, dominated by Poaceae with *Thymus* sp., *Salvia* sp., and *Onobrychis cornuta* cushions.
The other biotopes at Dizin – Shemshak, Hecarčal, Gardaneh-ye Tondrokosh and Kuh-e Samamus are all westerly (south-west to north-west) facing. There can be no doubt that the general warming up of the biotope and the longer evening sun is the deciding factor.

Zygaena cacuminum Christoph, 1877

"*Zygaena cacuminum* Chr." Christoph 1877: 243, pl. 6 fig. 17. Type locality: "auf dem mit Steingeröll bedeckten Plateau und den höchstgelegenen Abhängen des Felskammes bei Schahkuh" (original description); [Iran, prov. Golestan, Gorgan 37 km S., Shah-kuh-e Pain 6 km SE., Kuh-e Gawkoshan (3,813 m)]; (see distribution map, loc. no. 7).

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No information is provided on the number of specimens that were collected, but both sexes are mentioned. One specimen (probably ♂) is illustrated in a hand-coloured figure.

The rediscovery of *Z. cacuminum* around 120 years after it was first discovered by Christoph is described by Hofmann (2000d) and Naumann (2000) who also provide data on the biology and ecology (phenology, host-plants etc.). Until 2005, *Z. cacuminum* was one of the rare burnet moth species (like Z. *problematica* and *Z. halima*) that was known only from its type locality. Here *Z. cacuminum* – according to the original description – inhabits biotopes in the highest regions of the Shahkuh range. The rediscoveries in 1998 (B. Mollet), 1999 (A. Hofmann, J.-U. Meineke, B. Mollet), 2000 (B. Mollet), 2003 (A. Hofmann, J.-U. Meineke), 2005 (A. Hofmann, B. Mollet) as well as material collected by T. Keil (2003, 2006) were all on the north side of the mountain range in the boulder/scree zone between 2,800 and 3,100 m altitude.

If one proceeds around 25–30 km eastward from Shahkuh, as the crow flies, one reaches the highest peak of the eastern Alborz, a mountain known as Kuh-e Shavar (3,945 m). On its north side, this mountain is covered with forests that extend down to the Caspian Sea, while the slopes on its west, east and south sides are almost treeless with poor, high-mountain steppe vegetation (*Artemisia*, *Acantholimon*, etc.) where only isolated *Juniperus* trees occur. A typical high-mountain flora with cushion vegetation (*Astragalus* spp., *Onobrychis cornuta*) is found from above 2,500 m. Five permanent rivers rise from this mountain. Near the village of Tash, a trail that follows the course of one of these rivers leads to a coal mine in this mountain. Kuh-e Shahvar is visible from the upper parts of Shahkuh, but both are well separated from each other by deep valleys in which there is intensive cultivation of the land. It had already been assumed by Naumann (2000) and Hofmann that suitable biotopes for *Z. cacuminum* should exist on this mountain, which is why both explored this area several times, but without any success. A definitive clue that *Z. cacuminum* in fact has a population there was given when H. Akhani showed the author *Zygaena* photographs for determination, which he had made during his botanical fieldwork in 1998–2001. There was no doubt that one photograph depicted a fresh male of *Z. cacuminum* nectaring on *Acantholimon*. The photograph was taken at the end of July while Akhani was on his way from the village of Tash to the top of Kuh-e Shahvar at an altitude of about 3,350 m. Provided with this information, A. Hofmann and B. Mollet intensively explored the slopes of the two peaks of Kuh-e Shahvar from July 24–27, 2005, viz. the lower peak (Kuh-e Shahvar kucek) on the north side and the higher one (Kuh-e Shahvar bozorg) further south. At both sites the very local, white-flowering, larval host-plant *Trachydium eriocarpum* was found. At Kuh-e Shahvar kucek, *Z. cacuminum* was observed on both sides (north- and south-facing) of a ridge where the moths were flying and nectaring between 3,300 and 3,550 m altitude. The highest record is from Kuh-e Shahvar bozorg where a single male was found close to the snowfields at an altitude of 3,720 m. On both mountains, *Z. cacuminum* was accompanied by *Z. ecki* and *Z. carniolica*.

As a consequence of these new records, the expectation of finding *Z. cacuminum* at further localities in eastern Iran (Kuh-e Aladag, Kuh-e Binalut) becomes more realistic.

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The relationship of *Z. speciosa* and *Z. cacuminum* will be discussed when more concrete facts are available, based on successful exploration of the areas between Demavend and Semnan.

Acknowledgements

Extensive fieldwork in Iran in 2005, 2006 and 2007 would not only have been less successful but even impossible without the active help in Germany and Iran provided by many good friends to whom we express our sincere thanks: Prof. Dr. Hossein Akhani (Tehran), Bernd Gmelin (Freiburg), Ingmar Harry (Freiburg), Helen F. Hofmann (Hochstetten), Ahmad Karbalaye (Tehran), Bernard Mollet (Paris), Nadine Meseck (Freiburg), Dr. Jörg-Uwe Meineke (Kippenheim), Josef Mooser (Freising), Alireza Naderi (Karaj), Maike Stange (Freiburg), and Dr. W. Gerald Tremewan (Truro) helped during fieldwork or provided valuable advice, determined the preserved plants, or took care of the dog, garden, and house. Furthermore we do not forget the support and help in various ways from Dr. Wolfgang Eckweiler (Frankfurt), Günter Ebert (Karlsruhe), Astrid Grauel (Rutesheim), Dr. Bernard Landry (Genève), Thomas Keil (Dresden), Dr. Matthias Nuss (Dresden), Dr. Storai Naumann-Nawabi (Bonn), Dr. Wolfgang ten Hagen, and Dr. Robert Trusch (Karlsruhe).

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Digitale Literatur/Digital Literature

Zeitschrift/Journal: Nota lepidopterologica

Jahr/Year: 2008

Band/Volume: 31

Autor(en)/Author(s): Hofmann Axel, Kia-Hofmann Tabassom

Artikel/Article: Contribution to the knowledge of the genus Zygaena Fabricius, 1775 in Iran (Zygaenidae). Part VIII: Bionomics of high-mountain species in the Alborz Mountains and adjacent areas (introduction; Z. speciosa^ Z. cacuminum) 25-52