

# Analysis of Insect Distribution in the Northern Hemisphere by the Example of the Subfamily Arctiinae (Lepidoptera, Arctiidae).

## 1. Genus Level

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**Abstract**—An attempt is made to apply cluster analysis to comparison of local faunas in the Northern Hemisphere at the genus level by the example of the subfamily Arctiinae (Lepidoptera, Arctiidae). A total of 200 North African, Eurasian (to New Guinea inclusive), and North American (north of the United Mexican States) local faunas have been considered. It is found that the arctic fauna is clearly detached from the Palearctic and Nearctic faunas, being closer to the former. Therefore, it is not reasonable to recognize the united European-Canadian subprovince of the boreal province according to the tiger moth faunas. The Palearctic tiger moth fauna is characterized by relatively smooth variations within the boreal, subboreal, and western subtropical belts. The boundary between the Palearctic and the Oriental (Indo-Malayan) provinces should be drawn north of the Yangtze catchment area. The most dramatic fauna change at the genus level takes place between North and Northeast China. It is reasonable to recognize a broad transition area between the two zoogeographic provinces in Eastern Asia. On the grounds of the nonuniform tiger moth fauna, the South Chinese–East Himalayan subprovince should be assigned to the Oriental (Indo-Malayan) province rather than the Palearctic, as was repeatedly proposed. The Southwest-Asian fauna (Arabian Peninsula and southern Iran) is transitional between the Palearctic, African, and Oriental ones. Many African genera reach the west and south of the Arabian Peninsula, whereas Oriental and Paleotropical genera reach southern Iran.

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### INTRODUCTION

General zoogeographical concepts can be formulated only by taking into account the prevalence of as many animal groups as possible. Therefore, one of the main tasks faced by zoogeographers is to understand the distribution of their target animal groups over the Earth's surface. The wider area is examined, the more valuable are the results obtained. That is why I took an attempt to analyze the distribution of lepidopterans of the subfamily Arctiinae (Lepidoptera, Arctiidae) over the Northern Hemisphere. This subfamily, tiger moths, is a relatively well studied animal taxon.

### MATERIALS AND METHODS

The first problem in the analysis of tiger moth prevalence was to determine a reference area. This area should encompass a portion of the Earth's surface as large as possible; second, tiger moth distribution should have been well studied there. Unfortunately, the faunistic data on this group in South and Central Americas, tropical Africa, and Australia are insufficient. One cannot determine with certainty what range of taxa of this group inhabit a particular area in these regions. The author has investigated the Palearctic fauna for 25 years in expeditions in various regions of the FSU and by exam-

ining collections of the Siberian Zoological Museum of the Institute of Animal Systematics and Ecology (IASE), Siberian Branch (SB) of the Russian Academy of Sciences (RAS); Zoological Institute of the RAS; Zoological Museum of the Moscow State University; Yakutian Institute of Biology, SB RAS; Institute of Biology and Soil Science, Far-Eastern Branch of the RAS; Chita Pedagogical University; Khabarovsk Territorial Museum of Regional Studies; Zoological Museum of Kiev State University, Ukraine; Zoological Museum of Helsinki University, Finland; Zoological Department of the Hungarian Natural History Museum, Budapest; former Zoological Institute, Ashgabat, Turkmenistan; and Haik Mirzayants Museum of Insects, Tehran, Iran. Results of these studies were reported in [1–9]. The tiger moth distribution in the western Palearctic is presented according to [10]. The data on Southern Eurasia are taken from [11–42]. As the data on China compiled in [43] were incomplete, I compiled these data myself. This information is available at the site “Tiger moths (Lepidoptera, Arctiidae: Arctiinae) of China” (<http://szmn.eco.nsc.ru/~vvdubat/ArctiinaeChina.html> and <http://fen.nsu.ru/~vvdubat/ArctiinaeChina/html>). The analysis of tiger moth prevalence in North America rests on studies by Covell [44] on the west of the continent and by Ferguson et al. [45] on the east. Of great use were reports of the Alaska

Lepidoptera Survey, kindly provided by K. Philip (Fairbanks, Alaska, USA). The least studied region is the Oriental (Indo-Malayan) Province, illustrated by few fauna reviews concerning Borneo (Kalimantan) [46], the State of Arunachal Pradesh (Southeastern India) [47], the Andaman and Nicobar Islands [48], and Taiwan [49]. Other information had to be compiled from reports of the early 20th century [50–54] and numerous minor fauna reports and original descriptions sought in summaries by Strand [53], Bryk [54], Seitz [55], and Rothshild [52]; in the abstract bulletin “Zoological Record” from the first issues of the 19th century till 2002; and (for 2003) in the database formerly available at the US Congress Library site (<http://lcweb.loc.gov>). Also, Dr. Logunov (Manchester, UK) sought tiger moth taxa of the Arctiinae subfamily described past 1999 in the Zoological Record database. The data kindly provided by Dr. Y. Kishida (Tokyo, Japan) allowed recognition of new genera [56–59] and revision of several oriental genera: *Alphaea* Wlk., *Satara* Wlk., *Argyartia* Koda, *Aethalida* Wlk, and *Callindra* Röber [59–64]. By the courtesy of R. de Vos (Amsterdam, Netherlands) we have data on the system of species and genera of the tribe Nyctemerini, partly unpublished yet. All these data have been summarized. They are available at <http://szmn.eco.nsc.ru/~vvdubat/Arctiidae/ArctiinaeOriental.htm>; <http://szmn.eco.nsc.ru/~vvdubat/Arctiidae/ArctiinaeOriental.htm>.

The similarities between faunas of various geographic areas and landscapes were determined by using the Jacquard-Naumov coefficient. In addition to the similarity of the range of genera, the numbers of species of each genus for particular localities (a formal analogue of species population) were taken into account. The data arrays were processed by cluster analysis with the proprietary factor-classification program KLAFA developed at the Laboratory of Zoomonitoring, IASE, and analyzed by the correlation-pleiades method [65–67]. This program was chosen because it allows operation with data arrays of virtually unlimited sizes and their combination into an independent number of classes with the maximum similarity within each class and minimum outside [68]. Also, this approach does not generate artifacts in contrast to what sometimes happens in analysis of faunistic data by tree construction with the broadly used UPGMA (arithmetic mean) method. Thus, if a fauna C is the mean between faunas A and B, then the UPGMA method combines it first with the first-listed fauna of A and B, and such data can be misinterpreted. The KLAFA method detects the intermediate position of fauna C. This method also takes into account the effects of weaker remote relations. These were the main reasons for applying KLAFA.

To elucidate the irregularity of tiger moth fauna in the Palearctic and neighboring regions, the whole area of North Africa, Eurasia with the Sunda Islands, and North America was divided into 200 relatively small sectors, for which ranges of inhabiting tiger moth species could be reliably established (Figs. 1–5). The

knowledge of each of these sectors appears to be sufficient. An exception is the poorly known fauna of Southern Pakistan, which was extrapolated from separate reports [9]. Here is the list of the sectors:

1. Canary Islands
2. Atlas
3. Southwestern Africa plains
4. Algeria and Tunisia
5. Northeastern Africa
6. Arctic Fennoscandia
7. Taiga Fennoscandia
8. Southern Fennoscandia (subtaiga forests with large-leaved tree species)
9. England
10. Scotland
11. Ireland
12. Southern Iberia
13. Northern Iberia
14. Pyrenees
15. Southern France
16. Plains of Northwestern Europe and Ardennes
17. Alps
18. Italy
19. Corsica and Sardinia
20. Sicily
21. Southern Balkan Peninsula
22. Northern Balkan Peninsula
23. Mid-Danube Lowland
24. Carpathian Mts.
25. Plains of Germany and Pomerania
26. Baltia
27. Belarus
28. Ukraine and Moldova
29. Crimea
30. Tundra of European Russia
31. Arctic Urals
32. Taiga of European Russia
33. Nemoral forests of European Russia
34. Central Urals
35. Forest-steppe of European Russia
36. Southern Urals
37. Steppe of European Russia
38. Semideserts of European Russia and Western Kazakhstan
39. Deserts of European Russia and Western Kazakhstan
40. Ciscaucasia
41. Western Caucasus
42. Eastern Caucasus
43. Western coast of the Caucasus
44. Adjara (Georgia) and Rize (Turkey)

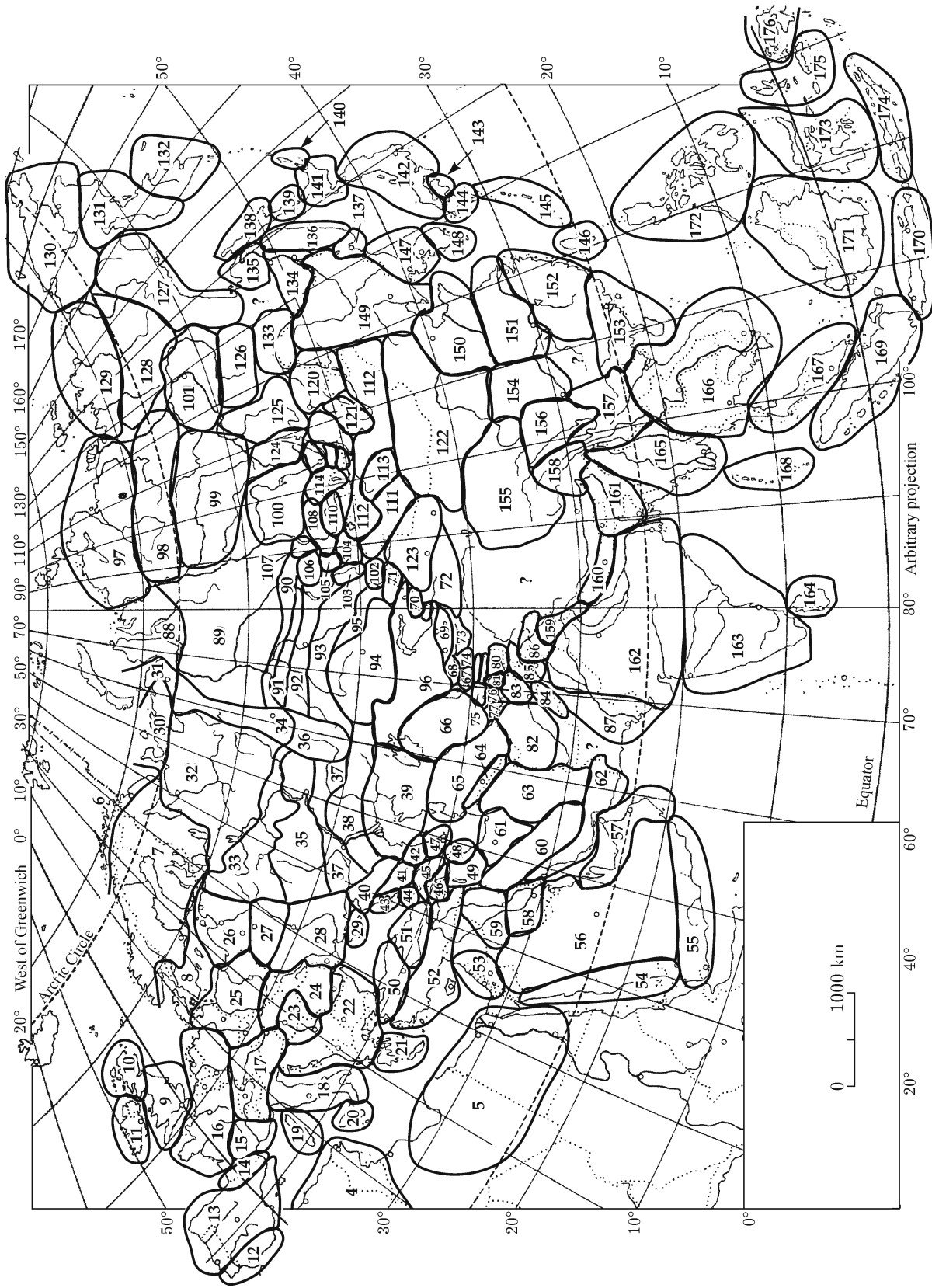


Fig. 1. Eurasian local tiger moth faunas considered in cluster analysis.

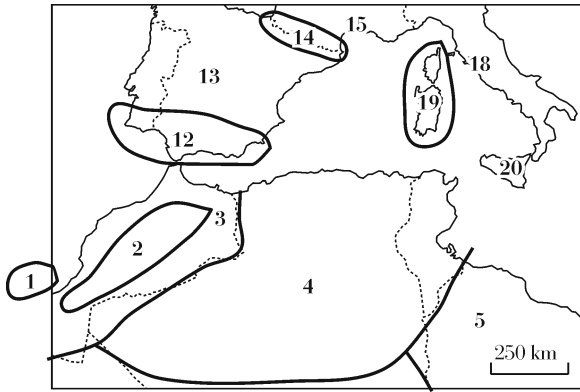


Fig. 2. North African local tiger moth faunas considered in cluster analysis.

- 45. Lesser Caucasus
- 46. Armenia and Nakhichevan
- 47. Eastern Transcaucasia
- 48. Talysh and Gilan
- 49. Northwestern Iran
- 50. Northwestern Asia Minor
- 51. Northeastern Asia Minor
- 52. Southern Asia Minor and Cyprus
- 53. Lebanon and Palestine
- 54. Western Arabia
- 55. Southern Arabia
- 56. Central Arabia
- 57. Eastern Arabia
- 58. Southern Iraq
- 59. Northern Iraq

- 60. Zagros
- 61. Northern Iran
- 62. Southern Iran
- 63. Eastern Iran
- 64. Kopet Dag and Balhany
- 65. Karakum Desert
- 66. Kyzyl Kum Desert
- 67. Fergana Valley
- 68. Western Tien Shan
- 69. Northern Tien Shan
- 70. Dzungarian Alatau
- 71. Tarbagatai
- 72. Eastern Tien Shan
- 73. Central and Inner Tien Shan
- 74. Southwestern Tien Shan (Fergana Range)
- 75. Hisor and Zeravshan
- 76. Darvaz and Peter I Range
- 77. Southwestern Hisor (Babatag and Kugitang)
- 78. Alai
- 79. Transalai Range (Chon Alai)
- 80. Pamir
- 81. Badakhshan
- 82. Parapamiz
- 83. Hindu Kush
- 84. Southeastern Afghanistan
- 85. Northern Pakistan
- 86. Kashmir
- 87. Southern Pakistan
- 88. West Siberian tundra
- 89. Northern and middle taiga of West Siberia

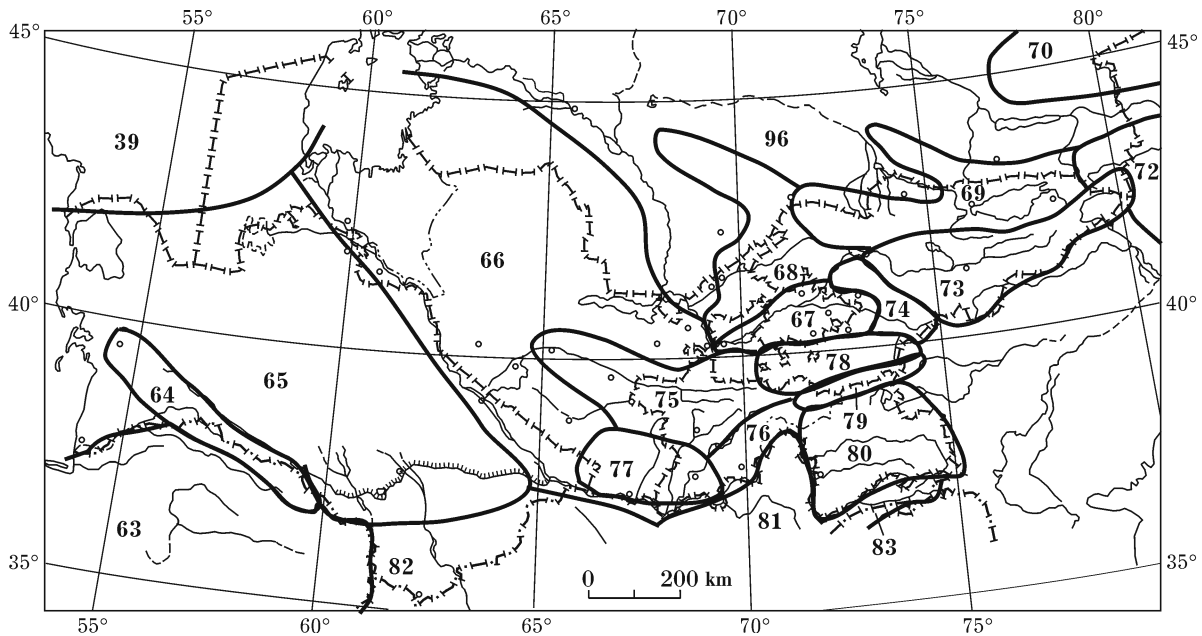


Fig. 3. Central Asian local tiger moth faunas considered in cluster analysis.

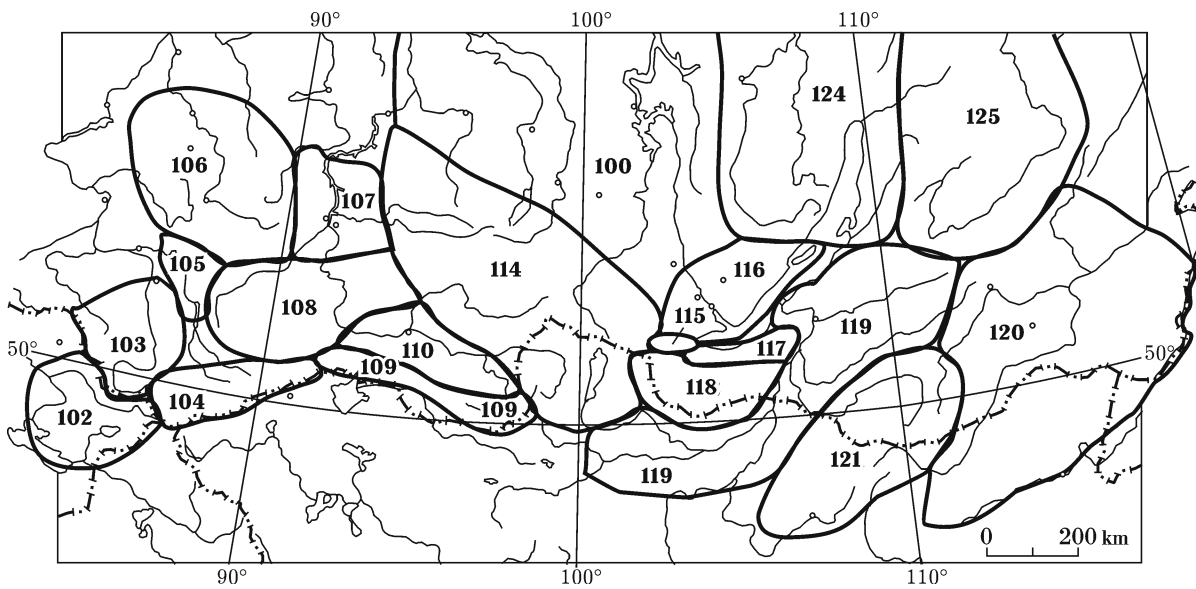


Fig. 4. Local tiger moth faunas of South Siberian mountains considered in cluster analysis.

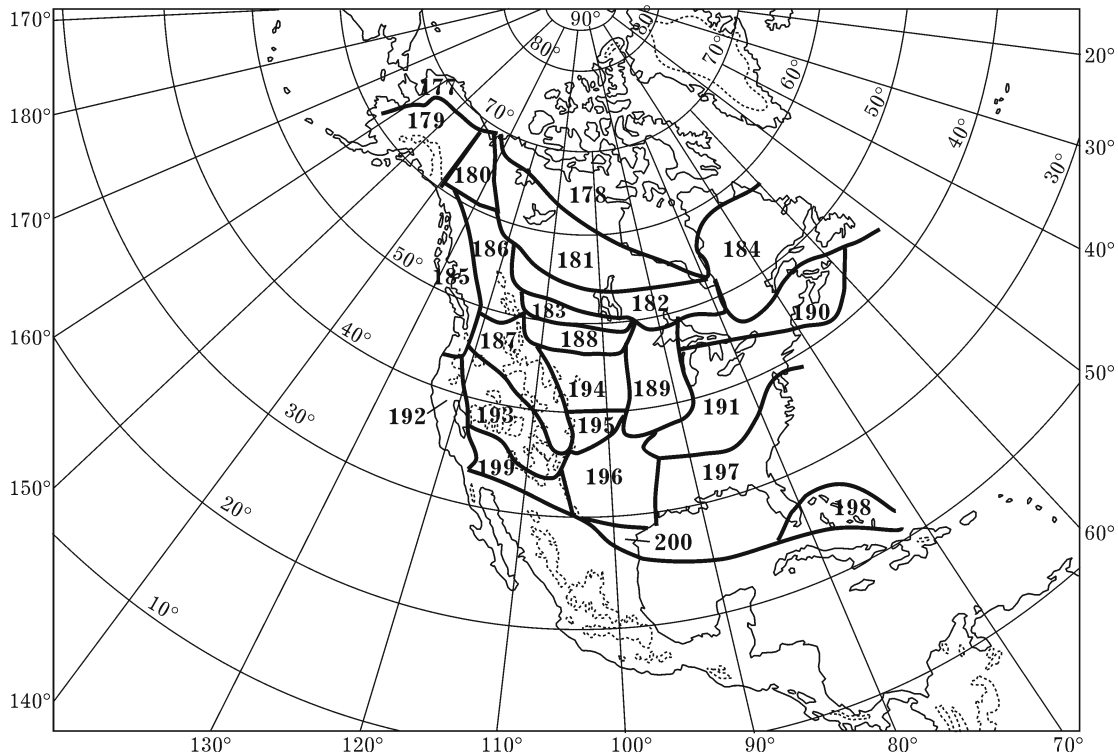


Fig. 5. North American local tiger moth faunas considered in cluster analysis.

- |  |   |
|--|---|
| 90. Southern taiga of West Siberia             | 97. Taimyr and northern Northwestern Yakutia          |
| 91. West Siberian subtaiga                     | 98. Southern Taimyr and southern Northwestern Yakutia |
| 92. West Siberian forest-steppe                | 99. Evenkia and Western Yakutia                       |
| 93. West Siberian steppe                       | 100. Angara region                                    |
| 94. Kazakh Uplands                             | 101. Central Yakutia                                  |
| 95. Eastern Kazakhstan semideserts             | 102. Southwestern Altai                               |
| 96. Deserts of Southern and Eastern Kazakhstan |   |

103. Northern and Central Altai
104. Southeastern Altai and Southwestern Tyva
105. Northeastern Altai
106. Kuznetsk Alatau and Salair Range
107. Khakas–Minusa Basin
108. West Sayan
109. Tannu-Ola
110. Central Tyva
111. Mongolian Altai
112. Uvs-Nuur Basin and semideserts of Eastern Mongolia
113. Hangayn
114. East Sayan
115. Tunkinskie Alps
116. Southern Baikal region
117. Khamar-Daban
118. Southwestern Buryatia
119. Selenga River valley
120. Southeastern Transbaikalia and Eastern Mongolia steppes
121. Hentiyn-Daurian Upland
122. Deserts of Eastern Mongolia and Northern China
123. Dzungaria
124. Northern Baikal region
125. Stanovoy Upland
126. Stanovoy Range and Southern Yakutia
127. Dzhugdzhur and southern Magadan oblast
128. Upper Yana region and Suntar-Khayata
129. Lowlands of Northeastern Yakutia
130. Chukotka and Wrangel Island
131. Koryakia
132. Kamchatka
133. Upper Amur reaches
134. Middle Amur reaches
135. Lower Amur reaches
136. Sikhote-Alin
137. Southern Primorye
138. Northern Sakhalin
139. Southern Sakhalin
140. Southern Kuril
141. Hokkaido
142. Honshu
143. Shikoku
144. Kyushu
145. Ryukyu
146. Taiwan
147. North Korea
148. South Korea
149. Northeastern China
150. Northern China
151. North of the Yangtze catchment area (Jiangsu, Anhui, Henan, Hubei)
152. South of the Yangtze catchment area (Zhejiang, Fujian, Jiangxi, Hunan)
153. Southern China (Guangxi, Guangdong)
154. Southern Shaanxi-eastern Sichuan
155. Qinghai and Gansu
156. Western Sichuan
157. Yunnan
158. Eastern Tibet
159. Northwestern Himalayas
160. Nepal
161. Southeastern India (northern West Bengal, Sikkim, Assam, and neighboring states), Bhutan
162. Northern India and Southern Pakistan
163. Southern India
164. Ceylon (Sri Lanka)
165. Burma (Myanmar)
166. Indochina
167. Malay Peninsula
168. Andaman and Nicobar Islands
169. Sumatra
170. Java and Bali
171. Borneo (Kalimantan)
172. Philippines
173. Celebes (Sulawesi) and Sangihe
174. Lesser Sunda Islands
175. Moluccas
176. New Guinea
177. Alaskan tundra
178. North American tundra except Alaska
179. Alaskan taiga
180. Yukon
181. Northern taiga of northwestern North America
182. Southern taiga of northwestern North America
183. Subtaiga of northwestern North America
184. Taiga of Quebec and Newfoundland
185. Taiga of western British Columbia, Washington, and Oregon
186. Mountains of British Columbia and Alberta
187. US Cordillera
188. Northern prairies
189. Forest-steppe of the Great Plains (North America)
190. New England
191. Forests of Allegan
192. California
193. Cordillera deserts
194. Middle prairies
195. Southern (subtropical) prairies
196. Subtropical forest–steppe of North America

197. Subtropical forests of the Gulf of Mexico  
 198. Southern Florida and Bahamas  
 199. Southwestern USA  
 200. Southeastern Texas

Below, by local faunas or, simply, faunas are meant sets of taxa of a certain rank for each of the listed geographic sectors.

Genus is the main taxonomic rank commonly used in zoogeographical analysis [e.g., 69–71]. Distribution of animal species over an area is used for finer zoning. Indeed, the areal heterogeneity of fauna at the level of genera should reflect, at least, tentatively, zoogeographic taxa of high ranks, particularly when not only the presence of a genus but also its diversity is considered in an area under consideration.

Although the systematics of the tiger moth genera inhabiting southern and eastern Asia and Sunda Islands has not been completed yet, my Japanese colleague Y. Kishida and I studied many oriental genera in 2003–2005 [56–64]. In addition to the investigated genera, groups of species probably deserving the genus rank are treated in the analysis as genera.

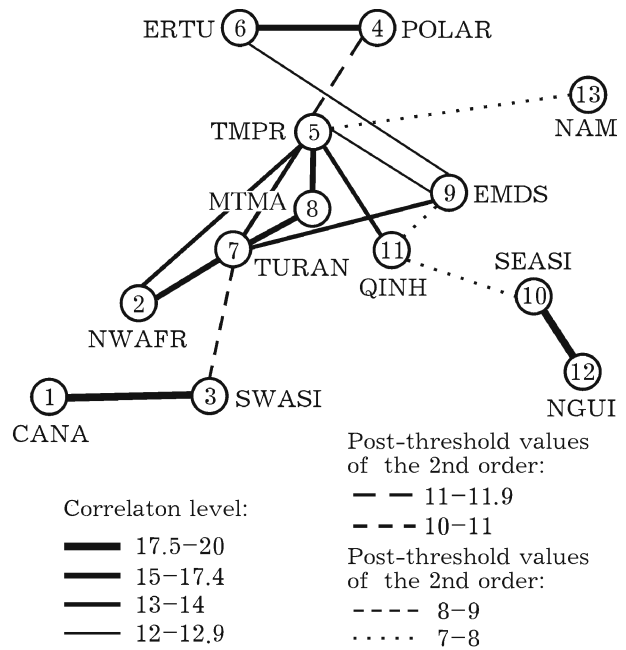
## RESULTS

The cluster analysis of Jacquard–Naumov pairwise similarity coefficient with the same classification program revealed 15 types, more or less matching zoogeographic provinces and subprovinces (Fig. 6). The areal distribution of the corresponding fauna supertypes, types, and subtypes is shown in Figs. 7 and 8. The tiger moth fauna of the Oriental province forms two types, and the local faunas of Southern Pakistan, Northern India, Ceylon, Andaman and Nicobar Islands, and Lesser Sunda Islands form a separate class, characterized by relatively poor faunas, whose notable portions are species of the genera *Utetheisa* Hb. and *Nyctemera* Hb., representatives of *Spilarctia* Btl. being scarce. The absence of *Spilarctia* may be related to insular isolation (Andaman and Nicobar Islands) or poor knowledge of the fauna (Ceylon and Lesser Sunda Islands). For this reason, it was decided to regard the whole Oriental fauna as a single type. The same decision was made for the dramatically depauperated Evenkia fauna (see below), which was bulked with the largest Eurasian temperate fauna type. Thus, 13 specific tiger moth fauna types were recognized in the Northern Hemisphere. The faunistic relationships between them were calculated with the Otsenka (Evaluation) program.

The fauna types were also consolidated into a unified pattern by the correlation-pleiades method. Two threshold correlation levels were established: 1st order (10% similarity) and 2nd order (12% similarity).

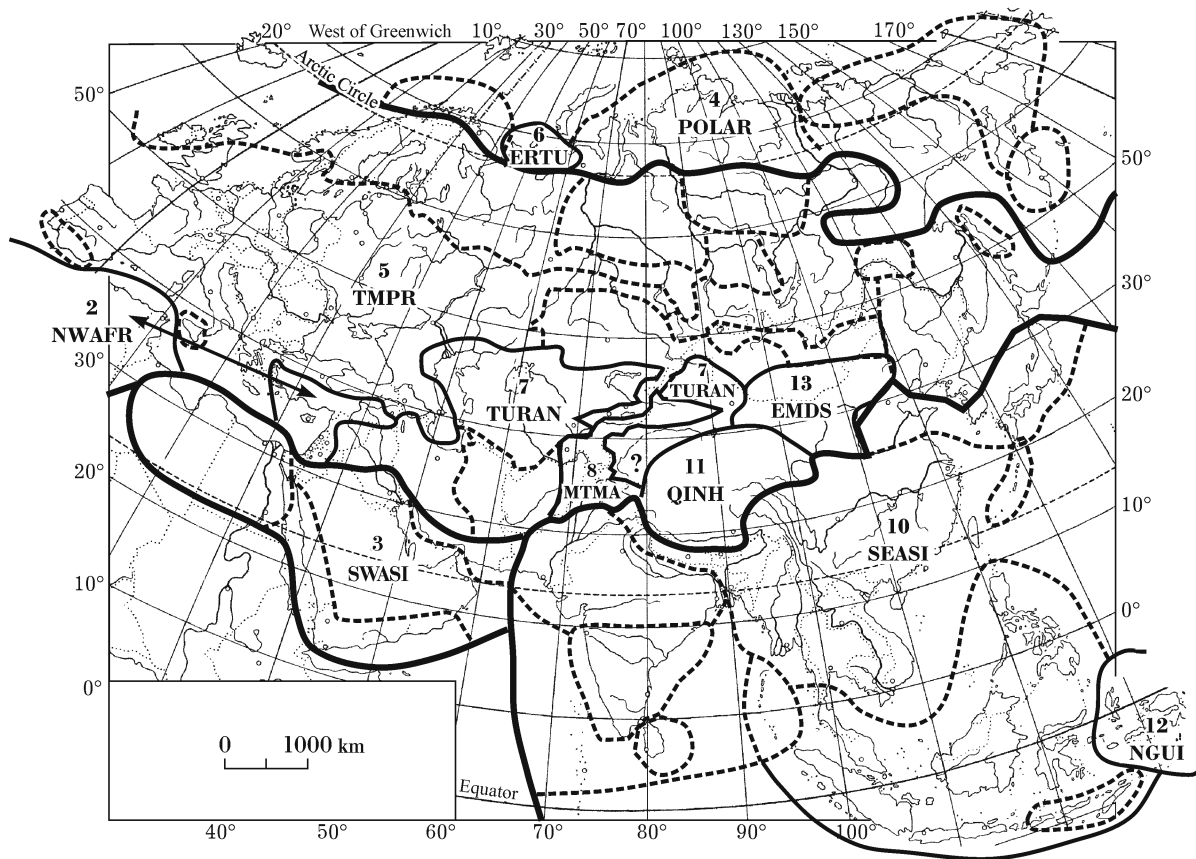
## DISCUSSION

According to the analysis of tiger moth fauna at the genus level, the faunas of the Palearctic and Oriental



**Fig. 6.** Heterogeneity of tiger moth fauna in the Northern Hemisphere at the level of genera. Fauna similarities between regions at the level of genera are indicated with proportional line thickness. The threshold is taken to be 12%. Post-threshold values are indicated with dashed lines. Fauna abbreviations: (1) CANA, Canary Islands; (2) NWAFFR, Northwest Africa; (3) SWASI, Southwestern Asia; (4) POLAR, Arctic regions, including mountains of Northeastern Asia and North American taiga; (5) TMPR, Eurasian temperate fauna; (6) ERTU, tundras of European Russia; (7) TURAN, Turan deserts and low arid mountains of Southwest Asia; (8) MTMA, mountains of Central Asia (excluding North and West Tien Shan); (9) EMDS, Gobi deserts; (10) SEASI, Southeastern Asia; (11) QINH, Qinghai and Northern Tibet; (12) NGUI, Moluccas and New Guinea; (13) NAM, nonarctic and nonboreal North America.

provinces, as well as of nonarctic North America are the closest: similarity about 6–8%. They can be considered separate zoogeographical units of a high rank. The change from the Arctic fauna to the North American one occurs between the northern and southern areas of taiga in northwestern North America. To the south and east, penetration of genera endemic to America (including Central and South) is evident, and in the west Arctic fauna type penetrates southward farther than in the east, where the whole taiga fauna belongs to the nonarctic class. This fact can be explained by the presence of numerous temperate genera in the taiga zone of eastern North America, e.g., *Estigmene* Hb. and *Pyrrharctia* Pack., which do not occur in western North America north of subtaiga forests, in addition to *Holomelina* H.-S., with one of its species (*H. ferruginosa* Wlk.) penetrating the taiga zone in British Columbia. A satisfactory explanation of this dramatic separation of the arctic and nonarctic faunas in North America is that in the Pleistocene the Bering land bridge could be traversed only by the arctic and partially boreal and temperate faunas. In contrast, Central and South American genera, which came to North America after the beginning



**Fig. 7.** Areal distribution of supertypes, types, and subtypes of tiger moth faunas in Eurasia and Northern Africa at the genus level. Designations follow Fig. 6. Boundaries between supertypes are shown with thick curves, boundaries between types, with solid thinner curves, and boundaries between subtypes, with dashed curves.

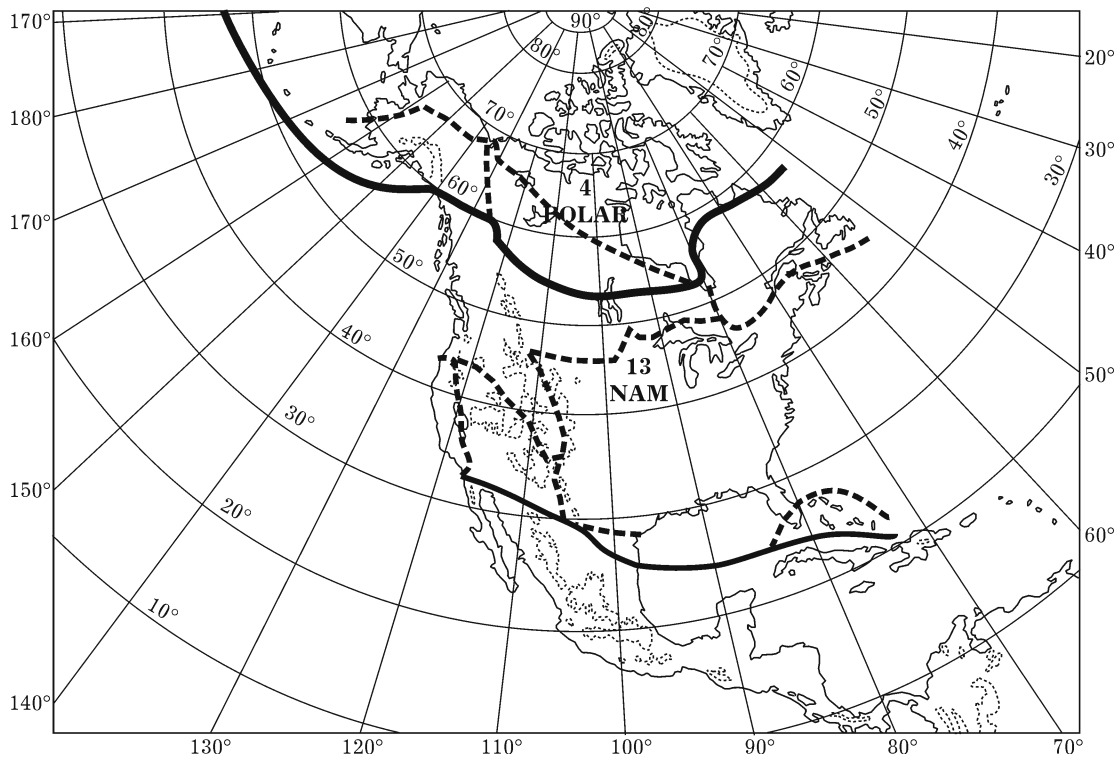
of the Great American Exchange in the Pleistocene [72] did not manage to colonize the boreal zone. They spread to the north mainly no farther than large-leaved and subtaiga forests.

The tiger moth fauna of the Oriental province differs at the genus level from the faunas of the neighboring Palearctic regions, having the similarity levels within 6–8%, whereas the similarity to remote regions of the same province, as well as to North America, is 2–5%. In Eastern Asia, the formal division assigned the faunas of Honshu, South Korea, Northern China, and some southern regions to the Oriental class. It is natural because typical oriental genera are recorded there: *Nyctemera* Hb. and *Utetheisa* Hb. Also, the numbers of species in *Spilarctia* Btl., *Lemyra* Wlk., etc. increase significantly, not to mention the genera *Aloa* Wlk. and *Cretonotos* Hb., which reach not only Honshu, but even Northeastern China. However, it should be taken into account that representatives of the Palearctic genera *Nyctemera* Hb. and *Utetheisa* Hb. can reach Northern China and the main Japanese islands only as migrants. Therefore, the area from Northern China to the Yangtze River and the Japanese islands Honshu, Shikoku, and Kyushu can be considered transitional between two zoogeographic provinces, but whole China

south of the Yangtze and the subtropical part of Sichuan certainly belong to the Oriental province. In the Northwestern Himalayas the boundary is less distinct, owing to poorer knowledge about the vertical distribution of genera, but the faunas of highland regions of Northern Pakistan, Kashmir, and Southeastern Afghanistan were assigned to the Palearctic class.

The fauna of Southwestern Asia, including Southern Iran, Southern Iraq, whole Arabia, and adjacent Northeastern Africa, proved to be less isolated from the Palearctic one but also very specific. The range of tiger moth genera in these regions is notably scarcer (2–7 genera), but it includes the endemic genus *Creataloum* Dubat. Therefore, the level of similarity to main Palearctic regions is slightly higher (10%), which is even less than the similarity to the Indian fauna (12.4%) owing to the presence of some Palearctic genera of wide occurrence. It is reasonable to regard the fauna of this region as transitional, because the contribution of Palearctic genera (*Argina* Hb. and *Cretonotos* Hb.) is significant even in Southern Iran, and the contribution of Palearctic and Afrotropical genera (*Galtara* Wlk., *Cretonotos* Hb., and *Amerila* Wlk.), in southern and western Arabia. The tiger moth fauna of the Canary Islands also differs significantly from the Palearctic





**Fig. 8.** Areal distribution of supertypes, types, and subtypes of tiger moth faunas in North America at the genus level. Designations follow Fig. 6. Boundaries between supertypes are shown with thick curves, boundaries between types, with solid thinner curves, and boundaries between subtypes, with dashed curves.

one. It includes only two genera, represented by two species: cosmopolitan *Utetheisa* Hb. and endemic *Canararctia* Dubat. Just because of this poverty, the Canary tiger moth fauna is combined with the Southwestern Asian fauna, also poor in the range of genera, having one cosmopolitan genus in common, *Utetheisa* Hb.

The most closely isolated faunas in the Palearctic are those of Arctic regions, including the mountainous region of Northeastern Asia to the Stanovoy Range and Kamchatka in the south, and northwestern North America. The faunas of this area demonstrate generic endemism, illustrated by *Pararctia* Sotav. This genus has two species, one of which is strictly confined to the region. There are also many genera (*Dodia* Dyar, *Acerbia* Sotav., *Holoarctica* Ferg., and *Hyperborea* Gr.-Gr.) insignificantly penetrating into much richer highland faunas, e.g., those of Southern Siberia and Tien Shan. The similarity levels in the range of genera between the faunas of these regions and other Palearctic regions seldom exceed 12%. An exception is the poor fauna of Evenkia and Western Yakutia (six genera and eight species), which includes one monotypic northern Asian-Beringian genus *Hyperborea* Gr.-Gr., known only in the very north of the region, and one species of the North Asian-North American genus *Platarctia* Pack. Therefore, the similarity to the Arctic fauna increases to 20.9%. However, if *Hyperborea* Gr.-Gr., mentioned only in old reports on northern Evenkia, is eliminated

from consideration, the similarity to the temperate class increases to the extent allowing these two types to merge into one. Therefore, it is decided to regard the Evenkian fauna as a subtype of the temperate type.

Also, the similarity between extremely depauperated variants of European Russia's tundras (two genera of one species each) and Gobi deserts (six genera of one species each) increases to 12.5% because of the presence of the common species *Phragmatobia fuliginosa* L.

The Palearctic faunas most separated from the main temperate class at the genus level are those of Northwestern Africa, Turan deserts, arid low mountains of Southwestern Asia, Central Asian mountains (to Kashmir) and the most distant faunas of Quinghai (probably, together with Northern Tibet) and Gobi deserts. In contrast, the tiger moth faunas of Western and Northern Tien Shan, which include many temperate genera (e.g., *Eucharhia* Hb., *Diacrisia* Hb., *Rhyparia* Hb., etc.) entered one Transpalearctic temperate cluster.

Thus, faunas of the largest zoogeographic units in the Northern Hemisphere are recognized at the 7–8% similarity level according to the ranges of genera. The nonarctic American and Oriental faunas should be distinguished from the Palearctic one. The arctic fauna is the closest to the Palearctic one.

Generally, according to the similarity graphs of the local tiger moth faunas of the Northern Hemisphere at

the levels of species and genera, the genus graph is less heterogeneous. This is particularly true for the faunas of the Nearctic and Oriental provinces, represented by the single fauna types; thus, these faunas are poorly segregated at the genus level.

The Eurasian tiger moth fauna, except for its Oriental part, is much more differentiated. Even if the markedly different faunas of Arctic and tropical regions of Southeastern Asia are left beyond consideration, it consists of seven fauna types at the level of genera. The faunas of Northwestern Africa and Eastern Mediterranean, Turan and mountains of Southwestern Asia, mountains of eastern Central Asia, Quinghai, and mountains of eastern Gobi differ notably from the main temperate-subtropical class at the 13–17% level. Apparently, these differences can be explained by either longer tiger moth evolution in Eurasia or faster evolutionary processes in this group within the continent.

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#### REFERENCES

1. M. A. Daricheva and V. V. Dubatolov, *Izv. AN. Turkenskoi SSR. Ser. Biol. Nauk* **2**, 39 (1989).
2. V. V. Dubatolov, in *Arthropods of Siberia and Far East* (Novosibirsk, 1985), pp. 134–159 [in Russian].
3. V. V. Dubatolov, in *Arthropods and Helminths* (Novosibirsk, 1990), pp. 139–169 [in Russian].
4. V. V. Dubatolov, in *Cadastre of the Gene Pool of Kyrgyzstan* (Bishkek, 1996), Vol. 3, pp. 242–244 [in Russian].
5. V. V. Dubatolov and G. S. Zolotarev, in *Arthropods and Helminths* (Novosibirsk, 1990), pp. 122–139 [in Russian].
6. V. V. Dubatolov, *Japan Heterocerists's Journal* **161**, 182 (1991).
7. V. V. Dubatolov, *Neue Entomologische Nachrichten* **37**, 39 (1996).
8. V. V. Dubatolov, Yu. A. Chistyakov, and Yu. N. Ammosov, in *Entomological Studies in Northeastern USSR* (Vladivostok, 1991 [1997]), Vol. 2, pp. 48–65 [in Russian].
9. V. V. Dubatolov and R. Zahiri, *Atalanta* **36** (3/4), 481 (2005).
10. J. de Freina and T. Witt, *Die Bombyces und Sphinges der Westpalaearktis* (München, 1987), Vol. 1, pp. 1–708.
11. J. J. de Freina, *Atalanta* **10** (3), 175 (1979).
12. J. J. de Freina, *Atalanta* **12** (1), 18 (1981).
13. J. J. de Freina, *Entomofauna. Zeitschrift für Entomologie* **3** (1) 1 (1982).
14. J. J. de Freina, *Mitteilungen der Münchner Entomologischen Gesellschaft* **72**, 57 (1983).
15. J. J. de Freina, *Atalanta* **30** (1/4) 187 (1999), plates 11–14a.
16. H. Zerny et al., *Deutsche Entomologische Zeitschrift, Iris*, **47**, 60 (1933), plate 1.
17. H. G. Amsel, *Zoogeographica. Internationales Archiv für vergleichende und kausale Turgeographie* **2**, 1 (1993).
18. H. G. Amsel, *Veröffentlichungen aus dem Deutschen Kolonial- und Übersee-Museum in Bremen* **1** (2), 223 (1935).
19. E. P. Wiltshire, in *The Lepidoptera of Iraq* (Bagdad, 1957), pp. 1–162.
20. E. P. Wiltshire, *Beitr. naturk. Forsch. SW-Dtschl.* **19** (3), 337 (1961), pl.
21. E. P. Wiltshire, *Fauna Saudi Arabia* **11**, 91 (1990).
22. F. Daniel, *Reichenbachia. Staatliches Museum für Tierkunde in Dresden* **7** (10), 93 (1965).
23. F. Daniel, *Zeitschrift der Wiener Entomologischen Gesellschaft* **75** (9/10), 121 (1965), plates 15–18.
24. F. Daniel, *Mitteilungen der Münchner Entomologischen Gesellschaft* **56** (7), 161 (1966), plate 3.
25. F. Daniel, *Reichenbachia. Staatliches Museum für Tierkunde in Dresden* **9** (23), 201 (1967).
26. F. Daniel, *Reichenbachia. Staatliches Museum für Tierkunde in Dresden* **11** (25), 265 (1968).
27. F. Daniel, *Zeitschrift der Arbeitsgemeinschaft Österr. Entomologen* **22**, 2 (1970).
28. F. Daniel, *Reichenbachia. Staatliches Museum für Tierkunde in Dresden* **13** (19), 193 (1970).
29. F. Daniel, *Annalen des Naturhistorischen Museums in Wien* **75** (1–2), 651 (1971), plates 1 and 2.
30. B. Alberti, *Deutsche Entomologische Zeitschrift, N.F.* **18** (4–5), 361 (1971).
31. G. Ebert, *Reichenbachia. Staatliches Museum für Tierkunde in Dresden* **14** (8), 47 (1973).
32. G. Ebert, *Beitr. Naturk. Forsch. SüdwDtl* **33**, 169 (1974).
33. W. Thomas, *Nachr. ent. Ver. Apollo, Frankfurt, N.F.* **4** (4), 85 (1984).
34. H. Inoue, in *Moths of Japan* (Tokyo, 1982), Vol. 1, pp. 638–659; Vol. 2, pp. 74–79, 136–137, 334–342, plates 154–162, 346–348.
35. S.-H. Nam, *Insecta Koreana* **5**, 119 (1985).
36. G. Orhant, *Bull. Soc. Sci. Nat.* **50**, 9 (1986).
37. G. Orhant, *Lambillionea* **100** (2), 269 (2000).

38. Y. Kishida, *Moths of Nepal* **1**, 72 (1992), plates 17–18.
39. Y. Kishida, *Moths of Nepal* **3**, 66 (1994), plate 79.
40. Y. Kishida, *Moths of Nepal* **4**, 39 (1995), plates 107–108.
41. Y. Kishida, *Moths of Nepal* **5**, 32 (1998), plate 132.
42. L. Przybylowicz and K.-T. Park, *Insecta Koreana* **5**, 119 (1985).
43. C. Fang, *Fauna Sinica Insecta*, Beijing **19**, 1 (2000) plates 1–20.
44. Ch. V. Covell, *A Field Guide to the Moths of Eastern North America* (Boston, 1984).
45. D. C. Ferguson, P. A. Opler, M. J. Smith, and J. P. Donahue, *Moths of Western North America. 3. Distribution of Arctiidae of Western North America. Part 1. Text, maps, and references* (Fort Collins, 2000), pp. 1–171.
46. J. D. Holloway, *The Moths of Borneo* **6**, 1 (1988), plates 1–6.
47. G. S. Arora and M. Chaudhury, *Technical Monograph of the Zoological Survey of India* **6**, 1 (1982).
48. G. S. Arora, *Rec. Zool. Surv. India. Miscell. Publ. Occas. Pap.* **60**, 1 (1983).
49. H. Inoue and Y. Kishida, *Lepidoptera of Taiwan* **1** (2), 166 (1992).
50. G. F. Hampson, *A Catalogue of the Moths of India* **2**, 41 (1887).
51. *Die Gross-Schmetterlinge der Erde*, Ed. by A. Seitz (Stuttgart, 1915), Vol. 10, pp. 264–276, plates 26–30.
52. W. Rothschild, in *Die Gross-Schmetterlinge der Erde*, Ed. by A. Seitz (Stuttgart, 1914), Vol. 10, pp. 236–263, plates 19–25.
53. E. Strand, *Lepidopterorum Catalogue* **22**, 1 (1919).
54. F. Bryk, *Lepidopterorum Catalogue* **82**, 1 (1937).
55. *Die Gross-Schmetterlinge der Erde*, Ed. by A. Seitz (Stuttgart, 1915), Vol. 2, pp. 43–103, plates 10–18, 56.
56. V. V. Dubatolov, *Tinea* **17** (5), 255 (2003).
57. V. V. Dubatolov, *Atalanta* **35** (1/2), 73 (2004), plate 4a.
58. V. V. Dubatolov, *Atalanta* **35** (3/4), 297 (2004), plate 16b.
59. V. V. Dubatolov and Y. Kishida, *Tinea* **18** (4), 307 (2005).
60. V. V. Dubatolov and Y. Kishida, *Tinea* **18** (4), 241 (2005).
61. V. V. Dubatolov and Y. Kishida, *Tinea* **18** (4), 276 (2005).
62. V. V. Dubatolov and Y. Kishida, *Tinea* **19** (1) 28 (2006).
63. V. V. Dubatolov and Y. Kishida, *Tinea* **19** (1) 48 (2006).
64. V. V. Dubatolov and Y. Kishida, *Tinea* **19** (2) 104 (2006).
65. P. V. Terent'ev, *Vestnik Leningradskogo Gosudarstvennogo Universiteta. Seriya Biologicheskaya*, No. 9, 137 (1959).
66. Yu. S. Ravkin, *Birds of Northeastern Altai* (Novosibirsk, 1973) [in Russian].
67. V. I. Shadrina, in *Problems of zoogeography and fauna history* (Novosibirsk, 1980), pp. 13–41 [in Russian].
68. V. A. Trofimov, in *Models of Aggregation of Socioeconomic Information* (Novosibirsk, 1978), pp. 91–106 [in Russian].
69. O. L. Kryzhanovskii, *Composition and Origin of the Central Asian Terrestrial Fauna* (Leningrad, 1965) [in Russian].
70. O. L. Kryzhanovskii, *Zhurnal Obshchei Biologii* **48** (1), 66 (1987).
71. V. A. Krivokhatskii, in *Antlions (Neuroptera, Myrmeleontidae) of the Palearctic (morphology, classification, and zoogeography)* (St. Petersburg, 1999), pp. 1–39.
72. D. G. Simpson, *Splendid Isolation. The Curious History of South American Mammals* (Yale Univ. Press, New Haven, London, 1980).