

Review of the Ph.D. Thesis entitled Nesting behaviour and population genetics of solitary bees (Hymenoptera: Anthophila) submitted by Mgr. Kateřina Černá to the Faculty of Science, Charles University in Prague

As the title indicates, the submitted thesis is composed of two topics that seem to be rather unrelated – nesting behaviour and population genetics of solitary bees. However, without understanding of genetics of an insect group the study of reproduction behaviour, namely the phenomena like cleptoparasitism, cuckoo behaviour, quasisociality, semisociality or primitive eusociality can be an empty-handed effort. The author of the reviewed thesis supported by the research group led by Dr. Jakub Straka directed her research strategy towards combining the field studies based on painstaking observations of nesting behaviour of marked bees with state-of-the-art population genetic technology based on the use of genetic microsatellite markers of their own design. Even though their ambitious research goals may still be short from being all achieved, the road they have taken is promising and rewarding. From this prospective the topics of the submitted thesis is timely and up to date.

Since neither the biology of solitary bees nor their population genetics are the current topics of my own research interests, I am not fully in the position to critically evaluate all technical minutiae of the submitted studies. Nevertheless, my academic background and long research and tutorial experience allows me to pass judgment on the enormous volume of work exerted during collection of data that lead to the final synthesis and conclusions presented in the thesis. The effort exerted by the candidate and her collaborators is admirable. Moreover, most of the results reported here have been already published, and thus, underwent a rigid peer-review procedure.

As for the formal arrangement of the thesis, the whole volume is written in English and consists basically of **five peer-reviewed papers** and **one submitted manuscript**. Kateřina Černá is the first author of all of them except for the submitted one. The understanding of the published results is facilitated by 37 pages of **introductory** section. This is preceded by a short comprehensive **summary** in English and Czech and followed by the **summaries of the individual papers** that are composing the thesis. The three main goals of the thesis are enumerated in the chapter **Aims of the study and list of papers**. These aims are: (i) to describe the nesting behaviour of solitary bees and find possible behavioural patterns that could serve as preadaptations to the sociality or cleptoparasitic behaviour; (ii) to detect the presence and frequency of intraspecific cleptoparasitism in solitary bees; and (iii) to enhance the knowledge about solitary bee genetics and their conservation state by describing their population structure. The last chapter **Conclusion and future prospects** summarizes how these aims were fulfilled and suggests the direction of future possible research. The list of **references** used and discussed by the author includes 193 items. The whole volume comprises 149 pages and is written in well understandable language and practically without misprints.

I am not going to describe the content of the work in details, because the candidate will do it more appropriately in her own exposé. Let me only briefly present some of my remarks and perception of individual sections and/or the enclosed papers as I see it as a reviewer.

Paper I that analysis nesting behaviour of *Andrena vaga* appeared to me remarkable from two aspects: (i) it has a long introduction that could serve as an excellent comprehensive mini-review of the topic, and (ii) it presents an extremely large volume of data from daily field observation of individually marked 289 females observed through the entire nesting season. This allowed the authors to construct well substantiated ethogram and confirm the existence

of distinctive pollen and nectar days in *A. vaga*. A similarly heroic task was collecting the field data for determinants of life-span under natural conditions of two solitary bee species (*Andrena vaga* and *Anthophora plumipes*) during four consecutive seasons. The results are reported in the submitted manuscript of paper V. The authors came to the conclusion that longevity is affected both directly by climate and indirectly by climate-dependent activity patterns. I wonder, could size and/or body mass at the adult emergence be also somehow related to the life expectancy of the bee? Is the number of repeated pollen days related to availability/abundance of resources (blooming blossoms) or their distance from the nest site? Can you reveal to which journal the manuscript was submitted and with what result? And technical questions: How do bees respond to the observer, if they do at all? How do bees recognize their own nest entrance in a dense aggregation, does scent play any role?

Paper II that appeared in *PLoS ONE* last month is devoted to the second aim; it reports the results of observations aimed at detection of the presence and frequency of intraspecific cleptoparasitism in 4 aggregating species of obligate solitary bees (*Andrena vaga*, *Anthophora plumipes*, *Colletes cunicularius* and *Osmis rufa*) – a phenomenon so far insufficiently recognized. Again, the study was based on regular field observation of individually marked females on several locations for four seasons (2007 through 2010), a task requiring collection of incredibly large amount of data and sophisticated ways of their evaluation. No wonder that the study brought several surprising and perhaps unexpected results as concerns regular nest switching and reusing that, by the opinion of the authors, reduces long term and costly intraspecific aggression, an important prerequisite for the origin and evolution of sociality. The results allowed the authors to express a belief that brood parasitism is more common in solitary bees than known and expected, similarly as a high frequency of nest usurpations.

The papers III, IV and VI deal with various aspects of population structure and dynamics of solitary bees, and their conservation genetics. Collecting material for this section required extensive international cooperation. The topic is very timely, because a number of studies have reported the threat of global loss of bee diversity that may lead to a potential global pollinator crisis.

Effect of habitat fragmentation, one of the most important factors believed to cause bee decline, on population structure in *A. vaga* (using nine microsatellite loci) was studied on populations living on the locations in Germany and Czech Republic, i.e. the regions that differ in homogeneity of the habitats. The results of the study appeared in *Conservation Genetics* this year (Paper III). Surprisingly, habitat fragmentation did not result in increased genetic isolation at the localities. However, the authors have plausible explanation at hand.

The last section of the thesis (paper VI) deals with phylogeography of the solitary bee *Anthophora plumipes* that is widespread through Palearctic region and the USA, where it was introduced to. To this end, the authors developed a set of microsatellites for this species and used them to map the distribution of seven major clades throughout the area of species distribution (six in Europe, one in Asia and USA). They could confirm the Japanese origin of the USA population and declare that the introduction was successful despite the dramatic decrease in genetic variability and low effective numbers of Japanese and American populations. My question is: should we consider this finding surprising (or unexpected) in the light of some other examples of successful man-assisted transcontinental invasions of pioneer populations of other hymenopteran taxa (e.g. invasive ants, wasps or honey bees)?

As the summary, I want to appreciate the ability of the candidate rationally to design, test and evaluate scientific hypotheses and properly present the conclusions to the scientific community. Acceptance of her results for publication in reputable scientific periodicals is

another virtue of the thesis to be appreciated. In addition, one has to appraise her potency to efficiently collaborate with colleagues both at home and abroad.

In conclusion, I declare that the submitted work demonstrates that **Mgr. Kateřina Černá** is well qualified to perform independent scientific research, thereby fulfilling one of the legal requirements for obtaining the academic degree of Ph.D. Therefore, **I recommend that the Scientific Board accepts her thesis as a basis for awarding its author the title Philosophy Doctor.**

26th October, 2013.

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