The distribution of *Zygonyx torridus* in the Palaearctic (Odonata: Libellulidae)

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Abstract

Zygonyx torridus is an Oriental-Afrotropical species, whose range also covers the southern margin of the Palaearctic. All known records from the latter region are listed, mapped and discussed. Records from single localities covering a longer period of time are available for the Canary Islands, the Jordan Valley, and Spain. The known occurrence in northern Africa is restricted to Morocco and Tunisia. In southern Europe the species is rare, and several populations seem to have been lost recently. Records are known from Portugal, Spain and Italy. One visual observation originates from southwestern Turkey. A record from Iran indicates a bridge to the population on the Indian subcontinent. The species is new to the fauna of Italy, Tunisia and Turkey.

Zusammenfassung

Die Verbreitung von *Zygonyx torridus* in der Paläarktis (Odonata: Libellulidae) — *Zygonyx torridus* ist ein orientalisch-äthiopisches Faunenelement, dessen Areal sich bis in die südliche Paläarktis erstreckt. Alle bisher bekannt gewordenen Funde aus diesem Teilareal werden aufgelistet, in Karten dargestellt und interpretiert. Von den Kanarischen Inseln, aus dem Jordantal und aus Spanien sind von einzelnen Lokalitäten Nachweise über mehrere Jahrzehnte bekannt. Aus Nordafrika liegen bisher nur Funde für Marokko und Tunesien vor. In Südeuropa ist die Art selten, die bekannten Fundorte sind aktuell zum Teil verwaist. Funde sind aus Portugal, Spanien und Italien bekannt. Eine Sichtbeobachtung stammt aus dem Südwesten der Türkei. Ein iranischer Fund kann als Brücke zu den Vorkommen in Indien gedeutet werden. Die Art ist neu für die Faunen von Italien, Tunesien und der Türkei.

Introduction

KIRBY (1889) described the new species *torrida* and assigned it to the newly erected genus *Pseudomacromia*. The description was based on a series of six specimens: one male and one female from Sierra Leone as well as one male each from West Africa, Abyssinia, Natal and Tenerife. Sierra Leone was defined as the type locality, and the male from there – also serving as a model for the male description – was indicated as the 'type', which defined this specimen to be the holotype. Curiously, KIMMINS (1968) overlooked this type designation when he selected the same specimen to be the lectotype. This must be regarded as an invalid nomenclatural act.

The species was described once again under the name *P. atlantica* by MARTIN (1900). This name is represented by only one female from Las Palmas, Gran Canaria (RIS 1912). A second synonym – *P. hoffmanni* – was created by GRÜNBERG (1903). This name refers to a single female from Sierra Leone. Both synonymies were recognized by RIS (1912), who also pointed out that the genera *Pseudomacromia* und *Zygonyx* were identical because they shared the same characters. FRASER (1924) combined both genera under the senior synonym *Zygonyx*; since then the correct name should read *Zygonyx torridus*. The version '*Z. torrida*' has been used by many authors but is incorrect because the genus name *Zygonyx* is masculine in gender (FLIEDNER 1993).

With regard to size, venation and coloration, some variation of *Z. torridus* has been pointed out (e.g., KIRBY 1889, RIS 1908, 1912, LONGFIELD 1931, WATERSTON 1985, WATERSTON & PITTAWAY 1991). Two subspecies have been described. The older one is ssp. *isis* which is said to inhabit the Indian subcontinent and is characterised by an overall darker appearance compared with the nominotypical ssp. (FRASER 1924). It was originally erected as a distinct species but later subspecifically assigned to *Z. torridus* (FRASER 1931). The other one is ssp. *insulanus*, described from Mauritius and said to be smaller than the nominotypical ssp. and to have some basal amber in all male wings (PINHEY 1981). Both subspecies definitions are not convincing from the present taxonomic point of view. Especially the endemic status of *insulanus* has been questioned (JACQUEMIN & BOUDOT 1999, CLAUSNITZER & MARTENS 2004). FRASER (1936) maintained the subspecific status of *isis* but this was never confirmed in a subsequent analysis. The present taxonomic concept of *Z. torridus* as a polytypical species is therefore untenable – a future revision is needed. We treat the species as monotypical in this paper and refrain from using a trinomen with regard to the Palaearctic populations.

The main range of *Z. torridus* covers the entire African continent (RIS 1921) and the southern Arabian Peninsula (WATERSTON 1985, SCHNEIDER & KRUPP 1993) beyond the huge belt of the Sahara and the Arabian Desert (maps in DUMONT 1982, WATERSTON & PITTAWAY 1991). The desert belt itself seems to be not colonized; no record is known so far. The species also occurs on the Indian subcontinent (FRASER 1936). Hence, it has been charaterized zoogeographically as an Oriental-Afrotropical species (HEIDARI & DUMONT 2002).

Typical habitats of the species are waterfalls and rapids of permanent rivers and brooks in the steppe and arid regions (e.g., SUHLING et al. 2003). Suitable sites are frequently successfully settled, even if they are extremely isolated, as in tropical rainforest (LEMPERT 1988) or in desert (PRINSLOO 1990, SUHLING et al. 2006). The same applies to the African islands; e.g., Soqotra (KIMMINS 1961, SCHNEIDER & DUMONT 1998), Comores (RIS 1915, STARMÜHLNER 1970), Mauritius (PINHEY 1976, 1981), Réunion (JACQUEMIN 1988), Cape Verde (MARTIN 1908) and Canary Islands (KIRBY 1889: paratype, this paper). The appearance on nearly all bigger islands surrounding the main distribution of the species in Africa indicates a highly effective mechanism to find suitable new habitats and a high potential as a migrant and colonizer.

The occurrence of *Z. torridus* in the Palaearctic is also consistent with the species' status as a migrant and colonizer. All the Palaearctic records are separated from the main range by sea or by a huge desert belt. In the present paper we analyse the current situation of the species at the northern edge of its range. Up to now, all existing Palaearctic maps or distribution analyses (e.g., VAN TOL & VERDONK 1988, D'AGUILAR et al. 1986, D'AGUILAR & DOMMANGET 1998, ASKEW 2004) can be significantly upgraded and updated. We also can – with respect to the situation in northern Africa – correct old erroneous ideas that have remained uncorrected until today.

Material and methods

In this study, the Palaearctic was demarcated against the Afrotropics along the desert belt in northern Africa and the Arabian Peninsula. That means that the Sahel along the southern edge of the Sahara as well as southern Arabia completely belong to the Afrotropics. Sahel records (e.g., LONGFIELD 1936, DUMONT 1977) are excluded here. In the Arabian Peninsula *Z. torridus* is common in the south (WATERSTON 1985, SCHNEIDER & KRUPP 1993), but there are also a few localities known from mountains along the Red Sea in Saudi Arabia up to 23°N (WATERSTON 1985). These localities almost touch the border to the Palaearctic but are completely assigned to the Afrotropical occurrences in Oman and Yemen in the present paper. All Indian records belong to the Oriental zone but the only Pakistani record must be assigned to the borderline between Oriental and Palaearctic – being situated in the Salt Range, a mountainous area forming the northern boundary of the arid Punjab. The Canary Islands, the complete North African region, the Jordan Valley and the Iran were considered to be Palaearctic.

Our collection of data was based on a comprehensive analysis of literature, comprising 33 paperss containing primary data. Through correspondence with persons experienced with *Zygonyx torridus* in the Canary Islands, Northwest Africa, Europe, and the Middle East, we can present 28 unpublished records

and important additional information. The following acronyms of museums and universities are used:

BNHM - Natural History Museum, London, United Kingdom
HUJI - The Hebrew University, Jerusalem, Israel
MNHN - Museum National d´Histoire Naturelle, Paris, France
MNMS - Museo Nacional de Ciencias Naturales, Madrid, Spain
NMW - Naturhistorisches Museum, Wien, Austria
RSME - National Museums of Scotland, Edinburgh, United Kingdom
SMF - Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt a.M., Germany
TAU - Tel-Aviv University, Tel-Aviv, Israel
UJIM - University of Jordan Insect Museum, Amman, Jordan
YU - Natural History Museum at Yarmouk University, Irbid, Jordan
ZMHB - Museum für Naturkunde der Humboldt-Universität, Berlin, Germany
ZSM - Zoologische Staatssammlung, München, Germany

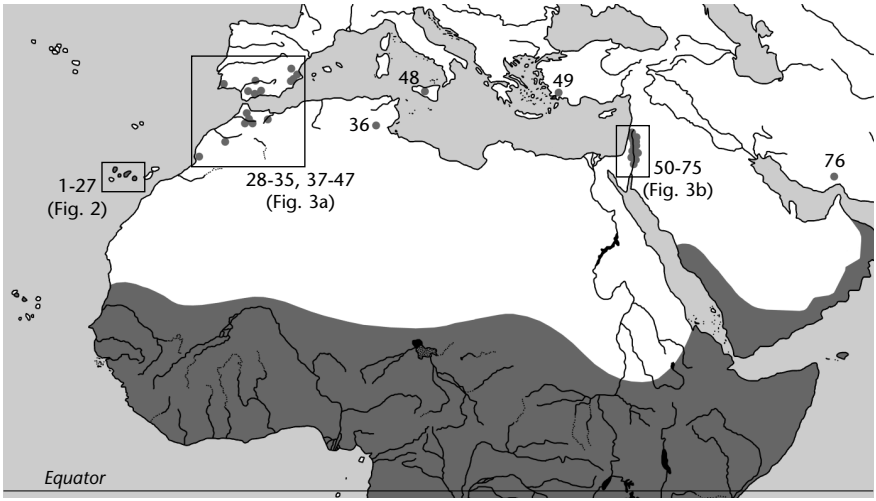

Figure 1: Distribution of *Zygonyx torridus* in the south-western Palaearctic. The Afrotropical range of distribution south of the Sahara and the Arabian Desert is shaded in grey but omitted south of the equator; the Oriental range on the Indian subcontinent is also omitted. The occurences in Tunisia (36), Sicily (48) and southwestern Turkey (49) are new to science. — Abbildung 1: Verbreitung von *Zygonyx torridus* in der südwestlichen Paläarktis. Das Verbreitungsgebiet in der Äthiopis südlich von Sahara und Arabischer Wüste ist grau angelegt, jedoch südlich des Äquators nicht dargestellt. Die orientalischen Vorkommen auf dem indischen Subkontinent sind ebenfalls nicht dargestellt. Die Funde aus Tunesien (36), Sizilien (48) und der südwestlichen Türkei (49) sind Erstnachweise für die jeweiligen Länder.

Data for 29 specimens from the Jordan Valley and surroundings, deposited in the collections of the HUJI (3 specimens), TAU (11), UJIM (14) and YU (1), have been provided by W. Schneider. Because this list contains more data than Schneider`s dissertation (1986), we refer to the unpublished source in the present paper. Also included in this study are 40 specimens from collections in several European institutions. We visited the following collections: NMW (10), SMF (6), ZMHB (4) and ZSM (5). The following institutions gave us information about their stored specimens: MNMS (9) and BNHM (6). No relevant material was found at Magyar Természettudományi Múzeum, Budapest, Hungary; Museu de Ciències Naturals de la Ciutadella, Barcelona, Spain; Museo Civico di Storia Naturale 'Giacomo Doria', Genova, Italy; Museo Civico di Storia Naturale, Milano, Italy; Museum für Tierkunde, Dresden, Germany; Naturhistorisches Museum, Basel, Switzerland; Naturhistoriska Riksmuseet, Stockholm, Sweden; Staatliches Museum für Naturkunde, Stuttgart, Germany, and Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany. Furthermore, field investigations were carried out by BK and RJ in Tunisia and by SVO in Libya and the Sinai (Egypt).

Results

Seventy-five Palaearctic localities were compiled, where *Zygonyx torridus* was found (Tab. 1, Fig. 1). Seven records (1, 3, 10, 26, 69, 73, 74) could not be assigned to a nominated locality. Altogether, 112 records were assembled. The species was recorded for the first time from Tunisia, Italy and Turkey. The Tunisian record occurred at a fast-running mountain brook with several waterfalls near Tamerza, close to the Algerian border. BK observed and photographed two emerging individuals, and collected their exuviae. SVO detected a series of specimens from Italy in the ZSM collection, all taken at a river in southwestern Sicily by G. von Rosen. The first Turkish record was based on a sighting of one male by P.W. Swire, at a small feeder canal near the coast of south-western Turkey.

The regions found to be colonized were: (I) the Canary Islands, with La Palma, La Gomera, Tenerife and Gran Canaria; (II) Northwest Africa, with Morocco and Tunisia; (III) southern Europe, with Portugal, Spain and Italy; and (IV) Southwest Asia, with Turkey, Israel, West Bank, Jordan, and Iran.

Discussion

Our analysis demonstrates that *Zygonyx torridus* is a regular and widespread inhabitant of the Palaearctic. The distribution maps (Figs 1-3) show a patchy belt with records stretching from the Atlantic islands, along the Mediterranean Sea, to western Asia. The easternmost record within the Palaearctic originates

from Iran. All localities are situated within a range characterized by a subtropical or Mediterranean climate. Such conditions are comparable with the situation in southern Africa beyond the tropical zone, where the species also occurs (see map in TARBOTON & TARBOTON 2002).

There are four centres of settlements: the Canary Islands (Fig. 2), the northwestern Maghreb (Fig. 3a), the southern Iberian Peninsula (Fig. 3a), and the Jordan Valley (Fig. 3b). Additionally, single records are available from southern Tunisia, Sicily, south-western Turkey and southern Iran. With respect to zoogeography, we grouped all records in these four regions.

(I) Canary Islands. — The oldest known specimen belongs to the type series from Tenerife (KIRBY 1889). Several other specimens also originate from the 19th and early 20th Century and have been collected also in La Gomera and Gran Canaria. From the latter island comes the holotype of *P. atlantica* (MARTIN 1900). Recent records confirm that the species still inhabits all of these three islands. In this respect, the actual finding in La Palma (O. Brauner pers. comm.) is an interesting addition, encouraging a systematic investigation of the whole archipelago. However, if the historic sources – especially BRAUER (1901) – are compared with recent reports, one gets the impression that the abundance of *Z. torridus* in the islands significantly decreased in the course of the 20th Century, due to human impact on the natural freshwater resources (e.g., MALMQUIST et al. 1993, BEMMERLE 2005, O. Brauner, R. Busse, A. Schröter pers. comm.).

(II) Northwest Africa. — The oldest record from Morocco – a specimen from Fès stored in the ZMHB – has not been published before. All Moroccan localities are scattered around the High and Medium Atlas Mountains and the Rif (JACQUEMIN & BOUDOT 1999) but there are no records from the Anti Atlas and the Sahara. Locality 29, which was visited several times between 1982 and 2002, marks the southernmost record and is next to the Canary Islands. The data indicate a stable occurrence in Morocco, and there is no indication of a decline of the species in this region. The Tunisian locality differs from all Moroccan ones in being situated in the northern edge of the Sahara. We observed individuals emerging from a mountainous brook with waterfalls, very close to the Algerian border. We suggest that similar habitats along the northern edge of the Sahara in Algeria are also colonized and link the Tunisian locality with the Moroccan ones.

(III) Southern Europe. — The oldest information about the occurrence of *Z. torridus* in Europe is an undated record from Spain (NAVÁS 1906a). Over the years more Spanish localities became known; hence the species has been judged a rare but regular inhabitant of Europe (e.g., VAN TOL & VERDONK 1988). Although the data base of odonate field work in Spain is relatively small (see OCHARÁN LARRONDO 1987), there are a few indications of long-term occupation of a given breeding site. For instance, at locality 41 the species was ob-

served from 1969 to 2003, and at locality 44 from 1983 to 2000 (see Table 1). The only known record from Portugal (AGUIAR 1989) was published in a popular science magazine without associated detailed information. Recently, voucher specimens have been discovered in a private collection (FERREIRA et al. 2006). A similar, fortuitous discovery is the three specimens at ZSM originating from Sicily but unpublished so far. The Sicilian record is nearest to the Tunisian one but – due to the sea barrier and Sicily's attachment to the northern coast of the Mediterranean Sea – may primarily be interpreted as a stepping-stone between Iberia and Turkey. A general obstacle to the existence of *Z. torridus* in southern Europe is the extensive destruction of Mediterranean running water systems due to human water consumption for agriculture and tourism. This, for instance, was demonstrated when E. Baierl (pers. comm.) revisited localities 43 and 45 in the 1990s, and found severe changes in habitat quality that had rendered the habitats unsuitable for the species.

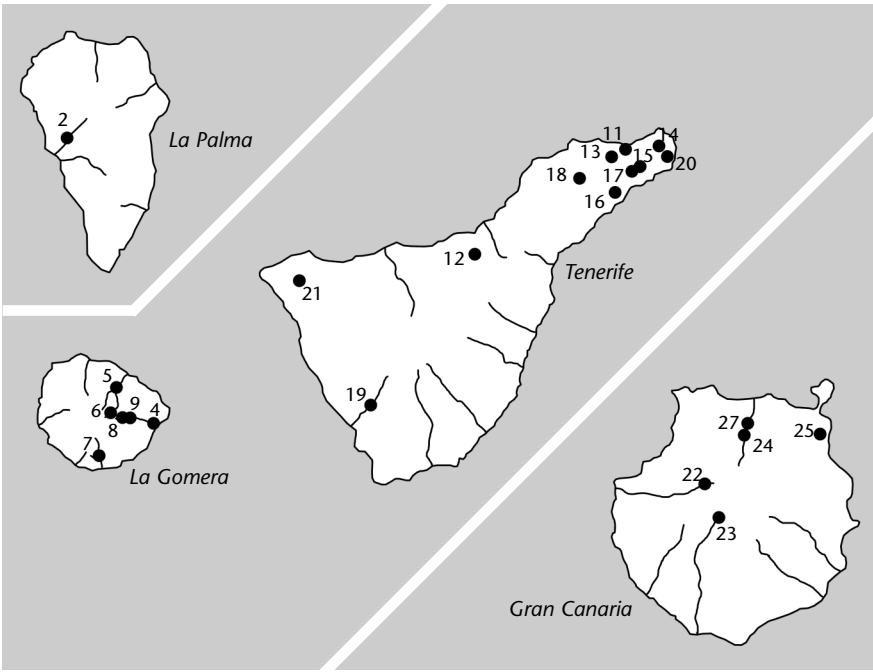

Figure 2: Distribution of *Zygonyx torridus* in the Canary Islands. All islands are to scale in area, but not with respect to the distances between them. Records 1, 3, 10 and 26 could not exactly be located. — Abbildung 2: Verbreitung von *Zygonyx torridus* auf den Kanarischen Inseln. Alle Inseln sind im selben Maßstab dargestellt, jedoch nicht in maßstäblich korrekter Entfernung zueinander. Die Fundorte 1, 3, 10, und 26 konnten nicht exakt lokalisiert werden.

(IV) Southwest Asia. — The only Turkish record is based on the sighting of a single male (ASKEW 2004), but judged by us as reliable when analysing the report by P.W. Swire (pers. comm.). KALKMAN et al. (2003) suggested in their annotated checklist of Turkey for *Z. torridus* that «it is possible that this species will be found in Turkey». In a closely related online checklist of Turkish Odonata (KALKMAN 2004), *Z. torridus* still appears as «to be expected», but an additional note says that the «presence in Turkey seems not very likely». In the Jordan Valley and adjacent mountains *Z. torridus* has been locally abundant (W. Schneider pers. comm.). The first records from this region were taken by P.A. Buxton (MORTON 1924). Although there are some recent records from Jordan (SCHNEIDER 1986, KATBEH-BADER et al. 2002), the water supply in the whole region dramatically decreased due to agricultural consumption (Z. Amr and W. Schneider pers. comm., SCHNEIDER 2004). Sections with permanent running water become continuously more restricted, as did the habitat situation for *Z. torridus*. No records are known so far from the easterly adjacent Mesopotamia. The only record from Iran is unusually informative for our understanding of the range of the species. Odonatological field work in that part of the world is chronically underrated; so it will be realistic to give prominence to this record in the distribution of the species. Accordingly the species probably occurs along the whole coast of the Gulf of Persia from Iran to Iraq and maybe Pakistan.

Our data-base does not allow a specific habitat analysis of the Palaearctic localities. Nevertheless, we are not aware of a single breeding site that would not fit the inferred habitat of the species: fast running sections of permanent rivers in a hot climate. At least in mountainous regions of the south-western Palaearctic this type of habitat is widespread, even if it may be very local in some regions and generally threatened by habitat destruction. Our presentation of the distribution pattern of *Z. torridus* (Fig. 1) reflects this situation perfectly. We can define the species to be resident in suitable parts of the Palaearctic and to exhibit a huge potential for dispersal, which regularly permits the establishment of new colonies, even far from existing ones. The result is a highly dynamic establishment in all suitable regions around the Mediterranean Sea.

The most recent additional records from Tunisia, Italy and Turkey provide a significantly advanced understanding of the distribution pattern by closing the gap between west and east Mediterranean occurrences. Previous maps (e.g., ASKEW 1988, D'AGUILAR & DOMMANGET 1998) would imply that western African individuals of *Z. torridus* once crossed the western Sahara – or followed the seashore – and colonized Morocco, the Canary Islands and the Iberian Peninsula, perhaps at a time when the Sahara still bore a true aquatic network. This west Mediterranean population could therefore be interpreted as a relic, lacking any current geneflow with populations living south in the Sahelian belt. With the desertification of northern Africa initiated from the

middle of the Holocene (ca 4500 yr BP), the northernmost populations became isolated from the main range of the species by a desert belt that today is more than 2200 km wide. The same could be assumed in the east, where the Jordan Valley is nowadays isolated by a desert belt approximately 1200 km wide from the occurrences in southern Saudi Arabia, Yemen, and Oman. In this respect, the population of the Jordan Valley could also be interpreted as a relic. With the new data we know that the whole Mediterranean region is part of the potential range of *Z. torridus*. This new knowledge suggests that the species' dispersal is much more effective than so far assumed. It now seems possible that migrating individuals provide a regular contact between Palaearctic and Sub-Saharan populations. Crossing the desert or the sea may be a regular feature of *Z. torridus*. We should emphasize, however, that this is highly speculative, as there is no true proof in favour of such present exchanges over long distances versus a 'relic theory'. But the occurrence of the species in several islands that were never connected to mainland Africa clearly demonstrates its ability to be an effective migrant and colonizer.

For the south of Europe, it should come as no surprise to see future records from other Mediterranean islands or coastal regions of Italy and Greece. As to northern Africa, we predict new records for Algeria. Although *Z. torridus* is not

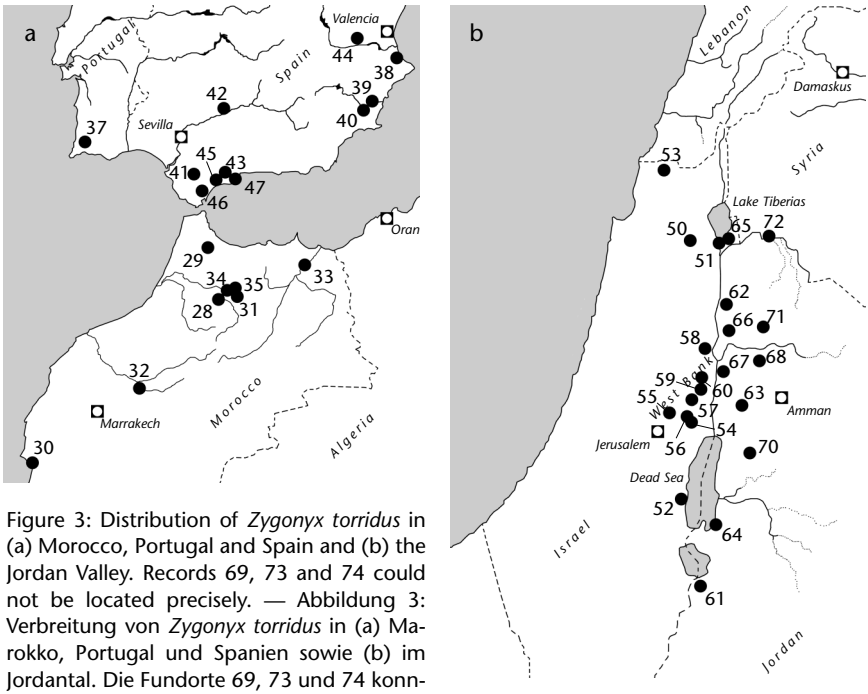

Figure 3: Distribution of *Zygonyx torridus* in (a) Morocco, Portugal and Spain and (b) the Jordan Valley. Records 69, 73 and 74 could not be located precisely. — Abbildung 3: Verbreitung von *Zygonyx torridus* in (a) Marokko, Portugal und Spanien sowie (b) im Jordantal. Die Fundorte 69, 73 und 74 konnten nicht exakt lokalisiert werden.

included in the typical species assemblage of aquatic habitats in the central Sahara (see DUMONT 1978a, 1978b, 1978c), it should not be discounted that the species utilizes suitable Saharan habitats – at least as a stepping-stone for further dispersal. The Saharan locality in Tunisia demonstrates the breeding in a short desert brook. Comparable habitats may be available very locally in mountainous regions with a permanent supply of spring water, e.g., in the Ahaggar, Aïr, and Tibesti mountains, or in other oases along the northern margin of the Sahara.

Up to now, most distribution maps of the western Palaearctic that include the eastern part of North Africa (e.g., D'AGUILAR et al. 1986, D'AGUILAR & DOMMANGET 1998, ASKEW 1988), show an extensive occurrence of *Z. torridus* in Libya. In fact, the species has never been recorded from Libya. This country broadly lacks potential habitats, but an occurrence in the northeastern Jabal Akhdar cannot be excluded a priori. There is also no record from Egypt. DUMONT (1980) predicted the presence in the Nile delta, but there has been no record from this region so far. An occurrence in the Sinai is much more likely. More erroneous information was given by AGUESSE (1968: 203) who listed the species for Morocco, Algeria and Tunisia although no published record existed at that time.

From a phenological point of view, a clear difference between subtropical and Mediterranean populations can be inferred from our data base. In the Canary Islands as well as in the Jordan valley imagines have been caught or seen during almost all months of the year. This suggests that the species is on the wing throughout the year – thus corresponding with the situation in the Afrotropics (V. Clausnitzer pers. comm.). The flying season in the Maghreb and southern Europe seems to be restricted to the summer period; more data are needed to identify the onset and end of the flying season. Nothing is known about the voltinism of the species, but the limitation of larvae to permanent running water may be seen as an indication for slow growth.

Acknowledgements

This paper significantly benefited from an extensive list of records in the Jordan Valley, provided by Wolfgang Schneider and Zuhair Amr. We also received unpublished data or additional remarks by Julia Adena, Jörg Arlt, Edgar Baierl, Bernd Bemmerle, Jean-Pierre Boudot, Oliver Brauner, Rolf Busse, Viola Clausnitzer, Henri Dumont, Sónia Ferreira, Manuel Ferreras Romero, Daniel Grand, Jens Kählert, Dietrich Kern, Geert de Knijf, Herwig Leinsinger, Andreas Martens, Jürgen Ott, Asmus Schröter and Peter Swire. For support in the respective institutions, we thank Ulrike Aspöck (Wien), Daniel Burckhardt (Basel), Isolde Dorandt & Michael Ohl (Berlin), Melanie Grimm & Wolfgang A. Nässig (Frankfurt), Bernhard Misof (Bonn), Maurizio Pavesi (Milano),

Roberto Poggi (Genova) and Arnold H. Staniczek (Stuttgart). The following persons answered inquiries about Palaearctic material in the respective museums: David Goodger (London), Rasmus Hovmöller (Stockholm), Anna Hundsdörfer & Uwe Kallweit (Dresden), Carolina Martín (Madrid), Glòria Masó i Ros (Barcelona), and György Sziráki (Budapest). Jean-Pierre Boudot, Andreas Martens and Wolfgang Schneider gave overall improvements to the manuscript; Philip Corbet polished the language. Thank you all.

Table 1. Palaearctic records of *Zygonyx torridus*. All localities are assigned to the regions (I) Canary Islands, (II) Northwest Africa, (III) Southern Europe and (IV) Southwest Asia. Within a region they are arranged island- or country-wise and in chronological order. If a locality is supplied with more than one date, all dates are pooled. We refer only to primary sources. A second source is cited if it provides additional information. The maps (Figs 1-3) show the geographical positions of localities. See text for the museum acronyms. — Tabelle 1. Paläarktische Funde von *Zygonyx torridus*. Alle Fundorte sind den Regionen (I) Kanarische Inseln, (II) Maghreb, (III) Südeuropa und (IV) Naher und Mittlerer Osten zugeordnet. Innerhalb der Regionen sind die Fundorte insel- bzw länderweise und in chronologischer Reihenfolge geordnet. Wenn von einem Fundort mehrere Begehungsdaten vorliegen, sind diese zusammengefasst. Die Zitate beziehen sich auf die Primärquellen. Falls weitere Quellen zusätzliche Information hergeben, sind diese ebenfalls zitiert. Die Verbreitungskarten (Abb. 1-3) geben die genauen geografischen Positionen der Fundorte an. Museumsakronyme siehe Text.

Region/locality	Date	Document	Reference
(I) Canary Islands			
(1) «Canarische Ins.»			
	1889/1890	2♂ leg. O. Simony, in NMW	this paper, for date cf. Brauer 1901
La Palma			
(2) Barranco de las Angustias N of Los Llanos			
	03-XII-2005	obs. O. Brauner	O. Brauner pers. comm.
La Gomera			
(3) La Gomera			
	VIII-1905	2♀ leg. A. Cabrera, in BNHM	D. Goodger pers. comm.
	-	«Mus. Nac.» = MNMS, today missing	Navás 1906b, C. Martín pers. comm.
(4) San Sebastián			
	11-VIII-1931	1♀ leg. A. Storå	Valle 1935
(5) Hermigua			
	11/13-VIII-1931	3♂ leg. A. Storå	Valle 1935
(6) El Cedro			
	12/13/22-VIII-1974	2♂, 1♀ leg. A.G. Parker, in BNHM	D. Goodger pers. comm.
(7) Barranco de Santiago, S Pastrana			
	late IV-2003	obs. H. Leinsinger	H. Leinsinger pers. comm., Bemmerle 2005

Region/locality	Date	Document	Reference
(8) Tributaries of Presa de La Laja			
	30-IX-2004	photos B. Bemmerle	Bemmerle 2005
	08-X-2004	photos B. Bemmerle	Bemmerle 2005
(9) Barranco de La Laja			
	06/07-X-2004	obs. B. Bemmerle	Bemmerle 2005
Tenerife			
(10) «Teneriffe»			
	-	1♂, paratype of *P. torrida*, in BNHM	Kirby 1889, D. Goodger pers. comm.
(10) «Tenerife»			
	26-VIII-1900	1♂ in MNMS	C. Martín pers. comm.
(10) «Teneriffa»			
	VIII-1986	1♂ leg. W. Bischoff, in ZMHB	Peters 1988
(11) Taganana			
	1889	-	Brauer 1901
(12) «Or.» = Orotava			
	1889	1♀ leg. O. Simony, in ZMHB; 2♀ leg. O. Simony, in NMW	Brauer 1901
(13) «Ag.» = Monte de Aguírre St. Cruz			
	1889	1♀ leg. O. Simony, in ZMHB; 3♂ leg. O. Simony, in NMW	Brauer 1901
(14) «Valle de Louis» = Anága Mts, Valle de Luis			
	14-VII-1889	obs. O. Simony	Brauer 1901
(15) Anága Mts, Valle de Jagua			
	16-VII-1889	obs. O. Simony	Brauer 1901
(16) Anága Mts, Barranco Tajodio			
	07-VIII-1889	obs. O. Simony	Brauer 1901
(17) Anága Mts, Valle Bufadero			
	09-VIII-1889	obs. O. Simony	Brauer 1901
(18) Laguna de Tenerife			
	VII-1905	8 specimens leg. A. Cabrera, in MNMS	Navás 1906b, C. Martín pers. comm.
(19) Barranco del Infierno, near Adeje			
	13-VI-1984	exuviae leg. A. Martens	A. Martens pers. comm.
	V-1985	obs. J. Ott	J. Ott pers. comm.
	1995	1♂ leg., obs. F. Dusoulier	Dusoulier 1996
	09-X-1996	exuviae leg. J. Adena	J. Adena pers. comm.
(20) Barranco near Igueste, NE of Santa Cruz			
	08-XI-1998	photo R. Busse	R. Busse pers. comm..
	01/06-X-1999	obs. R. Busse	R. Busse pers. comm.
	17-VII-2002	obs. R. Busse	R. Busse pers. comm.
(21) Barranco de Masca			
	15-III-2004	obs. A. Schröter	A. Schröter pers. comm.

Region/locality	Date	Document	Reference
Gran Canaria			
(22) near Roque del Nublo			
	04-VIII-1890	obs. O. Simony	Brauer 1901
(23) Plateau of Cumbre			
	-	obs. O. Simony	Brauer 1901
(24) near «Dáhamis» = Doramas?, 3 km SW of Firgas			
	16-II-1899	obs. O. Simony	Brauer 1901
(25) Las Palmas			
	-	1♀, holotype of *P. atlantica*, in MNHN, coll. Martin	Martin 1900, for locality cf. Ris 1912
(26) «Gran Canar»			
	VIII-1900	1♂, 2♀ in NMW, coll. Simony	Brauer 1901
(26) «Gran Canaria»			
	-	«Mus. Nac.» = MNMS, today missing	Navás 1906b
(27) Barranco «Azuaje» = B. de la Virgen, 1 km W of Firgas			
	17-XI-1995	larvae	Nilsson et al. 1998
(II) Northwest Africa			
Morocco			
(28) «Fès, 350 m»			
	ca 1919-1924	1♂ leg. C. Alluaud, in ZMHB	this paper, for date cf. Jeannel 1952
(29) Oued Laou near Chefchaouen, Rif			
	18-VII-1971	1♂ in coll. Dumont	Dumont 1972
(30) «Immouzzèr» = Asif Tamrhakht, N of Agadir			
	04-VIII-1982	3♂ in coll. Ocharán	Ocharán 1987, 1992
(30) «Immuzer» = Asif Tamrhakht, N of Agadir			
	V-1985	1♂ leg. R. Seidenbusch, in ZSM, coll. Seidenbusch	this paper
(30) Asif Tamrhakht, N of Agadir			
	04-VII-1992	-	Jacquemin & Boudot 1999
	17/18-V-1999	exuviae	D. Kern & J. Arlt pers. comm.
	19-IV-2002	1♂, exuviae, in coll. Arlt	J. Arlt pers. comm.
(31) Oued Bou Zemlane at Matmata			
	06-VII-1989	1♂ leg., photo J.-P. Boudot	Jacquemin & Boudot 1999
(32) Ditch 6 km E of Sidi Ben Tlaya, High Atlas			
	26-VII-1989	photo J. Kählert	J. Kählert pers. comm., Jacquemin & Boudot 1999, Kählert 2001
(33) Barrage de Machra Homadi, NE Morocco			
	30-VII-1989	obs. J. Kählert & A. Wendler	J. Kählert pers. comm., Jacquemin & Boudot 1999
(34) Oued Sebou, NE of Fès			
	early VII-1993	obs. J. Kählert	J. Kählert pers. comm.
	10-VI-1996	obs. H.J. Dumont & G. de Knijf	G. de Knijf pers. comm., Jacquemin & Boudot 1999
(35) Oued Sebou, near Sidi Harazem			
	10-VI-1996	obs. H.J. Dumont & G. de Knijf	G. de Knijf pers. comm., Jacquemin & Boudot 1999

Region/locality	Date	Document	Reference
Tunisia			
(36) Mountain brook near Tamerza			
	16-VI-2002	exuviae, photo B. Kunz	this paper
(III) Southern Europe			
Portugal			
(37) Serra de Monchique			
	09-VIII-1985	3♂ leg. S. Aguiar, in coll. Ferreira	S. Ferreira pers. comm., Aguiar 1989
Spain			
(38) Gandía, Valencia Prov.			
	-	leg. P. Barnola	Navás 1906a
(39) Orihuela, Alicante Prov.			
	24-VII-1908	1♂ leg. J. Andreu, in SMF, coll. Ris	Andreu 1911, Ris 1912
(40) Torre Isabel near El Palmar, Murcia Prov.			
	ca. 1950	1♂ leg. J.M. Andreu Rubio	Andreu Rubio 1953
(41) Río Majaceite, Cádiz Prov.			
	18-VII-1969	obs. J.O. de Boois, H. Overbeek, A. ten Houten	Overbeek 1970
	21-VII-1990	obs. J.-P. Boudot	J.-P. Boudot pers. comm.
	26-VI-2003	2♂, 1♀	Ferreras-Romero & Cano-Villegas 2004
(42) Río Guadiato, Castro y Picon, Córdoba Prov.			
	24-VII-1978	2♂, 1♀	Ferreras Romero 1982
(43) Río Grande, Coín, Málaga Prov.			
	10-VI-1982	1♂	Conesa García & García Raso 1983
	29-VII-1982	2♂, 1♀	Conesa García & García Raso 1983
(43) Rio Grande, NW of Coín			
	17-VI-1987	obs. E. and B. Baierl	E. Baierl pers. comm.
(44) Río Cabriel, Fuentepodrida, Valencia Prov.			
	08-IX-1983	2♂ in coll. Bonet	Bonet Betoret 1990
	26-VIII-1985	1♂ in coll. Bonet	Bonet Betoret 1990
	31-VII-1986	1♂ in coll. Bonet	Bonet Betoret 1990
	20-VIII-1987	1♂ in coll. Bonet	Bonet Betoret 1990
	17-VIII-1989	1♂ in coll. Bonet, 1♂ leg. C. Bonet in ZSM, coll. Seidenbusch	Bonet Betoret 1990, this paper
	29-VII-2000	obs. D. Grand	D. Grand pers. comm.
(45) Río Guadalmina, 1 km N of Benahavis, Málaga Prov.			
	16-VI-1987	photo, exuviae leg. E. and B. Baierl	E. Baierl pers. comm., cf. Gerken & Sternberg 1999
(46) Río Genal, Málaga Prov.			
	23-VII-2002	obs. M. Ferreras	M. Ferreras pers. comm.
(47) Río Alaminos, Tributary of Río Fuengirola, Málaga Prov.			
	08-VIII-2002	obs. F.J. Cano Villegas	Cano Villegas 2003

Region/locality	Date	Document	Reference
Italy			
(48) Belice, 10 km N of Selinunte, Sicily			
	16-VIII-1976	3♂ leg. G. von Rosen, in ZSM, coll. von Rosen	this paper
(IV) Southwest Asia			
Turkey			
(49) Canal at ruins of Kaunus, NW of Fethiye			
	16-V-1990	obs. P.W. Swire	P.W. Swire pers. comm., cf. Askew 2004
Israel			
(50) Bet Qeshed, W of Lake Tiberias			
	-	-	Dumont 1991
(51) Deganya, S of Lake Tiberias			
	-	-	Dumont 1991
(52) Ain Gedi, Dead Sea			
	16-III-1958	2♂ leg. I. Fishelson, in TAU	W. Schneider pers. comm., Dumont 1991
(52) «Ein Gedi», Dead Sea			
	10-VI-1975	1♂ leg. J. De Marmels	De Marmels 1995
(52) «En Gedi», with Wadi David and Wadi Arugot			
	1980/1981	specimens deposited at Inland Water Ecological Service, Israel	Furth 1983
(53) Nahal Ga'aton, NE of Haifa			
	04-X-1971	1♂ leg. M. Kaplan, in TAU	W. Schneider pers. comm.
West Bank			
(54) Jericho			
	02-VI-1922	1♂ leg. P.A. Buxton, in RSME	Morton 1924, Waterston & Pittaway 1991
	28-IV-1930	1♂ leg. G. Amsel	Schmidt 1939
	27-VII-1985	obs. W. Schneider & F. Krupp	W. Schneider pers. comm.
(55) Wadi Kelt (= Quilt)			
	02-IV-1923	1♂ leg. P.A. Buxton	Morton 1924
	16-V-1923	1♂, 1♀ leg. P.A. Buxton, in RSME	Morton 1924, Waterston & Pittaway 1991
(55) Wadi el Kelt			
	01-V-1927	1♂, 1W leg. E. Enslin	Schmidt 1939
(55) Wadi el Kelt, Georgskloster			
	31-III-1930	1♂ leg. G. Amsel	Schmidt 1939
(56) Ain es Sultan, Jericho			
	08-VI-1923	1♂ leg. P.A. Buxton	Morton 1924
(57) Ain Duyuk			
	14-IV-1970	2♂, 1♀ leg. H.J. Dumont, in TAU	W. Schneider pers. comm., Dumont 1991
	17-V-1970	2M leg. H.J. Dumont, in TAU	W. Schneider pers. comm., Dumont 1991
	26-V-1982	2♂ leg. P. Amitai, in HUJI	W. Schneider pers. comm.

Region/locality	Date	Document	Reference
West Bank			
(58) Wadi Fari'a			
	31-V-1973	1♀ leg. D.G. Furth, in TAU	W. Schneider pers. comm., Dumont 1991
(59) Wadi 'Auja			
	29-IX-1973	1♂ leg. D.G. Furth, in TAU	W. Schneider pers. comm., Dumont 1991
(60) «Fazael» = Wadi Fasa'il			
	28-IV-1976	1♂ leg. M. Kaplan, in TAU	W. Schneider pers. comm.
Jordan			
(61) «Ghor es Safieh»			
	23-III-1933	1♂ leg. M. Aigner	Schmidt 1939
(61) Ghawr as Safi			
	03-XI-1981	2♂, 2♀ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
	12-XI-1985	1♀ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
	30-XI-1987	1♀ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
(62) al-Mashare at Wadi Yabis			
	21-XI-1973	1♂ leg. V. Wissen & Ismail, in YU	W. Schneider pers. comm.
(63) Wadi Shu'ayb, 5 km E of Shunat Nimrin			
	21-VII-1980	1♂, 1♀ leg. W. Schneider & F. Krupp, in coll. Schneider	W. Schneider pers. comm.
	11-V-1982	1♀ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
(64) Ain al-Haditha, spring			
	02-VIII-1980	1♂ leg. W. Schneider & F. Krupp, in coll. Schneider	W. Schneider pers. comm.
(65) Al-Hamma			
	29-XI-1980	2♂ leg. W. Schneider & F. Krupp, in coll. Schneider	W. Schneider pers. comm.
(66) Kurayyimah			
	17-IV-1982	1♀ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
(67) Ghawr Kabid			
	11-V-1984	1♀ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
(68) Ar Rumaymin			
	16-IX-1991	1♂ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
(69) Near Dead Sea			
	16-XI-1992	1♀ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
(70) Ma'in			
	09-X-1993	1♂ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002

Region/locality	Date	Document	Reference
(71) Nahlah			
	11-V-1995	2♂ leg. A. Katbeh-Bader, in UJIM	Katbeh-Bader et al. 2002
(72) near Yarmuk River, border to Syria			
	1996	obs.	Katbeh-Bader et al. 2002
Dead Sea Region, country not to ascertain			
(73) Dead Sea			
	07/10-VI-1918	5♂ leg. Schwabel, in SMF, coll. Ris	Morton 1924
(74) Nahal Deza'el			
	05-VIII-1985	1♀ leg. R. Ortal, in HUJI	W. Schneider pers. comm.
Iran			
(75) 90 km NW of Bandar Abbas, Hormozgan Prov.			
	late III-1990	leg. A. Bostanchi	Heidari & Dumont 2002

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Manuskripteingang: 12. März 2006