

Beyond the sweetness

Nectar as an interface between plants and their pollinators in the genus *Fritillaria* (Liliaceae)

Katarzyna Roguz¹, Andrzej Bajguz², Magdalena Chmur², Agnieszka Gołębiewska², Agata Roguz³, Laurence Hill⁴, Marcin Zych¹

¹Botanic Garden, Faculty of Biology, University of Warsaw, Warsaw, Poland, **Correspondence:** k.roguz@biol.uw.edu.pl

²Department of Plant Biochemistry and Toxicology, Institute of Biology, Faculty of Biology and Chemistry, University of Białystok, Białystok, Poland

³Feature Forest, Trzy Lipy 3, 80-172 Gdańsk, Poland

⁴Petersham Lodge, River Lane, Richmond, Surrey TW10 7AG, United Kingdom

Introduction

Nectar is the most important floral reward, and should be regarded as a complicated multifunctional interface between plants, their mutualists and antagonists. However, nectar constituents other than dominant sugars are relatively rarely studied. This includes, for example, amino acids (AAs). Moreover, little is known on the phylogenetic constraints on nectar composition. For the reasons we studied nectar properties of members of the genus *Fritillaria*. Two closely related members of this genus growing in North America, *F. gentneri* and *F. recurva*, are regarded as hummingbird-pollinated, and Iranian *F. imperialis* as passerine-pollinated. To assess correlations between pollination systems and floral characters associated with nectar production, we studied nectar sugar and AAs composition for over 50 *Fritillaria* species.



Fig. 1. Members of genus *Fritillaria* are viewed as an insect pollinated, with the exception of two North America species, *F. gentneri* and *F. recurva*, which are described as hummingbird-pollinated and the Asian species, *F. imperialis*, described as passerine-pollinated.

Materials & methods

Nectar samples used for this study were obtained from *Fritillaria* species cultivated at the University of Warsaw Botanic Garden (BG) and in the private collections.

- Flowers were selected at the bud stage (flowers still closed) and bagged with nylon mesh to prevent visits by insects
- All the available nectar was sampled with microcapillary pipettes from nectaries and was placed into Eppendorf tubes
- AAs composition and the sugar composition in nectar was analyzed using high-performance liquid chromatography (HPLC)
- Nectar sugar concentration was analyzed with the use of spectrophotometer

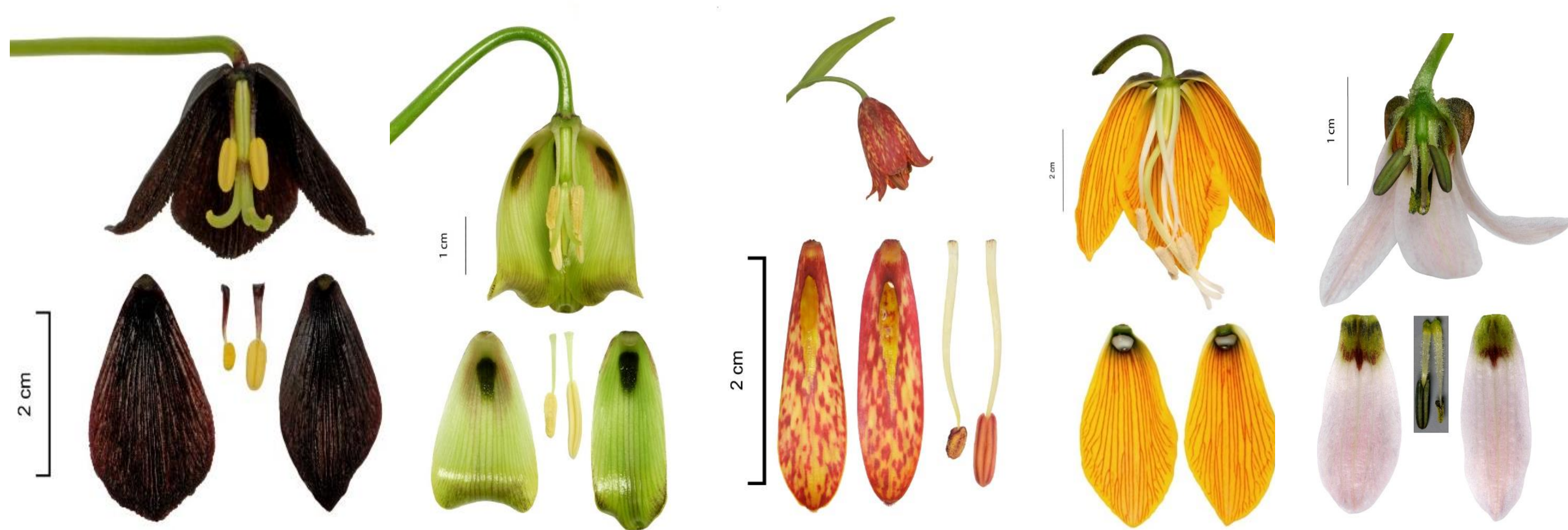


Fig. 2. Flowers of selected members of the genus *Fritillaria*.

Results – AAs in nectar

Thirty AA compounds or groups of AAs compounds in varying proportions were found in the floral nectar of studied fritillaries. On average, 23 different AAs were present in a nectar sample. Passerine bird-pollinated species produced nectar with the highest AAs concentration (Fig 3). The first two principal components of AAs concentration with the main pollinator and subgenera as explanatory variable explained 69.2% and 60% of the total variance, respectively (Fig 4).

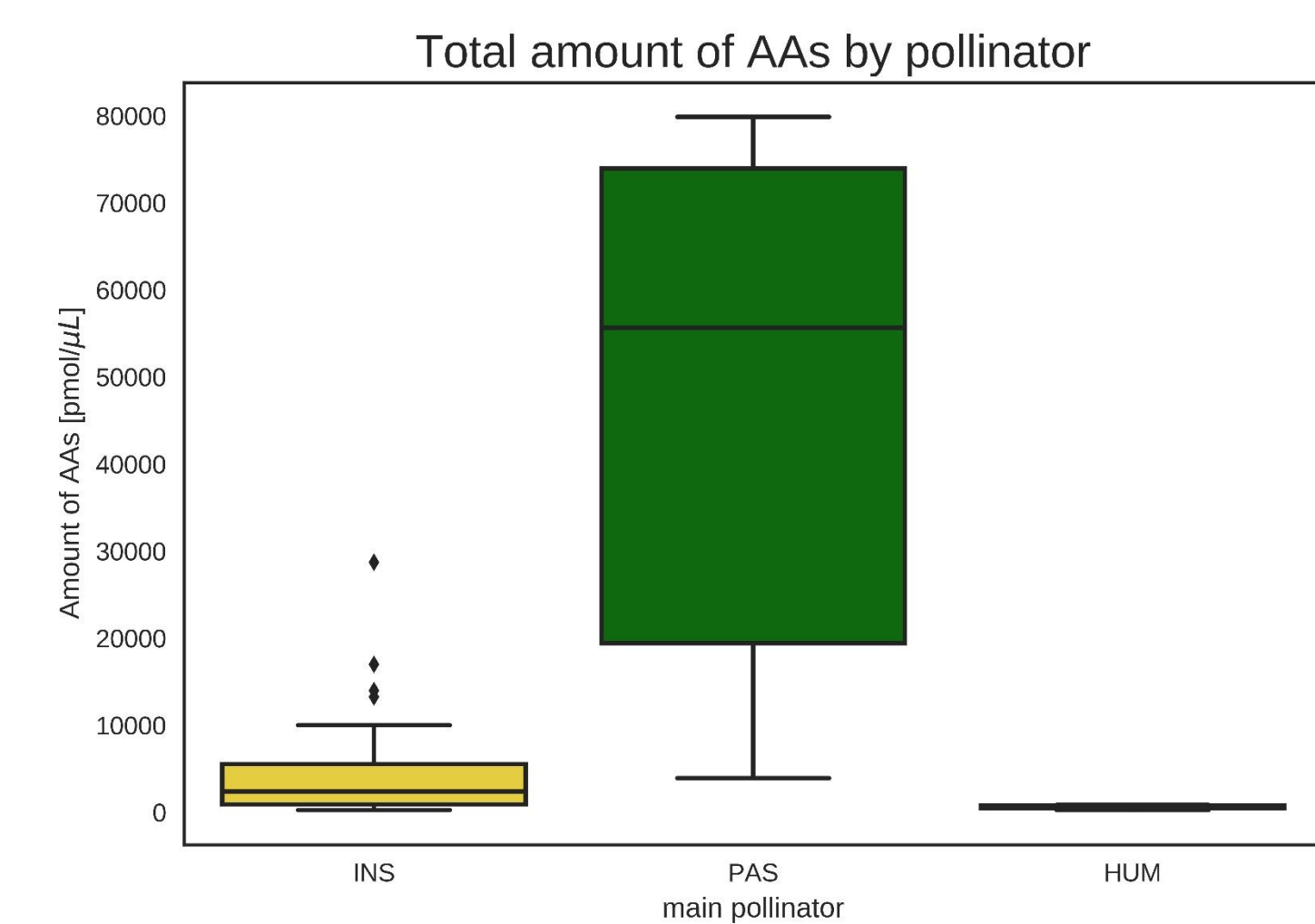


Fig. 3. Total amount of AAs in the nectar of *Fritillaria* grouped by pollinators (INS – insects, PAS – passerines, HUM – hummingbirds).

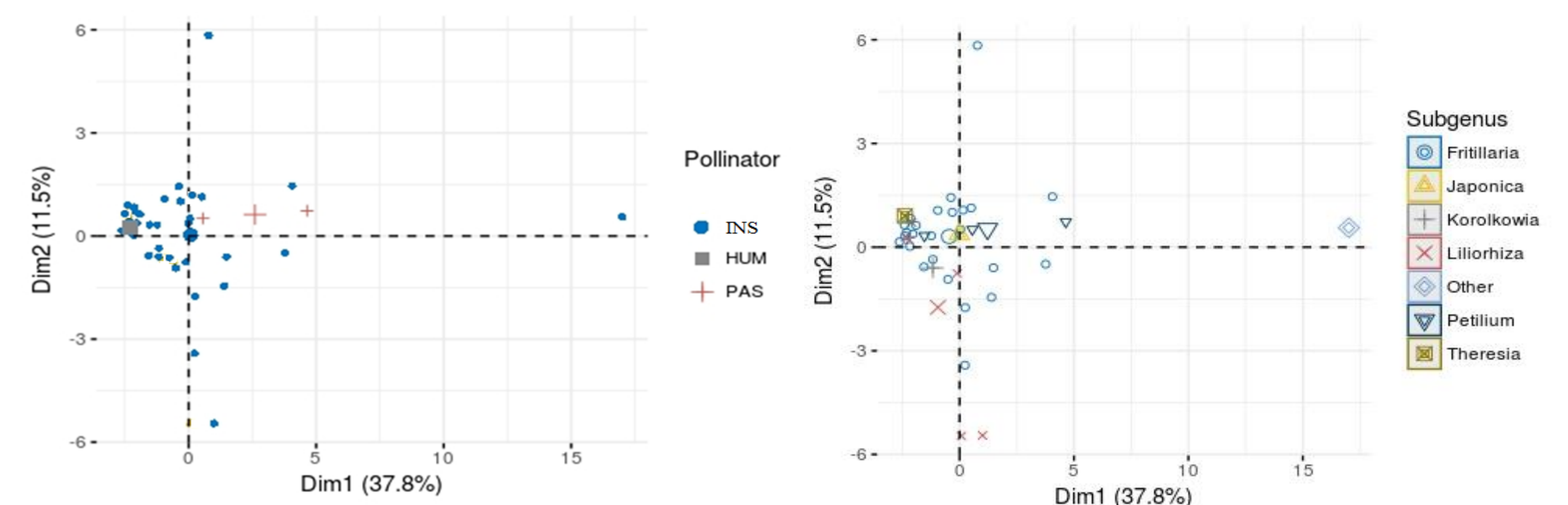


Fig. 4. Scatterplot of PCA. Left – data grouped by pollinators (INS – insects, HUM – hummingbirds, PAS – passerines), Right – data grouped by subgenus identity.

Results – nectar properties

The amount of nectar produced in *Fritillaria* flowers and its concentration depended on a pollinators type. Nectar of most *Fritillaria* species was hexose-rich, and the sugar profile of nectar was dominated by sucrose and glucose, which were also detected in the nectar of all species. Fructose was also a significant component of *Fritillaria* nectar, but it was not present in the nectar of all species studied.

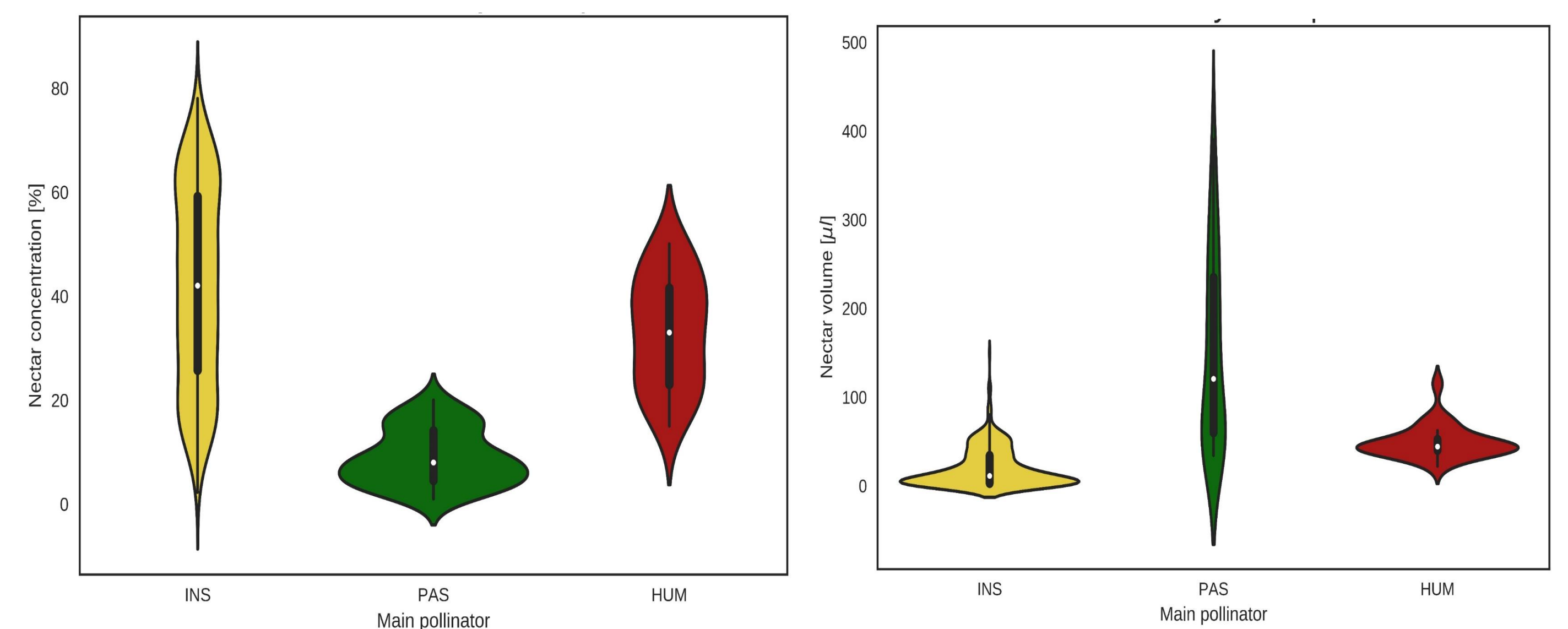


Fig. 5. The concentration (left) and amount (right) of nectar produced by *Fritillaria* flowers grouped by pollinators type (INS – insects PAS – passerines, HUM – hummingbirds).

Conclusions

- Flowers of different fritillaries produced nectar with varying composition and concentration of sugars and AAs. These differences result from several factors. While the phylogeny and environment play a role, selection imposed by pollinators might be regarded as the most important factor shaping nectar properties.
- Changes in nectar sugar and AAs concentration and composition play an important role in attracting new floral visitors in case of pollinators shift. Nectar of ornithophilous species reflected preferences of bird visitors.
- Passerine bird-pollinated species *F. imperialis* and *F. eduardii* produced huge amounts of low-concentrated nectar rich in AAs. Moreover, nectar of this species was hexose-rich, and lacks even traces of sucrose, which is not digested by some passerines.
- Hummingbird-pollinated species *F. gentneri* and *F. recurva* produced copious amounts of balanced nectar of medium sugar concentration and very low AAs concentration.
- New characters in passerine pollinated species (low sugar concentration and high AAs content) may be regarded as a floral filters discouraging illegitimate pollinators for instance bees.
- Nectar of presumably insect pollinated species was very variable, however, contrary to previous reports it did not contain a higher amount of proline.

Acknowledgements

We thank Paweł Pstrokoński, Piotr Woźniak, Justyna Ryniewicz, Mateusz Skłodowski, and Anna Szaciłło for their help in collecting field data and laboratory analyses, Paul Cumbleton, Colin Everett, and Paweł Kalinowski for providing plant material, Dorota Szubierajska for helping to maintain experimental plants. Source of pictures: www.fritillariaicones.com, www.commonswiki.org. The study was financially supported by research grant no. 4786 2013/11/N/NZ8/00611 from the Polish National Science Centre (to KR), and tests of the HPLC method for AAs analysis were supported via the Polish National Science Centre grant 2011/01/B/NZ8/03146 to M.Z.