

Lin, L.-K., Oshida, T. and Motokawa, M. (2020). Mammals of Taiwan. Volume 2. Rodentia. Tunghai University, Taichung, Taiwan. 165 pp.**Boris Kryštufek** *Slovenian Museum of Natural History, Prešernova 20, SI-1000 Ljubljana, Slovenia*Corresponding author : bkrystufek@pms-lj.si

Received: 29 July 2020

Accepted: 5 August 2020

Published online: 30 September 2020

It is a truism that mammalian systematics is a dynamic field of research and that new species are still being discovered. The rate of change, however, is truly spectacular and the number of mammal species, estimated at 5,416 in 2005 (Wilson and Reeder, 2005) reached 6,495 just 13 years later (Burgin et al., 2018), i.e. an astonishing rise of 20%. Behind this progress is the wide application of new research tools, above all, highly effective DNA-based methods capable of reconstructing evolutionary pathways and delimiting morphologically cryptic species. Faunal revisions are as badly needed in this time of taxonomic revolution as ever before. They are of particular value when done by experts active in the fields of taxonomy research and species delimitation. It was therefore a pleasant surprise to receive a new publication of this kind which focuses on the rodents of Taiwan.

Taiwan, formerly known as Formosa, is an island in Southeast Asia located on the Tropic of Cancer and close to China. Its surface area measures over 35000 km² and several much smaller islands are scattered off its coast, namely Lanyu, Lutaο, Pengfu, Kueishan, and Xiao Riuqiu. At lower elevations, the climate is subtropical and tropical, but it is more temperate in the mountains. Namely, Taiwan is among the most mountainous islands in the world with 286 peaks exceeding an elevation of 3,000 m above sea level. The Strait of Taiwan, which separates the island from mainland Asia, is 180 km wide at its broadest and less than 150 m deep. A combination of stable climate, high primary productivity, extreme topographic diversity, intermittent isolation from source fauna and its position on the overlap between major biogeographic regions, the Oriental and the Palearctic, is a secure predictor of high biological diversity.

Wikipedia (https://en.wikipedia.org/wiki/List_of_endemic_species_of_Taiwan) lists 70 mammal species for

Taiwan, which is likely an outdated underestimate (cf. 80 terrestrial species in Cheng et al., 2017), and 64% of these are endemic to the island. The proportion of mammal endemics is well above the total average for the island (20% for animals and 25% for plants), exceeding the averages for other vertebrates (where the ranges are between 16% for freshwater fish and 46% for amphibians), and is matched only by gymnosperms (64%) which have only 28 species on the island.

Given the high diversity and endemism in Taiwan, it does not come as a surprise that research on its mammal fauna dates back to the 19th century. It was pioneered by Robert Swinhoe (1836–1877), an English naturalist who worked as a consul in what was then Formosa. Swinhoe described two rodents endemic to Taiwan, the Taiwan red giant flying squirrel *Pteromys grandis* Swinhoe, 1863 (now *Petaurista grandis*) and the Taiwan spiny rat *Mus coninga* Swinhoe, 1864 (now *Niviventer coninga*). In addition, Swinhoe also named the Ricefield rat *Mus losea* Swinhoe, 1871 (now *Rattus losea*) which is a common pest to agriculture in Southeast Asia, including Taiwan. Swinhoe's striped squirrel *Tamiops swinhoei* (Milne-Edwards) from China, Vietnam and Myanmar, is just one of several eponyms to Swinhoe.

In the decades to follow, British naturalists continued collecting natural history specimens for the British Museum of Natural History (BMNH; now the Natural History Museum, London). This set the ground for the recognition of further island rodent endemics, this time described by Oldfield Thomas (1858–1929): the Taiwan giant flying squirrel *Petaurista lena* Thomas, 1907, the Formosan field mouse *Apodemus semotus* Thomas, 1908, and the Taiwan white-bellied rat *Rattus culturatus* Thomas, 1917 (now *Niviventer culturatus*). The most prominent among these collectors was Alan Owston (1853–1915) an enthusiastic natural history dealer in

East Asia, whose activities in Japan significantly influenced the Meiji era (Kawada, 2016). Japanese naturalists from this period took the leading role in mammal research in Taiwan in the first half of the 20th century. The most prominent was perhaps Nagamichi Kuroda (1889–1978), who described a further two of the Taiwanese endemics, the Formosan mouse *Mus formosanus* Kuroda, 1925, and Kikuchi's field vole *Microtus kikuchii* Kuroda, 1920 (now *Alexandromys kikuchii*).

As far as rodents are concerned, the single most notable achievement in the regional taxonomy during the previous century was the compilation of the island's "rats and mice" (actually Muridae and Cricetidae) by Aoki and Tanaka (1941). This remarkable revision is based on an in-depth survey which the senior author Bunichiro Aoki (1883–1954) conducted in the late 1920s and during the 1930s in the BMNH. Thirteen species were recognised, i.e. all existing on the island at that period. The only subsequent addition is *Rattus exulans* (Pearle), which is alien to the island and known there only for the last two decades.

Their revision contains plates with charming color illustrations of species and is remarkably, given when it was published, entirely in English. This book provided a firm taxonomic background for numerous studies undertaken since World War Two by Taiwanese students of native rodents. These are meticulously documented by Liang-Kong Lin, Tatsuo-Oshida and Masaharu Motokawa in their recent synthesis of the current rodent fauna on the island. All these authors are employed as university professors, Lin at Tunghai University, Taichung, Taiwan, Oshida at Obihiro University of Agriculture and Veterinary Medicine, Obihiro, Japan, and Motokawa at Kyoto University, Kyoto, Japan. They have published widely on the rodents of East Asia in general, and Taiwan in particular, and have a long history of mutual collaboration; Lin and Motokawa co-authored the first volume of *The Mammals of Taiwan*, issued in 2014, which covers shrews and moles (Soricomorpha).

In the present volume, six species of squirrels (Sciuridae) were elaborated by Oshida and Lin, 12 species of mice and rats (Muridae) by Motokawa and Lin, and two voles (Cricetidae) by Lin and Motokawa. In common with Aoki and Tanaka, the authors used resources from museums (National Museum of Natural Science, Taichung; BMNH; Kyoto University Museum) and collections from the Department of Life Science, Tunghai University, and Obihiro University of Agriculture and Veterinary Medicine.

The introductory section is limited to a single page and, if one does not count short generic interpretations and extensive list of references, the entire remaining volume is devoted to species accounts. Each species is introduced by a scientific name with the name of the author and the year of publication, followed by vernaculars in English and Chinese. The main body

of information is organised into eight chapters: (i) "Synonyms", (ii) "Distribution", (iii) "Taxonomic review", (iv) "Morphology and measurements", (v) "Fossils", (vi) "Genetics", (vii) "Ecology", and (viii) "Conservation and relationship with humans". Synonymy is elaborated in great detail and all names, as well as combinations of genus and species group names used for Taiwanese rodents are meticulously listed, together with quotations. This provides an insight into the history of species discovery and research, and also enables the reader to correctly interpret taxonomic names used by earlier authors. Distributional information is entirely descriptive and maps are sorely lacking. The lack of distributional maps is, in my view, the most serious shortcoming of the book. Under the title "Taxonomic review", a reader can find information on the type(s) and further historical details on taxonomic and nomenclatural changes. Descriptions in the "Morphology and measurements" account vary among species from brief drafts to more comprehensive content which is further sub-structured into headings "External", "Skull", "Skeletons" and "Dentition". At this point, the authors frequently provide only a quotation rather than a summary of published information. This method of presentation is also used elsewhere in the book. The account on fossils is blank for the majority of species ("There is no exact fossil record of ...") or at best contains information from the mainland.

Information on genetics is provided in great detail and typically contains separate parts on chromosomes and nucleotide sequences. The section titled "Ecology" has subheadings dealing with habitat, reproduction, growth and development, food habits, population, predation, physiology, and behavior. Accounts on conservation and relationships with humans reveal that a single species, the Hairy-footed flying squirrel *Belomys pearsonii kaleensis* (Swinhoe, 1863) is of conservation concern. On the other hand, four squirrels (all flying squirrels and the Pallas's squirrel *Callosciurus erythraeus* (Pallas)) are hunted for food, and 13 species are pests, namely all squirrels (causing debarking in forest plantations) and seven rats and mice.

The list of references is very complete and extends over 85 pages. All species are figured alive with good-quality color photographs. In addition, skulls are shown in dorsal, ventral and lateral views. Again, the photos are generally of good quality, the mandible, however, is shown in the dorsal view; in my opinion, the lateral side would be more informative. And finally, the masticatory surface of the upper and lower molars of mice, rats and voles are shown as black and white photographs. The book would benefit if the dentition of squirrels were also shown. The photographed skulls are deposited in the National Museum of Natural Science, Taichung.

Taxonomy follows recent revisions in the "Mammal Species of the World" (Musser and Carleton, 2005; Thorington and Hoffmann, 2005) with adjustments and up-dates found in Handbook of the Mammals of the

World (Koprowski et al., 2016; Denys et al., 2017; Pardiñas et al., 2017). The only deviation is *Petaurista grandis*, which is classified as a subspecies of *P. petaurista* (Pallas) in earlier editions (e.g. Koprowski et al., 2016). Taxonomic arrangements in the book are certainly not final. E.g., Oshida and Lin classified striped squirrels *Tamiops* Allen from Taiwan as the endemic subspecies (*T. formosanus* Bonhote, 1900) of *Tamiops maritimus* (Bonhote, 1900). As demonstrated by Chang et al. (2011), *T. maritimus* and *T. swinhoei* are not reciprocally monophyletic and phylogenetic relationships are further complicated by ancient hybridisation between divergent lineages. It would perhaps have been more appropriate to promote *T. formosanus* as a species in its own right, or synonymise it with *T. swinhoei* which holds priority over *T. maritimus*. Harvest mice are still classified as *Micromys minutus* (Pallas). Abramov et al. (2009) clearly showed that Oriental harvest mice are distinct from the Palearctic *M. minutus* (Pallas) and belong to a separate species *M. erythrotis* (Blyth). As far as one can conclude from the external measurements of Taiwanese harvest mice (Aoki and Tanaka, 1941) and from their geographical position, they belong to *M. erythrotis* and, in my view, it would be more appropriate to name them as such.

The twenty rodents found in Taiwan are in 13 genera, which give a low species-to-genus ration of 1.54. Seven species (two flying squirrels, four rats and mice and one vole) are endemic to Taiwan: *Petaurista grandis*, *P. lena*, *Apodemus semotus*, *Niviventer coninga*, *N. culturatus*, *Mus formosanus*, and *Alexandromys kikuchii*. With the exception of *Niviventer coninga* and *Alexandromys kikuchii*, all the remaining endemics were at one time considered to be insular races of more widely distributed continental species. Not a single genus is endemic to the island.

The proportion of rodents in need of conservation management is surprisingly low. Taiwan has a human population over 23 million, which ranks it among the world's most densely populated countries. Among others, five cities have over two million inhabitants each and the average density, which is high on its own (650 people/km²), is greatly exceeded in the coastal lowlands on the northern and western sides of the island. On the other hand, the mountainous regions are only scarcely populated and therefore offer good opportunities for biodiversity conservation. The only species which is classified as "rare and vulnerable" (written in the text as "valuable", which must be an error), the Hairy-footed flying squirrel is widespread in Southeast Asia, where it is classified as Data Deficient in the IUCN Red List (Molur, 2016). The local subspecies *B. p. kaleensis* (Swinhoe, 1863) represents less than 10% of the global population and is not included on the national Red List (Cheng et al., 2017).

The authors are to be congratulated for their compilation on Taiwanese rodents. Their book will be an invaluable source of information for years to come for all those engaged in rodent research and conservation

management in Southeast Asia. Its strongest point is a meticulous bibliographic survey. As for weaknesses, I would point to a lack of distributional maps and an identification key. Keys are crucial for proper taxonomic identification of specimens and are sorely missed throughout Oriental Asia (Jayaraj et al., 2019). Indeed, in a few cases (*Apodemus* and *Mus*) the authors provide the "Identification Key" but I would like to see such accounts throughout the book. I would also appreciate seeing more general information, starting from the history of faunal research on the one end, to a compilation of diversity pattern on the other.

The book is nicely put together (I saw only the digital version) and contains only a few typographical errors. For example, *Sciurus petaurista* is incorrectly spelled as *petaursita* (page 7). *Apodemus agrarius* and *Micromys minutus* have identical type locality which is spelled differently "Ulianovsk, ... Ulianovsk Obl." (page 41) and "Ulyanovsk, ... Ulyanovsk Obl." (page 84); Ulyanovsk is the correct spelling. Note also, the "Obl." is an abbreviation for "Oblast" (an administrative division or region in Russia and countries of the former Soviet Union) and should be spelled in full.

Acknowledgements

I would like to thank Ms. Karolyn Close for editing for grammar and style.

Conflict of interest

The author declares that there are no conflicting issues related to this book review.

References

- Abramov, A. V., Meschersky, I. G. and Rozhnov, V. V. (2009). On the taxonomic status of the harvest mouse *Micromys minutus* (Rodentia: Muridae) from Vietnam. *Zootaxa*, 2199 (1): 58–68.
<https://doi.org/10.11646/zootaxa.2199.1.2>
- Aoki, B. and Tanaka, R. (1941). The rats and mice of Formosa illustrated. *Memoirs of the Faculty of Science and Agriculture, Taihoku Imperial University*, 23 (4), *Zoology*, 13: 121–191.
- Bonhote, J. L. (1900). On squirrels of the *Sciurus maccllellandi* group. *Annals and Magazine of Natural History, Series 7*, 5 (25): 50–54.
<https://doi.org/10.1080/00222930008678239>
- Burgin, C. J., Colella, J. P., Kahn, P. L. and Upham, N. S. (2018). How many species of mammals are there? *Journal of Mammalogy*, 99 (1): 1–14.
<https://doi.org/10.1093/jmammal/gyx147>
- Chang, S.-W., Oshida, T., Endo, H., Nguyen, S. T., Dang, C. N., Nguyen, D. X., Jiang, X., Li, Z.-J. and Lin, L.-K. (2011). Ancient hybridization and underestimated species diversity in Asian striped squirrels (genus *Tamiops*): inference from paternal, maternal and biparental markers. *Journal of Zoology*, 285 (2): 128–138.
<https://doi.org/10.1111/j.1469-7998.2011.00822.x>

- Cheng, H.-C., Changchien, L.-W., Lin, R.-S., Yan, C.-H. and Chang, S.-W. (2017). *The Red List of terrestrial mammals of Taiwan*. Endemic Species Research Institute and Forestry Bureau, Council of Agriculture, Executive Yuan, Nantou, Taiwan. 35 pp.
- Denys, C., Taylor, P. J. and Aplin, K. P. (2017). Family Muridae (True Mice and Rats, Gerbils and Relatives), *In*: Wilson, D. E., Lacher, T. E. and Mittermeier, R. A. (Eds.), *Handbook of the Mammals of the World. Volume 7. Rodents II*. Lynx Edicions in association with Conservation International and IUCN, Barcelona, Spain. pp. 536–884.
- Jayaraj, V. K., Roslan, A., Taib, F. S. M., Faiz, M. Z. M., Yusof, M. A., Ali, R. and Abdullah, M. T. (2019). Rodent diversity in Pulau Pangkor underestimated due to complex taxonomic descriptions. *The Malaysian Forester*, 82 (1): 305–310.
- Kawada, S.-I. (2016). Biographic review of Alan Owston. *Journal of the Yamashina Institute for Ornithology*, 47 (2): 59–93.
<https://doi.org/10.3312/jyio.47.59>
- Koprowski, J. L., Goldstein, E. A., Bennet, K. R. and Mendes, P. (2016). Family Sciuridae (Tree, Flying and Ground Squirrels, Chipmunks, Marmots and Prairie Dogs), *In*: Wilson, D. E., Lacher, T. E. and Mittermeier, R. A. (Eds.), *Handbook of The Mammals of The World. Volume 6. Lagomorphs and Rodents I*. Lynx Edicions in association with Conservation International and IUCN, Barcelona, Spain. pp. 648–837.
- Kuroda, N. (1920). On a collection of Japanese and Formosan mammals. *Nihon dobutsugaku ihō [Annotationes Zoologicae Japonenses]*, 9 (5): 599–611.
- Kuroda, N. (1925). Description of a new species of the genus *Mus* from Formosa. *Zoological Magazine*, 37 (435): 1–16. [In Japanese with English abstract]
- Lin, L.-K. and Motokawa, M. (2014). *Mammals of Taiwan. Volume 1. Soricomorpha*. Center for Tropical Ecology and Biodiversity, Tunghai University, Taichung, Taiwan. 89 pp.
- Molur, S. (2016). *Belomys pearsonii*. *The IUCN Red List of Threatened Species* 2016: e.T2756A22256636. Downloaded on 15 July 2020.
<https://www.iucnredlist.org/species/2756/22256636>
- Musser, G. G. and Carleton, M. D. (2005). Superfamily Muroidea, *In*: Wilson, D. E. and Reeder, D. M. (Eds.), *Mammal Species of the World. A Taxonomic and Geographic Reference*. Third Edition. Johns Hopkins University Press, Baltimore, MA, USA. pp. 894–1531.
- Pardiñas, U. F. J., Myers, P., León-Paniagua, L., Ordóñez Garza, N., Cook, J. A., Kryštufek, B., Haslauer, R., Bradley, R. D., Shenbrot, G. I. and Patton, J. L. (2017). Family Cricetidae (True Hamsters, Voles, Lemmings and New World Rats and Mice), *In*: Wilson, D. E., Lacher, T. E. and Mittermeier, R. A. (Eds.), *Handbook of the Mammals of the World. Volume 7. Rodents II*. Lynx Edicions in association with Conservation International and IUCN, Barcelona, Spain. pp. 204–535.
- Swinhoe, R. (1862). On the Mammals of the Island of Formosa. *Proceedings of the Zoological Society of London*, 30 (1): 347–368.
<https://doi.org/10.1111/j.1469-7998.1862.tb06539.x>
- Swinhoe, R. (1864). On a new rat from Formosa. *Proceedings of the Zoological Society of London*, 1864: 185–187.
- Swinhoe, R. (1870). Catalogue of the mammals of China (south of the River Yangtze) and of the island of Formosa. *Proceedings of the Zoological Society of London*, 1870: 615–653.
- Thomas, O. (1907). A new flying-squirrel from Formosa. *Annals and Magazine of Natural History, Series 7*, 20 (120): 522–523.
<https://doi.org/10.1080/00222930709487383>
- Thomas, O. (1908). New Asiatic *Apodemus*, *Evotomys*, and *Lepus*. *Annals and Magazine of Natural History, Series 8*, 1 (5): 447–450.
<https://doi.org/10.1080/00222930808692431>
- Thomas, O. (1917). Two new rats of the *Rattus confucianus* group. *Annals and Magazine of Natural History, Series 8*, 20 (116): 198–200.
<https://doi.org/10.1080/00222931709486991>
- Thorington, R. W. and Hoffmann R. S. (2005) Family Sciuridae, *In*: Wilson, D. E. and Reeder, D. M. (Eds.), *Mammal Species of the World. A Taxonomic and Geographic Reference*. Third Edition. Johns Hopkins University Press, Baltimore, MA, USA. pp. 754–818.
- Wilson, D. E. and Reeder, D. M. (2005). *Mammal Species of the World. A Taxonomic and Geographic Reference*. Third Edition. Johns Hopkins University Press, Baltimore, MA, USA. 1206 pp.