

Biogeography of the genus *Notiophilus* Dumeril, 1806 (Coleoptera: Carabidae)

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In the article the outline of biogeography of world fauna of the genus *Notiophilus* Dumeril, 1806 (Coleoptera: Carabidae) is given. 57 species of the genus *Notiophilus* Dum. are known in the world. 47 species of this genus can be distributed in Palearctic, 16 species in Nearctic, but 2 species in the Neotropical region. The largest diversity of the species of this genus and the biggest number of endemics occur in Asia – 41 species, 28 out of which can be distributed only in Asia (many are endemics to particular mountain massives or parts of them), but 13 occur outside Asia, both in Palearctic and some in Nearctic. In the article the central part of Asia is indicated as the hypothetical centre of origin and spread off of the species of this genus. Most likely the species reached Europe through the territory of the ancient Mediterranean region, from which they arrived in Northern Africa and Iceland, but they reached Northern America through Beringia. Chorotypes of sub-regional level, which most usually occupy small territories, are characteristic to the majority of the species of genus *Notiophilus* Dum. Only one species (*N. aquaticus* (L.)) has Holarctic distribution, one species (*N. reitteri* Spaeth) is spread transpalearctically in taiga zone, but two species (*N. borealis* Harold, *N. semistriatus* LeC.) occur in Beringia (north-eastern part of Palearctic and Nearctic) and Beringian – Nearctic chorotype is characteristic for them. Chorotypes of sub-regional level are characteristic for other species except of three species introduced in North America. Altogether 27 chorotypes were defined during the process of description of the genus *Notiophilus*.

Key words: Biogeography, *Notiophilus*, Coleoptera, Carabidae, world fauna, chorotype.

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INTRODUCTION

Basically species of the genus *Notiophilus* Dumeril, 1806 occur in Holarctic from tundra zone till its southern borders including Macaronesia, Northern Africa, Middle East, Iran, southern slopes of Himalaya Mountains and southern part of Sichuan province in China, Korean peninsula, Japan, as well as mountains in Mexico, Guate-

mala and Costa Rica in Central America. Only two species, which occur in Central America, can be distributed outside Holarctic. For the time being 57 species of this genus are known in the world fauna. To genus *Notiophilus* Dum. belong ground beetles (Carabidae) with a specific shape of body: big eyes, between which frontal furrows and widened, usually glossy second interval are present (see Fig. 1).

The biogeographical features of the species of genus *Notiophilus* Dum. world fauna have not been analyzed so far. In literature only separate works about fauna of this genus in several regions of the world can be found. There have been published many lists of ground beetles in the world, Palearctic, Nearctic and other regions, in which the species of this genus have been enumerated. The aim of this article is to make a review of biogeography of the world's fauna of the genus *Notiophilus* Dum.

Taking into consideration the fact that in recent years many new taxa of the genus *Notiophilus* Dum. have been described, the analysis of their distribution will complement the data about world fauna and biogeography of ground beetles (Carabidae) family.

During the investigation the author has summarized both the data of literature and determined the material in 50 private and museum collections. As a result the author described 7 new species, synonymized 2 species, and changed the taxonomical status for two more species.

MATERIAL AND METHODS

The list of world's species of the genus *Notiophilus* Dum. has been compiled on the basis of literature data and by determining the specimens of this genus in 50 private and museum collections (the list of collections see in Table 1). Altogether more than 4000 specimens were processed. All in all the abbreviations of the collections conform to the abbreviations of world entomological collections published by V. R. E.M.J.-B. Bejsak-Colorado-Mansfeld (2004).

During the processing of the material of the collections, the name of species and sex was defined and in case of necessity the genitalia were prepared off and the morphometric measurements were made for all specimens. The information about each defined specimen is aggregated in the data base.

Microscopical and morphometric investigations were done by *Zeiss* stereo-microscopes *Zeiss SteREO Lumar V12*, *Zeiss SteREO Discovery V12* and digital photo camera *Axiocam*. The pictures were processed and the morphometric measurements were made using *Axioview 4.4* software. For investigation of particular features *Zeiss* confocal laser scanning microscope *Zeiss LSM 5 PASCAL* was used.

Author's private collection (ABC) of the genus *Notiophilus* Dum. is used as a basic collection, it is kept in Daugavpils, Latvia. In the collection more than 700 specimens of this genus are being kept, they represent 44 species, besides 5 types of taxa described by the author are deposited in the collection, the list of them is summarized in Table 2.



Fig. 1. *Notiophilus semistriatus* Say

Table 1. List of reviewed collections

| No | Abbreviation of the collection | Collection | Country, city | Curator / director |
|-----|--------------------------------|---|-------------------------------|--------------------|
| 1. | ABC | Arvīds Barševskis | Latvia, Daugavpils | --- |
| 2. | ANPC | Alexander Napolov | Latvia, Rīga | --- |
| 3. | BPBM | Bernice P. Bishop Museum | U.S.A., Hawaii, Honolulu | G.A.Samuels |
| 4. | BSAC | Bronius Šablevičius | Lithuania, Ignalina | --- |
| 5. | BYU | Brigham Young University, Monte L. Bean Life Science Museum | U.S.A., Provo | Sh.M.Clark |
| 6. | CLEV | Cleveland Museum of Natural History | U.S.A., Cleveland | C. Camillo |
| 7. | CMCL | Carl Mützel collection in Latvian Natural History Museum | Latvia, Rīga | N.Savenkov |
| 8. | CMNC | Canadian Museum of Nature | Canada, Ottawa | N.Boase |
| 9. | DUBC | Daugavpils University | Latvia, Daugavpils | A.Barševskis |
| 10. | DEI | Deutsches Entomologisches Institut, ZALF | Germany, Müncheberg | L.Zerche |
| 11. | DKOC | Detlef Kolligs | Germany, Kiel | --- |
| 12. | DUBC | Daugavpils University Institute of Systematic Biology (DU SBI) | Latvia, Daugavpils | A.Barševskis |
| 13. | EIUC | Eastern Illinois University | U.S.A., Charleston | M.A.Goodrich |
| 14. | EMEC | Essig Museum of Entomology, University of California | U.S.A., Berkeley | Ch. Barr |
| 15. | FSCA | Florida State Collection of Arthropods, Division of Plant Industry | U.S.A., Gainesville | M.C.Thomas |
| 16. | INHS | Illinois Natural History Survey | U.S.A., Champaign | C.Favret |
| 17. | LDM | Latvian Natural History Museum | Latvia, Rīga | N.Savenkov |
| 18. | LEMQ | Lyman Entomological Museum & Research Laboratory, McGill University | Canada, Ste. Anne de Bellevue | S. Boucher |
| 19. | LMSZ | Museum of Systemic Zoology, University of Latvia | Latvia, Rīga | M.Cinītis |
| 20. | MCFB | Museu de Ciències Naturals, Museu de Zoologia | Spain, Barcelona | G. Maso |
| 21. | MFSN | Museo Friulano di Storia Naturale | Italy, Udine | C. Morandini |
| 22. | MHNN | Muséum d'Histoire Naturelle, Ville de Neuchâtel | Switzerland, Neuchâtel | J.P.Haenni |
| 23. | MNMS | Museo Nacional de Ciencias Naturales | Spain, Madrid | C. Martin |
| 24. | MZUF | Museo Zoologico "La Specola" | Italy, Firenze | L.Bartolozzi |
| 25. | MSC | Mihails Stiprais collection in Latvian Natural History Museum | Latvia, Rīga | N.Savenkov |
| 26. | NCSU | North Carolina State University Insect Collection | U.S.A., Raleigh | R.L.Blinn |
| 27. | NHM | Natural History Museum | United Kingdom, London | S. Hine |
| 28. | OLML | Oberösterreichisches Landes Museum, Biologiezentrum | Austria, Linz | F.Gusenleitner |
| 29. | ONC | Olivier Nolte | Germany, Leimen | --- |
| 30. | PBVC | Paolo Bonavita | Italy, Roma | --- |

| | | | | |
|-----|------|--|----------------------------------|------------------------|
| 1. | RCC | Raimonds Cibulskis | Latvia, Daugavpils | --- |
| 2. | RDC | Roman Dudko | Russia, Novosibirsk | --- |
| 3. | SDAC | Stefano Dacatra | Italy, San Donato Milanese | --- |
| 4. | ROME | Royal Ontario Museum | Canada, Ontario, Toronto | B.Hubley |
| 5. | SFC | Sergio Facchini | Italy, Piacenza | --- |
| 6. | SMC | Seiji Morita | Japan, | --- |
| 7. | SMNK | Staatliches Museum für Naturkunde Karlsruhe | Germany, Karlsruhe | A.Riedel |
| 8. | SMNS | Staatliches Museum für Naturkunde Stuttgart | Germany, Stuttgart | W.Schawaller |
| 9. | UAAM | University of Arkansas, The Arthropod Museum | U.S.A., Fayetteville | J.K.Barnes |
| 10. | UCMC | University of Colorado Museum | U.S.A., Boulder | V.Scott |
| 11. | UMDB | Universidade da Madeira, Departamento de Biologia | Portugal, Funchal | D.A.Pombo, E. Nunes |
| 12. | UMRM | W.R.Enns Entomology Museum, University of Missouri-Columbia | U.S.A., Columbia | R.W.Sites |
| 13. | UNMC | University of New Mexico, Museum of Southwestern Biology | U.S.A., Albuquerque | S.Brantley |
| 14. | VMNH | Virginia Museum of Natural History | U.S.A., Martinsville | R.Hoffman |
| 15. | VTC | Vytautas Tamutis | Lithuania, Kaunas | --- |
| 16. | WSU | Maurice T. James Entomological Collection, Washington State University | U.S.A., Pullman | R.S.Zack |
| 17. | ZIN | Zoological Institute, Russian Academy of Science | Russia, St. Petersburg | B.M.Kataev |
| 18. | ZMUC | Zoological Museum, University of Copenhagen | Denmark, Copenhagen | O.Martin |
| 19. | ZMUK | Zoologisches Museum Christian Albrecht Universität Kiel | Germany, Kiel | W. Dreyer |
| 20. | ZMUZ | Zoologisches Museum der Universität Zürich | Switzerland, Zürich | W. Blanchenhorn |

RESULTS AND DISCUSSIONS

In “A systematic list of extant ground beetles of the world (Coleoptera “Geadephaga”: Trachypachidae and Carabidae incl. Paussinae, Cicindelinae, Rhysodinae)” Lorenz (1998, 2005) has named 51 (1998) and 54 (2005) species of this genus for the world fauna. In “Catalogue of Palearctic Coleoptera” Bousquet and Barševskis (2003) have determined 36 species for Palearctic region. In “A Natural History of

the ground – beetles (Coleoptera: Carabidae) of America north of Mexico” Laroche and Larivière (2003) have determined 15 *Notiophilus* Dum. species for Nearctic region. In recent years several significant articles about species of the genus *Notiophilus* Dum. have been published, new taxa have been described and recent information about distribution of species has been given in them. At the moment 57 species of this genus are known in the world’s fauna. Figure 2 shows the number of species of the genus *Notiophilus* Dum. in various regions.

Table 2. List of types of the genus *Notiophilus* Dum., which are in the author's collection

| Name of the taxon | Current status of taxon | Types |
|--|--------------------------------|----------------------|
| <i>N. stipraisi</i> Barševskis, 1993 | syn. of <i>N. germinyi</i> | Holotypus, paratypes |
| <i>N. solodovnikovi</i> Barševskis, 2001 | syn. of <i>N. semistriatus</i> | Holotypus |
| <i>N. schawalleri</i> Barševskis, 2003 | valid | Paratypus |
| <i>N. dacatrai</i> Barševskis, 2004 | valid | Paratypus |
| <i>N. katrinae</i> Barševskis, 2005 | valid | Holotypus, paratypes |

I would like to survey separately several articles, which are dedicated to problems of taxonomy of the genus *Notiophilus* Dum. One of them is Schmidt's and Hartmann's (2001) review of Nepalian species of this genus, which is based on processing of big series of *Notiophilus* Dum. specimens (more than 140 specimens from 5 species). In this review 3 *N. radians* Andrewes, 1926 sub-species have been described, these are: *N. r. gerdmuelleri* Schmidt, Hartmann, 2001, *N. r. bhotyia* Schmidt, Hartmann, 2001 and *N. r. dhaulagiricus* Schmidt, Hartmann, 2001. Previously described *N. franzi* Dostal, 1986 has been also defined as *N. radians* Andrewes, 1926 sub-species, but *N. darghariensis* Dostal, 1986 defines as *N. r. franzi* Dostal, 1986 junior synonym. The authors of the review give a wide description of spread and zoogeographical fluidity. They have not found significant differences in the structure of *aedeagus*.

Taking into consideration the big individual variability of the described taxons, nearness of separate sub-species' areas, comparatively small ecological differences, I would like to initiate a discussion about the status of the taxa described in this review. The general tendencies of the species of this genus in other parts of the world – Central Asia, China, Siberia, where the isolation of the taxons is not less than in Nepal, do not testify that *Notiophilus* Dum. species tend to form sub-species. The structure of *aedeagus* not always can be a good criterion for determination of the species of this genus. The structure of *aedeagus* for some other species of this genus in Asia outside Himalaya can be also very similar

(for example, in species group of *N. aquaticus* (L.)), however these are good valid species. To my mind *N. radians* Andr. is a complex of several similar species, a wider material of this genus from Nepal and new review of the taxa is needed for determination of its taxonomical status.

Barševskis (2001) has described new species – *N. solodovnikovi* Barševskis, 2001 from the Far East of Russia (Sakhalin Island). In Siberia *N. semistriatus* Say, 1823 (Dudko et al. 2002), which is widely distributed in Nearctic and occurs in the Altai mountains, in the surroundings of Lake Baikal and the Far East, was distributed. In later researches it was proved that *N. solodovnikovi* Barš. is synonymous to *N. semistriatus* Say (Barševskis 2006). A similar situation is also with *N. bodemeyeri* Roubal, 1916, which is not a valid species, but synonymous to *N. sibiricus* Motsch. (Barševskis, 2006). In this article there is a mistake in page 67, 3rd paragraph, 1st sentence: “After the correctness testing of type determination two of them are *N. spaethi* Reitter, 1913, but one – *N. aquaticus* (Linnaeus, 1758).” It should be correctly ... but one – *N. sibiricus* (Motschulsky, 1844).

In the overview of the genus *Notiophilus* Dum. Chinese fauna Barševskis (2003) described 5 new species: *N. facchinii* Barševskis, 2003, *N. gansuensis* Barševskis, 2003, *N. chinensis* Barševskis, 2003, *N. sichuanensis* Barševskis, 2003 and *N. schawalleri* Barševskis, 2003. 3 out of 5 species are described after only one holotype specimen.

Table 3. Contents of the genus *Notiophilus* Dum. fauna in various region of the world

| Region | Species, which occur | |
|-----------------|---|--|
| | Only in this region | In this and other regions |
| Africa | --- | <i>N. biguttatus</i> (F.), <i>N. geminatus</i> Dej. & Boisd., <i>N. marginatus</i> Gene, <i>N. quadripunctatus</i> Dej., <i>N. substriatus</i> Waterh. |
| Europe | --- | <i>N. aestuans</i> Dej., <i>N. aquaticus</i> (L.), <i>N. biguttatus</i> (F.), <i>N. danieli</i> Rtt., <i>N. geminatus</i> Dej. & Boisd., <i>N. germinyi</i> Fv. in Gren., <i>N. interstitialis</i> Rtt., <i>N. laticollis</i> Chaud., <i>N. marginatus</i> Gene, <i>N. palustris</i> (Dft.), <i>N. quadripunctatus</i> Dej., <i>N. reitteri</i> Spaeth, <i>N. rufipes</i> Curt., <i>N. substriatus</i> Waterh. |
| Asia | <i>N. brevisculus</i> Solsky, <i>N. chinensis</i> Barš., <i>N. dacatrai</i> Barš., <i>N. facchini</i> Barš., <i>N. gansuensis</i> Barš., <i>N. ghilarovi</i> Kryzh., <i>N. hauseri</i> Spaeth, <i>N. heinzi</i> Dost., <i>N. hiemalis</i> Semenov & Arnoldi, <i>N. hilaris</i> Freder., <i>N. hyperboreus</i> Kryzh., <i>N. impressifrons</i> Mor., <i>N. jakovlevi</i> Tschitsch., <i>N. kaszabi</i> Jedl., <i>N. katrinae</i> Barš., <i>N. kirschenkoferi</i> Dost., <i>N. nepalensis</i> Dost., <i>N. orientalis</i> Chaud., <i>N. ovalis</i> Breit, <i>N. persicus</i> Breit, <i>N. radians</i> Andr. (<i>N. r. radians</i> Andr., <i>N. r. bhotiya</i> Schm. & Hartm., <i>N. r. dhaulagiricus</i> Schm. & Hartm., <i>N. r. franzi</i> Dost., <i>N. r. gerdmuelleri</i> Schm. & Hartm.), <i>N. schawalleri</i> Barš., <i>N. semenovi</i> Tschitsch., <i>N. sibiricus</i> Motsch., <i>N. sichuanensis</i> Barš., <i>N. spaethi</i> Rtt., <i>N. stackelbergi</i> Kryzh., <i>N. sublaevis</i> Solsky, <i>N. tschitscherini</i> Zaitz. | <i>N. aestuans</i> Dej., <i>N. aquaticus</i> (L.), <i>N. biguttatus</i> (F.), <i>N. borealis</i> Harold, <i>N. danieli</i> Rtt., <i>N. germinyi</i> Fv. in Gren., <i>N. interstitialis</i> Rtt., <i>N. laticollis</i> Chaud., <i>N. palustris</i> (Dft.), <i>N. reitteri</i> Spaeth, <i>N. rufipes</i> Curt., <i>N. semistriatus</i> LeC., <i>N. substriatus</i> Waterh. |
| North America | <i>N. aeneus</i> Herbst, <i>N. directus</i> Casey, <i>N. intermedius</i> Lindr., <i>N. nemoralis</i> Fall, <i>N. nitens</i> LeC., <i>N. novemstriatus</i> LeC., <i>N. semiopacus</i> Eschsch., <i>N. sierranus</i> Casey, <i>N. simulator</i> Fall, <i>N. sylvaticus</i> Eschsch. | <i>N. aquaticus</i> (L.), <i>N. biguttatus</i> (F.)*, <i>N. borealis</i> Harold, <i>N. palustris</i> (Dft.)*, <i>N. rufipes</i> Curt.*, <i>N. semistriatus</i> LeC., |
| Central America | <i>N. chihuahuae</i> Casey, <i>N. specularis</i> Bates | --- |

* - introduced from Europe

Table 4. Chorotypes of world fauna species of the genus *Notiophilus* Dum.

| | Chorotype | Species | |
|---|---------------------------|---|--|
| HOLARCTIC Eastsiberian – Nearctic Nearctic | Circumboreal | <i>N. aquaticus</i> (L.) <i>N. borealis</i> Harold, <i>N. semistriatus</i> LeC. | |
| | Nearctic | <i>N. novemstriatus</i> LeC. | |
| | Canadian | <i>N. intermedius</i> Lindr. | |
| | West-American | <i>N. directus</i> Casey, <i>N. nitens</i> LeC., <i>N. simulator</i> Fall, <i>N. sylvaticus</i> Eschsch. | |
| | East-American Sonorian | <i>N. aeneus</i> Hbst., <i>N. nemoralis</i> Fall, <i>N. semiopacus</i> Eschsch., <i>N. sierranus</i> Casey, | |
| Palearctic | Palearctic | <i>N. reitteri</i> Spaeth | |
| | West-Palearctic | <i>N. biguttatus</i> (F.) | |
| | Sibero-European | <i>N. germinyi</i> Fv. in Gren., <i>N. palustris</i> (Dft.) | |
| | European | <i>N. aestuans</i> Dej., <i>N. laticollis</i> Chaud., <i>N. rufipes</i> Curt. | |
| | Mediterranean | | <i>N. substriatus</i> Waterh. |
| | | East-Mediterranean | <i>N. danieli</i> Rtt., <i>N. hilaris</i> Frieder., <i>N. interstitialis</i> Rtt. |
| | West-Mediterranean | | <i>N. geminatus</i> Dej. & Boisd., <i>N. marginatus</i> Gene, |
| | | | <i>N. quadripunctatus</i> Dej. |
| | Siberean | Hyperboreal | <i>N. hyperboreus</i> Kryzh. |
| | | Baikalo-Japanian | <i>N. sibiricus</i> Motsch. |
| | | Altaian | <i>N. jakovlevi</i> Tschitsch. |
| | Central-Asiatic | | <i>N. sublaevis</i> Solsky, <i>N. hiemalis</i> Semenov & Arnoldi |
| | | Dzhungaro-Tianshanian | <i>N. ghilarovi</i> Kryzh., <i>N. ovalis</i> Breit, <i>N. semenovi</i> Tschitsch., <i>N. spaethi</i> Rtt, <i>N. stackelbergi</i> Kryzh., <i>N. tshitsherini</i> Zaitz. |
| Mongolian | | <i>N. kaszabi</i> Jedl. | |
| Turanian | | Kopet-Daghian <i>N. persicus</i> Breit | |
| East-Asiatic | Manchurian | <i>N. impressifrons</i> Mor., <i>N. brevisculus</i> Solsky | |
| | Central-Chinaean | <i>N. chinensis</i> Barš., <i>N. dacatrai</i> Barš., <i>N. facchini</i> Barš., <i>N. gansuensis</i> Barš., <i>N. hauseri</i> Spaeth, <i>N. katrinae</i> Barš., <i>N. schawalleri</i> Barš., <i>N. sichuanensis</i> Barš. | |
| | | East-Himalayan | <i>N. nepalensis</i> Dost., <i>N. radians</i> Andr. (<i>N. r. radians</i> Andr., <i>N. r. bhotiya</i> Schm. & Hartm., <i>N. r. dhaulagiricus</i> Schm. & Hartm., 2001, <i>N. r. franzi</i> Dostal, 1986, <i>N. r. gergmuelleri</i> Schm. & Hartm.) |
| | West-Himalayan | <i>N. heinzi</i> Dostal, <i>N. kirschenhoferi</i> Dostal, <i>N. orientalis</i> Chaudoir, <i>N. chihuahuae</i> Casey, <i>N. specularis</i> Bates | |
| | NEOTROPICAL | Central-American | |

The author has described two more species from China: *N. dacatrai* Barševskis 2004 and *N. katrinae* Barševskis, 2005 (Barševskis 2004, 2005). In 2004 supplementary information about new findings of the species *N. facchini* Barš., *N. sichuanensis* Barš. and *N. schawalleri* Barš. in China were published. New information about *N. spaethi* Reitt. in Tian Shan part of China (Kabak 2002) is published as well.

In Western Palearctic some controversial questions still exist, they are related to distribution of species of genus *Notiophilus* Dum. in various territories. During determination of the specimens of this genus in Natural History Museum in London (NHM) Barševskis defined *N. biguttatus* (Fabricius, 1779) (Lybia, Cyrenaica, Bangazi) (Barševskis 2004b) as a new species for Northern Africa. The light was thrown on the contents of Check - list of the *Notiophilus* Dum. species in fauna of Macaronesia (Barševskis

2005) as well. In the list of ground beetles of Madeira Island *N. geminatus* Dej. has been included, which had been excluded from the list as incorrectly defined (Serrano 1989). It was possible to prove this fact due to the museums' material from Madeira Island as well as due to the author's expedition to Madeira island in September 2004, during which he managed to collect several specimens of this genus. The ground beetles' list (Mochado, Oromi 2000) in other Macaronesian island archipelago – the Canary Islands, has been supplemented with *N. quadripunctatus* Dej. (Barševskis 2005). The data about recent deposits of this species in the east of its area have been published - *N. quadripunctatus* Dej. has been defined for the first time for fauna of Germany (Hemmann, Trautner 2002).

Concerning Nearctic fauna the author of this article has defined new species for Northern

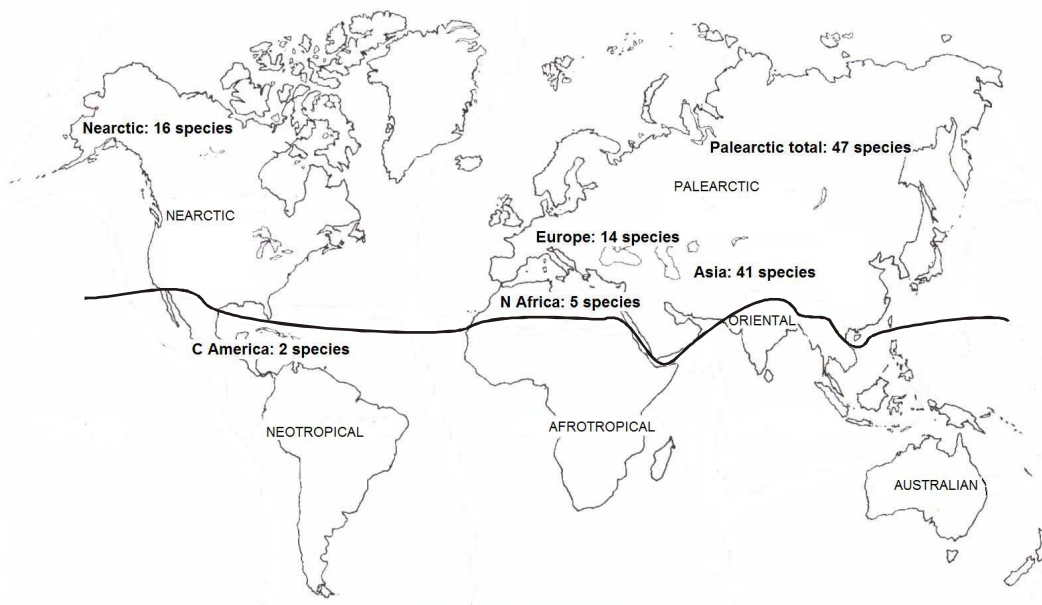


Fig. 2. Number of species of the genus *Notiophilus* Dum. in various parts of areal

America - *N. rufipes* Curtis, 1829 (Barševskis 2004a) (U.S.A., Georgia, Ware Co.), which has been introduced from Europe and found in the collection of University of Arkansas Arthropod Museum (UAAM). Thus we can consider already 3 species, which are widely spread in Palearctic (*N. palustris* (Duft.), *N. biguttatus* (F.) un *N. rufipes* Curt.), to be introduced in Nearctic. On the other hand, no species have been found to be introduced from Nearctic in Palearctic.

In table 3 the structure of fauna of the genus *Notiophilus* Dum. in various regions has been shown. As we can see in the table, the majority of species occur in Asia, where 41 species have been found (apart from *N. radians* Andr. subspecies), which form 72% of the world fauna of this genus. In Asia the biggest number of species unique for the region (the species, which have not been found outside the region) – 28 (49% of world fauna) have been distributed. 11

of the species of this genus (19% of world fauna), which occur in Asia, can be distributed in Europe as well, but 3 species (5% of world fauna) are common for Asia and Northern America.

If compared with other regions, in Europe only 14 species can be distributed, none of them is endemic species, in Northern Africa and Macaronesian archipelagos – 5 species, all of them can be found in Southern Europe as well. 16 species, which can be found in Nearctic, also can not be conspicuous for narrow localized number of endemics. Only two species *N. semiopacus* Eschsch. and *N. sierranus* Casey, which can be found in highland regions of Arizona and California, can be considered to be endemics localized in comparatively small territories. In the west of Northern America number of specie of the genus *Notiophilus* Dum. is bigger than in the east of the continent. Similar situation is also with both unique species found outside Palearctic –



Fig. 3. Hypothetical origin centre of species of the genus *Notiophilus* Dum.

N. specularis Bat. and *N. chihuahuae* Casey, which are spread in hilly regions of Central American states.

From the above mentioned we can try to outline hypothetical species' origin centre and directions of distribution of species of this genus, which are shown in figure 3. Irrespective of the insufficient data about species of this genus in highland regions of Central Asia (in majority of Himalaya Mts, including the wide Plateau of Tibet, Kunlun Shan, Hindu Kush, the Pamirs, Tian Shan, Plateau of Iran and other) it is well grounded to consider, that species' formation centre could be exactly in the mentioned region. Right here is the biggest diversity of *Notiophilus* Dum. species and the major number of endemics. Though the majority of the species of this genus were found in forests and highland territories, one of the ways of species spread in the direction of Europe could be through the ancient Mediterranean region from Central Asia, along the region of the Caspian and the Black Sea in the direction of Southern Europe, through which a small part reached Northern Africa and Macaronesian archipelagos, as well as expanded to the north of Europe. To a certain extent we can conclude this from the present diversity of species, which diminishes in the south to the north direction and from south east to south west in Europe. The same way of spread could also stretch in eastern direction through Central and Northeastern China, Southern Siberia, the Far East regions of Russia, Beringia, Alaska and further it expanded to whole Nearctic through western mountain massives of North America, thus reaching Central America in the south.

Unfortunately the tribe Notiophilini is monotypical and is represented in the world fauna only by one genus - *Notiophilus* Dum., the attempts to divide it into sub-genera or groups of species did not have significant results so far (Barševskis 1994), therefore it is still impossible to compare representation of groups of species, sub-genera or genera in various regions of the world.

The cheme of chorotype classification used in this article (see table 4) is elaborated by the author and is adapted to the biogeographical features of the genus *Notiophilus* Dum. Chorotype classification in Western Palearctic offered by Vigna Taglianti et al. (1999) was used at the basis. Separate ideas have been adapted from the voluminous Kryzhanovskij's work (Kryzhanovskij 2002) and from Erwin's (1970) review of bombardier beetles (Coleoptera: Brachinida) in Northern and Central America.

Big diversity of chorotypes is characteristic to the genus *Notiophilus* Dum. Many species have comparatively narrow localized areals, related to mountain massives (for example, Tian-Shan Mts., Altai Mts., Himalaya Mts. and other). Transcontinental or transregional chorotypes are characteristic just to small part of species.

Only one species of this genus – *N. aquaticus* (L.) is Holarctic. Circumboreal areal is characteristic to this species. It can be distributed in Palearctic and Nearctic and from tundra zone till steppe zone, in the south more frequently in mountain areas.

Also only one species – *N. reitteri* Spaeth is Transpalearctic, it is very frequent in Eurasian taiga zone from Northern Norway to Japan (Hokkaido, Shirataki). It is one of the most numerous and most frequent species of this genus in Siberia and the Far East of Russia. In July, 2006 after sifting the soil in Bureyinskij Nature Reserve (Khabarovsk Area, Verhnebureyinskij Distr.) the author marked this species as the dominant species of beetles (Coleoptera) in taiga.

Only one species – *N. biguttatus* (F.) is West-Palearctic, it is known from Northern Africa [Lybia] (Barševskis 2004b), majority of Europe, Asia Minor, West Siberia (Bousquet, Barsevskis 2003). The species is introduced also in Nearctic.

Two species *N. palustris* (Duft.) and *N. germinyi* Fauv.in Gren. are Sibero-European. Both species have rather similar distribution areals. They can be distributed from the eastern part of Iberian Peninsula (Serrano 2003) in Western Europe to

Kazakhstan and south-western part of Eastern Siberia in the east of the area (Kryzhanovskij et al. 1995). *N. palustris* (Duft.) is introduced in Nearctic (Larochelle, Lariviere 1990, 2003).

European chorotype is characteristic to three species of this genus: *N. aestuans* Motsch., *N. laticollis* Chaud. and *N. rufipes* Curt. The first one can be distributed in majority of Europe and Asia Minor. The second species can be found in Central Europe, South-Eastern Europe and particular parts in Caucasus. It is a typical species of steppe zone. The third species is spread in majority of Europe, excepting Northern Europe and North-Eastern Europe. This species inhabit forest of broad-leaved trees. It is introduced in Eastern Siberia (?) and Northern America (Barševskis 2004a).

Notiophilus Dum. species, which are distributed in Mediterranean region, can be divided into three groups:

1) species found in the whole Mediterranean region – *N. substriatus* Waterh., which can be distributed in northern direction to Great Britain and Germany;

2) West-Mediterranean species – *N. geminatus* Dej. & Boisd., *N. marginatus* Gene, *N. quadripunctatus* Dej., only the last of the species is distributed in northern direction in Western Europe to Germany, but the first two – in Southern Europe from Italy to Portugal, in Northern Africa from Lybia to Morocco and in the archipelagos of Macaronesia;

3) East-Mediterranean species – *N. danieli* Reitt., *N. interstitialis* Reitt. and *N. hilaris* Freder., first two species can be distributed in the Balkans and Asia Minor, but the last one, which has not been found since its description (Frederichs 1903), is known from Syria. The taxonomical status of *N. hilaris* Freder. is temporarily unclear, while the material of types has not been investigated and there are no new findings of this species.

Notiophilus Dum. species from Central Asia can be divided into three chorotype groups:

1) species, which are distributed in the whole Central Asia;

2) species which are spread in Dzhungarian and Tian-Shan mountains and

3) species, which are distributed in Mongolia.

Only two species of this genus: *N. sublaevis* Solsky and *N. hiemalis* Semenov & Arnoldi stat. nov. belong to the first Central-Asiatic chorotype group. The last taxon initially has been described as *N. sublaevis* Solsky sub-species (Semenov Tian-Shanskij, Arnoldi 1937). Taking into consideration series of morphological features which are divergent enough for both species, and because of overlapping of areals of these species, the author has reason to consider *N. hiemalis* Semenov & Arnoldi, 1937 to be a separate species. The taxonomical status of this species will be discussed in a separate article.

Discussing *Notiophilus* Dum. fauna in Dzhungarian and Tian-Shan mountains, the comparatively big number of endemics of this genus in the mountain massives should be mentioned – 5 species: *N. ghilarovi* Kryzh., *N. ovalis* Breit, *N. spaethi* Reitt., *N. stackelbergi* Kryzh., *N. tschitscherini* Zaitz. In this chorotype I have included also *N. semenovi* Tschitsch. stat. nov., whose areal is a little bit wider than the mentioned mountain massives in Kazakhstan and Kirgizia. Previously *N. semenovi* Tschitsch. was rated as *N. aquaticus* (L.) synonymous, but further it is to be considered an valid species. The taxonomical status, morphology of this species will be discussed in a separate article as well.

Information about fauna and distribution of species in Central Asia can be found in several works published during last ten years (Kryzhanovskij 1995, Kryzhanovskij et al. 1995, Kabak 2002). Information about taxonomical status of *N. bodemeyeri* Roub. has been published separately (Barševskis 2006). Although Kryzhanovskij (2002) divides this mountainous region of Central Asia into several smaller chorotypes, I have united all species found in this region into one chorotype – Dzhungaro-Tianshanian in order not to complicate the chorotype system of the genus *Notiophilus* Dum.

N. kaszabi Jedl. belongs to the third Central – Asiatic chorotype group – Mongolian chorotype. This species has been described from Central aimak, Zaisan (Jedlička 1968) and has not been found any more after the description (the description was based on 6 females). The status of the species may become clear after the studies of types. It may be some of the forms of *N. reitteri* Spaeth, which occurs in Siberia (including Altai) and is very variable.

Turanian chorotype group is represented only by one obscure species from Kopet-Dagh mountains in Northern Iran – *N. persicus* Breit. Author has seen one specimen of this species in ZIN (Saint Petersburg, Russia) collection and does not have any reason to question the status of the species.

What concerns genus *Notiophilus* Dum. Asian fauna, it is very diverse in Eastern Asia. Majority of Eastern Asian species can be distributed mainly in small, often geographically isolated territories. The following chorotypes have been included in East-Asiatic chorotype group: 1) West-Himalayan; 2) East-Himalayan, 3) Central-Chinaean, 4) Manchurian. *Notiophilus* Dum. fauna in Eastern Asian region has been investigated most incompletely, therefore it is being investigated most intensively at the moment. It is acknowledged by several articles with description of new taxons (Schmidt, Hartman 2001, Barševskis 2003, 2004, 2005) published in recent years.

West-Himalayan chorotype is represented by 3 species: *N. heinzi* Dost., *N. kirschenhoferi* Dost., *N. orientalis* Chaud., only the last of them is spread in Western Himalayan region (Pakistan, Northern India). *N. heinzi* Dost. described after 2 males and 7 females from surroundings of Jabba in Pakistan (Dostal 1986), *N. kirschenhoferi* Dost. in its turn has been described according to one female from Ziarat surroundings in Beluchistan province in Pakistan (Dostal 1981).

In East-Himalayan chorotype I have included species found in Nepal: *N. nepalensis* Dost. and *N. radians* Andr. (with 5 sub-species).

At the moment 8 species have been found in the central part of China: (Sichuan, Gansu): *N. chinensis* Barš., *N. dacatrai* Barš., *N. facchinii* Barš., *N. gansuensis* Barš., *N. hauseri* Spaeth, *N. katrinae* Barš., *N. schawalleri* Barš., *N. sichuanensis* Barš. Almost all named species have been described in recent years (Barševskis 2003, 2004, 2005). For the time being distribution of species is unclear, because only for some of them new finds have been found after their description.

N. impressifrons Mor. occurs in the south of Siberia from Transbaikal to North-Eastern part of China (Manchuria), Korean peninsula and Japan. The author has included it in Manchurian chorotype.

N. brevisculus Solsky can be found in the Far East of Russia, mainly in Maritime Territory. In the defined museum materials no data exist about occurrence of this species in Northern China.

Siberian fauna does not contain many endemic species of this genus. Only three species have not been found yet outside Siberian borders (incl. Far East of Russia). Besides each of them has its own chorotype: *N. hyperboreus* Kryzh. – hyperboreal species; *N. sibiricus* Motsch. – Southern Siberian species, which can be found most probably also in Japan and *N. jakovlevi* Tschitsch. is endemic in Altai mountains.

Beringian – Nearctic chorotype is characteristic to two species of the genus *Notiophilus* Dum. – *N. borealis* Harold and *N. semistriatus* LeC. They occur both in eastern or north-eastern part of Siberia and in majority of Nearctic. *N. borealis* Harold is distributed in North-Eastern Siberia and northern part of Nearctic but *N. semistriatus* LeC. – much more widely from Altai mountains in Southern Siberia to the east to the Pacific Ocean in Palearctic and majority of Nearctic territory.

16 species of the genus *Notiophilus* Dum. can be found in Nearctic. Three of the species *N. aquaticus* (L.), *N. semistriatus* LeC. and *N. borealis* Harold have been discussed previously,

while analyzing Palearctic fauna. 3 species *N. palustris* (Duft.), *N. biguttatus* (F.) and *N. rufipes* Curt. are introduced from Europe. Only in Nearctic region 10 species occur: *N. aeneus* Hbst., *N. directus* Casey, *N. intermedius* Lindr., *N. nemoralis* Fall, *N. nitens* LeC., *N. novemstriatus* LeC., *N. semiopacus* Eschsch., *N. sierranus* Casey, *N. simulator* Fall and *N. sylvaticus* Eschsch. Bigger diversity of the species of this genus is in Western Nearctic. *N. directus* Casey, *N. nitens* LeC., *N. sylvaticus* Eschsch., *N. simulator* Fall, *N. semiopacus* Eschsch. and *N. sierranus* Casey can be traced there. The last two occur in small territory in highland regions Sierra Nevada Mts., San Bernardino Mts. and other mountain massives in south-western states of the USA – Arizona and California. In the eastern part of Nearctic only three species *N. aeneus* Hbst., *N. nemoralis* Fall, *N. novemstriatus* LeC. can be found. However only one rare boreal species *N. intermedius* Lindr. occurs transcontinentally in Canada and Alaska. Probably Beringian – Nearctic chorotype could be characteristic to this species similarly as to *N. borealis* Harold and its detection can be forecasted in NE Siberia.

Two species of the genus *Notiophilus* Dum. can be found outside Holarctic borders – in Neotropical region (Erwin 1991). They occur in Central America (*N. specularis* Bates. found in Mexico and Guatemala and *N. chihuahuae* Casey, which is obscure and described from the northern part of Mexico, for the time being only scarce information exists about its spread).

CONCLUSION

57 species of the genus *Notiophilus* Dum. are known for the world's fauna. 47 species of this genus occur in Palearctic, 16 species in Nearctic, but two species in Neotropical region. Common species for both region cannot be distributed in Holarctic and Neotropical regions. Comparing fauna in both parts of Holarctic: Nearctic and Palearctic 3 species are common for them and 3 more species are introduced in Nearctic from

Palearctic. For the time being there is no data about Nearctic species to be introduced in Palearctic.

The biggest diversity of the species of this genus and the biggest number of endemics is in Asia – 41 species, 28 of them occur only in Asia (many are endemics to particular mountain massives or parts of them), but 13 can be found outside Asia, both in Palearctic and some also in Nearctic. Therefore the hypothetical centre of origin and spread of species of this genus could be exactly the central part of Asia. Most probably the species reached Europe through the territory of ancient Mediterranean region, from which they reached Northern Africa and Iceland, but they reached Northern America through Beringia.

Majority of species of genus *Notiophilus* Dum. have chorotypes of sub-regional level, which occupy as often as not small territories, which cover for many species particular mountain massives or their parts). One species (*N. aquaticus* (L.)) is Holarctic with a characteristic circumboreal areal in majority of Holarctic. In taiga zone one species (*N. reitteri* Spaeth) is transpalearctically distributed from the Northern Europe to coasts of the Pacific Ocean in Far East of Russia and Japan. Two species (*N. borealis* Harold, *N. semistriatus* LeC.) occur in Beringia (NE part of Palearctic and Nearctic) and Beringian – Nearctic chorotype is characteristic for them. Other species, with the exception of three species introduced in Northern America, have chorotypes of sub-regional level. Altogether 27 chorotypes were defined while characterizing spread of the genus *Notiophilus*.

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