

Bees are the major terrestrial pollinators, critically important for the reproduction of many wild and agricultural plants species¹ and providing an essential ecosystem service for a significant percentage of agricultural crops². More recently, much attention has been focused on a few high-profile declines of honey bees and bumble bees, leading to fears of a collapse in pollination services and a greatly increased focus on native pollinators^{3,4}. While future decline of pollinators appears likely, there is a need for additional study to fully reveal the extent and causes of the problems facing them⁵.

However, it is only possible to monitor and conserve known and described species. Without a system in place that allows the identification and communication of bee species, effective and targeted conservation is impossible. Bee taxonomy is at a time in which many of the identification resources are falling out of date, and western bees especially are plagued by incomplete knowledge of the existing fauna. I plan to tackle a part of this problem by performing a taxonomic revision of the genus *Dufourea* with the help of Dr. Terry Griswold at Utah State University.

I became interested in the topic of bee taxonomy while working on a plant-pollination interaction study in Carlinville, IL. Due to the exceptional efforts of Charles Robertson, the plants and pollinators were exhaustively collected and documented, eventually resulting in the publication of *Flowers and Insects* in 1929, which recorded 15,172 visits to 441 species of flowers⁶. I was quickly disabused of the notion that my work would merely be a matter of collecting bees and matching them up to Robertson's records. The knowledge of bee systematics has changed and evolved over time, with many species split up, synonymized, reclassified, and renamed. For many of the bees, their tortuous taxonomic history must be traced back to Robertson's time in order to figure out what he called them. Seeing the current outdated state of many of the bee identification resources which I use on a daily basis, I am determined to do my part in the forward progress of the collective taxonomic knowledge.

The genus *Dufourea* is a large but little-studied genus of bees from the family Halictidae. It is a widespread holarctic genus, spanning Europe, North Africa, Asia, and North America. It contains approximately 130 described worldwide species, about 60 of which occur in North

¹ Steffan-Dewenter, I. and C. Westphal, 2008. The interplay of pollinator diversity, pollination services and landscape change. *Journal of Applied Ecology*. 45: 737-741

² Klein, A., Vaissière, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., Tschardtke, T., 2007. Importance of pollinators in changing landscapes for world crops. *Proc. R. Soc. Lond. [Biol]*, 274 (1608), 303–313.

³ Steffan-Dewenter I, Potts S.G., Packer L., 2005. Pollinator diversity and crop pollination services are at risk. *Trends Ecol. Evol.* 20, 651–652.

⁴ Winfree, R., Williams, N.M., Dushoff, J., Kremen, C., 2007. Native bees provide insurance against ongoing honey bee losses. *Ecology Letters* 10, 1105–1113.

⁵ Steffan-Dewenter, I., Westphal, C., 2008. The interplay of pollinator diversity, pollination services and landscape change. *J. Appl. Ecol.* 45, 737–741.

⁶ Robertson, C. 1929. *Flowers and insects. Lists of visitors to four hundred and fifty-three flowers*. Science Press Printing Company, Lancaster, Pennsylvania, USA.

America, with the vast majority occurring in western states⁷. The palearctic species were most recently revised by Ebmer in 1993⁸, but in North America, *Dufourea* has never undergone a taxonomic revision and there are no keys or identification resources other than the original species descriptions. The renowned late entomologist Dr. Richard Bohart described a total of 34 new species of *Dufourea* over the course of his career^{9,10}, laying the groundwork for further taxonomic work and the creation of identification keys.

I propose to continue the work started by Dr. Bohart using a combined approach of traditional morphological analysis and DNA barcoding, following the procedure outlined by Gibbs (2009)¹¹. The sequences generated by the DNA barcoding will be uploaded to the Barcode of Life Data System (BOLD)¹², and the BOLD analytical software will be used to generate systematic trees. In cases where the morphological and genetic analysis are at odds (i.e. if two specimens have the identical DNA sequences but are distinct morphologically) then the morphology will take precedence.

In addition to furthering the knowledge of bee diversity, a taxonomic revision of *Dufourea* will lay the groundwork for further ecological and conservation work. Proper identification is also an essential part of pollination studies, and the identification of these bees will provide valuable new data points to studies of pollination and phenology. Furthermore, *Dufourea* contains a large number of rare and little-studied species, and in the current era of anthropogenic climate change, it is becoming increasingly important to know more about their life histories and floral associations to ensure they are protected and conserved.

The identification resources produced by this research will allow for the consistent and accurate identification of *Dufourea* by a wide range of scientists and researchers. There is common complaint against taxonomists that they exist in their own world, and that "keys are made by biologists who don't need them for those who can't use them." It is my goal to make keys and identification resources as accessible as possible, making them available online and creating a matrix key for the Discover Life website, a format that is easier for non-expert entomologists to use.

⁷ Michener, C.D. 2007. *The Bees of the World*. Johns Hopkins Univ. Press, Baltimore, MD.

⁸ Ebmer, A. W., 1993. Die westpaläarktischen Arten der Gattung *Dufourea* Lapeletier 1841 mit illustrierten Bestimmungstabellen, Dritte Nachtrag. *Linzer Biologische Beiträge* 25: 15-42.

⁹ Bohart, G.E., 1947. New North American bees of the genus *Dufourea* (Apoidea: Halictidae). *Ann. Entomol. Soc. Am.* 40, 692–704.

¹⁰ Bohart, G.E., 1980. New species of North American bees of the genus *Dufourea* (Hymenoptera, Halictidae) with descriptions of two previously undescribed females. U.S. Department of Agriculture, Technical Bulletin No. 1618.

¹¹ Gibbs, J., 2009. New species in the *Lasioglossum petrellum* species group identified through an integrative taxonomic approach. *The Canadian Entomologist*, 141, 371–396.

¹² Ratnasingham, S. & Hebert, P.D.N., 2007. BOLD: the barcoding of life data system (www.barcodinglife.org). *Molecular Ecology Notes*, 7, 355–364.