

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/267942897>

# A revised check-list of the genus *Zygaena* Fabricius, 1775 (Lepidoptera: Zygaenidae, Zygaeninae), based on the biospecies concept

Article in *Entomologist's Gazette* · April 2010

CITATIONS

10

READS

839

2 authors, including:



**Axel Hofmann**

ABL Büro Freiburg

96 PUBLICATIONS 276 CITATIONS

SEE PROFILE

## **A revised check-list of the genus *Zygaena* Fabricius, 1775 (Lepidoptera: Zygaenidae, Zygaeninae), based on the biospecies concept**

A. HOFMANN

*Verenenweg 4, D-79206 Breisach-Hochstetten, Germany*  
*hofmann@abl-freiburg.de*

W. G. TREMEWAN<sup>1</sup>

*Department of Entomology, Natural History Museum, Cromwell Road, London SW7 5BD, U.K.*  
*wgt.pentreath@btinternet.com*

### **Synopsis**

Based on the biospecies concept, a check-list of the 108 currently recognized species representing the monophyletic genus *Zygaena* Fabricius, 1775, is provided. Three subgenera are recognized: of these, *Mesembrynus* Hübner, [1819], is monophyletic, while *Agrumenia* Hübner, [1819], and *Zygaena* Fabricius, 1775, are paraphyletic. Three nominal taxa that were originally described as subspecies (two belonging to the *Zygaena manlia*-group, one belonging to the *purpuralis*-group, all within the subgenus *Mesembrynus*) are newly raised to species level, while two (one in the *manlia*-group, one in *Agrumenia*) are newly reinstated as valid species. Moreover, eight new combinations are established at subspecies level. Biological/ecological data and comparisons with other taxa are provided in support of such taxonomic placements.

**Key words:** Zygaenidae, Zygaeninae, subgenera, *Zygaena*, *Mesembrynus*, *Agrumenia*, species groups, biospecies concept, biospecies, taxonomy, new status, check-list.

### **Introduction**

As a result of intensive fieldwork by the present authors throughout the central and western Palaearctic region during the past 40 years or so, much biological/ecological information on many species of the genus *Zygaena* has been accrued; the data, some of which are as yet unpublished, will form the greater part of a book on the natural history of each species and of the genus as a whole (Hofmann & Tremewan, *b*, in prep.). As a consequence of such fieldwork, our present knowledge of the distribution, ecology and biology of *Zygaena* species provides a clearer insight into their systematics and taxonomy, beyond what was known when the first check-list based on the biospecies concept was published (Naumann & Tremewan, 1984). The majority of the new taxonomic changes were to have been established in a revision of the *manlia*-group of the subgenus *Mesembrynus* (Hofmann & Tremewan, *a*, in

<sup>1</sup> Scientific Associate. Correspondence address: Pentreath, 6 Carlyon Road, Playing Place, Truro, Cornwall TR3 6EU, U.K.

prep.). However, we believe it is timely to provide an updated and annotated systematic check-list in advance of that revision which, in addition to reflecting the biospecies concept, will take into account the genital morphology of the species concerned. Moreover, the check-list provides a basis for the forthcoming book mentioned above and which is now nearing completion (Hofmann & Tremewan, *b*, in prep.).

Following the publication of a phylogenetic analysis of the genus *Zygaena*, based on nuclear and mitochondrial data (Niehuis, Hofmann, Naumann & Misof, 2007), Hofmann & Tremewan (2009: 101–103) provided a synonymic check-list of the nominal subgenera and species-groups within the genus; moreover, they discussed at length the undesirability of splitting the genus into more than three subgenera. Below we now provide a check-list that also includes the species as revised by us in the autumn of 2009. The monophyletic genus *Zygaena* is subdivided into three subgenera one of which is monophyletic (*Mesembrynus*) while two are paraphyletic (*Agrumenia*, *Zygaena*); these three subgenera consist of nine monophyletic stems (Hofmann & Tremewan, 2009). The 26 subordinate species-groups comprise 108 currently recognized biospecies. The taxonomic changes at species and subspecies level, either new or those established since the publication of a systematic catalogue of the subfamily Zygaeninae (Hofmann & Tremewan, 1996), are marked with superscript numbers that refer to the explanatory notes that follow the check-list.

### Check-list of species representing the genus *Zygaena* Fabricius, 1775

Genus **ZYGAENA** Fabricius, 1775 (monophylum)

Subgenus **MESEMBRYNUS** Hübner, [1819] (monophylum)

*Hesychia* Hübner, [1819]

*Hyalia* Burgeff, 1926

*Santolinophaga* Burgeff, 1926

*Peucedanophila* Burgeff, 1926

*Coelestis* Burgeff, 1926

*Yasumatsuia* Strand, 1936

*Cirsiphaga* Holik, 1953

*Libania* Holik & Sheljuzhko, 1956

*Usgenta* Holik & Sheljuzhko, 1956

*Mesembrynoidea* Holik & Sheljuzhko, 1958

#### *manlia*-group

*Zygaena (Mesembrynus) seitzi* Reiss, 1938<sup>1</sup>

*Zygaena (Mesembrynus) nocturna* Ebert, 1974<sup>2</sup>

*Zygaena (Mesembrynus) kermanensis* Tremewan, 1975<sup>3</sup>

*Zygaena (Mesembrynus) turkmenica* Reiss, 1933 **stat. nov.**<sup>4</sup>

*Zygaena (Mesembrynus) cacuminum* Christoph, 1877

*Zygaena (Mesembrynus) speciosa* Reiss, 1937

*Zygaena (Mesembrynus) cuvieri* Boisduval, [1828]

*Zygaena (Mesembrynus) tamara* Christoph, 1889

*Zygaena (Mesembrynus) manlia* Lederer, 1870

*Zygaena (Mesembrynus) araxis* Koch, 1936 **stat. rev.**<sup>5</sup>

*Zygaena (Mesembrynus) fredii* Reiss, 1938<sup>6</sup>

- Zygaena (Mesembrynus) mirzayansi* Hofmann & Keil, 2010  
*Zygaena (Mesembrynus) rubricollis* Hampson, 1900  
*Zygaena (Mesembrynus) hindukuschi* Koch, 1937  
*Zygaena (Mesembrynus) halima* Naumann, 1977  
*Zygaena (Mesembrynus) wyatti* Reiss & Schulte, 1961  
*Zygaena (Mesembrynus) aisha* Naumann & Naumann, 1980<sup>7</sup>  
*Zygaena (Mesembrynus) ginnereissi* Hofmann, 2000 **stat. nov.**<sup>8</sup>  
*Zygaena (Mesembrynus) haematina* Kollar, 1849  
*Zygaena (Mesembrynus) fusca* Hofmann, 2000<sup>9</sup>  
*Zygaena (Mesembrynus) lydia* Staudinger, 1887

*purpuralis*-group

- Zygaena (Mesembrynus) brizae* (Esper, 1800)  
*Zygaena (Mesembrynus) rubicundus* (Hübner, [1817])  
*Zygaena (Mesembrynus) cambysea* Lederer, 1870  
*Zygaena (Mesembrynus) erythrus* (Hübner, [1806])  
*Zygaena (Mesembrynus) minos* ([Denis & Schiffermüller], 1775)  
*Zygaena (Mesembrynus) pseudorubicundus* Klir & Naumann, 2002  
**stat. nov.**<sup>10</sup>

- Zygaena (Mesembrynus) purpuralis* (Brünnich, 1763)  
*Zygaena (Mesembrynus) alpherakyi* Sheljuzhko, 1936

*graslini*-group

- Zygaena (Mesembrynus) graslini* Lederer, 1855

*cynarae*-group

- Zygaena (Mesembrynus) cynarae* (Esper, 1789)

*centaureae*-group

- Zygaena (Mesembrynus) centaureae* Fischer von Waldheim, 1832  
*Zygaena (Mesembrynus) laeta* (Hübner, 1790)  
*Zygaena (Mesembrynus) huguenini* Staudinger, 1887

*corsica*-group

- Zygaena (Mesembrynus) corsica* Boisduval, [1828]

*zuleima*-group

- Zygaena (Mesembrynus) zuleima* Pierret, 1837

*favonia*-group

- Zygaena (Mesembrynus) loyselii* Oberthür, 1876  
*Zygaena (Mesembrynus) favonia* Freyer, 1844  
*Zygaena (Mesembrynus) aurata* Blachier, 1905  
*Zygaena (Mesembrynus) sarpedon* (Hübner, 1790)  
*Zygaena (Mesembrynus) contaminei* Boisduval, 1834  
*Zygaena (Mesembrynus) punctum* Ochsenheimer, 1808

Subgenus **AGRUMENIA** Hübner, [1819] (paraphylum)

- Thermophila* Hübner, [1819]  
*Lycastes* Hübner, [1819]  
*Epizygaena* Jordan, [1907]  
*Lictoria* Burgeff, 1926  
*Agrumenoidea* Holik, 1937  
*Coelestina* Holik, 1953

*fausta*-group

- Zygaena (Agrumenia) excelsa* Rothschild, 1917  
*Zygaena (Agrumenia) tremewani* Hofmann & Reiss, 1983

- Zygaena (Agrumenia) alluaudi* Oberthür, 1922  
*Zygaena (Agrumenia) algira* Boisduval, 1834  
*Zygaena (Agrumenia) fausta* (Linnaeus, 1767)
- hilaris*-group  
*Zygaena (Agrumenia) youngi* Rothschild, 1926  
*Zygaena (Agrumenia) maroccana* Rothschild, 1917  
*Zygaena (Agrumenia) marcuna* Oberthür, 1888  
*Zygaena (Agrumenia) hilaris* Ochseneheimer, 1808
- cocandica*-group  
*Zygaena (Agrumenia) kavrigini* Grum-Grshimailo, 1887  
*Zygaena (Agrumenia) truchmena* Eversmann, 1854  
*Zygaena (Agrumenia) essenii* Blom, 1973 **stat. rev.**<sup>11</sup>  
*Zygaena (Agrumenia) transpamirina* Koch, 1936  
*Zygaena (Agrumenia) magiana* Staudinger, 1889  
*Zygaena (Agrumenia) cocandica* Erschoff, 1874  
*Zygaena (Agrumenia) pamira* Sheljuzhko, 1919  
*Zygaena (Agrumenia) sogdiana* Erschoff, 1874  
*Zygaena (Agrumenia) storaiiae* Naumann, 1974
- olivieri*-group  
*Zygaena (Agrumenia) ferganae* Sheljuzhko, 1941  
*Zygaena (Agrumenia) chirazica* Reiss, 1938  
*Zygaena (Agrumenia) naumanni* Hille & Keil, 2000  
*Zygaena (Agrumenia) tenhagenova* Hofmann, 2005  
*Zygaena (Agrumenia) haberhaueri* Lederer, 1870  
*Zygaena (Agrumenia) olivieri* Boisduval, [1828]  
*Zygaena (Agrumenia) sedi* Fabricius, 1787
- fraxini*-group  
*Zygaena (Agrumenia) separata* Staudinger, 1887  
*Zygaena (Agrumenia) rosinae* Korb, 1903  
*Zygaena (Agrumenia) bakhtiyari* Hofmann & Tremewan, 2005  
*Zygaena (Agrumenia) sengana* Holik & Sheljuzhko, 1956<sup>12</sup>  
*Zygaena (Agrumenia) fraxini* Ménétris, 1832  
*Zygaena (Agrumenia) escalerai* Poujade, 1900  
*Zygaena (Agrumenia) formosa* Herrich-Schäffer, 1852  
*Zygaena (Agrumenia) peschmerga* Eckweiler & Görgner, 1981  
*Zygaena (Agrumenia) afghana* Moore, [1860]
- felix*-group  
*Zygaena (Agrumenia) johannae* Le Cerf, 1923  
*Zygaena (Agrumenia) felix* Oberthür, 1876  
*Zygaena (Agrumenia) beatrix* Przegendza, 1932
- orana*-group  
*Zygaena (Agrumenia) orana* Duponchel, 1835
- carniolica*-group  
*Zygaena (Agrumenia) carniolica* (Scopoli, 1763)  
*Zygaena (Agrumenia) occitanica* (Villers, 1789)
- exulans*-group  
*Zygaena (Agrumenia) exulans* (Hohenwarth, 1792)
- viciae*-group  
*Zygaena (Agrumenia) viciae* ([Denis & Schiffermüller], 1775)

*Zygaena (Agrumenia) niphona* Butler, 1877

**loti-group**

*Zygaena (Agrumenia) christa* Reiss & Schulte, 1967

*Zygaena (Agrumenia) loti* ([Denis & Schiffermüller], 1775)

*Zygaena (Agrumenia) armena* Eversmann, 1851

*Zygaena (Agrumenia) ecki* Christoph, 1882

*Zygaena (Agrumenia) ignifera* Korb, 1897

Subgenus **ZYGAENA** Fabricius, 1775 (paraphylum)

*Anthrocera* Scopoli, 1777

*Eutychia* Hübner, [1819]

*Anthilaria* Hübner, [1819]

*Aeacis* Hübner, [1819]

*Silvicola* Burgeff, 1926

*Peristygia* Burgeff, 1926

*Polymorpha* Burgeff, 1926

*Biezankoia* Strand, 1936

*Huebneriana* Holik & Sheljuzhko, 1957

*Burgeffia* Holik & Sheljuzhko, 1958

*Rhaphidozygaena* Burgeff, 1975

**anthyllidis-group**

*Zygaena (Zygaena) anthyllidis* Boisduval, [1828]

**lavandulae-group**

*Zygaena (Zygaena) lavandulae* (Esper, 1783)

*Zygaena (Zygaena) theryi* Joannis, 1908

**rhadamanthus-group**

*Zygaena (Zygaena) rhadamanthus* (Esper, [1789])

*Zygaena (Zygaena) oxytropis* Boisduval, [1828]

*Zygaena (Zygaena) problematica* Naumann, 1966

**persephone-group**

*Zygaena (Zygaena) persephone* Zerny, 1934

**nevadensis-group**

*Zygaena (Zygaena) mana* (Kirby, 1892)

*Zygaena (Zygaena) nevadensis* Rambur, 1858

*Zygaena (Zygaena) romeo* Duponchel, 1835

*Zygaena (Zygaena) osterodensis* Reiss, 1921

**transalpina-group**

*Zygaena (Zygaena) dorycnii* Ochseneimer, 1808

*Zygaena (Zygaena) ephialtes* (Linnaeus, 1767)

*Zygaena (Zygaena) transalpina* (Esper, 1780)

*Zygaena (Zygaena) angelicae* Ochseneimer, 1808

**filipendulae-group**

*Zygaena (Zygaena) filipendulae* (Linnaeus, 1758)

*Zygaena (Zygaena) lonicerae* (Scheven, 1777)

*Zygaena (Zygaena) trifolii* (Esper, 1783)

## Notes

1. *Zygaena seitzi*. Keil (2003c: 31) incorrectly placed the nominal taxon '*Zygaena (Mesembrynus) rubricollis tenhageni* Hofmann & Tremewan, 2003' as

a subspecies of *Z. araxis*. It is here considered to be a subspecies of *Z. seitzi*, based on knowledge of its biology, ecology, ethology and new distributional records. The early stages reared ab ovo are illustrated by Hofmann & Tremewan (2003: pl. 3, figs 10–17); the larva has two morphs, one with larger anterior dorsal spots, the other with the body greenish yellow instead of pale green, with the anterior dorsal spots reduced and the posterior dorsal spots vestigial.

*Zygaena seitzi tenhageni* is represented by two main morphs that are red or yellow; an orange morph also occurs but this is rare. Tremewan (2006: 177–178) has described the Mendelian genetics of the yellow morph. Recent findings in the central Zagros show that there are dichromatic populations in several localities, which vary in the percentages of the different morphs, from 80% yellow to 20% yellow. Of 48 specimens taken on the Kuh-e Kalar, 39 are of the typical yellow *seitzi* morph, while 9 specimens are pure red in coloration. Represented by two subspecies: *Z. seitzi seitzi* Reiss, 1938; *Z. seitzi tenhageni* Hofmann & Tremewan, 2003 (**comb. nov.**).

2. ***Zygaena nocturna***. Relegated to a subspecies of *Z. seitzi* by Naumann & Tremewan (1984: 170, 187), *Z. nocturna* was reinstated as a valid species by Hofmann & Tremewan (2003: 9), based on knowledge of its early stages, ecology and ethology (unlike *Z. seitzi*, which is strictly diurnal, *Z. nocturna* is almost strictly nocturnal).

The male genital morphology of *Z. nocturna* was described and illustrated by Ebert (1974: 164–166, figs 3–6), that of *Z. seitzi* by Haaf (1952: pl. 6) and Alberti (1958: 340, pl. 7, fig. 85, pl. 12, fig. 85, pl. 28, fig. 85; 1959: pl. 40, fig. 85, pl. 46, fig. 85, pl. 58, fig. 85).

Represented by three subspecies: *Z. nocturna nocturna* Ebert, 1974, *Z. nocturna eberti* Hofmann, 2005, *Z. nocturna meimekei* Hofmann & Tremewan, 2003.

3. ***Zygaena kermanensis***. The nominal taxa '*Zygaena (Mesembrynus) manlia kermanensis* Tremewan, 1975', '*Zygaena (Mesembrynus) manlia askarii* Tremewan, 1975' and '*Zygaena (Mesembrynus) manlia qashqai* Tremewan, 1975', were described in the same paper; two of them originate from the province of Fars, the other from the province of Kerman. Subsequently they were placed as subspecies of *Z. rubricollis* by Hofmann & Tremewan (1996: 42), but ethological, ecological and biological data have shown that they represent a distinct biospecies. The adult is characterised by its very fast flight while the larva (Tremewan, 1975: 237–239, pl. 6, figs 1–3) can be distinguished from those of other species in the group by its phenotype and comparatively long setae which give it a somewhat hairy appearance reminiscent of that found in the larva of *Z. loniceræ*. It feeds on *Eryngium billardieri* Delar. (also on *E. nigromontanum* Boiss. & Buhse which some botanical authorities consider to be synonymous with *E. billardieri*). The record of *Echinophora* sp. as a larval host-plant of *Z. kermanensis* (Keil, 2003c: 32) requires confirmation.

The nominal taxon '*Zygaena manlia kermanensis* Tremewan, 1975' was first raised to species level by Keil (2003a) in the Abstracts of the VIII International Symposium on Zygaenidae, which was held in Dresden from 10–14 September 2003. While one has to accept the change in status as valid, Keil provided no clear evidence for his actions; that is to say, he merely listed the taxon as '*Zygaena (Mesembrynus) kermanensis* Tremewan, 1975 **stat. nov.**'. Four pages later, in another abstract, Keil (2003c: 32) listed the same nominal

taxon in a heading, as follows: '*Zygaena rubricollis kermanensis* Tremewan, 1975', thus reverting to the combination as listed in Hofmann & Tremewan (1996: 42); however, the name '*rubricollis*' had been deleted by hand in each copy of the printed abstracts received by the participants on the first day of the symposium! Efetov (2004: 37) and Alipanah (2005: 6) have also listed *kermanensis* as a valid species, the former author with reference to Keil (2003a), but without comment. In spite of such shortcomings we accept this taxonomic act, based on the First Reviser Principle of the *Code*.

We have compared the male genitalia of *Z. kermanensis qashqai* and *Z. kermanensis askarii* with those of *Z. manlia manlia*, *Z. turkmenica excellens* (male genitalia illustrated by Naumann & Tremewan, 1984: figs 16a–16d, 24a, 24b) and *Z. turkmenica isfahanica*. Haaf (1952: pl. 6) figured the male genitalia of *Z. turkmenica turkmenica*.

Represented by three subspecies: *Z. kermanensis qashqai* Tremewan, 1975 (**comb. nov.**), *Z. kermanensis askarii* Tremewan, 1975 (**comb. nov.**), *Z. kermanensis kermanensis* Tremewan, 1975.

4. ***Zygaena turkmenica***. The early stages and larval host-plants provide strong evidence for placing the nominal taxon '*Zygaena (Coelestis) manlia* Lederer subsp. *turkmenica* Reiss, 1933', as a valid species (**stat. nov.**). The larva feeds on *Eryngium billardi* Delar., also on *E. nigromontanum* Boiss. & Buhse and *Ferula latisecta* Rech. f. & Aell. What is extraordinary is the record by R. Trusch and T. Keil (pers. comm.) who, in 2007, found several larvae feeding on *Artemisia* cf. *herba-alba* Asso north-east of Birjand. The larva of *Z. manlia* has never been found on any of the host-plants cited above, but feeds on *Bupleurum exaltatum* M. Bieb. and *Semenovia tragioides* (Boiss.) Manden. The male genitalia of *Z. turkmenica isfahanica* have been compared with those of *Z. manlia manlia*. Haaf (1952: pl. 6) has figured the male genitalia of *Z. turkmenica turkmenica*. In the central Zagros range and adjacent areas, populations occur that appear to have characters typical of *Z. turkmenica* and/or *Z. cuvieri*; therefore the occurrence of hybrid populations in this region is not impossible.

Represented by four subspecies: *Z. turkmenica turkmenica* Reiss, 1933, *Z. turkmenica excellens* Reiss, 1940 (**comb. nov.**), *Z. turkmenica isfahanica* Tremewan, 1975 (**comb. nov.**), *Z. turkmenica pjotri* Hofmann, 1983 (**comb. nov.**).

5. ***Zygaena araxis***. The nominal taxon '*Zygaena manlia* Led. subsp. *araxis* Koch, 1936', has had a confusing history and its status and taxonomic limitation have still to be satisfactorily resolved. It was placed as a subspecies of *Z. manlia* by Reiss & Tremewan (1967: 7), but established by Görgner & Hofmann (1982) as a valid species (with *daralagezica* Holik & Sheljuzhko, 1955, as a synonym) together with the then newly described subsp. *kurdi* Görgner & Hofmann, 1982, from the Van Gölü region of Turkey. Subsequently, Hofmann & Tremewan (1996: 41) placed *Zygaena araxis* as a subspecies of *Z. rubricollis* whilst retaining *daralagezica* as a synonym. Keil (2003a) reinstated *Z. araxis* as a valid species, but provided no evidence for doing so. Moreover, he transferred (Keil, 2003c: 31) four nominal taxa that were formerly placed under *Z. rubricollis* to *Z. araxis*, viz. *tenhageni* Hofmann & Tremewan, 2003, *escaleraiana* Holik, 1958, *qashqai* Tremewan, 1975, and *askarii* Tremewan, 1975; such combinations are not accepted for reasons explained elsewhere in the present paper.

Fieldwork undertaken by the authors in Iran in 2004 and 2005 confirmed the various placements and taxonomic changes that had already been made by Hofmann & Tremewan (2003); moreover, in addition to good phenotypic characters, it showed that there are significant biological/ecological differences between *Z. araxis* and *Z. fredii* and between all of the remaining species that were formerly placed as subspecies under *Z. rubricollis*. As a consequence, *Z. araxis* is here formally reinstated as a valid species (**stat. rev.**).

All investigated populations in Iran, which were formally referred to *Z. rubricollis*, e.g. those from the Gardaneh Qaderabad (Shiraz N.), the vicinity of Eqlid (Fārs), the Gardaneh Hasan Abad (Neyriz NE.), Kotale Khane Sorkh (Sirjan), Gardaneh Khorasani (Kerman N.), Kūh-e Chabr (Baft S.) and Pariz (Kerman NW.), live on species of *Eryngium* and are here referred to *Z. kermanensis*. Populations from eastern Turkey (*Z. araxis kurdi* Görgner & Hofmann, 1982) also live on *Eryngium* spp. on which fully-grown larvae were found in the vicinity of Van Gölü by C. M. Naumann in 1986 (documented in the transparency archives) and by H. & P. Kautt (pers. comm.) in 1992; from the latter, *ab ovo* cultures were successfully reared on *Eryngium* by A. Hofmann in 1993 and 1994. However, in addition to the geographical distance, there are significant phenotypic differences between the adults and the larvae of *Z. araxis* and *Z. kermanensis*. Preimaginal similarities indicate a closer relationship between *Z. araxis* and *Z. fredii*.

The male genitalia of *Z. araxis araxis* have been examined; those of *Z. araxis kurdi* have been illustrated by Görgner & Hofmann (1982: 50, figs 6.1–6.3), who made a comparison with those of *Z. fredii*.

Represented by two subspecies: *Z. araxis araxis* Koch, 1936, *Z. araxis kurdi* Görgner & Hofmann, 1982 (**comb. rev.**).

6. ***Zygaena fredii***. The nominal taxon '*Zygaena (Peristygia) fredii* Reiss, 1938', was placed by Naumann & Tremewan (1984: 170, 187) as a subspecies of *Z. araxis* and by Hofmann & Tremewan (1996: 42) as a subspecies of *Z. rubricollis*, in spite of being recognized as a valid species by Görgner & Hofmann (1982: 49, 51–53, figs 4.14–4.16, 7.1–7.4). It was reinstated as a valid species by Hofmann & Tremewan (2003: 17), as there is now sufficient evidence to show that it is a distinct biospecies, based on knowledge of its early stages, the phenotype of the adult and its genital morphology; moreover, the larval host-plants are *Bupleurum falcatum* M. Bieb. and a *Semenovia* sp., not *Eryngium billardieri* Delar. as previously thought.

Keil (2003c: 32) listed three taxa as subspecies under *Z. fredii*, viz. the nominotypical *Z. fredii fredii* Reiss, 1938, *Z. fredii syntopica* Hofmann & Tremewan, 2003, and *Z. rubricollis ginnereissi* Hofmann, 2000. However, it should be noted that the last-mentioned taxon is here considered to be a distinct biospecies whose status is discussed below.

The male genitalia of *Z. fredii fredii* are illustrated by Görgner & Hofmann (1982: 51, figs 7.1–7.3)

Represented by four subspecies: *Z. fredii fredii* Reiss, 1938, *Z. fredii escaleraiana* Holik, 1958 (**comb. nov.**), *Z. fredii syntopica* Hofmann & Tremewan, 2003, and a further undescribed subspecies from Kerman (Hofmann & Keil, 2010: in press).

7. ***Zygaena aisha***. The nominal taxon '*Zygaena (Mesembrynus) manlia aisha* Naumann & Naumann, 1980', was formally raised to species level by Hofmann & Tremewan (2003: 13–16), who provided detailed knowledge of its

early stages, ethology and ecology; moreover, the phenotypic characters of the adult are quite remarkable and easily allow separation of even single specimens from all known subspecies of *Z. manlia*.

The genital morphology will be described in a forthcoming revision of the *manlia*-group (Hofmann & Tremewan, a, in prep.).

8. ***Zygaena ginnereissi***. The tentative original placement of the nominal taxon '*Zygaena rubricollis ginnereissi* Hofmann, 2000', as a subspecies is no longer tenable, as biological and ecological data obtained by the present authors subsequent to its description show that it is in fact a valid biospecies (**stat. nov.**); moreover, its systematic position is perhaps nearer to *Z. kermanensis*. In addition to its biology, the most significant character of *Z. ginnereissi* is the phenotype of the adult, which exhibits extreme melanism that is characteristic of a high-mountain species rather than that of an eremic species occurring at a lower elevation. Quite remarkable is the absence of spot 1 or its reduction to a vestige at the base of the forewing; spot 3 is vestigial, spots 2, 4 and 5 are reduced and the hindwings are almost or even completely black. The two populations of *Z. ginnereissi* from Deh Bakri and Shingara are syntopic with the melanistic<sup>2</sup> *Z. chirazica eckweileri* Naumann & Naumann, 1980. While the strict allopatry with *Z. kermanensis* provides some scepticism for the specificity of *Z. ginnereissi*, individuals that undoubtedly belong to *Z. kermanensis* and have very distinct, only slightly melanistic phenotypes have been recorded at a biotope near Shingara, only a few kilometres away from the biotopes of *Z. ginnereissi*. However, the biology and early stages of *Z. kermanensis qashqai* (Tremewan, 1975: 237–239, pl. 6, figs 1–5) and *Z. ginnereissi* (A. Hofmann & W. G. Tremewan, unpublished) are known and, amongst other distinctive characters, the chaetotaxy of the larvae differs – the setae of the larva of *Z. kermanensis* are longer, giving it a comparatively hairy appearance, whereas those of *Z. ginnereissi* are short. Moreover, the ova of *Z. kermanensis* are usually deposited in a single layer, or in two or three flat layers, whereas those of *Z. ginnereissi* are deposited in a more irregularly shaped batch five layers deep. One might suggest that *Z. ginnereissi* is conspecific with *Z. fredei*, but both species are syntopic at Shingara.

The genital morphology will be described in a forthcoming revision of the *manlia*-group (Hofmann & Tremewan, a, in prep.).

9. ***Zygaena fusca***. Originally described as '*Zygaena (Mesembrynus) haematina fusca* Hofmann, 2000', the subsequent finding of the larva and identification of its host-plant by A. Hofmann has shown that *Z. fusca* is a valid biospecies whose range is restricted to the Kuh-e Karkas and the Kuh-e Marshenan, a mountain range that lies to the north-east of the city of Esfahān and is isolated from the Zagros range where *Z. haematina* occurs. On both mountains the larval host-plant is a *Trachydium* sp. or a *Semenovia* sp. (Apiaceae), whereas that of *Z. haematina* is *Ferulago carduchorum* Boiss. & Hausskn. With its restricted and isolated range, different ecology, biology and early stages, there

<sup>2</sup>The term 'melanistic' is only used to describe darkened populations of *Zygaena* such as those occurring at high elevations, or those that exhibit littoral melanism (Tremewan, 2006: 73–85). The term 'melanic' is used to describe those individuals in which the normal red coloration of the forewing spots and hindwings is replaced by dark brown or black; such recessive morphs are extremely rare and are assumed to be controlled by a pair of alleles that form part of a multiple allelomorphous series (Tremewan, 2006: 222).

is no doubt that *Z. fusca* is a distinct biospecies. Quite extraordinary are the dark olive green ground colour of the larva and the yellowish green coloration of its setae.

Keil (2003d) formally raised *Zygaena haematina fusca* to species level, an action that is valid because descriptions of the larva and cocoon were provided and compared with those of *Z. haematina*, thus providing selective evidence as required by the First Reviser Principle of the *Code*.

The genital morphology will be described in a forthcoming revision of the *manlia*-group (Hofmann & Tremewan, a, in prep.).

10. ***Zygaena pseudorubicundus***. The nominal taxon '*Zygaena (Mesembrynus) purpuralis pseudorubicundus* Klir & Naumann, 2002', was described from Iran and placed by Keil (2003e) as a subspecies of *Z. minos*, following his discovery of the early stages and larval host-plant (*Falcaria vulgaris* Bernh.) and examination of the genitalia. However, it is here placed as a valid biospecies (**stat. nov.**), as it is sympatric with *Z. minos persica* Burgeff, 1926, in the Reshteh-ye Alborz, while the larval host-plant, which belongs to the Apiaceae, clearly shows that it cannot be *Z. purpuralis*. Moreover, recent records from the Zagros range show that the species has a more extensive distribution and is not restricted to the Alborz range. In Iran, the larval host-plant of *Z. minos* is assumed to be an *Eryngium* species.
11. ***Zygaena essenii***. Originally described as a valid species, it was recognized as such by Tremewan (1980) and Naumann & Tremewan (1984: 165, 176); subsequently, Hofmann & Tremewan (1996: 80) placed it as a subspecies of *Z. truchmena*. However, based on evidence from DNA research of the two taxa (Niehuis *et al.*, 2007: 512), it has been shown that *Z. truchmena* and *Z. kavrigini* are more closely related to each other than either is to *Z. essenii*. Moreover, the phenotype of the adult of *Z. essenii*, especially the opaque coloration of the hindwings that always lack hyaline areas, cannot be confused with that of any individual of *Z. truchmena*. The two species have a disjunct distribution and transitional phenotypes are unknown. Therefore, *Z. essenii* is here reinstated as a valid species (**stat. rev.**).  
As *Z. essenii* was originally described without a description of the male and female genitalia, these were illustrated by Tremewan (1980: 126–127, figs 5–9) who placed the taxon in the *truchmena*-subgroup of the *escalerai-truchmena*-group (sensu Alberti, 1958: 292–293) within the subgenus *Agrumenia*; the taxon was considered by Tremewan to be most closely related to *Z. truchmena*.
12. ***Zygaena sengana***. The nominal taxon '*Zygaena (Coelstis) brandti* Reiss ssp. *sengana* Holik & Sheljuzhko, 1956', has had a most confusing taxonomic history. It was placed by Alberti (1958: 298) as a subspecies of *Zygaena afghana* and by Reiss & Tremewan (1967: 65) as a valid species, but without comment, a status that was followed by Tremewan (1975: 232). Naumann & Racheli (1978: 211–212) placed the nominal taxon '*Zygaena (Agrumenia) brandti xerxes* Tremewan, 1975', as a subspecies of *Z. sengana*, thereby recognizing the latter as a valid species and considering that it had sufficient differences in the genital morphology to separate it from the taxa '*Z. brandti nissana* Reiss, 1937' and '*Z. rosinae* Korb, 1902'. Subsequently, Racheli & Naumann (1979: 53) placed *Z. brandti xerxes* as a subspecies of '*Zygaena (Agrumenia) cyrus* Tremewan, 1975', raising the latter to species level by merely stating, with reference to Tremewan (1977: 68), that it is not conspecific with '*Z. brandti* Reiss, 1937'. Based on morphological characters of

the male and female genitalia, Tremewan (1979: 252–256) formally placed *Z. sengana* as a valid species, with the taxon *xerxes* as a subspecies, which was followed by Naumann & Naumann (1980: 47–48). Naumann & Tremewan (1984: 165, 166, 176, 177) made no direct comment on *Z. sengana*, but subsequently the latter was placed by Hofmann & Tremewan (1996: 78) as a subspecies of *Z. rosinae*.

Keil (2003a) reinstated *Z. sengana* as a valid species but, as with the other taxa that were raised to species level in this particular abstract, provided no evidence for doing so. However, in the abstract that follows, Keil (2003b: 29) formally raised the taxon to species level by describing and comparing the biology of *Z. sengana* with that of *Z. rosinae*, thus validating his action. Moreover, he listed two subspecies, viz. *Z. sengana sengana* and *Z. sengana kermana* Naumann & Naumann, 1980, the latter newly transferred from *Z. rosinae* but without comment. With reference to Keil (2003b: 29), Efetov (2004: 55) also listed *Z. sengana* as a valid species. Based on morphological characters, as described and illustrated by Tremewan (1979: 252–255, figs 9–14, 18, 19, 26–28), we accept Keil's reinstatement of *Zygaena sengana* as a valid species.

Represented by two subspecies: *Z. sengana sengana* Holik & Sheljuzhko, 1956, *Z. sengana kermana* Naumann & Naumann, 1980.

### Acknowledgements

We are greatly indebted to Dr K. Sattler (London) and Professor Dr G. M. Tarmann (Innsbruck) for providing constructive comments on an early draft of this paper.

### References

- Alberti, B.** 1958–1959. Über den stammesgeschichtlichen Aufbau der Gattung *Zygaena* F. und ihrer Vorstufen (Insecta, Lepidoptera). *Mitteilungen aus dem Zoologischen Museum in Berlin* **34**: 245–396, text-figs 1–4, pls 1–32 (1958); **35**: 203–242, pls 33–64 (1959).
- Alipanah, H.** 2005. Insects of Iran. The list of Lepidoptera in the Hayk Mirzayans Insect Museum of Plant Pests & Diseases Research Institute. Lepidoptera (XXX): Zygaenoidea Fam. Zygaenidae. *Plant Pests & Diseases Research Institute. Insect Taxonomy Research Department Publication* no. 13: 1–23.
- Ebert, G.** 1974. Zwei neue Taxa der Gattung *Zygaena* (*Mesembrynus*) aus Iran nebst einigen Bemerkungen zur Problematik nachtaktiven Verhaltens. *Beiträge zur Naturkundlichen Forschung in Südwestdeutschland* **33**: 163–168, figs 1–6.
- Efetov, K. A.** 2004. *Forester and Burnet Moths (Lepidoptera: Zygaenidae)* 272 pp., 9 tables, frontispiece, 1 pl., 183 text-figs. Simferopol.
- Görgner, E. & Hofmann, A.** 1982. Eine neue Zygaenenart für die Türkei (Lepidoptera; Zygaenidae, *Zygaena* Fabricius, 1775, Subgenus *Mesembrynus* Hübner, [1819]). *Entomofauna* **3**: 33–54, figs 1–7.
- Haaf, E.** 1952. Ueber die Genitalmorphologie der Zygaenen (Lep.). *Veröffentlichungen der Zoologischen Staatssammlung München* **2**: 125–159, fig. 1, pls 4–16.
- Hofmann, A. & Keil, Th.** 2010. Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775, in Iran (Lepidoptera: Zygaenidae). Part IX: On two newly discovered *Mesembrynus* taxa from the central and southern Zagros range. *Nota lepidopterologica* **33**: in press.

- Hofmann, A. & Tremewan, W. G.** 1996. *A Systematic Catalogue of the Zygaeninae (Lepidoptera: Zygaenidae)* 251 pp. Colchester.
- 2003. Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775, in Iran (Lepidoptera, Zygaenidae). Part VI: *Zygaena nocturna*, *Z. aisha*, *Z. rubricollis* and *Z. fredii* (addenda based on results of fieldwork in 2001 and 2002). *Linneana Belgica* **19**: 9–20, text-figs, pl. 1, figs 1–18, pl. 2, figs 1–12, pl. 3, figs 1–18.
- 2009. How many nominal subgenera are necessary in the Zygaenidae (Lepidoptera), with special reference to the genus *Zygaena* Fabricius, 1775? *Entomologist's Gazette* **60**: 91–106.
- *a.* The biospecies concept and its application to the *Zygaena manlia*-group within the subgenus *Mesembrymus* Hübner, [1819] (Lepidoptera: Zygaenidae, Zygaeninae) (in preparation).
- *b.* *The Natural History of Burnet Moths (Zygaena Fabricius, 1777) (Lepidoptera: Zygaenidae)* (in preparation).
- International Commission on Zoological Nomenclature** 1999. *International Code of Zoological Nomenclature*, Fourth edn xxix, 306 pp. London.
- Keil, Th.** 2003a. Distribution of Burnet moths in south Iran (Lepidoptera: Zygaenidae, Zygaeninae), p. 28. In Keil, Th. (Ed.), *Abstracts of the VIII International Symposium on Zygaenidae, Dresden, 10–14 September 2003* x, 54 pp. Dresden.
- 2003b. New data on the biology of *Zygaena (Agrumenia) rosinae* Korb, 1903 and *Z. (A.) sengana* Holik & Sheljuzhko, 1956 stat. rev. in south Iran (Lepidoptera: Zygaenidae, Zygaeninae), pp. 29–30. In Keil, Th. (Ed.), *Abstracts of the VIII International Symposium on Zygaenidae, Dresden, 10–14 September 2003* x, 54 pp. Dresden.
- 2003c. Attend [sic] for a new classification of the taxa around *Zygaena rubricollis* Hampson, 1900 (Lepidoptera: Zygaenidae, Zygaeninae), pp. 31–32. In Keil, Th. (Ed.), *Abstracts of the VIII International Symposium on Zygaenidae, Dresden, 10–14 September 2003* x, 54 pp. Dresden.
- 2003d. New data on the biology of *Zygaena haematina* Kollar, 1849 and *Z. fusca* Hofmann, 2000 (Lepidoptera: Zygaenidae, Zygaeninae), pp. 33–34. In Keil, Th. (Ed.), *Abstracts of the VIII International Symposium on Zygaenidae, Dresden, 10–14 September 2003* x, 54 pp. Dresden.
- 2003e. New data on the biology of *Zygaena minus* ([Denis & Schiffermüller] 1775) (Lepidoptera: Zygaenidae, Zygaeninae), pp. 35–36. In Keil, Th. (Ed.), *Abstracts of the VIII International Symposium on Zygaenidae, Dresden, 10–14 September 2003* x, 54 pp. Dresden.
- Naumann, C. M. & Naumann, S.** 1980. Neue Zygaenen aus den Aufsammlungen W. Eckweiler's aus dem Iran (Lepidoptera, Zygaenidae). *Mitteilungen der Entomologischen Gesellschaft Basel* (N.F.) **30**: 47–54, figs 1–16.
- Naumann, C. M. & Racheli, T.** 1978. Taxonomic and ecological observations on *Zygaena* F. from the province of Fars, southern Iran (Lepidoptera, Zygaenidae). *Atalanta, Würzburg* **9**: 208–218, figs 1–8.
- Naumann, C. M. & Tremewan W. G.** 1984. Das Biospecies-Konzept in seiner Anwendung auf die Gattung *Zygaena* Fabricius, 1775 (Insecta, Lepidoptera, Zygaenidae). *Spixiana* **7**: 161–193, figs 1–24.
- Niehuis, O., Hofmann, A., Naumann, C. M. & Misof, B.** 2007. Evolutionary history of the burnet moth genus *Zygaena* Fabricius, 1775 (Lepidoptera: Zygaenidae) inferred from nuclear and mitochondrial sequence data: phylogeny, host-plant association, wing pattern evolution and historical biogeography. *Biological Journal of the Linnean Society* **92**: 501–520, tables 1–4, fig. 1.
- Racheli, T. & Naumann, C. M.** 1979. On *Zygaena* Fabricius (Zygaenidae from Fars, south Iran). *Nota lepidopterologica* **2**: 53–55.

- Reiss, H. & Tremewan, W. G.** 1967. A systematic catalogue of the genus *Zygaena* Fabricius (Lepidoptera: Zygaenidae). *Series Entomologica* 2: xvi, 329 pp.
- Tremewan, W. G.** 1975. On *Zygaena* Fabricius (Lep., Zygaenidae) from Iran. *Entomologist's Gazette* 26: 229–248, pl. 6, figs 1–12.
- 1977. Distribution of the Burnet moths in Iran (synopsis). *Proceedings and Transactions of the British Entomological and Natural History Society* 10: 67–68.
- 1979. On *Zygaena* Fabricius (Lepidoptera: Zygaenidae) from Iran. *Entomologist's Gazette* 30: 249–256, text-figs 1–31.
- 1980. On the systematic position of *Zygaena* (*Agrumenia*) *essenii* Blom (Lepidoptera: Zygaenidae). *Entomologist's Gazette* 31: 126–128, text-figs 1–9.
- 2006. *Ecology, Phenotypes and the Mendelian Genetics of Burnet Moths (Zygaena Fabricius, 1775)* 390 pp., 194 figs. Wallingford.