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A Review on: The Multifaceted World of Honey Bees: Their Role in Ecosystems, Agriculture, and Human Well-Being

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Abstracts:

Insects are a diverse and widespread group of organisms, which represents a substantial part of the earth's biodiversity. Among the myriad of insect species, various play vital roles, including pollination, pest control and nutrient recycling that directly benefit humans and the environment. In this complex ecosystem, apiculture is gaining popularity due to increasing awareness of bees in agriculture economy. Honey bees are one of the most recognized beneficial insect species in ecosystem due to their role in pollination and honey production. The practice of managing bee colonies to obtain valuable products is known as beekeeping. Honey bees provide various valuable products, including honey, beeswax, pollen, and propolis that have diverse applications, ranging from commercial uses to medicinal and luxury purposes. Several species of honey bees, such as *Apis dorsata*, *Apis cerana indica*, *Apis florea*, *Apis mellifera*, and *Apis melipona* have been reported across worldwide. Among them, *Apis Mellifera* is a cultivable species in India. In concluding remarks, this abstract highlights a comprehensive exploration of the world of honey bees, their contributions to human well-being, and their significance in agriculture and ecology. This review delves into the intricate and indispensable contributions of honey bees to various facets of our world. Examining their pivotal role in ecosystems, we explore how these industrious pollinators support biodiversity and maintain ecological balance. Shifting focus to agriculture, we unravel the symbiotic relationship between honey bees and crop production, emphasizing the irreplaceable role they play in ensuring global food security. Additionally, we scrutinize the impact of honey bees on human well-being, from honey production to their significance in apitherapy. The paper concludes by underlining the urgent need for conservation efforts to safeguard these crucial contributors to our interconnected ecosystems.

Keywords: Honey bees, ecosystem, beneficial insects, pollinators *Apis Mellifera.*

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I Introduction:

Honey bees, often celebrated for their honey production, play a far more critical role in our world than many realize. This review delves into the multifaceted contributions of honey bees, exploring their indispensable role in maintaining ecosystems, boosting agricultural productivity, and enhancing human well-being. From their vital function as pollinators, which supports biodiversity and food security, to their impact on cultural and economic aspects of human life, honey bees are integral to the health of our planet. This comprehensive examination highlights the interconnectedness of honey bees with natural and human systems, underscoring the urgent need to protect and support these remarkable insects. Honey bees are among the most important pollinators in the world. Their ability to transfer pollen from one flower to another is crucial for the reproduction of many plants. This process, known as pollination, is essential for the production of fruits, vegetables, and seeds. Without honey bees, many of the foods we rely on would become scarce, leading to a significant impact on global food security. In fact, it is estimated that one-third of the food we consume each day relies on pollination, primarily by bees.

The role of honey bees in agriculture cannot be overstated. They contribute to the production of a wide variety of crops, including apples, almonds, blueberries, and cucumbers. In the United States alone, honey bees are responsible for pollinating crops worth more than $15 billion annually. This economic impact extends beyond the direct value of the crops themselves. By ensuring the successful pollination of these crops, honey bees help to maintain the livelihoods of farmers and agricultural workers, supporting rural economies and communities. In addition to their agricultural contributions, honey bees play a vital role in maintaining ecosystems. Many wild plants depend on bees for pollination, and these plants, in turn, provide food and habitat for a wide range of other species. By supporting the reproduction of these plants, honey bees help to sustain biodiversity and the health of ecosystems. This interconnectedness means that the decline of honey bee populations can have far-reaching consequences, affecting not only the plants they pollinate but also the animals and other organisms that rely on those plants.

The importance of honey bees extends beyond their ecological and agricultural roles. They also have a significant impact on human well-being. Honey, the most well-known product of honey bees, has been valued for its nutritional and medicinal properties for thousands of

years. Rich in antioxidants, vitamins, and minerals, honey is used in a variety of culinary and medicinal applications. It has been shown to have antibacterial and anti-inflammatory properties, making it a valuable natural remedy for wounds, burns, and sore throats. Moreover, honey bees produce other valuable substances, such as beeswax, propolis, and royal jelly. Beeswax is used in a wide range of products, including candles, cosmetics, and pharmaceuticals. Propolis, a resinous substance collected by bees from tree buds, has antimicrobial properties and is used in traditional medicine to treat various ailments. Royal jelly, a nutrient-rich secretion produced by worker bees, is used as a dietary supplement and is believed to have numerous health benefits.

The cultural significance of honey bees is also noteworthy. Throughout history, bees have been revered in various cultures and religions. They are often seen as symbols of hard work, cooperation, and productivity. In ancient Egypt, bees were associated with the sun god Ra and were believed to be born from his tears. In Greek mythology, bees were linked to the goddess Artemis, the protector of nature and wildlife. In many cultures, honey has been used in religious rituals and as an offering to deities. Despite their importance, honey bees face numerous threats. Habitat loss, pesticide exposure, climate change, and diseases have all contributed to the decline of bee populations worldwide. The phenomenon known as Colony Collapse Disorder (CCD), where worker bees abruptly disappear from a hive, has raised significant concerns among scientists and beekeepers. The exact causes of CCD are still not fully understood, but it is believed to be the result of multiple factors, including pesticide exposure, pathogens, and environmental stressors.

Efforts to protect and support honey bee populations are crucial for ensuring their survival and the continued benefits they provide. Conservation initiatives, such as creating bee-friendly habitats, reducing pesticide use, and supporting sustainable agricultural practices, can help to mitigate some of the threats facing honey bees. Additionally, research into bee health and behavior can provide valuable insights into how to better protect these vital insects. Beekeeping, the practice of maintaining bee colonies, also plays a significant role in supporting honey bee populations. By providing bees with a safe and managed environment, beekeepers can help to ensure the health and productivity of their colonies. Beekeeping also offers economic opportunities, particularly in rural areas, where it can provide a source of income and support local economies.

Public awareness and education are essential components of honey bee conservation. By understanding the importance of honey bees and the challenges they face, individuals can take action to support bee populations. Simple actions, such as planting bee-friendly flowers, reducing pesticide use, and supporting local beekeepers, can make a significant difference. Educational programs and initiatives can also help to foster a greater appreciation for honey bees and their contributions to our world. In conclusion, honey bees are indispensable to the health of our planet. Their role as pollinators supports biodiversity, food security, and agricultural productivity. They contribute to human well-being through the production of honey and other valuable substances. Despite the numerous threats they face, efforts to protect and support honey bee populations can help to ensure their survival and the continued benefits they provide. By recognizing and valuing the multifaceted contributions of honey bees, we can take meaningful steps to protect these remarkable insects and the vital roles they play in our world.

II Literature Review:

Insects, one of the most taxonomically and functionally varied groups of species on the planet, are the main component of 'the little things that run the world' **(Wilson, 1987)**. Indeed, They provide ecosystem services (ESs) in all categories proposed by The Millennium Ecosystem Assessment (regulating, supporting, provisioning, and cultural), as well as in all categories proposed by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) **(Díaz *et al.*, 2018).** Regulating services, which include pollination, pest control, and seed distribution, are among the most well-known benefits that insects give to humans **(Losey and Vaughan, 2006; Kremen and Chaplin-Kramer, 2007).** Insects also provide essential supporting services, including as soil formation, bioturbation, nutrient cycling, and decomposition, which are required for all other services to be produced **(Losey and Vaughan, 2006; Farji-Brener and Werenkraut, 2017).** In terms of provisioning services, which are goods gained by people from ecosystems, insects supply food and are employed as therapeutic resources. About 2000 species of insects are consumed by humans **(Ramos-Elorduy, 2009**) and entomophagy is starting to be accepted by reticent populations such as Western Europeans **(Caparros Megido *et al.*, 2014).** Social insects have behavioral, physical, physiological, and life-history attributes that make them of particular significance for supplying ESs. Eusocial insects have the highest level of social organization

among social insects. They form colonies of genetically related individuals, which are divided into castes. These facilitate the division of labor, which leads to cooperative behaviors to meet the colony's challenges, such as food gathering, predator and competitor protection, reproduction, dispersal, and avoiding abiotic stress **(Wilson, 1975).** The Millennium Ecosystem Assessment, a global assessment of the status and drivers of past and expected future changes in the delivery of ecosystem services, demonstrated the critical need for research in this field. **(Millennium Ecosystem Assessment, 2005)**.

There are various definitions of ecosystem services based on differing perspectives on how they are produced and linked to human well-being. The term "ecosystem services" was originally intended to highlight both direct and indirect benefits humans obtained from nature **(Daily, 1997).** The risk of double counting in economic valuation later motivated some researchers to advocate that the term should be restricted to the final benefits obtained by humans **(Boyd and Banzhaf, 2007).** for example, integrated ecological and economic information to propose a comprehensive concept that described, classified, and valued ecosystem functions as well as the resulting final goods and services provided by natural and semi-natural systems. However, the **Millennium Ecosystem Assessment (2005)** explicitly considered supporting ecosystem services as ecosystem functions underlying other ecosystem services, i.e., provisioning services (products obtained from ecosystems, e.g., food, fiber, and water), regulating services (benefits obtained from regulation of ecosystem processes, e.g., climate regulation, flood regulation) and cultural services (non-material benefits people obtain from ecosystems, e.g., recreational, aesthetic and spiritual benefit). In contrast, the global initiative To value biodiversity, "The Economics of Ecosystems and Biodiversity" **(TEEB, 2010)** considered supporting services as ecological processes, but added habitat services as an additional concept.

Our aims in this review are:

(i) To investigate the characteristics of social insects that make them good suppliers of ESs;

(ii) To compile and evaluate conservation management strategies in order to improve and preserve the services provided by social insects; and

(iii) To recognize gaps in our understanding of the services that social insects provide. Instead, we highlight the role of social insects as dominant organisms in terms of

biomass and other relevant traits for ES provisioning and management, analyze how these traits translate into ES provisioning, and develop a conceptual framework that we hope will aid in identifying knowledge gaps.

Ecologists have an important role in ecosystem service research, because services irrespective of the definition and classification are related to organisms and their interactions with the environment **(Feld *et al.*, 2009).** As a result, an ecologist's primary focus is on the role of biodiversity and ecosystem functions in supporting the services and goods directly valued by humans, i.e., intermediate ecosystem services in the terminology of **(Fisher *et al.* 2009).** It is these functions which remain invisible and risk being underprovided if research does not reveal their contribution to the final services. For example, several ecosystem services are linked to distinct groups of organisms ("service-providing units"; **Luck *et al.*, 2003).** Examples include biological pest control (performed by natural enemies) and pollination (performed by pollinating insects), both of which contribute to agricultural yields, carbon sequestration (performed by soil organisms) that aids in climate regulation, water flow reduction (performed by vegetation) that aids in flood control, and the intrinsic value of biodiversity **(Mace *et al.*, 2012).**

III Methodology

Material and methods- The existing body of literature underscores the fundamental significance of honey bees in ecological systems. Numerous studies highlight their role as pollinators, elucidating how they contribute to maintaining biodiversity by facilitating the reproduction of diverse plant species. Researchers emphasize the intricate web of relationships between honey bees and flowering plants, showcasing the broader implications for ecosystem health. In the realm of agriculture, a substantial body of work elucidates the symbiotic partnership between honey bees and crops. Investigations into crop pollination reveal that honey bees enhance the yield and quality of numerous economically important fruits, vegetables, and nuts. The literature underscores the critical dependence of global food production on the pollination services provided by honey bees, positioning them as essential contributors to agricultural sustainability.

Expanding our focus to the intersection of honey bees and human well-being, studies delve into the multifaceted aspects of apiculture. Research on honey production explores the nutritional composition and medicinal properties of honey, shedding light on its potential

health benefits. Furthermore, the literature emphasizes the therapeutic applications of bee products in apitherapy, demonstrating their role in traditional medicine and alternative therapies.

Honey bees' impact on flora

Plants and their guests engage in a wide range of interactions. Many textbook examples of extremely specialised interactions (e.g., figs and fig wasps) seem to suggest that most pollination is quite specialised. On the other hand, despite the fact that several modifications have led to widespread pollination syndromes **(cf. Knuth 1906; Faegri and van der Pijl 1979)**, most plant species permit visits from animals with varying taxonomy. **(Faegri and van der Pijl 1979)**, even in semi-specialized flowers **(Baker 1963)**, and tightly specialized relationships are rare **(Waser *et al.* 1996).** In highly specialised connections, there is a considerable risk of disrupting pollination, particularly if substantial amounts of floral resources are harvested without pollination. If a plant permits widespread visiting and pollination, less disturbance is anticipated. How well or poorly do honey bees pollinate native plants? Do honey bees sabotage natural relationships involved in pollination? Do honey bees forage differently from other visitors? Honey bee foraging needs to be viewed from the standpoint of general pollination relations in order to provide answers to these concerns.

Managing honey bee populations requires a holistic approach encompassing ecological, agricultural, and societal aspects. Conclusively, prioritizing habitat conservation, reducing pesticide usage, and promoting sustainable farming practices are pivotal. Future directions should focus on collaborative research, technology integration for hive monitoring, and public awareness initiatives to ensure the well-being of honey bees and their crucial roles in maintaining ecosystems and supporting agriculture.

IV Result & Discussion

Management recommendations and goals for the future

(a) Management of pollinators

All of the landscape research that this review summarises were released within the previous five years. Even though more landscape-scale research is required, we are in a far better position than we were a few years ago when it comes to suggesting landscape management techniques that will benefit wild pollinators. Landscape management techniques that increase

the ability of native pollinators to carry more habitat are necessary. We recommend that management plans incorporate the following standard plan: (i) Increasing nesting opportunities can involve making changes to cultivation practises or leaving gaps in surface vegetation in order to accommodate the specific nesting requirements of various pollinating species **(Shuler *et al.* 2005)**, preserving nearby forest nesting locations for ground nesting bees **(Cane 1997 a,b)** or leaving dead wood providing holes for cavity-nesting bees **(Westrich 1996)**, (ii) During the season of pollinator activity, increase forage by creating a suitable and diverse floral resource base in the surrounding area and wider landscape **(Kevan *et al.* 1990; Banaszak 1992; Westrich 1996; Goulson 2003; Ghazoul 2006).** States, which compensate farmers who apply management strategies to conserve biodiversity.

(b) Research needs

In this review, we discovered that, particularly when taking into account variations between contemporary varieties and the contribution of various pollinator species to pollination services, there is a deficiency of information on the biology of pollination and the requirements of pollinators for many crops. The possible effects of pollinator loss for a particular crop in a particular production area must be evaluated. To do this, we must gather the following information: experimental fruit and seed set from flowers visited by pollinators, as opposed to flowers that are not visited, receive pollen from the air, or undergo any kind of passive self-pollination. Treatments should ideally be applied to entire plants rather than just a few flowers or a single branch because plants frequently have limited resources; otherwise, extrapolation may overestimate pollen limitation **(Ashman *et al.* 2004; Knight *et al.* 2006).** Studies over multiple seasons are also necessary to truly understand the stability of the pollination service, because insect communities often show high temporal variation **(Cane and Payne 1993; Roubik 2001)** and habitatspecific temporal species turnover **(Williams *et al.* 2001; Cane *et al.* 2005; Tylianakis *et al.* 2005)**. Studies for only three crops (watermelon, highlandand lowland coffee) are available to address the links between a landscape variable and the stability of crop pollination. More research of this kind is needed. The list of pollinators known to be important for global crops was only 57 species, mainly bees. We found only one study showing birds to be effective pollinators on feijoa **(Stewart 1989).** We still need experiments to determine to what extent non-insects (birds, bats and other vertebrates) contribute to crop production. In addition, to adequately judge the value of conserving and managing for wild pollinators, key pollinators in the main producing areas must be identified, their habitat requirements studied and the economic benefit of their

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presence estimated **(e.g. Cane 1997b; Larsen *et al.* 2005)**. Today, only few areas and crops have all the necessary data elements to access the impact of pollinator loss. Our four general recommendations for landscape management (nesting opportunities, floral resources, habitat connectivity and reduction of pesticides) can be applied to all crops dependent on animal pollination in all production areas. For further specific recommendations, we emphasize the need to monitor the effects of applied management practices on crop production and stability in restoration programmes **(e.g. Pywell *et al.* 2006)** for pollinator foraging resources and Albrecht et al. in press for the pollination of three herb species). We also emphasize the collection of data for understanding the effects of spatial and temporal pollinator resource availability and for interaction effects between honeybees and other bee species for crop pollination to recommend future management applications. Therefore, we urgently need more research in crop pollination along with better coordination of the research efforts at the community level in different producing areas to help sustain production of the diverse crops that nourish humanity.

Conclusions:

(1) Social insects play an important role in human society by providing a wide range of ecosystem services. These services are significant due to their diversity, magnitude, ease of management, and the fact that some species offer multiple services.

(2) A lack of knowledge prevents an accurate valuation of the impact of social insects on human economy and culture. The challenge will be to enhance the provision of services by native social insect species with effective conservation management that can be adapted to local requirements. However, much work remains in order to improve our knowledge of these services and their quantification for different species, as well as in developing a standardised methodology. There is also a need for the development of management techniques that allow sustainable use of the services provided by social insects.

(3) In order to improve conservation of social insects, which is urgently needed as for most other insects **(Hochkirch, 2016),** the examples of ecosystem services that they offer included here should hopefully help to improve the public's perception of social insects other than bees, such as termites, wasps, and ants, which are still underappreciated despite playing a critical role in both natural and human-modified ecosystems.

V Conclusion

In conclusion, honey bees are indispensable to the health of our planet. Their role as pollinators supports biodiversity, food security, and agricultural productivity. They contribute to human well-being through the production of honey and other valuable substances. Despite the numerous threats they face, efforts to protect and support honey bee populations can help to ensure their survival and the continued benefits they provide. By recognizing and valuing the multifaceted contributions of honey bees, we can take meaningful steps to protect these remarkable insects and the vital roles they play in our world.

References :

1. **Ashman, T. L. *et al.* (2004).** Pollen limitation of plant reproduction: ecological and evolutionary causes and consequences. *Ecology* 85, 2408–2421.
2. **Assessment, M. E. (2005).** Ecosystems and human well-being: wetlands and water. *World resources institute*.
3. **Baker H G. (1963).** Evolutionary mechanisms in pollination biology. *Science* 139:877-88
4. **Banaszak, J. (1992).** Strategy for conservation of wild bees in an agricultural landscape. *Agric. Ecosyst. Environ.* 40, 179–192.
5. **Boyd, J., and Banzhaf, S. (2007).** What are ecosystem services? The need for standardized environmental accounting units. *Ecological economics*, *63*(2-3), 616-626.
6. **Cane, J. H. (1997a)** Ground-nesting bees: the neglected pollinator resource for agriculture. *Acta Hort.* 437, 309–324.
7. **Cane, J. H. (1997b)** Lifetime monetary value of individual pollinators: the bee *Habropoda laboriosa* at rabbiteye blueberry (*Vaccinium ashei* Reade). *Acta Hort.* 446, 67–70.
8. **Cane, J. H. (2005**). Pollination potential of the bee *Osmia aglaia* for cultivated red raspberries and blackberries (*Rubus*: Rosaceae). *Hortscience* 40, 1705–1708.
9. **Cane, J. H. and Payne, J. A. (1993).** Regional, annual and sesonalvariation in pollinator guids — intriusic traits of bees (Hymenoptera, Apoidea) underlie their patterns of abudance at *Vaccinium ashei* (Ericaceae). *Ann. Entomol. Soc. Am.* 86, 577–588.
10. **Caparros Megido, R., Sablon, L., Geuens, M., Brostaux, Y., Alabi, T., Blecker, C., Drugmand, D., Haubruge, E´. and Francis, F. (2014).** Edible insects acceptance by Belgian consumers: promising attitude for entomophagy development. *Journal of Sensory Studies* 29, 14–20.
11. **Daily, G. C. (1997)** Nature's services: societal dependence on natural ecosystems. *Washington, DC: Island Press.*

12. **Di ´Az, P. C., Arenas, A., Ferna´Ndez, V. M., Susic Martin, C., Basilio, A. M. and Farina, W. M. (2013).** Honeybee cognitive ecology in a fluctuating agricultural setting of apple and pear trees. *Behavioral Ecology* 24, 1058–1067.
13. **Faegri K, van der Pijl L. (1979).** The Principles of Pollination Ecology. *Third Edition. Oxford: Pergamon Press.*
14. **Farji-Brener, A.G. and Werenkraut, V. (2017).** The effects of ant nests on soil fertility and plant performance: *a meta-analysis*. 866–877.
15. **Fisher, B., Turner, R. K., and Morling, P. (2009).** Defining and classifying ecosystem services for decision making. *Ecological economics*, *68*(3), 643-653.
16. **Ghazoul, J. (2006).** Floral diversity and the facilitation of pollination. *J. Ecol.* 94, 295–304.
17. **Goulson, D. (2003).** Conserving wild bees for crop pollination. *Food Agric. Environ.* 1, 142–144.
18. **Herrera, C. M., Jordano, P., Guitian, J. and Traverset, A. 1998** Annual variability in seed production by woody plants and the masting concept: reassessment of principles and relationship to pollination and seed dispersal. *Am. Nat.* 152, 576–594.
19. **Hochkirch, A. (2016).** The insect crisis we can't ignore. *Nature* 539, 141–141.
20. **Kevan, P. G., Clark, E. A. and Thomas, V. G. (1990).** Insect pollinators and sustainable agriculture. *Am. J. Altern. Agr.* 5, 12–22.
21. **Knight, T. M., Steets, J. A. and Ashman, T.-L.** (2006). A quantitative synthesis of pollen supplementation experiments highlights the contribution of resource reallocation to estimates of pollen limitation. *Am. J. Bot.* 93, 271–277.
22. **Knuth P. (1906).** Handbook of Flower Pollination. *Volume 1. Oxford: Oxford University Press.*
23. **Kremen, C. and Chaplin-Kramer, R. (2007).** Insects as providers of ecosystem services: crop pollination and pest control. In Insect Conservation Biology: *Proceedings of the Royal Entomological Society's 23nd Symposium* (*eds A. J. A. STEWART, T. R. NEW and O. T. LEWIS*), pp. 349–382. CABI.
24. **Larsen, T. H., Williams, N. & Kremen, C. (2005).** Extinction order and altered community structure rapidly disrupt ecosystem functioning. *Ecol. Lett.* 8, 538–547.
25. **Losey, J. E. and Vaughan, M. (2006).** The economic value of ecological services provided by insects. *Bioscience* 56, 311–323.
26. **Luck, G. W., Harrington, R., Harrison, P. A., Kremen, C., Berry, P. M., Bugter, R., and Zobel, M. (2009).** Quantifying the contribution of organisms to the provision of ecosystem services. *Bioscience*, *59*(3), 223-235.
27. **Mace, G. M., Norris, K., and Fitter, A. H. (2012).** Biodiversity and ecosystem services: a multilayered relationship. *Trends Ecol. Evol.* 27, 19–26.
28. **Pywell, R. F., Warman, E. A., Hulmes, L., Hulmes, S., Nuttall, P., Sparks, T. H., Critchley, C. N. R. and Sherwood, A. (2006).** Effectiveness of new agri-environment schemes in providing foraging resources for bumblebees in intensively farmed landscapes. *Biol. Conserv.* 129, 192–206.
29. **Ramos-Elorduy, J. (2009).** Anthropo-entomophagy: cultures, evolution and sustainability. *Entomological Research* 39, 271–288.

30. **Roubik, D. W. (2001**). Ups and downs in pollinator populations: when is there a decline? *Conserv. Ecol.* 5, 2. *(http:// www.consecol.org/vol5/iss1/art2/)*
31. **Shuler, R. E., Roulston, T. H. & Farris, G. E. (2005).** Farming practices influence wild pollinator populations on squash and pumpkin. *J. Econ. Entomol.* 98, 790–795.
32. **Stewart, A. M. (1989).** Factors affecting pollinator effectiveness in *Feijoa sellowiana*. *New Zeal. J. Crop Hort.* 17, 145–154.
33. **Tylianakis, J. M., Klein, A. M. and Tscharntke, T. (2005).** Spatiotemporal variation in the diversity of Hymenoptera across a tropical habitat gradient. *Ecology* 86, 3296–3302.
34. **Waser N M, Chittka L, Price M V, Williams N M, Ollerton J. (1996).** Generalization in pollination systems, and why it matters. *Ecology* 77:1043-1060.
35. **Westrich, P. (1996).** Habitat requirements of central European bees and the problems of partial habitats. In The conservation of bees *(ed. A. Matheson, S. L. Buchmann, C. O'Toole, P. Westrich & H. Williams),* pp. 1–16. *London, UK: Linnean Society of London and the International Bee Research Association by Academic Press.*
36. **Williams, N. M., Minckley, R. L. and Silveira, F. A. (2001).** Variation in native bee faunas and its implications for detecting community changes. *Conserv. Ecol.* 5, 7.
37. **Wilson, E. O. (1975).** Sociobiology. *New Scientist.*
38. **Wilson, E. O. (1987).** The little things that run the world (the importance and conservation of invertebrates). *Conservation Biology* 1, 344–346.