ISRAEL JOURNAL OF ENTOMOLOGY, Vol. 41–42, 2011–2012, pp. 95–106

Distribution of two *Epomis* species (Carabidae, Chlaeniini) in Israel, with notes on their habitat

GIL WIZEN,[1,3] CLAUDIA DREES,[2,3] AND AVITAL GASITH[3]
[1]*Department of Biology, University of Toronto at Mississauga, Mississauga, Ontario L5L 1C6, Canada. E-mail:* wizentrop@gmail.com
[2]*Leuphana University Lüneburg, Institute of Ecology and Environmental Chemistry, Scharnhorststr. 1, D-21335 Lüneburg, Germany*
[3]*Tel Aviv University, George S. Wise Faculty of Life Sciences, Department of Zoology, Tel Aviv 69978, Israel*

ABSTRACT

The records of *Epomis dejeani* Dejean, 1831 and *E. circumscriptus* (Duftschmid, 1812) in Israel are summarized and their geographical distribution is described. The two *Epomis* species are mainly found in the northern and central parts of Israel but also extend southward to the Central Negev region and Arava Valley. Museum records combined with the present survey data suggest a relatively wide albeit patchy distribution of *Epomis* in Israel. Whereas the records suggest that *E. dejeani* is relatively more abundant than *E. circumscriptus* in Israel, records for other regions in the Palaearctic Region suggest the opposite. However, at least in Italy, *E. circumscriptus* is rare and recommended for listing as a critically endangered species. In none of the surveys conducted in Israel over four consecutive years were the two species recorded from the same site. None of the habitat parameters examined (vicinity to a water body; soil moisture; vegetation cover; presence of amphibians, or soil type) revealed any prominent difference in habitat choice by the two species. *Epomis* larvae feed exclusively on amphibians, and indeed we found the beetles sharing their habitat with amphibians during the beetles' breeding period. In conclusion, in the absence of either a physical barrier or any apparent habitat difference, the segregation of the species to different sites may be a case of sympatric species that do not occur at the same sites.

KEYWORDS: *Epomis*, Carabidae, distribution, Israel

INTRODUCTION

Carabid beetles of the genus *Epomis* Bonelli, 1810 have a unique biology as their larvae feed exclusively on amphibians (Shiina and Tachikawa, 1988; Tachikawa, 1994; Elron et al., 2007; Wizen and Gasith, 2011a). The taxonomic status of *Epomis* is under debate:

Kirschenhofer (2003) considers *Epomis* as a subgenus of *Chlaenius*, while Basilewsky (1955) and Makarova (2005) consider it a separate genus. Brandmayr et al. (2010), who examined and described the larvae of the two species (including material from Israel), support the separate standing of *Epomis* as a genus. Here we have adopted the latter taxonomic approach.

The genus *Epomis* belongs to the tribe Chlaeniini. About 20 *Epomis* species are known, mainly from tropical Africa and south and southeastern Asia (Kryzhanovskij, 1983). Five species are known from the Palaearctic Region (Kirschenhofer, 2003). Two species of *Epomis* are found in Israel: *E. dejeani* Dejean, 1831 and *E. circumscriptus* (Duftschmid, 1812). These two species also occur in Europe: *E. dejeani* is known mainly from southeastern Europe, as well as the Middle East (Bodenheimer, 1937; Kirschenhofer, 2003), while *E. circumscriptus* does not occur in northern and central Europe but has a wide distribution throughout the rest of Europe—from Portugal in the west to as far as Ukraine and Turkey in the east. It also extends eastward into central west Asia and southward to North Africa (Kirschenhofer, 2003). The Palaearctic catalogue of Coleoptera (Löbl and Smetana, 2003) does not list *Epomis* species as occurring in Israel, even though *E. dejeani* appears on the checklist of carabid beetles of Israel compiled by Bodenheimer (1937).

According to Brandmayr and Algieri (2000), in Italy *E. circumscriptus* is rare and should be considered as a critically endangered species. Consequently, and because little is known about the ecology of the genus *Epomis*, it was of special interest to investigate the distribution and habitat preferences of the two species. We report here all known records of occurrence of *Epomis* species in Israel, from the oldest record in 1921 to the present day, and describe the type of habitat that these species occupy in Israel.

MATERIALS AND METHODS

Data on the distribution of *Epomis* species in Israel are based on examination of museum records and field surveys. The museum records include material from the National Collections of Natural History at Tel Aviv University (TAUI), Beit Ussishkin Nature Museum, Kibbutz Dan (BU), the collection of Eylon Orbach, Qiryat Tiv'on (COQ), in Israel; and the collections of David Wrase, Berlin (CWB) and Thorsten Assmann, Bleckede (CAB), in Germany. We also examined and recorded data from photographs of *Epomis* larvae taken by Merav Vonshak and Zohar Yanai (Tel Aviv University).

Survey information is based on 177 daytime surveys that we conducted at 56 sites in Israel, from Upper Galilee (UG) in the north to the Northern Negev region (N) in the south, during 2005–2010. We searched for *Epomis* under shelters (e.g., wooden debris, tree bark, rocks of various sizes). The *Epomis* specimens were collected by hand, identified, and deposited at TAUI, where a database was compiled from collection records. The distribution map was produced with GIS-software (DIVA GIS, ver. 5.4.0.1). Because the majority of data were recorded after 2005, it is indicated separately from those reported before 2005.

In the surveys we examined habitat characteristics in the locations where the beetles

were found, including soil moisture, vicinity to water body, vegetation cover, and presence of amphibians. Soil moisture was measured in 5-cm-deep "core samples" collected from the location where the beetles were recorded, and determined by measuring soil loss of weight following drying of the samples in an oven at 100 ºC for 24 hrs. We also incorporated data regarding soil type that was reported in a previous study (Elron et al., 2007).

RESULTS

Distribution

We examined a total of 140 specimens of *Epomis*, 109 of which are survey records after 2005. The 31 museum records are from 19 sites; the recent surveys added eight new sites. The museum records consist of light-trap (n = 11) and hand-collected specimens (n = 5). For the rest of the specimens (n = 15) we have no information on the means of collection (Table 1). The surveys records after 2005 were all hand-collected. The records are reported in a sequence from north to south of Israel.

Epomis dejeani

The museum records show that this species is found in Mt. Hermon, the Hula Valley (Hulata, Lehavot, Kefar Blum, light-trap record), Upper Galilee (Mahanayim), Sea of Galilee area (Nahal Daliyyot), the Jordan Valley (Ma'oz Hayyim, light-trap record), eastern Carmel Ridge (Ma'agar Daliyya), Central Coastal Plain (Hadera, Berekhat Ramadan, Tel Barukh), Dead Sea Area (Yeriho), and the Central Negev region ('En Avedat; Table 1, Fig. 1).

The surveys added a new site in the Golan Heights ('En Um-A-Sharshia), two new sites in the Central Coastal Plain (Berekhat Ya'ar and Samar rainpool), and one new site in the western Judean Hills (Matta'; Table 1, Fig. 1).

Epomis circumscriptus

The museum records show that this species is found in the Jordan valley (Ma'oz Hayyim; light-trap record), Central and Southern Coastal Plain (Hadera, Miqwe Yisra'el, Palmahim), eastern Judean Hills (Nahal Perat; light-trap record), Dead Sea Area (Al Maghtas), Northern Negev region (Shoval) and the Arava Valley (Nahal Shezaf; light-trap record; Table 1, Fig. 1).

The surveys added three new sites in the Central Coastal plain (Dora rain-pool, Qadima rain-pool and Kefar Netter rain-pool) and one new site in the Sea of Galilee area (Kefar Nahum; Table 1, Fig. 1).

At an additional 48 surveyed sites, we found no evidence for the presence of either species of *Epomis* (Fig. 1). There was no apparent difference in habitat characteristics between the sites in which *Epomis* beetles were absent and the sites in which they were present.

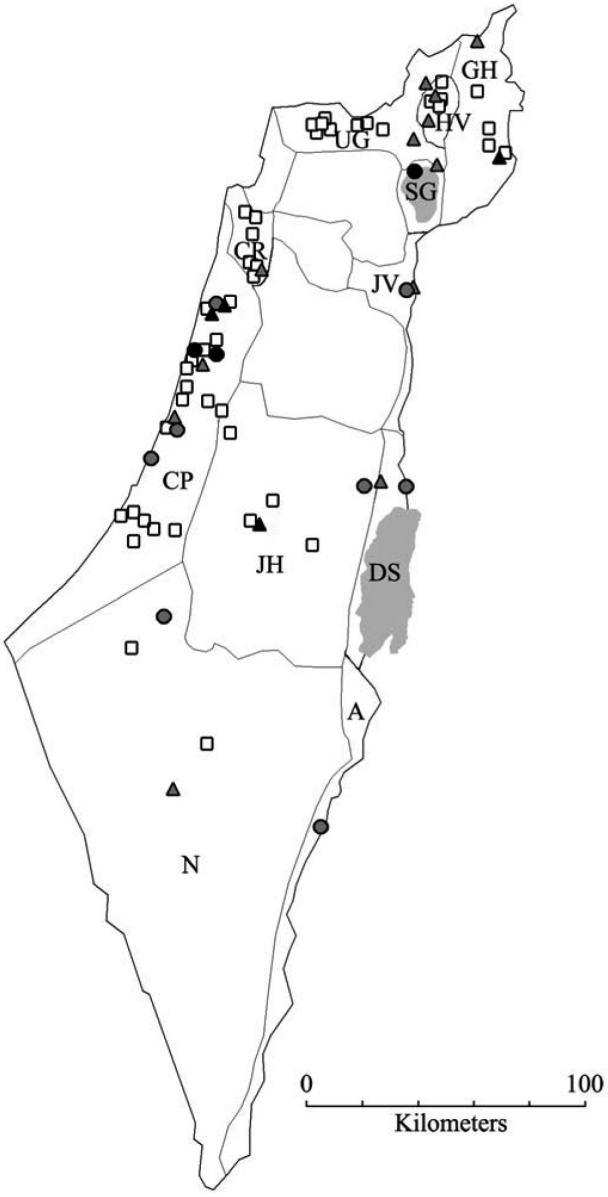

Fig. 1. Distribution of *Epomis* species in Israel. Old records (before 2005) of *E. dejeani* and *E. circumscriptus* are marked in gray triangles and circles, respectively; new records (after 2005) of *E. dejeani* and *E. circumscriptus* are marked in black triangles and circles, respectively. Sites where the beetles were not found are marked in open squares. Legend for the abbreviations depicting geographical regions is given in Table 1.

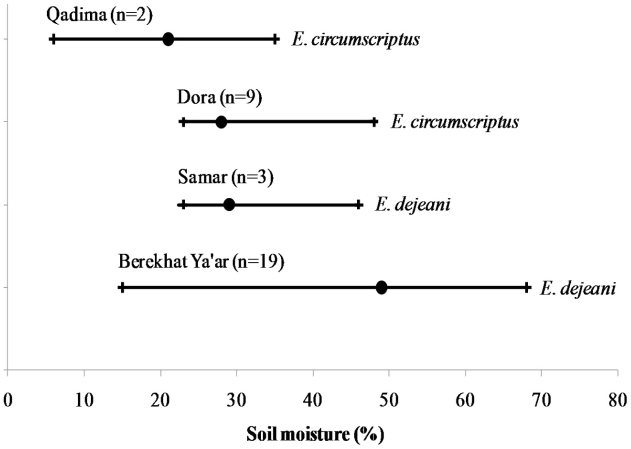

Fig. 2. Median (solid circles) and range (bars) of moisture of 5 cm top soil collected at a location in which *Epomis* beetles were observed. n indicates number of samples.

Habitat characteristics

Habitat information exists only for *Epomis* collected and observed during the surveys conducted after 2005. We found most of the beetles in the vicinity of rain-pools. A few records of *E. dejeani* were from the vicinity of streams (COQ, Table 1) and of *E. circumscriptus* from a nearby lake (Sea of Galilee; Fig. 1).

Our surveys confirmed a previous report by Elron et al. (2007) that *Epomis* beetles are found in both clay-type and sandy soils. *E. dejeani* was found at locations with soil moisture ranging from 15 to 68%, and *E. circumscriptus* at sites with moisture ranging from 6 to 48% (an overlapping moisture range of 15 to 48% for the two species; Fig. 2). Both species were found in vegetation-free habitat (e.g., Qadima site) as well as in grass and low vegetation (e.g., Berekhat Ya'ar site). *E. circumscriptus* was found also in a wooded area (*Eucalyptus* grove, Dora rain-pool; *Tamarix* floodplain, Kefar Nahum). The survey records indicate that both *Epomis* species co-occur with amphibians. We never found the beetles in the absence of amphibians, but did find locations where amphibians were present but the beetles were absent.

DISCUSSION

Prior to the present study only *E. dejeani* had been reported from Israel (Bodenheimer, 1937; Elron et al., 2007). We know now that at one of the reported sites (Dora rain-pool; Elron et al., 2007) the authors had mistakenly identified the *Epomis* as *E. dejeani* instead of *E. circumscriptus* (reexamined and identified by Brandmayr, personal communication).

The two *Epomis* species are found mainly in the northern and central parts of Israel but also extend southward to the Central Negev region and Arava Valley. Museum re-

Table 1

Epomis specimens recorded and collected in Israel, and deposited in nature museums and private collections. Coordinates and Geographical regions in Israel are given. BU = Beit Ussishkin Nature Museum; COQ = Private collection of Eylon Orbach (Qiryat Tiv'on); CWB = working collections of David Wrase, Berlin; TAUI = National Collections of Natural History at Tel Aviv University. GH = Golan Heights; HV = Hula Valley; UG = Upper Galilee; SG = Sea of Galilee; JV = Jordan Valley; CR = Carmel Ridge; CP = Coastal Plain; DS = Dead Sea; N = Negev region; JH = Judean Hills; A = Arava Valley

Species	Location	Date	Collector	Collecting method	Sex	Collection	Latitude	Longitude	Region
E. circumscriptus	Kefar Nahum	31.iii.2008	D.W. Wrase	by hand	1♂	CWB	32.880805	35.572716	SG
E. circumscriptus	Ma'oz Hayyim	16.iv.1969	Z. Shoham	light trap	1♂	BU	32.493523	35.550786	JV
E. circumscriptus	Hadera	20.iii.1927	O. Theodor	unknown	1♂	TAUI	32.443013	34.920744	CP
E. circumscriptus	Netanya, Dora rain-pool	12.ii.2006	G. Wizen	by hand	1♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	31.xii.2007	G. Wizen	by hand	6♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	11.iii.2008	G. Wizen	by hand	1♂; 1♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	27.iii.2008	D.W. Wrase	by hand	3♂	CWB	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	9.v.2008	G. Wizen	by hand	1♂	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	19.v.2008	G. Wizen	by hand	1♂	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	25.v.2008	G. Wizen	by hand	1♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	28.v.2008	G. Wizen	by hand	2♂; 2♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	12.vi.2008	G. Wizen	by hand	1♂	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	9.iii.2009	G. Wizen	by hand	1♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	1.iv.2009	G. Wizen	by hand	1♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	26.v.2009	G. Wizen	by hand	1♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	27.v.2009	G. Wizen	by hand	1♂	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	29.v.2009	G. Wizen	by hand	1♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	1.vi.2009	G. Wizen	by hand	6♂; 8♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	2.vi.2009	G. Wizen	by hand	1♂	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	3.vi.2009	G. Wizen	by hand	2♂	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	9.vi.2009	G. Wizen	by hand	9♀	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	10.vi.2009	G. Wizen	by hand	2♂	TAUI	32.292203	34.846369	CP
E. circumscriptus	Netanya, Dora rain-pool	11.vi.2009	G. Wizen	by hand	1♂	TAUI	32.292203	34.846369	CP

Table 1 *con't.*

Species	Location	Date	Collector	Collecting method	Sex	Collection	Latitude	Longitude	Region
E. circumscriptus	Netanya, Dora rain-pool	13.vi.2009	G. Wizen	by hand	1♂	TAUI	32.292203	34.846369	CP
E. circumscriptus	Kefar Netter rain-pool	6.ivi.2007	A. Gasith	photo	1♂	–	32.286130	34.872987	CP
E. circumscriptus	Qadima	28.iv.2007	A. Gasith	by hand	1♀	TAUI	32.271253	34.896469	CP
E. circumscriptus	Qadima	22.v.2007	G. Wizen	by hand	2♂	TAUI	32.271253	34.896469	CP
E. circumscriptus	Qadima	27.v.2007	G. Wizen	by hand	1♂; 1♀	TAUI	32.271253	34.896469	CP
E. circumscriptus	Qadima	1.vi.2007	G. Wizen	by hand	2♂	TAUI	32.271253	34.896469	CP
E. circumscriptus	Qadima	26.vi.2007	G. Wizen	by hand	4♀	TAUI	32.271253	34.896469	CP
E. circumscriptus	Miqwe Yisra`el	27.vii.1946	H.Bytinski-Salz	unknown	1?	TAUI	32.031175	34.783022	CP
E. circumscriptus	Palmahim, Nahal Soreq	13.iii.1921	I. Aharoni	unknown	1♂	TAUI	31.932597	34.706839	CP
E. circumscriptus	Nahal Perat	20.v.2002	V. Kravchenko	light trap	1♂	TAUI	31.841922	35.414139	JH
E. circumscriptus	Al Maghtas	23.v.1942	H.Bytinski-Salz	unknown	1♀	TAUI	31.837191	35.545916	DS
E. circumscriptus	Shoval	28.iv.1981	I .Kugler	unknown	1♀	TAUI	31.413611	34.745555	N
E. circumscriptus	Shezaf, Nature Reserve	8.vi.1999	I. Yarom	light trap	1♀	TAUI	30.716666	35.266666	A
E. dejeani	Mt. Hermon	20.iv.1969	Ch. Sandler	unknown	1♂	TAUI	33.310833	35.779166	GH
E. dejeani	Kefar Blum	29.vi.1971	Z. Shoham	light trap	1?	BU	33.173213	35.612913	HV
E. dejeani	Lehavot	18.vi.1975	Z. Shoham	light trap	1?	BU	33.139779	35.643741	HV
E. dejeani	Lehavot	2.vii.1976	Z. Shoham	light trap	1?	BU	33.139779	35.643741	HV
E. dejeani	Hulata	20.vi.1969	Z. Shoham	light trap	1?	BU	33.050607	35.620108	HV
E. dejeani	Hulata	21.v.1971	Z. Shoham	light trap	1?	BU	33.050607	35.620108	HV
E. dejeani	Mahanayim	9.v.1975	Z. Shoham	light trap	1?	BU	32.989022	35.570728	UG
E. dejeani	En Um-A-Sharshia	11.vi.2010	Z.Yanai	photo	2 larvae	–	32.928830	35.855378	GH
E. dejeani	Nahal Daliyyot	27.iv.2000	E. Orbach	by hand	1♂	COQ	32.901506	35.652440	SG
E. dejeani	Ma`agar Daliyya	7.iv.1988	E. Orbach	by hand	1♂	COQ	32.566356	35.067783	CR
E. dejeani	Ma`agar Daliyya	31.iii.2001	E. Orbach	by hand	3♂	COQ	32.566356	35.067783	CR
E. dejeani	Ma'oz Hayyim	16.iv.1969	Z. Shoham	light trap	1♂	TAUI	32.493523	35.550786	JV
E. dejeani	Ma'oz Hayyim	3.v.1969	Z. Shoham	light trap	1?	BU	32.493523	35.550786	JV
E. dejeani	Hadera	20.iii.1927	O. Theodor	unknown	2♂; 2♀	TAUI	32.443014	34.920744	CP
E. dejeani	Hadera	5.iv.2005	E. Elron	by hand	1♀	TAUI	32.443014	34.920744	CP

Table 1 *con't.*

Species	Location	Date	Collector	Collecting method	Sex	Collection	Latitude	Longitude	Region
E. dejeani	Hadera, Samar rain-pool	3.v.2007	G. Wizen	by hand	1♂; 1♀	TAUI	32.434388	34.904252	CP
E. dejeani	Berekhat Ya'ar	25.ii.2007	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	27.xi.2007	G. Wizen	by hand	1♂; 1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	7.i.2008	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	4.iii.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	11.iii.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	14.iii.2008	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	27.iii.2008	D.W. Wrase	by hand	2♂	CWB	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	7.iv.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	17.v.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	21.v.2008	G. Wizen	by hand	1♂; 1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	31.v.2008	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	5.vi.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	13.vi.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	17.vi.2008	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	18.vi.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	21.vi.2008	G. Wizen	by hand	2♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	22.vi.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	7.vii.2008	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	11.xi.2008	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	9.iii.2009	G. Wizen	by hand	1♂; 2♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	1.iv.2009	G. Wizen	by hand	1♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	1.vi.2009	G. Wizen	by hand	1♂; 1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	3.vi.2009	G. Wizen	by hand	2♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	5.vi.2009	G. Wizen	by hand	3♂	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	8.vi.2009	G. Wizen	by hand	2♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	9.vi.2009	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berekhat Ya'ar	11.vi.2009	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP

Table 1 *con't.*

Species	Location	Date	Collector	Collecting method	Sex	Collection	Latitude	Longitude	Region
E. dejeani	Berekhat Ya'ar	27.vi.2009	G. Wizen	by hand	1♀	TAUI	32.412777	34.902566	CP
E. dejeani	Berehkat Ramadan	12.iii.1940	H.Bytinski-Salz	unknown	1♂	TAUI	32.244417	34.874321	CP
E. dejeani	Tel Aviv, Tel Barukh	23.ii.1969	K. Yefenof	unknown	1♂	TAUI	32.066025	34.778194	CP
E. dejeani	Yeriho	17.ii.1943	H.Bytinski-Salz	unknown	1♂	TAUI	31.857303	35.460786	DS
E. dejeani	Matta'	4.ii.2007	I. Shtirberg	pitfall trap	1♂	TAUI	31.715872	35.060422	JH
E. dejeani	'En Avedat	2004	M. Vonshak	photo	2 larvae	–	30.838393	34.775709	N

cords combined with the present survey data seem to suggest a relatively wide albeit patchy distribution of *Epomis* in Israel. This is reflected in the fact that out of the 56 surveyed wetland sites where amphibians were present, the beetles were recorded in only 13% of the sites. They were usually found in very small numbers (no more than two individuals) at each locality, making it likely that they could have been overlooked. More extensive surveys are needed to either confirm a fragmented distribution or a possible meta-population structure (e.g., Niemelä, 2001).

Past museum records (prior to 2005) indicate a wider distribution of the two *Epomis* species in Israel relative to what the more recent records show. Despite a smaller number of past records in comparison to the recent survey data (31 and 109, respectively), in the former *E. dejeani* was recorded at 12 sites and *E. circumscriptus* at eight sites, whereas in the recent study they were recorded at only four and three sites, respectively. It is possible that the difference in distribution is partly related to a longer period of collecting in the past (1921–2002), as well as to the use of light-traps for collecting the beetles in approximately a third of the events (Chikatunov et al., 2006). Light-traps usually attract flying insects from a distance of up to several hundred meters (Matalin, 1994), so that such specimens are not necessarily the true inhabitants of the collection site (Hanski et al., 1993). A possible contributing factor to the present narrower recorded range of *Epomis* distribution might be habitat destruction, both terrestrial and aquatic ones. In 2008–2009 the senior author observed alteration of two *Epomis* sites in the Central Coastal Plain (Dora rain-pool and Qadima). Moreover, over a period of ca. 80 years 157 rain-pools (ca. 82% of the rain-pools in Israel) have disappeared, combined with an overall gradual decline of natural land in Israel (Levin et al., 2009).

Museum and survey records suggest that in Israel *E. dejeani* is relatively more abundant than *E. circumscriptus* (recorded at 16 and 11 sites, respectively), whereas records for other regions from the Palaearctic suggest the opposite (Kirschenhofer, 2003). However, this apparent difference in species relative abundance may be an artefact of insufficient data. It is worth noting that although *E. circumscriptus* is relatively widely distributed in Europe, at least in Italy this species is rare and recommended for listing as a critically endangered species (Brandmayr and Algieri, 2000).

An interesting aspect of *Epomis* distribution in Israel is that the two species were never recorded at the same site in any of the surveys conducted over four consecutive years. We wish also to note that in the Central Coastal Plain we found the two species within a radius of <20 km at separate sites (Wizen and Gasith, 2011b). All but two museum records support the above observation that the two species do not co-occur at the same site. One record that lists the two species under the same locality is from 1927 (O. Theodor, record in TAU), where both species were collected in Hadera (a city in the Central Coastal Plain); but neither specific site information nor means of collection was given. Moreover, in the Hadera area we examined 10 sites and only *E. dejeani* was recorded. A second record of the two species at the same site (Z. Shoham, 1969; Ma'oz Hayyim, record in TAU) is based on light-trap collection, which may not necessarily indicate the existence of the two species at the same site.

Preliminary data on habitat characteristics that we examined (vicinity to a water

body; soil moisture; vegetation cover; presence of amphibians) as well as information on soil type (Elron et al., 2007), fail to indicate any prominent difference in habitat choice by the two species. However, we cannot exclude the possibility that microhabitat characteristics that we overlooked may influence species occurrence. One such factor that we did not measure is the soil pH, which has been reported to influence the distribution of other species of ground beetles (Paje and Mossakowski, 1984; Matern et al., 2008). Considering that *Epomis* larvae feed exclusively on amphibians (Elron et al., 2007; Wizen and Gasith, 2011a), the beetles are expected to be found near water bodies, where amphibians are present, at least during spring, the beetles' breeding period (Elron et al., 2007; Wizen and Gasith, 2011b). Our findings support this assumption.

In conclusion, in the absence of either a physical barrier or an apparent habitat difference, the segregation of the species to different sites may be simply a case of sympatric species that do not occur at the same sites (reviewed in Fitzpatrick et al., 2008). Further studies are needed to verify this conclusion.

ACKNOWLEDGMENTS

We thank Thorsten Assmann, Eylon Orbach, and David Wrase for providing information on their Epomis collection, and Yossi Lev-Ari and Giora Gisis from Beit Ussishkin Nature Museum, for providing museum records and collection information. We thank Naomi Paz (Tel Aviv University, Department of Zoology) for editorial assistance.

REFERENCES

Basilewsky, P. 1955. Révision des epèces africaines du genre *Epomis* (Carabidae). *Transactions of the Royal Entomological Society of London* 107: 95–116.

Bodenheimer, F.S. 1937. Prodromus Faunae Palestinae. *Mémoires de l'Institut d'Egypte* 33: 110.

Brandmayr, P. and Algieri, M.C. 2000. Habitat affinities of Chlaeniine species (Coleoptera, Carabidae) in Calabria and the status of *Epomis circumscriptus*, evaluated by the "*Cronogeonemie*" software. In: Brandmayr, P., Lövei, G., Zetto- Brandmayr, T., Casale, A., and Vigna Taglianti, A. (eds.). *Natural History and Applied Ecology of Carabid Beetles*, pp. 71–78.

Brandmayr, P., Bonacci, T., and Zetto-Brandmayr, T. 2010. Larval morphology of *Epomis circumscriptus* (Duftschmid, 1812) and of first instar *E. dejeani*, Dejean, 1831, (Coleoptera, Carabidae, Chlaeniini), with morphofunctional remarks. *Zootaxa* 2388: 49–58.

Chikatunov, V., Kravcenko, V.D. and Müller, G.C. 2006. Carabidae (Coleoptera) collected in the Israel light trap survey and their association with the major phyto-geographical zones of Israel. *Buchreihe zur Entomologie* 12: 291–298.

Elron, E., Shlagman, A., and Gasith, A. 2007. First detailed report of predation on anuran metamorphs by terrestrial beetle larvae. *Herpetological Review* 38(1): 30–33.

Fitzpatrick, B.M., Fordyce, J.A., and Gavrilets, S. 2008. What, if anything, is sympatric speciation? *Journal of Evolutionary Biology* 21: 1452–1459.

Hanski, I., Woiwod, I., and Perry, J. 1993. Density dependence, population persistence, and largely futile arguments. *Oecologia* 95: 595–598.

Kirschenhofer, E. 2003. Tribe Chlaeniini Brullé, 1834. In: Löbl, I., and Smetana, A. (eds.). *Catalogue of Palaearctic Coleoptera, Vol. 1: Archostemata, Myxophaga, Adephaga*. Apollo Books, Stenstrup, pp. 347–356.

Kryzhanovskij, O.L. 1983. *Fauna of the USSR. Coleoptera. Beetles of the suborder Adephaga: Rhysodidae, Trachypachidae; family Carabidae*. Nauka, Leningrad. Vol. 1(2): 90–120 (in Russian).

Levin, N., Elron, E., and Gasith, A. 2009. Decline of wetland ecosystems in the coastal plain of Israel during the 20th century: Implications for wetland conservation and management. *Landscape and Urban Planning* 92: 220–232.

Löbl, I. and Smetana, A. (eds.). 2003. *Catalogue of Palaearctic Coleoptera, Vol. 1: Archostemata, Myxophaga, Adephaga*. Apollo Books, Stenstrup,p. 353.

Makarova, E.V. 2005. The larva of the ground beetle *Epomis dejeani* (Coleoptera, Carabidae). *Entomological Review* 85: 100–106.

Matalin, A.V. 1994. The strategy of dispersal behaviour in some Carabidae species of southeastern Europe. In: Desender, K., Dufrêne, M., Loreau, M., Luff, M.L., and Maelfait, J.P. (eds.). *Carabid Beetles: Ecology and Evolution, Ser. Entomologica, Vol. 51*. Kluwer Acad. Publ., Dordrecht, Boston, London, pp. 183–188.

Matern, A., Drees, C., Kleinwachter, M., and Assmann, T. 2007. Habitat modelling for the conservation of the rare ground beetle species *Carabus variolosus* (Coleoptera, Carabidae) in the riparian zones of headwaters. *Biological Conservation* 136: 618–627.

Niemelä, J. 2001. Carabid beetles (Coleoptera: Carabidae) and habitat fragmentation: a review. *European Journal of Entomology* 98: 127–132.

Paje, F. and Mossakowski, D. 1984. pH-preferences and habitat selection in carabid beetles. *Oecologia* 64: 41–46.

Shiina, M. and Tachikawa, S. 1988. The life history of *Epomis nigricans* and its larval stage feeding on toads. *Abstracts of the 48th Annual Meeting of the Entomological Society of Japan*. Nishibaru, Okinawa, p. 35 (in Japanese).

Tachikawa, S. 1994. Predation on anurans by *Epomis nigricans* larvae. In: *Amazing Life of Insects, Atlas of the 48th Special Exhibition*. Otaru Museum, Otaru, p. 20. (in Japanese).

Wizen, G. and Gasith, A. 2011a. An unprecedented role reversal: Ground beetle larvae (Coleoptera: Carabidae) lure amphibians and prey upon them. *PLoS ONE* 6(9): e25161. doi:10.1371/journal.pone.0025161

Wizen, G. and Gasith, A. 2011b. Predation of amphibians by carabid beetles of the genus *Epomis* found in the central coastal plain of Israel. In: Kotze, D.J., Assmann, T., Noordijk, J., Turin, H., and Vermeulen, R. (eds.). *Carabid Beetles as Bioindicators: Biogeographical, Ecological and Environmental Studies*. *ZooKeys* 100: 181–191.