The species of *Scarabaeus* Linnaeus (Coleoptera: Scarabaeidae) in Bulgaria and adjacent regions: faunal review and potential distribution

Jorge M. Lobo, Borislav V. Guéorguiev & Evgeni I. Chehlarov

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We compile the available georeferenced information on Bulgarian *Scarabaeus* species, including both bibliographic and natural history data to provide basic ecological and biogeographical information as well as maps of climatically favourable areas (potential distributions) for each one of the species. *Scarabaeus* species in Bulgaria seem to be generally distributed across low altitude areas mainly under warm temperate or Mediterranean conditions, although *S. variolosus* appears to be the species adapted to the warmest conditions and *S. armeniacus* inhabits areas of medium altitude. Our results indicate that it is necessary to carry out an extra survey effort in the northern lowlands, away the Stara Planina Mts. in order to validate current climatically suitable territories for some species. However, the recent land use transformations of these lowland areas, together with the general decline of roller dung beetle populations, suggest that this validation may not be possible.

J. M. Lobo, Departamento de Biodiversidad y Biología Evolutiva, Museo Nacional de Ciencias Naturales, C.S.I.C., Madrid, Spain; E-mail: mcnj117 @mncn.csic.es
B. V. Guéorguiev, National Museum of Natural History, BAS, Blvd. Tzar Osvoboditel 1, 1000, Sofia, Bulgaria; E-mail: bobivg@yahoo.com
E. I. Chehlarov, Institute of Zoology, BAS, Blvd. Tzar Osvoboditel 1, 1000 Sofia, Bulgaria; E-mail: evgeni.chehlarov@gmail.com

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1. Introduction

The family Scarabaeidae contains many species highly specialized in the consumption of herbivorous faeces (Halffter & Edmonds 1982). Although there is no agreement on the phylogenetic relationships within this family (see Halffter & Edmonds 1982, Zunino 1984, 1985, Cambefort 1991, Montreuil 1998, Browne & Scholtz 1995, 1998, 1999), it has been subdivided classically into two subfamilies (Scarabaeinae and Coprinae, *sensu* Balthasar 1963) according to behavioural and morphological criteria. While Coprinae species bury the dung in the soil beneath the dung pats for nidification or feeding purposes (tunnelers), Scarabaeinae species construct more or less spherical pieces of dung and roll them several meters away from the dung source before burying them (rollers). Recent molecular (Villalba *et al*. 2002) and morphological data

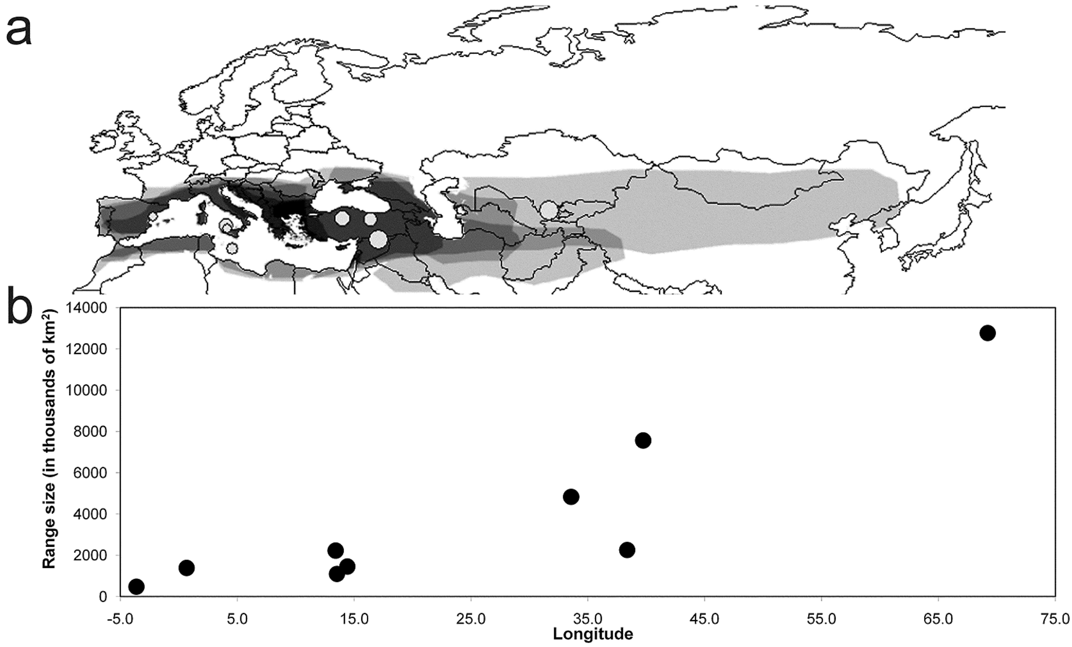

Fig. 1. – a. Geographic variation in the number of *Scarabaeus* species present in Europe. The circles represent the central distribution of each one of the nine species. The size of each circle is proportional to the total range-size. – b. Relationship between the central longitude of each species and its range size. Note that the species with narrow distributions are those occupying south-western Europe and north-western Africa.

(Philips *et al.* 2002, 2004, Forgie *et al.* 2005, 2006) suggest that this classical division lacks phylogenetic sense, because the rolling behaviour probably originated independently several times along the evolutionary history of Scarabaeinae dung beetles.

Of the six recognized tribes of Scarabaeinae, the Scarabaeini contain 11 genera according to Hanski & Cambefort (1991), which are mainly distributed in arid regions of the Afrotropical and Palaearctic regions (Davis *et al.* 2002). Within this tribe, *Scarabaeus* Linnaeus, 1758 is the most speciose genus (142 species; see Schoolmeesters 2007) and is the only one present in the Palaearctic region (Löbl *et al*. 2006). *Scarabaeus* species are mainly distributed in the southern part of the Afrotropical region under drier climates, but also in warmer climatic areas of the Palaearctic region from the Western Mediterranean to central Asia (Zur Strassen 1967). Thirty one species of *Scarabaeus* inhabit the Palaearctic region (22% of the world total) belonging to five subgenera: *Scarabaeus, Ateuchetus, Pachysoma, Kheper and Mnematidium*. In Europe it is possible to find only nine species belonging to the two first subgenera (see Löbl *et al*. 2006), which rarely surpass the 48°N in latitude and generally are also present in the Asia Minor region or North Africa (see Fig. 1).

Scarabaeus species have very special behavioural and physiological adaptations (Byrne *et al.* 2003, Verdú *et al.* 2004) and have been used as indicators for conservation purposes (Mc Geoch *et al*. 2002, Davis *et al*. 2004). Being found in open biomes, these species seem to have suffered a considerable recent decline both in geographical area of occupancy and in population sizes since the last half of the 20th century (Lobo 2001, see also Leclerc *et al*. 1980, Lumaret 1990, Lumaret & Kirk 1991, Barbero *et al*. 1999, Lobo *et al*. 2001, Romero-Samper & Lobo 2006, Carpaneto & Mazziota 2007) probably due to a great reduction in traditional pastoral practices (Hutton & Giller 2003, Barbero *et al*. 1999), urban development with the associated changes in land use (Lobo 2001, Lobo *et al*. 1997, 2001), the increase of chemical contamination (Hole *et al.* 2005) and/or the increase in predation by some bird species (Gittings *et al*. 1994, Gittings & Giller 1999, Horgan & Berrow 2004).

Table 1. List of the studied references from which localities for *Scarabaeus* species were extracted.

Joakimov 1899	Mikšić 1953, 1955, 1957	Dimitrova & Genov 1966
Markovich 1904	Panin 1957	Trifonov 1966
Nedelkov 1905	Karnoschitzky 1959	Dimitrova, & Genov 1968
Markovich 1909	Mikšić 1959	Zaharieva-Stoilova 1974
Nedelkov 1909	Angelov 1960	Zaharieva & Dimova 1975
Netolitzky 1912	Balthasar & Hrubant 1960	Zaharieva *et al*. 1975
Stolfa 1938	Muche 1964	Zaharieva-Stoilova & Dimova 1980, 1981
Pittioni 1940	Angelov 1965	Král & Malý 1993
Drenski 1942	Dimitrova & Trifonov 1965	Bunalski 2000
Csiki 1943	Zacharieva 1965a, b, c	Guéorguiev 2001

The main aim of this study is to provide comprehensive information on the distribution of the five *Scarabaeus* species cited from Bulgaria and present in closest adjacent territories by revising the distributional data available both in bibliographic sources and in several natural history collections. We firstly examined the sources and the available information on the distribution of each species individually. We afterwards applied a procedure able to generate potential distributions (see Jiménez-Valverde *et al*. 2008) to estimate for each species the location of those climatically favourable areas in Bulgaria and its closest neighbouring regions, according to the available distributional data. Finally, we examined the intra-species variation in environmental conditions of these species as well as the temporal increase in the compiled information across decades.

2. Material and methods

The present research is based in a critical revision of all the available material from the collections of the Institute of Zoology, Sofia (Bulgaria), the National Museum of Natural History, Sofia (Bulgaria) and the private collection of Mr. E. Migliaccio (Rome, Italy). A total of 274 specimens have been studied; 178 of them have been recorded in the literature, and 96 are new records. The revised literature includes 40 papers (see Table 1) which include records of *Scarabaeus* species both in Bulgaria and in its neighbouring countries. Papers which repeat older data or contain inaccurate records are not considered. All except five sources (Netolitzky 1912, Mikšić 1955, Panin 1957, Karnoschitzky 1959, Balthasar & Hrubant 1960) contain data for Bulgaria. In the whole, faunistic information on Bulgarian *Scarabaeus* species has been published more or less regularly during the last 110 years. All locality data was georeferenced when no information was available in the original sources (see Appendix).

The data from seventeen environmental variables were extracted from the Worldclim 1.4 database (Hijmans *et al*. 2005) freely accessible at http://www.worldclim.org/. These variables are: mean altitude, precipitation, maximum, mean and minimum temperatures for each one of the four annual seasons and their values for each 5 × 5 km cell calculated for the Bulgarian territory and bordering areas (from –39000 to 15500 in longitude, and from 4560000 to 4950000 in latitude; UTM 36N reference system); an approximated area of 196,275 km^2 (7851 UTM cells). Using this climatic and topographic information we firstly carried out exploratory analyses to identify the main environmental requirements for each species according to the available presence information. The recommended Ecological-Niche Factor Analysis (ENFA) was used for this purpose (see Hirzel *et al*. 2002, Basille *et al*. 2008, Calenge & Basille 2008, Calenge *et al.* 2008) since it provides a means of identifying the response of the species to the main environmental variations in the study area. ENFA transforms the original ecogeographical variables into new orthogonal axes; the first one accounts for the marginality of the species (the differences between the conditions inhabited by the species and the regional average conditions) while subsequent axes account for the tolerance of the species in the study area (specialisation axes). ENFA was performed using the freely available software Biomapper

Table 2. Median scores of some selected environmental variables for the localities in which each *Scarabaeus* species have been cited. The lower and upper quartiles are included in brackets. N is the number of cells of 0.083º at which each species was recorded, A is altitude, AP is annual precipitation, JP is July precipitation, mTJ is minimum temperature of January, and MTJ is maximum temperature of July. KW are Kruskal-Wallis non-parametric test values for between species differences in each explanatory variable. Precipitation values are in mm while temperature ones are in ºC. The initials of the species name of each species (Sa, Sv, Sp, St and Ss) represent those species with statistically significant differences using post-hoc multiple comparison test of mean ranks to estimate which species are particularly different from each other with regard to each one of the climatic variables. *: P≤0.05, **: P≤0.01, ***: P≤0.001.

	N	A	AP	JP	mTJ	MTJ
S. armeniacus	15	616 (488/767)$^{Sp, Ss, St}$	542 (511/592)^{Sv}	42 (34/44)	–3.6 (–4.6/–1.8)$^{Sp, Sv}$	26.7 (24.5/28.2)
S. variolosus	53	327 (180/584)St	1072 (683/1312)$^{Sa, Sp, Ss, St}$	30 (18/46)St	1.3 (0.2/2.5)$^{Sa, Sp, Ss, St}$	28.4 (27/30)
S. pius	49	232 (132/416)^{Sa}	574 (515/674)^{Sv}	37 (31/46)	–1.1 (–2.5/0.2)$^{Sa, Sv}$	28.5 (26.7/29.6)
S. sacer	23	206 (109/461)^{Sa}	592 (563/674)^{Sv}	34 (30/47)	–1.8 (–2.8/–0.2)^{Sv}	27.9 (27.0/29.8)
S. typhon	93	158 (80/316)$^{Sa, Sv}$	589 (531/709)^{Sv}	44 (32/51)^{Sv}	–2.0 (–3.3/–0.1)^{Sv}	27.9 (27.1/28.8)
KW		30.6***	35.3***	10.7*	55.0***	8.7

(Hirzel *et al.* 2004). For each species this analysis allows us to select the most relevant variables from all those considered. Thus, the variables with factor scores higher than 0.30 that in turn were not highly correlated between them (absolute Pearson correlation values lower than 0.90) were selected.

Once the most relevant environmental variables were selected for each of the five Bulgarian *Scarabaeaus* species, they were used to estimate the Mahalanobis Distance (Farber & Kadmon 2003) between the climatic conditions present in known cells containing the species and the whole considered territory. This measured distance differs from the Euclidean one in that it takes into account the dependence among variables and is scale-invariant (i.e. the variables have the same weight independently of their variance). Once rescaled to a 0 to 100 interval, this environmental distance from presence localities was used as a measure of climatic favourability. The 10th percentile of these distances (the values below which 10 percent of observations may be found) were arbitrarily mapped and considered as the most climatically favourable areas for each species. In all occasions doubtful or imprecise species localities were discarded and although map representations were focused on the Bulgarian territory, calculations were carried out considering the complete data mentioned in the text, including those from other adjacent countries.

For each locality with the presence of *Scarabaeus*, we finally extracted the values of the variables detected more frequently as relevant by ENFA analyses (altitude, annual precipitation, July precipitation, minimum temperature in January and maximum temperature in July). These values were compared among species by a nonparametric Kruskal-Wallis ANOVA test in order to detect the statistically significant differences in environmental conditions that prevail in those cells inhabited by the five species.

3. Results

3.1. Basic information on the species

3.1.1. Scarabaeus (Ateuchetus) armeniacus Ménétriés, 1832 [= puncticollis Auct. nec (Latreille, 1819)]

Literature data. Bulgaria. *Scarabaeus puncticollis*: Pittioni 1940: 219 (Dragoman; Pazardzhik; Slavyanka Mt.); Csiki 1943: 215 (Slavyanka Mt., 1,000–1,500 m); Angelov 1965: 101

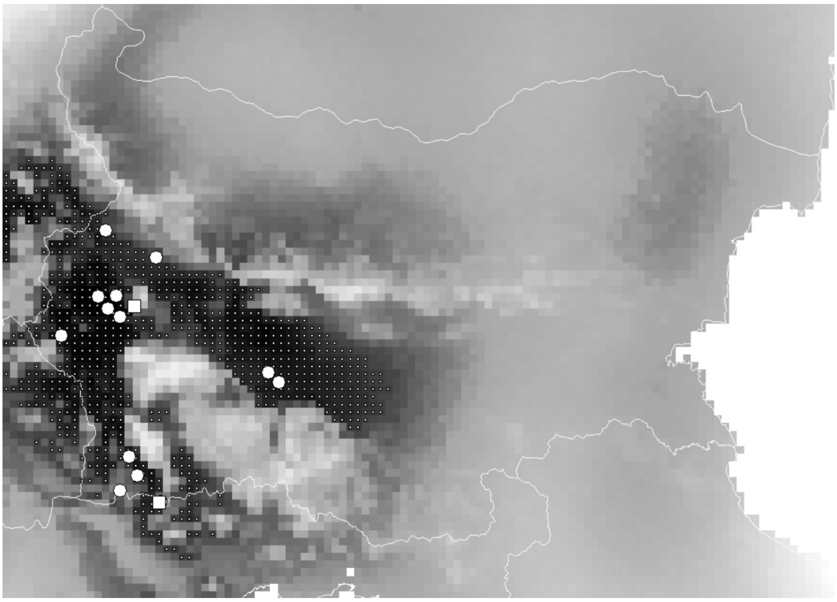

Fig. 2. Distribution map of *Scarabaeus armeniacus* in Bulgaria and adjacent areas. White circles represent the well-known localities while white squares are doubtful or imprecise localities. Grey tones represent the favourability for species occurrence (scale 0-100) according to the Mahalanobis distance from the climatic conditions in presence localities varying from black (low distance or high favourability) to white (high distance or low favourability). Little white dots represent the values below 10th percentile (the most favourable). UTM projection at a cell resolution of 5 × 5 km.

(Ognyanovo near Pazardzhik; Novi Iskar (= Kurilo)); Kyustendil; Golo Bardo Mt.); Zacharieva 1965c: 230 (Pazardzik; Elin Vrah near Ognyanovo); Zaharieva, Dimova 1980: 18 (Drangovo); Zaharieva, Dimova 1981: 90 (Drangovo). *Scarabaeus armeniacus*: Král, Malý 1993: 21 ((Bornarevo (= Bomarevo); Dolna Dikanya; Lilyanovo; Melnik). Macedonia. *Scarabaeus puncticollis*: Mikšić 1953: 57 (Prilep); Mikšić 1955: 229 (Bitolja).

New data. Bulgaria. Golo Bardo Mt.: Radomir, 28.IV.1937, 1 s., P. Drenski leg. / Gradishte, 29.IV.1937, 2 s., P. Drenski leg.; Slavyanka Mt., 18.VI.1959, 2 s., A. Prostov leg.; Vitosha Mt., 19.VII.1961, 1 s., S. Minkova leg. Macedonia. Bitolja, VI.1917, 1 s., P. Drenski leg.

Altitudinal range. From 400 m (Melnik) to 1,500 m (Slavyanka Mt.), although this last citation lacks details. Most occurrence records range from approximately 490 to 770 m (Table 2).

Seasonality. From April to July.

Material examined. 13 specimens.

Comments. The data from the Slavyanka Mt. (Pittioni 1940, Csiki 1943) and Vitosha Mt. are not used in the estimation of the potential distribution by the lack of a precise locality. According to Löbl *et al.* (2006) and Schoolmeesters (2007) this species is distributed across Azerbaijan, Armenia, Bulgaria, Georgia, Greece, Macedonia, South Russia, Ukraine, Cyprus, Iran, Iraq, Israel, Egypt (Sinai), Syria and Turkey.

In Bulgaria this species seems to be confined to the south-western portion of the country, in the Struma, Maritsa, Iskar and Nishava valleys. This species does not seem to colonize the relatively climatically suitable areas far away from the Stara Planina Mts. (Fig. 2).

3.1.2. Scarabaeus (Ateuchetus) variolosus Fabricius, 1787

Literature data. Albania. *Scarabaeus variolosus*: Mikšić 1953: 57 (Berat; Vlorë (= Valona)); Dukati; Kanine; Maj’ e Kjores (= Kjores Mt.); Mikšić 1959: 50 (Liquen i Butrintit; Llogora); Balthasar, Hrubant 1960: 147 (Liquen i Butrintit;

Llogora). Bosnia-Herzegovina. *Scarabaeus variolosus*: Mikšić 1953: 57 (Mostarsko Blato; Mostar; Velež Mt.; Podvelež; Donje Hrasno; Ljubinje; Bileće; Trebinje). Bulgaria. *Scarabaeus variolosus*: Nedelkov 1905: 19 (Samokov); Pittioni 1940: 219 (Belasitsa Mt.). Croatia. *Scarabaeus variolosus*: Mikšić 1953: 57 (Rijeka; Grižane; Krasica; Crikvenica; Novi Vinodolski; Senj; Cres; Baška Nova – Krk Island; Lakmartin; Babin Dub; Knin; Trogir; Starigrad – Hvar Island; Vrgorac – Propotnica); Mikšić 1957: 142 (Biokovo Mt.); Mikšić 1959: 50 (Meja; Bakar; Kraljevica; Bokanjac; Dugi Otok; Metkovic). European Turkey. *Scarabaeus variolosus*: Pittioni 1940: 219 (Kuru Dagh Mt.). Greece. *Scarabaeus variolosus*: Pittioni 1940: 219 (Oktchilar near to Xanthi; Eleftera Monastery); Mikšić 1953: 57 (Korfu Island; Chani Driskos near Janina; Hortiatis Mt.; Velestino; Stylis; Parnass Mt.; Kiphissia; Athens; Tripolis; Syra Island; Crete Island); Mikšić 1957: 142 (Volo; Pelion Monastir Survias); Mikšić 1959: 50 (Lianikladia near Kamia; Delphi; Amphissa; Zachlorou; Megaspilaon; Nauplia; Limenaria-Thasos Island; Rhodos Island). Montenegro. *Scarabaeus variolosus*: Mikšić 1953: 57 (Sutorman; Titograd).

New data. Greece. Kavala, 18.IV.1943, 1 s., N. Karnoshitsky leg.; Thasos Island, Theologos, 2.V.1943, 2 s., N. Karnoshitsky leg.

Altitudinal range. Most known records range from 180 to 580 m (Table 2).

Seasonality. From April to July, also in October.

Material examined. 16 specimens.

Comments. In our opinion the locality near Samokov (Nedelkov 1905) is rather doubtful (see also Mikšić 1959: 50). The occurrence of this species in Bulgaria needs to be confirmed. Löbl *et al*. (2006) and Schoolmeesters (2007) recognize their presence from Albania, Algeria, Bosnia-Herzegovina, Bulgaria, Croatia, Greece, Italy, Malta, Morocco, Sardinia, Serbia, Sicily, Tunisia and Turkey.

The areas climatically suitable for this species seem to be limited to the southern border of Bulgaria. The northernmost favourable localities are along the southern Black Sea coast, the Maritsa valley and mainly along the Struma valley (Fig. 3). The few Bulgarian records for this species outline its marginal distribution there, occupying probably the most extreme cold climate conditions for this Mediterranean species.

3.1.3. Scarabaeus (Scarabaeus) pius (Illiger, 1803)

Literature data. Albania. *Scarabaeus pius*: Mikšić 1953: 56 (Oroshi). Bosnia-Herzegovina. *Scarabaeus pius*: Mikšić 1953: 56 (Mostarsko Blato; Domanovići; Stolac); Mikšić 1959: 50 (Klobuk). Bulgaria. *Ateucus pius*: Joakimov 1899: 7 ("common species inhabiting between Dupnitsa and the Rilski Manastir"). *Scarabaeus pius*: Nedelkov 1905: 19 (Rila Mt.); Pittioni 1940: 218–219 ((Lyulin Mt.; Asenovgrad (= Stanimaka); Plovdiv; Parvenets (= Ferdinandovo); Sliven; Turia; Peshtera; Rila Mt.; Vitosha Mt.; Burgas; Belasitsa Mt.; Slavyanka Mt.)); Csiki 1943: 215 (Marino Pole; Petrovo); Mikšić 1959: 49 (Asenovgrad (= Stanimaka)); Angelov 1960: 22 (Ostrova Place in Plovdiv); Muche 1964: 61 (Nesebar); Angelov 1965: 102 (Hrabrino; Gara Krichim); Zacharieva 1965b: 129 (Mandritsa; Meden Buk; Kardzhali); Zaharieva 1965c: 230 (Sestrimo; Harmanli); Zaharieva *et al.* 1975: 31 (Primorsko; outfall of Kamchia River); Zaharieva, Dimova 1980: 18 (Drangovo); Zaharieva, Dimova 1981: 90 (Drangovo); Bunalski 2000: 88 (Kozhuh Hill). Croatia. *Scarabaeus pius*: Mikšić 1953: 56 (Grižane; Grobnik; Novi Vinodolski; Split; Dubrovnik); Mikšić 1959: 50 (Rijeka; Crikvenica). Greece. *Scarabaeus pius*: Pittioni 1940: 218–219 (Chamkjoiski Momastery near Soufli; Soufli; Xanthi; Athens – Pentelikon); Karnoschitzky 1959: 244 (Limenaria – Thasos Island); Mikšić 1953: 56 (Phaleron; Athens – Pentelikon; Kiphissia); Mikšić 1957: 142 (Ossa Mt.; Volo); Mikšić 1959: 50 (Zachlorou; Limenaria). Macedonia. *Scarabaeus pius*: Mikšić 1953: 56 (Gevgelja); Mikšić 1955: 229 (Gara Pcinja; Gevgelja). Montenegro. *Scarabaeus pius*: Mikšić 1959: 50 (Kotor). Romania. *Scarabaeus pius*: Netolitzky 1912: 163 (Turno-Severin); Panin 1957: 57 (Techirghiol; Constantsa). Serbia. *Scarabaeus pius*: Mikšić 1953: 56 (Vojvodina – Sušara); Mikšić 1959: 50 (Grebenac – Vojvodina Region).

New data. Bulgaria. Petrich, 20.IV.19??, 1 s., A. Martino leg.; Kresna (= Gara Pirin),

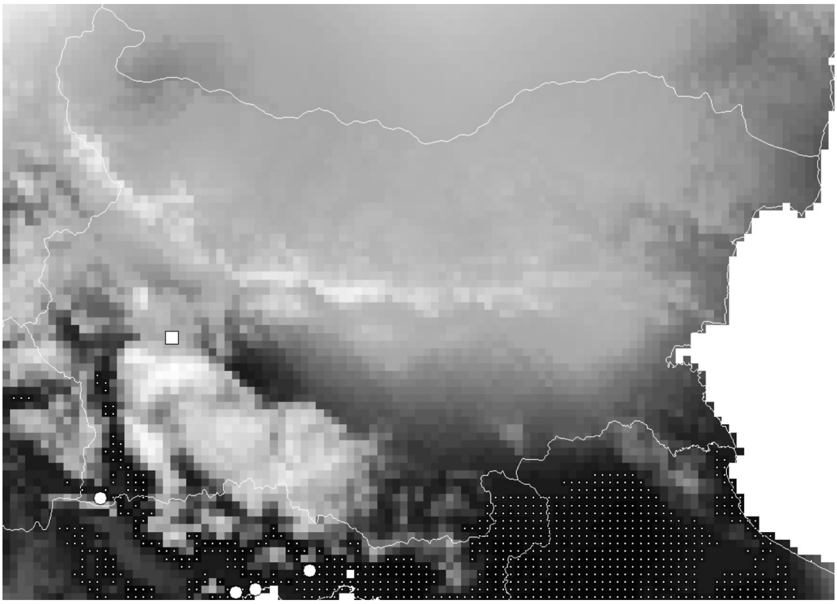

Fig. 3. Distribution map of *Scarabaeus variolosus* in Bulgaria and adjacent areas. White circles represent the well-known localities while white squares are doubtful or imprecise localities. Grey tones represent the favourability for species occurrence (scale 0-100) according to the Mahalanobis distance from the climatic conditions in presence localities varying from black (low distance or high favourability) to white (high distance or low favourability). Little white dots represent the values below 10^{th} percentile (the most favourable). UTM projection at a cell resolution of 5 × 5 km.

24.VI.1935, 1 s., Tuleshkov; Petrich, 14.V.1955, 3 s., A. Prostov leg.; Bachkovski Monastery, VI.1956, 1 s., I. Belog leg.; Slavyanka Mt., 18.VI.1959, 3 s., A. Prostov; Kresna Gorge, 23.VI.1959, 1 s., A. Prostov leg. / 12.VI.1966, 1 s., D. Lukov leg.; Lebnitsa in Ograzhden Mt., 300–500 m, 25.IV.1985, 1 s., M. Josifov leg; Kresna, 200–250 m, 1.VI.1993, 1 s., B. Guéorguiev leg; Simitli, 5.V.2002, 1 s., E. Migliaccio leg; Struma Valley: Kamenitsa Village, 170–240, 9.V.2002, 1 s., E. Migliaccio; SE slope of Sveti Illya Hill, near Kalimantsi, 450–510 m, 10–11.V.2002, 4 s., E. Migliaccio leg. / 10.V–1.VI.2002, 7 s. in soil traps, M. Langourov leg.; Kalimantsi, 12.V.2002, 1 s., E. Migliaccio leg; Maleshevska Planina along Gornobrezdnishka River, 200–550 m, 15.VI.2002, 1 s., B. Guéorguiev leg; Maleshevska Planina, west of G. Breznitsa, 600–1,000 m, 9.VII.2002, 1 s., B. Guéorguiev; Maleshevska Planina, north of Gornobreznishka River, 600–1,000 m, 11.VII. 2002, 1 s., B. Guéorguiev leg; Maleshevska Planina, west of Valkovo, 190 m, 4.VII–8.VIII.2003, 1 s., B. Guéorguiev leg. Greece. Gerakas – Sminthi, 11.V.2006, 1 s., P. Beron leg.

Altitudinal range. Most records are from sea level to 1,000 m (Slavyanka Mt., cfr. Pittioni 1940). The latter author (op. cit.) recorded *S. pius* from the Vitosha Mt., at 1,300 m above sea level, and Joakimov (1899) cite the species as living near the Rilski Monastery, ca. 1,400 m. In our opinion, these two last records are doubtful. In general, most of the records range from approximately 130 to 410 m (Table 2).

Seasonality. From April to August, also in November.

Material examined. 113 specimens.

Comments. Several records are doubtful or imprecise (Lyulin Mt., Pittioni 1940; Vitosha Mt., Pittioni 1940; Rila Mt., Nedelkov 1905 and Pittioni 1940; Belasitsa Mt., Pittioni 1940; Slavyanka Mt., Pittioni 1940). The material published by Markovich (1904: 239 sub *Ateucus pius*) and Markovich (1909: 10 sub *Ateucus pius*) from the vicinity of Razgrad does not belong to the genus *Scarabaeus*. Löbl *et al*. (2006) and

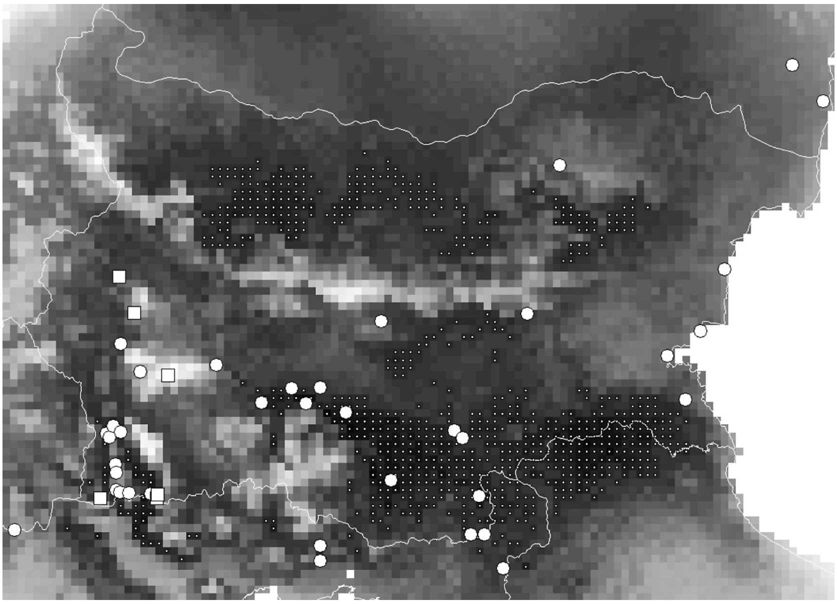

Fig. 4. Distribution map of *Scarabaeus pius* in Bulgaria and adjacent areas. White circles represent the well-known localities while white squares are doubtful or imprecise localities. Grey tones represent the favourability for species occurrence (scale 0-100) according to the Mahalanobis distance from the climatic conditions in presence localities varying from black (low distance or high favourability) to white (high distance or low favourability). Little white dots represent the values below 10th percentile (the most favourable). UTM projection at a cell resolution of 5 × 5 km.

Schoolmeesters (2007) mention *S. pius* from Afghanistan, Albania, Anatolia, Andorra, Armenia, Austria, Azerbaijan, Bulgaria, Croatia, Caucasus, France, Georgia, Greece, Hungary, Iran, Israel, Italy, Jordan, Kazakhstan, Lebanon, Macedonia, Palestine, Romania, South Russia, Serbia, Spain, Syria, Tajikistan, Turkey, Turkmenistan and Uzbekistan.

This species seems to be distributed both in southern (Struma or Maritsa valleys) and in northern (Danube Plain) localities situated on both sides of the Stara Planina Mts. (Fig. 4), as well as in proximity to or along the Black Sea coast. The current occurrence in the northernmost climatically favourable Bulgarian regions needs to be confirmed.

3.1.4. Scarabaeus (Scarabaeus) sacer Linnaeus, 1758

Literature data. Albania. *Scarabaeus sacer*: Mikšić 1953: 55 (Durres; Vlorë (= Valona)). Bulgaria. *Ateuchus sacer*: Markovich 1904: 239 (Razgrad env.); Markovich 1909: 10 (Razgrad). *Scarabaeus sacer*: Nedelkov 1909: 97 (Stara Zagora, based on remains of single specimen); Pittioni 1940: 217 (Novi Iskar (= Kurilo)); Sliven; Burgas; Nesebar; Primorsko (= Kyupria); Malko Tarnovo; Blagoevgrad – Parangalitsa); Drenski 1942: 40 (north of Varna); Mikšić 1953: 55 (Burgas); Angelov 1960: 22 (Ostrova Place in Plovdiv); Muche 1964: 61 (Nesebar); Zacharieva 1965a: 141 (Sredets = Grudovo); Zacharieva 1965c: 230 (Muldava); Trifonov 1966: 1074 (Strandzha); Zacharieva *et al*. 1975: 31 (Primorsko (= Stamopolu); Guéorguiev 2001: 171 (place Stara Kresna above Kresna Town). Greece. Scarabaeus sacer: Mikšić 1953: 55 (Zante); Mikšić 1959: 49 (Asteri near Skala – Elos District in Lakonia; Chalkis – Euboea Island; Askifou at Lefka Ori, 1,200–2,000 m, Crete Island; Rhodos Island). Montenegro. *Scarabaeus sacer*: Mikšić 1953: 55 (Krasići). Romania. *Scarabaeus sacer*: Netolitzky 1912: 163 (Turno-Severin).

New data. Bulgaria. Nesebar, 22.V.1922, 1 s., D. Joakimov leg.; Strandzha Mt., Ravna Gora,

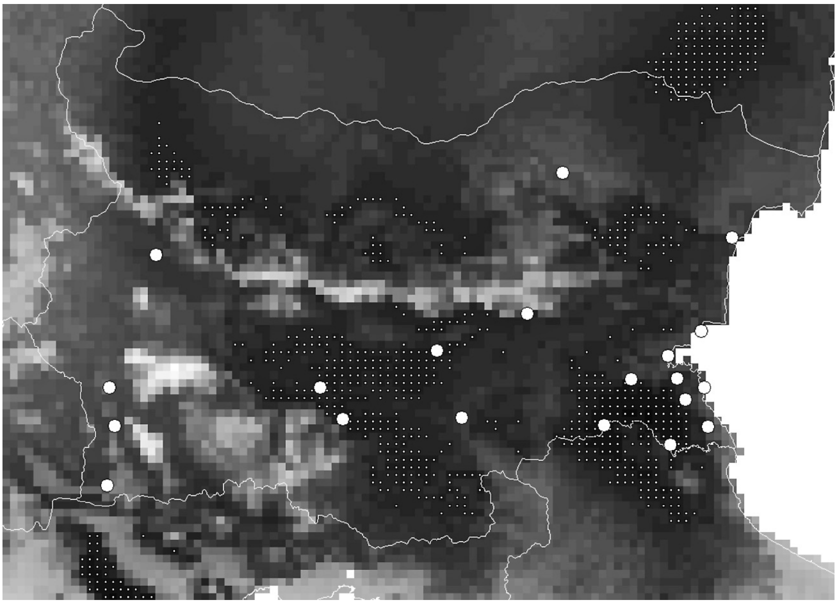

Fig. 5. Distribution map of *Scarabaeus sacer* in Bulgaria and adjacent areas. White circles represent the well-known localities while white squares are doubtful or imprecise localities. Grey tones represent the favourability for species occurrence (scale 0-100) according to the Mahalanobis distance from the climatic conditions in presence localities varying from black (low distance or high favourability) to white (high distance or low favourability). Little white dots represent the values below 10^{th} percentile (the most favourable). UTM projection at a cell resolution of 5 × 5 km.

21.VI.1923, 1 s., Ilchev leg; Varna, 1.V.1936, 1 s., / 9.V.1940, 1 s., / 27.VI.1953, 1 s., N. Karnoschitsky leg; Ropotamo, 5.V.1957, 1 s., A. Valkanov; Simeonovgrad, 20.V.1940, 4 s., N. Karnoschitsky leg; Struma Valley: "Sv. Vargoo" near Petrich, 1.VII.1941, 2 s., I. Buresh leg; Primorsko, 25.VI.1954, 2 s., T. Marinov leg. / 13.VII.1955, 3 s., Vichodzevsky leg.; Malko Tarnovo, 2.VII.1955, 2 s.; Primorsko, 29.VI. 1958, 1 s., Karnoschitsky leg.

Altitudinal range. Most of the recorded localities are distributed from 100 to 460 m (Table 2). The localities near Malko Tarnovo and Novi Iskar (cfr. Pittioni, 1940; our present data) seem to be the highest ones (around 600 m).

Seasonality. from April to October

Material examined. 35 specimens.

Comments. According to Stolfa (1938) and Mikšić (1953) this species is confined to the southern and eastern regions of the Balkan Peninsula. Löbl *et al*. (2006) and Schoolmeesters (2007) mention the species from Afghanistan, Albania, Algeria, Armenia, Azerbaijan, Bulgaria, Caucasus, China Northeast, Corsica, Egypt, Sinai, France, Greece, Hungary, India (Kashmir), Iraq, Iran, Israel, Italy, Jordan, Libya, Morocco, Pakistan, Palestine, Portugal, Romania, South Russia, Sardinia, Saudi Arabia, Serbia, Sicily, South Siberia, Spain, Syria, Transcaspia, Tunisia, Turkistan, Turkey and Ukraine.

In Bulgaria the known records of this species are mainly located in the lowlands to the south of the Stara Planina Mts. (Struma, Maritsa and Tundzha valleys), near the Black Sea coast, but also in the lowlands near the Turkish boundary (Fig. 5). However, there are also climatically favourable potential areas in some northern lowlands, albeit without currently detected populations.

3.1.5. Scarabaeus (Scarabaeus) typhon (Fischer von Waldheim, 1824) [= affinis (Brullé, 1832)]

Literature data. Albania. *Scarabaeus afiinis*: Mikšić, 1959: 49 (Vlorë); Balthasar, Hrubant

1960: 147 (Vlorë). Bosnia-Herzegovina. *Scarabaeus afiinis*: Mikšić 1953: 56 (Mostar; Hutovo Blato; Neum; Trebinje); Mikšić 1959: 49 (Klobuk). Bulgaria. *Scarabaeus afiinis*: Stolfa 1938: 149 (Asenovgrad (= Stanimaka)); Pittioni 1940: 217 (Lom; Vidin; Stara Zagora; Krichim; Peshtera; Kazanlak; Sadovo; Turia; Sliven; Pazardzhik; Vitosha (dubious locality!); Evksinograd; Burgas; Meden Rudnik (= Karabair); Rezovo; Strandzha Mt.; Petrich); Mikšić 1953: 56 (Akrianu; Varna); Mikšić 1959: 49 (Asenovgrad (= Stanimaka)); Muche 1964: 61 (Nesebar); Angelov 1965: 102 (Mitino in Petric District, not "Mitinovo"); Zacharieva 1965b: 129 (Kamilski Dol Place near Ivaylovgrad; Krumovgrad; Mandritsa; Podkova); Dimitrova, Genov 1966: 1216 (Grudovo; Belila); Dimitrova, Genov 1968: 81 (Grudovo; Belila); Zaharieva 1974: 123–124 (Venets near Burgas); Zaharieva, Dimova 1975: 184 (Mandritsa; Orlitsa); Zaharieva, Dimova 1980: 18 (Drangovo); Zaharieva, Dimova 1981: 90 (Drangovo). *Scarabaeus typhon*: Bunalski 2000: 88 (Kozhuh Hill; Arkutino). Croatia. *Scarabaeus afiinis*: Mikšić 1953: 56 (Grobnik; Vinodol; Obrovac; Visoko; Bokanjac; Dubrovnik); Mikšić 1957: 141 (Nadimsko Blato); Mikšić 1959: 49 (Kraljevica). European Turkey. *Scarabaeus afiinis*: Pittioni 1940: 217 (Merefte near Sharkjoi). Greece. *Scarabaeus afiinis*: Pittioni 1940: 217 (Eleftera Monastery); Mikšić 1953: 56 (Stylis; Velouhi Mt.; Peloponnese; Tripolis; Naxos Island); Mikšić 1957: 141 (Ossa Mt.; Volo); Mikšić 1959: 49 (Zante; Cyclades Islands; Syra Island; Rhodops Island). Kosovo. *Scarabaeus afiinis*: Mikšić 1953: 56 (Gračanica). Macedonia. *Scarabaeus afiinis*: Mikšić 1953: 56 (Gevgelija); Mikšić 1955: 229 (Zelenikovo; Gevgelija); Mikšić 1957: 141 (Vodoca; Stari Dojran). Montenegro. *Scarabaeus afiinis*: Mikšić 1957:141 (Virpazar). Romania. *Scarabaeus afiinis*: Panin 1957 (Constantsa; Vasile-Roaita; Hirshova; Agigea; Istria; Letea; Cardon; Tulcea; Braneshti; Tecuci; Calarashi; Calafat; Sadova; Jiana Mare; Bucharest). Serbia. *Scarabaeus afiinis*: Mikšić 1953: 56 (Vojvodina – Mramorak; Vojvodina – Sušara; Požarevats; Zatonje near Veliko Gradište; Niš; Bela Palanka; Kosovo Polje – Gračanica); Mikšić 1957: 141 (Usje; Ram; Vince); Mikšić 1959: 49 (Vojvodina – Palić; Vojvodina – Horgos near Grebenac).

New data. Bulgaria. Bratsigovo, 1 s., A. Markovich leg; Varna, 1 s., A. Markovich leg.; Perushtitsa, VII.1921, 2 s., Sakazov leg; Turia, 2.VI.1923, 1s., D. Joakimov leg; Shtit (= Yuskudar) near Svilegrad, 23.VI.1928, 2 s., P. Tchorbadjiev leg; Harmanli, VI.1939, 1 s., Drenski leg / 22.V.1949, 1 s.; Struma Valley: "Sv. Vargoo" near Petrich, 1.VII.1941, 2 s., I. Buresh leg.; Burgas, 1.V.1948, 1 s., N. Karnoshisky; Beloslav, 27.VI.1948, 1 s., N. Karnoshisky / 2.VII.1953, 1 s., A. Valkanov / 9.V.1954, 1 s., T. Marinov; Zvezditsa near Varna, 2.V.1949, 1 s., N. Karnoshisky leg; Dulovo, 14.VI.1952, 1 s., Drenski leg; Nesebar, 23.VI.1953, 1 s., A. Valkanov; Varna, 9.X.1955, 2 s., N. Karnoshisky; Hisar, 15.X.1955, 1 s., Karnoshisky leg; Petrich, 23.VI.1957, 1 s., A. Prostov leg. / 15.VI.1959, 1 s., G. Peshev leg.; Karnobat, 17.6.1967, 1 s., B. Zaharieva leg; Kamchia, 13.VI.1968, 1 s., B. Zagarieva; Kamenitsa Vill. in Struma valley, 170–240, 9.V.2002, 1 s., E. Migliaccio; SE slope of Sveti Illya Hill, near Kalimantsi, 450–510 m, 10.V–1.VI.2002, 3 s. in soil traps, M. Langourov leg. / 22.V–6.VIII.2002, 4 s., D. Chobanov leg. Greece. Thasos Island, Limenaria, 1.5.1943, 1 s., N. Karnoshisky leg. Serbia. Dimitrovgrad (= Tsaribrod), 1 s., N. Bahmetiev leg.

Altitudinal range. Most of the recorded localities range from approximately 80 to 320 m (Table 2).

Seasonality. from May to August, also in October.

Material examined. 97 specimens.

Comments. The recorded specimen from "Vitosha" (Pittioni, 1940) is doubtful and/or imprecise. Löbl *et al*. (2006) and Schoolmeesters (2007) recognize the species from Afghanistan, Albania, Armenia, Asia Minor, Azerbaijan, Bosnia-Herzegovina, Bulgaria, Central Asia, Corsica, Croatia, Cyprus, France, Georgia, Greece, Hungary, Iran, Iraq, Israel, Italy, Jordan, Kazakhstan, Lebanon, Macedonia, Mongolia, Morocco, North Korea, Portugal, Rhodes, Romania, Sardinia, Serbia, Slovakia, South Korea, South Russia, Spain, Syria, Turkey, Turkmenistan, Ukraine, Uzbekistan and China (Xinjiang and Xizang).

The known records for this species are distributed along the south-western Struma and Mesta valleys, the south-eastern areas near the Maritsa valley and the Black Sea coast, as well as in some

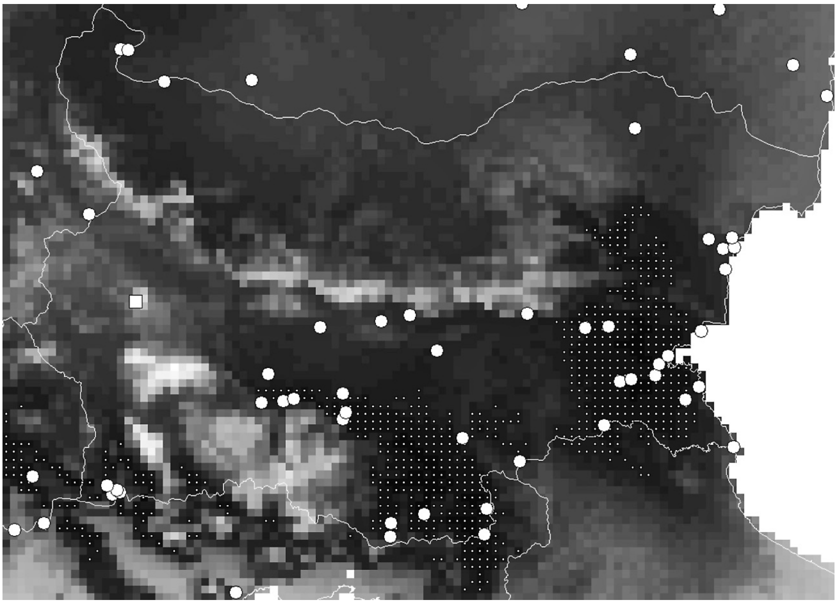

Fig. 6. Distribution map of *Scarabaeus typhon* in Bulgaria and adjacent areas. White circles represent the well-known localities while white squares are doubtful or imprecise localities. Grey tones represent the favourability for species occurrence (scale 0-100) according to the Mahalanobis distance from the climatic conditions in presence localities varying from black (low distance or high favourability) to white (high distance or low favourability). Little white dots represent the values below 10th percentile (the most favourable). UTM projection at a cell resolution of 5 × 5 km.

northern localities near to the Danube River and lowlands located on the southern slopes of the Stara Planina Mts. However, the most climatically favourable areas are those located in the southern and eastern lowland areas (Fig. 6), although some records from northern Bulgaria seem to be associated with localized xerothermic microhabitats, situated within relatively unsuitable zones of temperate climate.

3.2. Temporal distribution of records

The temporal distribution of *Scarabaeus* records concerning Bulgaria and neighbouring territories shows that the distributional information on these species increased gradually until the 1960's at an approximate rate of 25 records per decade, diminishing since then to a rate of 9 records per decade mainly due to the collection of *S. pius* (Fig. 7). Most of the remaining species display a low or even no rate of increase in the number of records since the sixties. Only one specimen of *S. sacer* and none of *S. variolosus* have been recorded during the last forty years.

During the first two decades of the 20th century, N. Nedelkov, a prominent pioneer of Bulgarian entomology, collected most of the known specimens of *Scarabaeus* in Bulgaria. This prom-

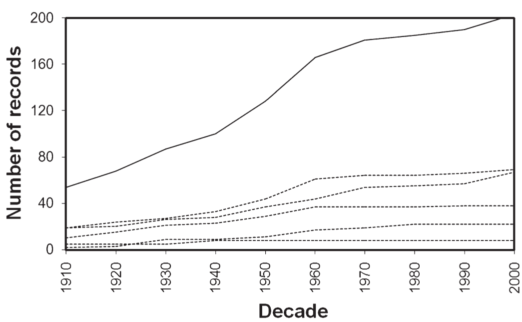

Fig. 7. Accumulative increase in the total number of records of Bulgarian *Scarabeus* species across decades (continuous line) and for each species (discontinuous lines). Order of the species, from top to bottom: *S. typhon*, *S. pius*, *S. sacer*, *S. armeniacus* and *S.variolosus*.

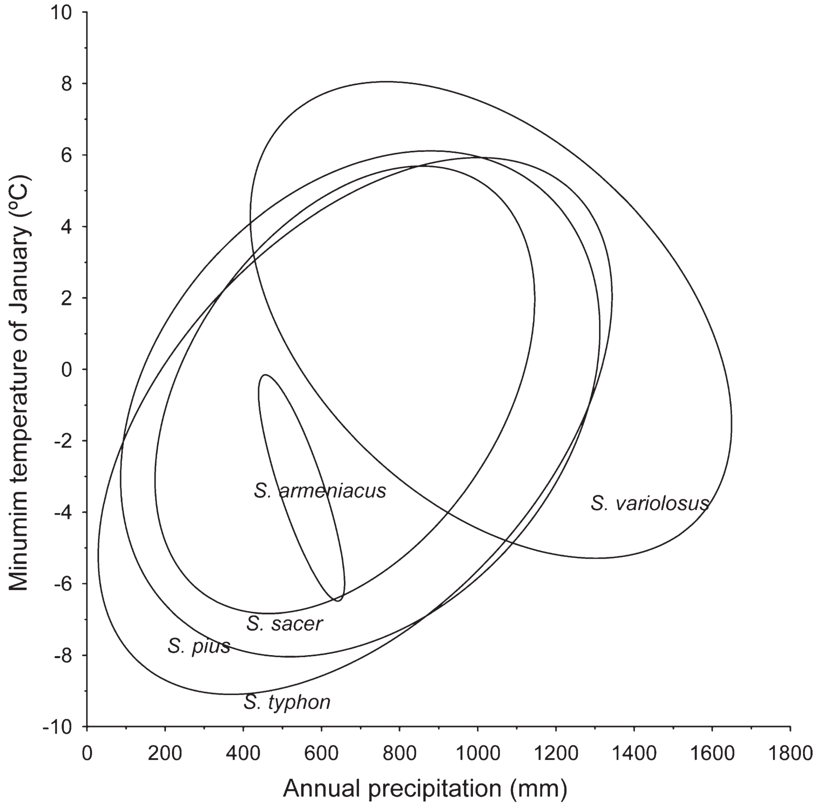

Fig. 8. Range ellipses of winter minimum mean temperature and annual precipitation values for the available presence data of the five Bulgarian *Scarabaeus* species. The ellipses include 99% of the data. Precipitation and temperature were selected because of their higher discrimination capacity than with the rest of the climatic variables (see Table 2).

inent work was followed by the sampling carried out by other entomologists such as I. Buresch, D. Joakimov, A. Markovich and D. Tschorbadjiev. In the decades of 1950–1960 and 1960–1970 most records came from the fieldwork accomplished by B. Zaharieva, the most well known native specialist of Bulgarian dung beetles.

3.3. General environmental adaptations

Mean maximum temperatures for July in the presence localities do not show statistically significant differences among species. July rainfall values only differ among *S. variolosus* and *S. typhon*. On the contrary, annual precipitation and minimum temperature in January seem to be the climatic variables with higher intra-species discrimination capacity (Table 2). However, the five species largely overlap in their inhabited climatic conditions (Fig. 8). *S. variolosus* seems to reach areas with a Mediterranean climate (low summer precipitation values) and with the highest winter temperatures. On the contrary, *S. armeniacus* seems to inhabit areas of higher altitude with the lowest winter and summer temperatures (Table 2). The remaining three species have very similar environmental requirements according to the distributional data analysed (Fig. 8).

4. Discussion

In Bulgaria, *Scarabaeus* species seem to be generally distributed across low altitude areas mainly under warm temperate or Mediterranean conditions. *S. variolosus* is the species adapted to the warmest conditions, being rare in the southernmost boundary of the country. *S. armeniacus* appears to prefer the opposite climatic spectrum, inhabiting the medium altitude areas of south-western Bulgaria. The distributions of the remaining species overlap greatly in terms of the climatic conditions of the analyzed presence data. This result can partially be a consequence of the limited studied area against the whole distributional area of the species; *S. pius*, *S. sacer* and *S. typhon* are the species with a wider distribution (around 4,800, 7,500 and 12,700 km^2, respectively) compared with the more localised *S. variolosus* (1,100 km^2) or *S. armeniacus* (2,200 km^2). The three widely distributed species are also those that seem to have wider distributional areas in Bulgaria, occurring both in northern and in southern lowland territories.

In this paper we provide the classical dot maps, binary maps reflecting the most favourable localities (those below 10th percentile) but also potential distribution representations in which a continuous suitability value was assigned to each grid cell. As the estimation of realized distributions inevitably require the use of reliable absence information (Lobo *et al*. 2010), the proportioned maps are just geographical representations dependent of the used resolution, the selected predictors and the available observed presences; potential distributions directed to reflect all the environmentally suitable places at which a species may occur according to the information provided by a group of climatic variables in observed occurrence localities. These so obtained potential distribution maps suggest that extra survey efforts should be carried out in the northern lowlands away from the Stara Planina Mts. in order to examine if these climatically suitable territories harbour new observations for some species. However, these areas near to the Danube lowlands have suffered considerable transformations in land use and *Scarabaeus* species seem to be especially sensitive to chemical contamination and habitat disturbance (Lobo 2001, Carpaneto & Mazziota 2007). Recent exhaustive dung-beetle surveys (Lobo J.M., Guéorguiev, B. and Chehlarov, E., unpublished data) have only allowed us to collect two specimens of *Scarabaeus pius* in spite of a considerable sampling effort carried out in 77 localities distributed across the Bulgarian territory. Interestingly, this is the only *Scarabaeus* species for which a slight increase in the number of recorded specimens since 1970 can be observed (see Fig. 7). Based on year-long observations and fieldwork on Bulgarian dung beetles, Zacharieva-Stoilova (1969, 1974) already presented some time ago the existence of a "sensitive decrease" in the populations of *Scarabaeus sacer*, *S. pius* and *S. typhon* in Bulgaria. According to this author, an increase in the extent of agricultural areas and changes in cattle breeding practices appear to be the main reasons leading to the decline of roller dung beetle populations. The current paper confirms that *S. pius* and *S. typhon* have been found in Bulgaria during the last four decades.

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Appendix. Localities cited by countries and their geographic coordinates in latitude and longitude (decimals).

Locality	Latitude	Longitude
Albania		
Berat	40.70	19.93
Dukati	40.33	19.43
Durres	41.32	19.43
Kanine	40.44	19.52
Liquen i Butrintit	39.78	20.03
Llogora	40.20	19.58
Maj’e Kjores (= Kjores Mt.)	40.22	19.62
Oroshi	41.83	20.08
Vlorë (= Valona)	40.47	19.49
Bosnia Herzegovina		
Bileće	42.87	18.43
Domanovići	43.14	17.78
Donje Hrasno	42.99	17.76
Hutovo Blato (= Utovo Blato)	43.06	17.79
Klobuk	43.28	17.45
Ljubinje	42.95	18.09
Mostar	43.34	17.81
Mostarsko Blato	43.33	17.69
Neum	42.95	17.73
Podvelež	43.29	17.92
Stolac	43.08	17.88
Trebinje	42.73	18.31
Velež Mt.	43.87	17.68
Bulgaria		
Arkutino	42.33	27.73
Asenovgrad (= Stanimaka)	42.02	24.97
Bachkovski Monastery	41.93	24.85
Belasitsa Mt.	41.37	23.13
Belila near Grudovo	42.33	27.10
Beloslav	43.20	27.73
Blagoevgrad (? Parangalitsa)	42.02	23.10
Bornarevo (= Bomarevo) near Radomir	42.53	22.93
Bratsigovo	42.02	24.37
Burgas	42.50	27.47
Dolna Dikanya	42.43	23.12
Dragoman	42.92	22.93
Drangovo	41.42	23.28
Dulovo	43.82	27.08
Dupnitsa	42.28	23.15
Evksinograd near Varna	43.15	28.00
Gara Krichim	42.13	24.53
Gara Razgrad	43.57	26.50
Golo Bardo Mt.	42.55	23.07
Gorna Breznitsa (N of)	41.77	23.09
Gorna Breznitsa (W of)	41.75	23.12
Gradishte (Golo Bardo Mt.)	42.55	23.07
Harmanli	41.93	25.90
Hisar	42.50	24.70
Hrabrino	42.05	24.65
Kamchia River (outfall)	43.03	27.88
Kalimantsi	41.47	23.48
Kamenitsa near Strumyani	41.65	23.17
Kamilski Dol near Ivailovgrad	41.53	26.13
Kardzhali	41.65	25.37
Karnobat	42.65	26.98
Kazanlak	42.62	25.40
Kozhuh Hill	41.43	23.25
Kresna (= Gara Pirin)	41.77	23.23
Kresna Gorge	41.80	23.17
Krichim	42.05	24.47
Krumovgrad	41.47	25.65
Kyustendil	42.28	22.68
Lebnitsa (Ograzhden Mt.)	41.53	23.23
Lilyanovo	41.62	23.32
Lom	43.83	23.25
Lyulin Mt.	42.67	23.08
Malko Tarnovo	41.98	27.53
Mandritsa	41.38	26.13
Marino Pole near Petrich	41.42	23.35
Meden Buk	41.37	26.03
Meden Rudnik (= Karabair)	42.45	27.40
Melnik	41.52	23.40
Mitino	41.43	23.25
Muldava	41.98	24.95
Nesebar (= Mesemvria)	42.65	27.73
Novi Iskar (= Kurilo)	42.82	23.35
Ognyanovo near Pazardzhik	42.15	24.42
Orlitsa	41.32	25.40
Ostrova Place near Plovdiv	42.15	24.70
Parvenets (= Ferdinandovo)	42.07	24.67
Pazardzhik	42.20	24.33
Perushtitsa	42.07	24.55
Peshtera	42.03	24.30
Petrich	41.40	23.22
Petrich (”Sv. Vargoo” Place)	41.45	23.17
Petrovo	41.43	23.52
Plovdiv	42.15	24.75
Podkova	41.40	25.40
Primorsko (= Kyupria; Stamopolu)	42.25	27.63
Radomir env. (Golo Bardo Mt.)	42.47	23.02
Ravna Gora (Strandzha Mt.)	42.37	27.55
Razgrad	43.53	26.52
Rezovo	41.99	28.03
Rila Mt.	42.13	23.55
Rilski Monastery	42.13	23.33
Ropotamo River’s outfall	42.33	27.77
Sadovo	42.13	24.93
Samokov	42.33	23.55
Sestrimo near Pazardzhik	42.22	23.92

Locality	Latitude	Longitude
Shtit (= Yuskudar) near Svilengrad	41.83	26.36
Simeonovgrad	42.05	25.88
Simitli	41.88	23.17
Slavyanka Mt.	41.38	23.60
Sliven	42.69	26.33
Sredets (= Grudovo)	42.35	27.19
Stara Kresna	41.80	23.18
Stara Zagora	42.43	25.64
Strandzha Mt.	42.07	27.00
Tsarevo	42.10	27.82
Turia	42.57	25.18
Varna	43.22	27.92
Varna (N of)	43.23	28.02
Venets near Burgas	42.63	26.80
Vidin	43.99	22.87
Vitosha Mt.	42.55	23.25
Vulkovo (W of)	41.58	23.22
Zvezditsa near Varna	43.15	27.85
Croatia		
Babin Dub	44.09	15.32
Bakar	45.31	14.53
Baška Nova (Krk Island)	44.97	14.75
Biokovo Mt.	43.33	17.05
Bokanjac	44.15	15.25
Cres	44.96	14.41
Crikvenica	45.17	14.70
Dubrovnik	42.65	18.09
Dugi Otok	43.98	15.07
Grižane	45.20	14.72
Grobnik	45.23	14.10
Knin	44.04	16.20
Kraljevica	45.27	14.57
Krasica	45.31	14.56
Lakmartin	45.05	14.59
Meja	45.29	14.59
Metkovic	43.05	17.65
Nadimsko Blato	44.03	15.48
Novi Vinodolski	45.13	14.79
Obrovac	44.20	15.68
Rijeka	45.34	14.41
Senj	42.63	18.70
Split	43.38	16.60
Starigrad (Hvar Island)	43.18	16.60
Trogir	43.53	16.17
Vinodol	45.22	14.70
Visoko	46.09	16.33
Vrgorac – Propotnica	43.20	17.37
European Turkey		
Kuru Dagh Mt.	40.70	26.75
Merefte	40.67	27.25

Locality	Latitude	Longitude
Greece		
Amphissa	38.40	22.45
Askifou (Lefka Ori, Crete Island)	35.28	24.18
Asteri nead Skala (Elos District)	36.50	22.43
Athens	37.98	23.73
Chalkis (Euboea Island)	38.46	23.60
Chamkjoiski Monastery near Soufli	41.19	26.30
Chani Driskos near Janina	39.67	20.85
Crete Island	35.25	24.75
Delphi	38.63	23.83
Eleftera Monastery near Kavala	40.91	24.25
Hortiatis Mt.	40.58	23.12
Kavala	40.94	24.40
Kiphissia	38.07	23.82
Korfu Island	39.67	19.75
Lianikladia near Kamia	38.54	22.26
Limenaria (Thasos Island)	40.63	24.58
Megaspilaon	38.50	22.10
Nauplia	37.56	22.81
Naxos Island	37.11	25.38
Okchilar near Xanthi	41.08	24.80
Ossa Mt.	39.75	22.58
Parnass Mt.	38.53	22.62
Pelion Monastery	36.17	28.00
Phaleron	37.93	23.70
Rhodos Island	36.17	28.00
Soufli	41.19	26.30
Stylis	38.92	22.62
Syra Island	37.45	24.93
Theologos (Thasos Island)	40.67	24.70
Tripolis	37.51	22.38
Velestino	39.38	22.75
Velouchi Mt.	38.56	21.48
Volo	39.37	22.95
Xanthi	41.14	24.88
Zachlorou	38.50	22.90
Zante	37.75	20.75
Kosovo		
Gračanica	42.60	21.20
Macedonia		
Bitolya env.	41.03	21.34
Gara Pcinja	41.82	21.67
Gevgelja	41.20	22.40
Prilep	41.33	21.58
Stari Dojran	41.19	22.72
Vodoca	41.45	22.59
Zelenikovo	41.89	21.59
Montenegro		
Kotor	42.43	18.77

Locality	Latitude	Longitude
Krasići	42.41	18.64
Sutorman	42.16	19.10
Titograd	42.44	19.26
Virpazar	42.25	19.09
Romania		
Agigea	44.08	28.62
Branesti	45.82	28.08
Bucharest	44.50	26.08
Calafat	43.99	22.93
Calarashi	44.25	27.00
Cardon	45.23	29.63
Constantsa	44.25	28.33
Hirshova	44.68	27.93
Istria	44.57	28.72
Jana Mare	44.41	22.69
Letea	45.30	29.52
Sadova	43.90	23.95
Techirghiol	44.05	28.60
Tecuci	45.87	27.42
Tulcea	45.17	28.80
Turno-Severin	44.63	22.66
Vasile-Roaita	44.55	27.70
Serbia		
Bela Palanka	43.22	22.33
Dimitrovgrad (= Tsaribrod)	43.01	22.78
Grebenac (Vojvodina Region)	44.90	21.23
Horgos near Grebenac (Vojvodina)	46.16	19.97
Mramorak (Vojvodina)	44.90	21.08
Palić (Vojvodina)	46.11	19.77
Pozharevats	44.61	21.17
Ram	44.81	21.33
Sušara (Vojvodina)	44.94	21.13
Usje	44.68	21.60
Vince	44.71	21.61
Zatonje near Veliko Gradiste	44.76	21.38