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BOOK REVIEW

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Book review: The Bumblebees of the Himalaya – An Identification Guide, by Paul H. Williams

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Presentation of the book

"The Bumblebees of the Himalaya – An Identification Guide", written by Dr. Paul H. Williams and published in May 2022, is a ~200-page guide for the bumblebee fauna of the Himalaya, aiming to provide an up-to-date aid for laboratory identification of all species recorded in the region.

The introduction of the book presents general traits of bumblebees, how to recognize them among other bees, how to catch them in the field, and how to preserve them properly in entomological collections. The biogeographical region of interest – the Himalaya – is also introduced, and a habitat classification for Himalayan bumblebees is proposed and briefly illustrated. The last part of the introduction mostly covers taxonomy, with a concise introduction on what a species is, and importantly with an explanation of the taxonomic concepts followed by the author. An updated checklist of all 62 species present in the Himalaya is provided, including common synonyms present in the literature. Four pages are dedicated to color pattern diagrams formatted to illustrate the distribution of these forms in the studied region, and the type of habitat they are associated with. Bumblebee anatomy is described and illustrated to prepare the reader for the keys that follow, the first being a key to bumblebee subgenera from the studied region.

Then starts the main part of the book ("Systematic account"), that consists in chapters with content organized by subgenera. Every bumblebee subgenus is first briefly described with general notes on its ecology, including habitat requirements, nesting behavior, and type of visited flowers. Following this section are keys for males and females for all Himalayan species belonging to each subgenus. The author then proposes information on every species, including (i) frequently encountered synonyms and type revision, (ii) the color patterns male and female specimens can present, (iii) an illustration of the male genitalia, (iv) the habitat type the species is associated with, (v) maps highlighting the regions in which the species has either been recorded, where the species is likely to be present, or has not yet been recorded from and (vi) notes including taxonomic revisions, accompanied with comments on intraspecific variation. One new species for science is described (*Bombus rainai* Williams), with information on the type series (holotype, paratype) and a formal description. Several species have their status revised and a taxon is synonymized.

General appreciation and scientific appreciation

Bumblebees are the most studied wild bees worldwide (Cameron and Sadd 2020; Ghisbain 2021). Their big body size, colorful appearance, natural abundance and diversity in areas visited by naturalists of the northern hemisphere have made them relatively well represented in museum collections compared to other bees (Wood et al. 2019, 2021). As a direct consequence, scientists were able to gather immense quantities of data about their biogeography, ecology, taxonomy and conservation (Kleijn and Raemakers 2008; Williams and Osborne 2009; Goulson et al. 2011, 2015). Most scientific and naturalist works, however, are still very centered around North America and Europe (Cameron and Sadd 2020; Ghisbain et al. 2020; Rasmont et al. 2021), and Asia (the continent hosting by far the highest species diversity) is still largely overlooked (Williams et al. 2010, 2020).

With more than 40 years of in-depth work on Asian bumblebees, there is no doubt that Dr. Paul H. Williams was the best candidate for writing such a book. Through this publication, the author shares a synthetic, yet critical knowledge on the extremely diversified bumblebee fauna of the Himalaya. Written as a "lockdown project" with no access to museums due to the COVID-19 pandemic, the book is a solid base for building further knowledge on the ecology, taxonomy, and conservation of this strikingly difficult and polymorphic fauna.

General background

The introduction of the work covers most important notions needed for this identification guide to be used properly. As stated by the author himself, the book is "not an introduction to bumblebee general ecology", and therefore the reader must not expect to find there a deep revision. Overall, the introduction is clear, concise and pragmatic, allowing a reader to acquire a sufficient background for properly using the book.

Taxonomy

The taxonomic part is rigorous. The author is aware of how difficult bumblebee taxonomy is, and how complex data analysis and interpretation appear when investigating large, polymorphic species complexes. A positive aspect is that the author provides his vision on how taxonomic work should be conducted to achieve the most robust hypotheses possible. This habit of defining the species concept followed is in line with the author's previous works on subgeneric revision of bumblebees (e.g. Williams et al. 2019, 2020; Williams 2021).

In addition to the discovery and description of a new *Alpigenobombus* species, *Bombus rainai* Williams, the author suggests that some taxa (*Bombus hilaris* (Tkalců), *B. kotzschi* Reinig, *B. sikkimi* Friese, *B. longiceps* Smith) deserve a species status, and justifies this interpretation rigorously based on a combination of morphological and genetic characters (some still to be formally published). Such taxonomic modifications and additions are critical for the implementation of future conservation strategies, and therefore bring a great value to the book. The author took care to thoroughly revise the type material of many taxa, and was careful to document the location of these specimens for future research, which is also immensely appreciated.

One noticeable weakness of the book, however, lies in the fact that the introductory section on taxonomy is very centered around one view of bumblebee taxonomy, rather than a concise, synthetic view of how to approach species delineation in this group of bees. A reader who is not fully aware of the scientific literature about bumblebee taxonomy thus receives only one particular interpretation of how bumblebee taxonomy can be conducted, and only involving the tools that the author is routinely using (*i.e.* morphology and genetic barcodes). Other lines of evidence for species delineation such as the analysis of cuticular hydrocarbons, cephalic labial gland secretions and non semio-chemical tools such as geometric morphometrics are not mentioned, despite their common use (Dehon et al. 2019; Valterová et al. 2019). This is unfortunate as all these approaches are complementary to the author's rigorous view of taxonomy. Such analyses would also help bring key information on the ecology and evolutionary history of the bumblebees of the Himalaya, for which so much is still to discover. As these approaches are not mentioned, the section of the book about the collection and preservation of specimens does not account for their preparation for such analyses. As the addition of such complementary lines of evidence can lead to divergence in opinion on the taxonomic status of some species (*cf.* Williams et al. 2019; Rasmont et al. 2021), we believe that mentioning their existence is essential.

In line with the previous taxonomic works he led (e.g. Williams et al. 2012, 2019, 2020), the author does not recognize subspecies, although he does appreciate the importance of carefully illustrating and documenting the rich intraspecific diversity of bumblebee species. We certainly agree with the author that (i) the use of subspecies in bumblebees can be challenging for some species and (ii) caution should be drawn when extrapolating or inferring (sometimes unmeasured) characteristics of subspecies. Keeping this in mind, we believe that the book could have benefitted from presenting complementary

arguments to balance these points. First, in a purely taxonomic framework, it is relatively uncommon that such ecological extrapolations are done, and the fact that some authors could make unjustified inferences does not constitute an argument against the concept of subspecies itself ; in that case the issue would lie in the authors themselves extrapolating the concept. Second, knowledge from other widely studied insect models (e.g. the Neotropical *Heliconius* butterflies) shows that recognizing infraspecific status can be extremely useful for understanding how evolutionary patterns and processes shape natural diversity (e.g. Flanagan et al. 2004; Baxter et al. 2008; Supple et al. 2013; Arias et al. 2017; Concha et al. 2019). Furthermore, the absence of names from recognizable entities is risky as it makes the knowledge gathered about them unstable across time ("*Nomina si nescis perit cognitio rerum; et nomina si perdas, certe distinctio rerum perditur*", Edward Coke). This is especially important as what we assume today to be infraspecific variation might later appear distinct genetically, semio-chemically, or ecologically when data become available (cf. the case of *B. konradini*, Martinet et al. 2018; and other cases recently presented by the author in his works Williams et al. 2020; Williams 2021). As this scenario is relatively common in bumblebees (many species indeed show a high degree of crypticism: Ghisbain et al. 2020, 2021; Williams 2021), properly naming entities with different phenotypic aspects can be helpful for future research. Finally, because subspecies can be recognized as valid taxonomic entities that can receive conservation measures following the IUCN standards, presenting them in identification guides could be useful to allow their monitoring at local scales. Overall, we would advocate for a more balanced view on the topic of subspecies, above all in a group of insects that represents such a good model to understand phenotypic radiation across space and time.

Ecology and conservation

The author presents information on the ecology of each species, including some information on their habitat. This information is concise and is based on the author's own original observations. These data are greatly appreciated as barely anything is currently known about the habitat requirements of the bumblebees of the Himalaya. It also suggests that further research is strongly needed to investigate more in detail both their habitat and climatic requirements.

With bumblebee conservation currently of global interest and concern (Cameron and Sadd 2020), we feel that the introduction of the book would have benefitted from a broader perspective about this topic, above all given the author's renowned experience on the field (cf. Williams et al. 1996; Williams and Araéjo 2000; Williams and Osborne 2009, among many other important works). Although we acknowledge that barely anything is known about the conservation of the bumblebees in the Himalaya (none has received a proper IUCN conservation status), we believe that the publication of such an important book would also be a great opportunity for raising awareness about how critical conservation is for bumblebees, and how much we need involvement from local communities for avoiding reproducing in the Himalaya the mistakes seen in other regions of the world.

Illustrations

The book has been written during the COVID-19 pandemic, at a time of highly limited access to entomological resources in museums. Despite this, the book is well illustrated. The genitalia of each species are photographed, which can be of great aid (and sometimes critical) for the identification of males in many species. For all taxa, intraspecific variation is illustrated with color diagrams, which are also greatly appreciated given the high degree of polymorphism of the Himalayan fauna. Although the maps can look very synthetic as no individual data points are shown, the idea of the author to highlight where the species could be expected (using a color code) is highly informative, as it can help in further investigation and field trips across the regions.

Conclusion

Overall, the book "The Bumblebees of the Himalaya – An Identification Guide" is an essential contribution to its field. It properly serves its role to document and help in the identification of the strikingly diverse fauna of the Himalaya. Although we regret some short-cuts in the introduction (mostly about taxonomy and conservation), we are certain that the research that will be allowed thanks to this book in the near future will help better understand the remarkable ecology of this fauna.

We sincerely congratulate Dr. Paul H. Williams for his identification guide. With ongoing and incoming work from local scientists and passioned naturalists, we hope that his book will raise interest to study, admire and protect this largely overlooked yet critically important Asian bumblebee hotspot.

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