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ECOLOGY AND EYE MORPHOLOGY IN *BUBOPSIS AGRIONOIDES, PUER MACULATUS* AND *DELEPROCTOPHYLLA DUSMETI* (NEUROPTERA, ASCALAPHIDAE)

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ABSTRACT

Field observations were made on Bubopsis agrionoides, Puer maculatus *and* Deleproctophylla dusmeti *(Ascalaphidae) in the Mediterranean area of France.* B. agrionoides *and* P. maculatus *were found in the biotopes covered with* Quercus ilex*, whereas* D. dusmeti *was collected in open areas covered with low vegetation. Individuals of* B. agrionoides *and* D. dusmeti *regroup to constitute populations of variable importance, but individuals of* P. maculatus *were always observed solitarily. The daily activity period of the adults was determined only for* B. agrionoides *and* D. dusmeti. *Like the* Libelloides *species, the three species mentioned in this paper may use the dorso-frontal UV-sensitive part of their divided compound eyes for detecting preys or mates flying on blue sky background.*

Key words: owl-flies, *Deleproctophylla dusmeti, Bubopsis agrionoides, Puer maculatus*, France, ecology, eye morphology

ECOLOGIA E MORFOLOGIA OCULARE IN *BUBOPSIS AGRIONOIDES, PUER MACULATUS* E *DELEPROCTOPHYLLA DUSMETI* (NEUROPTERA, ASCALAPHIDAE)

SINTESI

Tre specie di ascalafidi, Bubopsis agrionoides, Puer maculatus *e* Deleproctophylla dusmeti *(Ascalaphidae), sono state osservate nell'area mediterranea della Francia.* B. agrionoides *e* P. maculatus *sono state rinvenute in biotopi caratterizzati dalla presenza di* Quercus ilex*, mentre esemplari di* D. dusmeti *sono stati raccolti in aree aperte con vegetazione bassa. Gli individui di* B. agrionoides *e* D. dusmeti *si raggruppano e formano popolazioni di importanza variabile, mentre gli individui di* P. maculatus *sono stati osservati sempre solitariamente. Il periodo di attività diurna degli adulti è stato determinato solo per* B. agrionoides *e* D. dusmeti. *Come le specie del genere* Libelloidess*, le tre specie menzionate nell'articolo sono capaci di utilizzare la parte dorso-frontale UV-sensoria dei loro occhi compositi, per percepire la presenza di prede o compagni che volano nel cielo azzurro come sottofondo.*

Parole chiave: ascalafidi, *Deleproctophylla dusmeti, Bubopsis agrionoides, Puer maculatus*, Francia, ecologia, morfologia oculare

INTRODUCTION

Conversely to the tropical fauna, the systematics of the Ascalaphidae of the Palaearctic region is well known even if the exact status of some species, particularly within the genus *Libelloides* Schäffer, 1763, remains uncertain (Van der Weele, 1908; Aspöck *et al.*, 1980, 2001; Medvedev, 1987). The ten species recorded from the continental part of France belong to the genera *Libelloides* (6 spp), *Deleproctophylla* (1 sp), *Bubopsis* (1 sp) and *Puer* (1 sp) (Aspöck *et al.*, 2001). However, the biology of the species has been poorly investigated and only little information on the adult ecology is available. Recently, some observations made in the South of France on *Bubopsis agrionoides* (Rambur, 1838), *Puer maculatus* (Olivier, 1789) and *Deleproctophylla dusmeti* Navás, 1914 brought some data on the flight period, the frequented biotopes and the behaviour of the adults (Wachmann & Saure, 1997; Mazel, 2001; Morin & Maldés, 2001; Peslier, 2002). The aim of this publication is to present complementary and original information on the biology of these species and to investigate the relationships between the adult ecology and the eye morphology of these three species.

MATERIAL AND METHODS

Studies were carried out in the natural environment of the Montpellier region in Southern France. The morphology of the compound eyes was investigated by magnified images of photographs taken on alive or dried specimens. The colour of the screening pigment in the dorso-frontal and ventral regions of the compound eye was determined by orthodromic illumination of alive specimens with white light using a stereomicroscope and a digital camera.

Tab. 1: Localities of the collected Ascalaphidae in Southern France (coordinates from www.geoportail.fr).
Tab. 1: Lokalitete vrst iz družine Ascalaphidae, odkrite v južni Franciji (koordinate s spleta www.geoportail.fr).

Departements/Localities	**longitude (E)**	**latitude (N)**	***B. agrionoides***	***P. maculatus***	***D. dusmeti***
Pyrénées Orientales (66)					
Sahorre	02°21′43″	42°31″57″		**X**	
Estagel	02°41″57″	42°46″20″		**X**	
Vinça	02°31′40″	42°38′41″	**X**		
Sainte Colombe de la Commanderie	02°44′59″	42°36′57″	**X**		
Vingrau	02°46′52″	42°50′49″	**X**		
Cases de Pène	02°47′10″	42°46′44′	**X**		
Espira de l′Agly	02°50′04″	42°46′40″	**X**		
Banyuls sur Mer	03°07′43″	42°28′52″	**X**		
Hérault (34)					
Saint Guilhem le Désert	03°32″55″	43°46″46″		**X**	
Pégairolles de Buèges	03°35′15″	43°48′21″	**X**		
Argelliers	03°40′14″	43°41′59″	**X**	**X**	
Valmalle	03°40′34″	43°36″33″			**X**
Vailhauquès	03°41″10″	43°40″22″		**X**	
Le Frouzet	03°41″26″	43°49″01″		**X**	
Murviel les Montpellier	03°44″13″	43°36″16″			**X**
Saint Gély du Fesc	03°48″16″	43°41″41″		**X**	
Causse de l′Hortus	03°49′34″	43°51′06″	**X**		
Gard (30)					
Region of Nîmes	none	none		**X**	
Bouches du Rhône (13)					
Plaine de la Crau	04°49′50″	43°31′32″			**X**
Region of Marseille	none	none		**X**	
Var (83)					
Hyères	06°07′51″	43°0′45″		**X**	
Saint Aygulf	06°43′13″	43°23′01″			**X**

RESULTS

Ecology of the species

***Bubopsis agrionoides* (Rambur, 1838)**

B. agrionoides was described by Rambur from a male collected in the South of Spain at the foot of the Sierra-Prieta. Now this species is known from Morocco, Italy and France (Aspöck *et al.*, 2001). In France, *B. agrionoides* was recorded from two departments only, Pyrénées Orientales (Auber & Delamarre Debouttevillle, 1955) and Hérault (Schaefer, 1974) (Tab. 1).

The observations were made in the locality of Argelliers at the place named Les Hauts de Boscorre. The station is located on a southern hillside. The soil is composed of calcareous rock with fissures and vertical holes, whose biggest dimension can reach one meter. The substratum is covered by Mediterranean evergreen holm-oak *(Quercus ilex* Linnaeus, 1753). The oak forest is interrupted by area without vegetation, where Mastic tree *(Pistacia lentiscus* Linnaeus, 1753) and annual plants like *Centranthus angustifolius* (Miller, 1805) and *Sedum sediforme* (Jacquin, 1909) (Fig. 1) are flourishing.

Adults fly in July and August. During the journey, several individuals were collected beating the lowest branches of the oaks at the limit of the open rocky areas. When disturbed, the adults fly a short distance before they settle under another tree, where the grey colour of their bodies makes them very difficult to spot when resting on the bark of *Q. ilex*. This behaviour was observed only in a calm weather with light cloudy sky. On windy and sunny days, no adults were found even beating the trees at all their heights. That could mean that the resting sites vary according to the weather conditions. When the conditions are unfavourable, the adults look for a shelter inside the vegetation, where they are very difficult to find. Whatever the weather conditions, no individual was found within the fissures and rocky cavities.

The flight activity was observed in August 2007 on one female. This individual was resting on a twig of *P. lentiscus* at a height of almost two meters (Fig. 2). At 20:30, it began to vibrate its wings for some minutes. This behaviour probably helps to warm the muscles and its duration has to be a function of the temperature. But it has not been possible to observe this behaviour again. Then it flew away and made go-and-come motions above the trees at a height of almost four-five meters. This activity corresponds probably to the behaviour of hunting. It has been possible to observe this female for one hour until 21:30. During this time, no other individual was observed.

On July 14, 2007, a female was collected by light trapping.

Fig. 1: (A) Habitat of** Bubopsis agrionoides **at Argelliers consists of small-sized holm-oaks** Quercus ilex **growing on rocky soil. (B) Aerial picture of the locality with calcareous areas in grey (source www.geoportail.fr).
Sl. 1: (A) Habitat vrste** Bubopsis agrionoides **pri Argelliersu sestoji iz nizkega črničevja** Quercus ilex, **rastočega v skalovitem območju. (B) Zračni posnetek lokalitete z apnenčastim območjem v sivi barvi (vir www.geoportail.fr).

Fig. 2: *B. agrionoides* ***female resting on a branch of*** *Pistacia lentiscus* ***at Argelliers before taking flight.***
Sl. 2: Samica vrste *B. agrionoides,* ***počivajoča na mastiki*** *Pistacia lentiscus* ***pri Argelliersu, tik pred poletom z veje.***

***Puer maculatus* (Olivier, 1789)**

This species was described from specimens from Avignon in Southern France (Aspöck & Aspöck, 1987). It is now recorded from Spain, France and Israel (Aspöck *et al.*, 2001).

In spite of its wide distribution (Tab. 1), this species is rarely observed and its ecology remains quite unknown. The recent report from the region of Montpellier by several colleagues *(pers. comm.)* indicates that *P. maculatus* fly in July. In the department of Hérault it was recorded from five localities. Only at Argelliers it was collected in the biotope also frequented by *B. agrionoides*. It was never observed in association with *D. dusmeti* (Tab. 1). Individuals have been collected resting on twigs of grass in the morning and at the end of the afternoon. It seems that it flies above the low vegetation (Fig. 3) and not above trees like *B. agrionoides*. The adults do not fly when it is raining, even when drizzling, and when wind is blowing.

***Deleproctophylla dusmeti* (Navás, 1914)**

This species was described from individuals collected in Spain (Navás, 1914). It is now recorded from Spain and France (Aspöck *et al.,* 2001). In France, it has been recorded from three departments, *i.e.* Hérault, Bouches du Rhône and Var.

The observations were made in the plain of Crau near the village of Saint Martin de Crau and in three places close to Montpellier, Murviel les Montpellier (place named Mas Dieu), Valmalle and on the Causse de l'Hortus, which is a calcareous tableland (Tab. 1).

In all the localities the individuals were observed in Mediterranean grassland covered by low vegetation with only few small trees here and there. At Murviel les Montpellier, the first author also collected *Libelloides ictericus* (Charpentier, 1825) and *Libelloides longicornis* (Linnaeus, 1764) in the same grassland where *D. dusmeti* was collected. Adults flew from mid June to end of July.

In the plain of Crau, the individuals were observed during the morning. The adults began to fly at around 09:30 when the temperature was getting higher. Then they stopped to fly at the end of the morning and rested on grass twigs. Several individuals were flying at the same time. They captured the prey flying, and settled on grass twigs to feed. In the region of Montpellier, the observations were made during the afternoon until sunset. During this period, no flight activity was detected. The individuals were collected after being disturbed by beating the grasses. They flew away, covering quite a long distance, and settled in the grass. The adult activity ceased completely from the sunset onwards. Even beat-

Fig. 3: Habitat of** Puer maculatus **at Vailhauquès consists of grass covered area surrounded by** Q. ilex **formation with rocky areas.
Sl. 3. Habitat vrste** Puer maculatus **pri Vailhauquèsu sestoji iz travnatega območja, ki ga obkrožajo formacije črničevja** Q. ilex **na skalnatem svetu.

ing the grass did not permit to observe individuals, which probably rested inside the vegetation. No adults were attracted to light. The colour of this species makes it very difficult to spot the individuals resting on the dry twigs of grass (Fig. 4). This homochromy represents a protective coloration for individuals resting inside the vegetation.

Eye morphology

The compound eyes of living and dried specimens of *B. agrionoides*, *P. maculatus* and *D. dusmeti* were photographed via a stereo optical microscope and the images analyzed. Externally, the eyes exhibit traits typical of the Ascalaphinae (Aspöck *et al.*, 2001; Winterton, 2003). The eyes are divided into a dorso-frontal area and a ventral area, separated by a transverse sulcus. As with other *Libelloides* species studied (Fischer *et al.*, 2006), the division appears particularly prominent. The dorso-frontal region of the eye is distinctly larger than the ventral region. Furthermore, the facet diameters of dorso-frontal ommatidia appear to be larger than those of ventral ommatidia. To a certain extent, the surface of the dorso-frontal region appears somewhat flatter than that of the ventral region, indicating a somewhat greater radius of curvature. This suggests smaller interommatidial angles in these areas, which would mean that greater spatial resolution is to be expected for the dorso-frontal region than for the ventral region. In the closely related *Libelloides macaronius* (Scopoli, 1763), increased visual acuity in the dorso-frontal region due to smaller interommatidial angles has been demonstrated experimentally (for review see Kral, 2002).

Fig. 4:** Deleproctophylla dusmeti **female resting on a twig of grass at Murviel Les Montpellier.
Sl. 4: Samica vrste** Deleproctophylla dusmeti **na steblu trave pri kraju Murviel Les Montpellier.

Orthodromic illumination of the compound eye ommatidia regarding the living specimens of *B. agrionoides* and *D. dusmeti* indicates distinct differences in the spectral reflection properties of the dorso-frontal and ventral parts of the eye. Overall, the former appears yellow, while the latter appears dark (Fig. 5). Depending upon the angle of illumination, this effect can be masked to a greater or lesser extent by the yellowish luminous tracheole system of the ommatidia (luminous pseudopupils, typical of superposition eyes of neuropteran species). However, it indicates yellowish screening pigment in the dorsofrontal and dark screening pigment in the ventral pigment cells that surround the crystalline cone of an ommatidium. In the closely related *L. macaronius*, it has been shown experimentally that the yellowish pigment in the dorso-frontal region of the eye is associated with receptivity to short-wave (violet to UV) light. This provides optimal stimulus conditions for the UV-sensitive retina. In contrast, the dark pigment in the ventral region of the eye permits stimulation of the retina over a broad spectral range (Gogala, 1967; Schneider *et al.*, 1978; Gribakin *et al.*, 1995; Stušek *et al.*, 2000; for review see Kral, 2002).

DISCUSSION

The observations made in Southern France on three species of Ascalaphidae, *B. agrionoides*, *P. maculatus* and *D. dusmeti* corroborate the information found in the literature (Schaefer, 1974; Rehfeldt, 1989; Wachmann & Saure, 1997; Mazel, 2001; Morin & Maldés, 2001; Peslier, 2002).

However, Mazel (2001) mentioned that *B. agrionoides* can be found also in vegetal formation constituted by Tree Heath *Erica arborea* Linnaeus, 1753 and Hedelyng *Calluna vulgaris* (Linnaeus, 1753) grown on schistose ground. The period of the flight activity of *B. agrionoides* was also observed by Peslier (2002). But this author mentioned that according to the weather conditions, when the sky is cloudy and the light level is low, the adults can begin to fly from 19:30 instead of 20:30. *B. agrionoides* flies at the end of the afternoon until the sunset, but could also be nocturnal, as several captures were made with light trap (Schaefer, 1974; Mazel, 2001; Peslier, 2002).

With regard to *P. maculatus*, the observations reported by Mazel (2001) and Morin & Maldés (2001) indicated that this species can be found in the same biotopes as *B. agrionoides* but conversely to this species it flies lower, above the grass vegetation, and not above trees. *P. maculatus* was also observed at around 700 m above sea level in a locality characterized by a gneiss ground (Mazel, 2001).

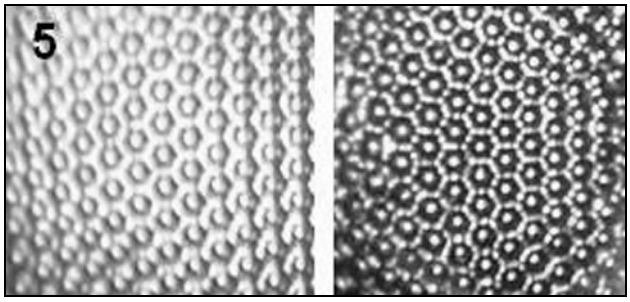

Fig. 5: Ommatidia of compound eye of alive** B. agrionoides **illuminated directly from above with white light showing pseudopupils (light spots) and the yellow screening pigment in the dorso-frontal part and the 'dark' screening pigment in the ventral part (masked by reflecting tracheoles and perhaps by corneal nipples).
Sl. 5: Omatidiji sestavljenega očesa žive metuljčnice** B. agrionoides**, osvetljene naravnost od zgoraj z belo svetlobo; na njej vidimo psevdopupile (svetle lise), rumeni pigment v hrbtno-čelni strani in "temni" pigment v trebušni strani (ki ga zastirajo odsevajoče traheje in morda kornealne bradavice).

Contrary to the precedent species, *D. dusmeti* was found only in open land covered with low vegetation. The same information is reported by Wachmann & Saure (1997) and for *D. australis* by Devetak (1995, 1998). *D. dusmeti* has been observed flying at the end of the morning and resting in the vegetation for the rest of the day.

From the optical and morphological differentiation of the eyes, flight activity can be expected to occur during the daytime in open terrain or above the vegetation, primarily during fine weather (Fischer *et al.*, 2006). This is in fact the case. However, the fact that nocturnal activity is also exhibited by *B. agrionoides* indicates that the eyes can also be utilised with nocturnal lighting conditions. Whether this also applies to the other species, has yet to be investigated. So far, no nocturnal activity has been observed for *Libelloides* species, such as *L. macaronius* and *L. coccajus* (Denis and Schiffermüller, 1775) (Gogala, 1967; for review see Kral, 2002; Fischer *et al.*, 2006; Kral, *unpubl. data).*

In summary, it is clear that without a detailed histological investigation with the aid of electron microscopy as well as without electrophysiological recordings the questions concerning the vision in *B. agrionoides*, *P. maculatus* and *D. dusmeti* cannot be fully answered. However, whether studies including these techniques will be possible will depend upon the availability of these very rare species.

EKOLOGIJA IN MORFOLOGIJA OČESA PRI VRSTAH *BUBOPSIS AGRIONOIDES*, *PUER MACULATUS* IN *DELEPROCTOPHYLLA DUSMETI* (NEUROPTERA, ASCALAPHIDAE)

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POVZETEK

Avtorja sta v sredozemskem območju Francije preučevala vrste Bubopsis agrionoides, Puer maculatus *in* Deleproctophylla dusmeti *(Ascalaphidae). Vrsti* B. agrionoides *in* P. maculatus *sta zabeležila v biotopih, poraščenih s črničevjem* Quercus ilex, *medtem ko sta vrsto* D. dusmeti *našla v odprti pokrajini, poraščeni z nizko vegetacijo. Osebki* B. agrionoides *in* D. dusmeti *se pregrupirajo, da oblikujejo različno pomembne populacije, osebki vrste* P. maculatus *pa so bili vselej zabeleženi posamično. Čas dnevne aktivnosti je bil ugotovljen le za vrsti* B. agrionoides *in* D. dusmeti. *Vse tri vrste, omenjene v tem prispevku, lahko tako kot vrste iz rodu* Libelloides *uporabljajo za ultravijolične žarke občutljivo hrbtno-čelno stran svojih sestavljenih oči za odkrivanje letečega plena ali partnerjev na ozadju modrega neba.*

Ključne besede: metuljčnice, *Deleproctophylla dusmeti, Bubopsis agrionoides, Puer maculatus*, Francija, ekologija, morfologija oči

REFERENCES

Aspöck, U. & H. Aspöck (1987): Wiederentdeckung von *Puer maculatus* (Olivier) in Europa (Neuropteroidea: Planipennia: Ascalaphidae). Z. ArbGem. öst. Ent., 39, 5–11.

Aspöck, H., U. Aspöck & H. Hölzel (1980): Die Neuropteren Europas. Eine zusammenfassende Darstellung der Systematik, Ökologie und Chorologie der Neuropteroidea (Megaloptera, Raphidioptera, Planipennia) in Europas. Goecke & Evers, Krefeld, I: 495 p., II: 355 p.

Aspöck, H., H. Hölzel & U. Aspöck (2001): Kommentierter Katalog der Neuropterida (Insecta: Raphidioptera, Megaloptera, Neuroptera) der Westpaläarktis. Denisia, 2, 606 p.

Auber, J. & C. Delamarre Deboutteville (1955): Deux Ascalaphides de la Région de Banyuls.Vie Milieu, 6, 354–358.

Devetak, D. (1995): *Deleprotophylla australis* (Fabricius 1787) in Istria and Quarnero (Neuroptera: Ascalaphidae). Annales, Ser. Hist. Nat., 5(1), 193–198.

Devetak, D. (1998): Neuroptera in different habitats in Istria and Quarnero (NW Balkan). Acta Zool. Fennica, 209, 95–98.

Fischer, K., H. Hölzel & K. Kral (2006): Divided and undivided compound eyes in Ascalaphidae (Insecta, Neuroptera) and their functional and phylogenetic significance. J. Zool. Syst. Evol. Res., 44, 285–289.

Gogala, M. (1967): Die spektrale Empfindlichkeit der Doppelaugen von *Ascalaphus macaronius* SCOP. (Neuroptera: Ascalaphidae). Z. vergl. Physiol., 57, 232–243.

Gribakin, F., E. Alekseyev, S. Shukolyukov & M. Gogala (1995): Unconventional ultraviolet sensitivity spectra of *Ascalaphus* (Insecta, Neuroptera). J. Comp. Physiol., 177, 201–206.

Kral, K. (2002): Ultraviolet vision in European owlflies (Neuroptera: Ascalaphidae): a critical review. Eur. J. Entomol., 99, 1–4.

Mazel, R. (2001): Notes sur les Ascalaphidae du sud de la France (Neuroptera). Rev. Assoc. Roussillonnaise Entomol., 10(1), 3–7.

Medvedev, G. S. (1987): Key to insects of the European part of the USSR. IV, Part 6. Megaloptera, Raphidioptera, Neuroptera, Mecoptera, Trichoptera. Izdaltelstvo "Nauka", Leningradskoe Otdelenie, 200 p.

Morin, D. & J.-M. Maldés (2001): Les lapiaz d'Argelliers: bonne localité héraultaise pour les Ascalaphidae (Neuroptera). Rev. Assoc. Roussillonnaise Entomol., 10(1), 1.

Navás, L. (1914): Acaláfido Nuevo de España. *Deleproctophylla dusmeti* sp. n. Brotéria, Sér. Zool., 12, 57–60.

Olivier, A. G. (1789): Encyclopédie méthodique. Histoire naturelle. Insectes. Vol. 4. (Ascalaphe, *Ascalaphus).* Panckoucke, Paris, pp. 241–246.

Peslier, S. (2002): Observation nouvelles sur le comportement de *Bubopsis agrioides* Rb. (Neuroptera, Ascalaphidae). Rev. Assoc. Roussillonnaise Entomol., 11 (3), 101.

Rambur, M. P. (1838): Faune entomologique de l'Andalousie. Vol. 2. Arthus Bertrand, Paris.

Rehfeldt, G. (1989): Eine Massenwanderung von *Deleproctophylla dusmeti* Navás (Neuroptera: Ascalaphidae) in der Crau (Frankreich). Entomol. Zeitschr., Frankf. a. M., 99, 65–80.

Schaefer, L. (1974): Extrait du procès-verbal de la séance du 5.X.1974. Annales de la Société d'Horticulture et d'Histoire Naturelle de l'Hérault, 114 (4), 144.

Schneider, L., M. Gogala, K. Drašlar, H. Langer & P. Schlecht (1978): Feinstruktur und Schirmpigment-Eigenschaften der Ommatidien des Doppelauges von *Ascalaphus* (Insecta: Neuroptera). Cytobiology, 16, 274–307.

Stušek, P., K. Drašlar, G. Belušič & G. Zupančič (2000): Adaptation mechanisms in insect eyes. Acta Biol. Slov., 43, 41–70.

Van der Weele, H. W. (1908): Ascalaphiden: Monographisch Bearbeitet. Coll. Zool. Selys Longchamps, Fasc. VIII, pp. 1–326.

Wachmann, E. & C. Saure (1997): Netzflügler, Schlamm- und Kamelhalsfliegen: Beobachtung, Lebensweise. Naturbuch Verlag, Augsburg, 159 p.

Winterton, S. L. (2003): Molecular phylogeny of Neuropterida with emphasis on the lacewings (Neuroptera). Entomol. Abh. Staatl. Mus. Tierkunde Dres., 61, 58–160.