

The Journal of Threatened Taxa (JoTT) is dedicated to building evidence for conservation globally by publishing peer-reviewed articles online every month at a reasonably rapid rate at www.threatenedtaxa.org. All articles published in JoTT are registered under [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/) unless otherwise mentioned. JoTT allows unrestricted use, reproduction, and distribution of articles in any medium by providing adequate credit to the author(s) and the source of publication.

Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

COMMUNICATION

POLLINATION IN AN ENDEMIC AND THREATENED MONOECIOUS HERB *BEGONIA SATRAPIS* C.B. CLARKE (BEGONIACEAE) IN THE EASTERN HIMALAYA, INDIA

Subhankar Gurung, Aditya Pradhan & Arun Chettri

26 August 2019 | Vol. 11 | No. 10 | Pages: 14328–14333

DOI: 10.11609/jott.4256.11.10.14328-14333



For Focus, Scope, Aims, Policies, and Guidelines visit <https://threatenedtaxa.org/index.php/JoTT/about/editorialPolicies#custom-0>

For Article Submission Guidelines, visit <https://threatenedtaxa.org/index.php/JoTT/about/submissions#onlineSubmissions>

For Policies against Scientific Misconduct, visit <https://threatenedtaxa.org/index.php/JoTT/about/editorialPolicies#custom-2>

For reprints, contact <ravi@threatenedtaxa.org>

The opinions expressed by the authors do not reflect the views of the Journal of Threatened Taxa, Wildlife Information Liaison Development Society, Zoo Outreach Organization, or any of the partners. The journal, the publisher, the host, and the partners are not responsible for the accuracy of the political boundaries shown in the maps by the authors.

Partner



صندوق محمد بن زايد
للمحافظة على
الكائنات الحية

The Mohamed bin Zayed
SPECIES CONSERVATION FUND

Member



Publisher & Host





POLLINATION IN AN ENDEMIC AND THREATENED MONOECIOUS HERB *BEGONIA SATRAPIS* C.B. CLARKE (BEGONIACEAE) IN THE EASTERN HIMALAYA, INDIA

ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

PLATINUM
OPEN ACCESS



Subhankar Gurung¹ , Aditya Pradhan²  & Arun Chettri³ 

^{1,2,3} Taxonomy & Biodiversity Lab, Department of Botany, Sikkim University, 6th Mile, Tadong, Gangtok, Sikkim 737102, India.

¹subhankargurung@hotmail.com, ²apradhan512@gmail.com, ³achettri01@cus.ac.in (corresponding author)

Abstract: *Begonia satrapis* was studied for its pollination aspects at Sumbuk, Sikkim, India. The floral details and the foraging behaviour of insects visiting the flowers were examined to define the pollination syndrome and its functionality for the success of sexual reproduction in this species. The flowers do not produce nectar and offer only pollen as floral reward to foraging insects. Therefore, male flowers were foraged more for its pollen than the female flowers. There was a significant difference in the visit to male and female flowers by both *Apis florea* and *Bombus breviceps*, respectively. The bees spent more time on male flowers than on female flowers. The bees appear to rely on visual stimuli to visit male and female flowers. The plant produces abundant fruit and seed set in both hand and open-pollinations indicating that it is facultatively xenogamous. The female flowers lacking any reward resemble male flowers and in effect are pollinated by deceit.

Keywords: *Apis florea*, *Bombus breviceps*, deceit, northeastern India, Sumbuk.

Nepali सार: भारतको उत्तर-पूर्वीय राज्य सिक्किमको सुम्बुकमा पाइने मंगरकाँजे (*Begonia satrapis*)को परागण प्रक्रिया माथीको विशेष अध्ययन हो। यहाँ पाइने यस प्रजातिको प्रजनन प्रक्रिया तथा स्त्री फूल अनि नर फूलको पराग मिलन प्रक्रियालाई बुझ्न, फूलको मुख्य भागको जाँच साथै फूलको पराग खान आउने किटपतङ्गको क्रिया कलापमाथी विशेष जाँच गरिएको छ। फूलमा रस नहुनाले गर्दा किटपतङ्गले परागको धुलोलाई नै टिप्ने गर्दछ। विशेष गरि नर फूलमा परागको धुलो पाइनाले गर्दा मौरी (*Apis florea*) अनि भमरा (*Bombus breviceps*)ले नर फूलमा मात्र अधिक समय बिताएको पायो। आफ्नै हातले गरिएको परागण प्रक्रिया साथै प्राकृतिक स्वभावले हुने परागण (Open pollination)द्वारा अधिक मात्रामा फल र बिज लागेको हुनाले मँगरकाँजेको यस प्रजातिलाई *फ्याकलटेटिम जिनोग्यामस* भन्न सकिन्छ। मौरी अनि भमराले आफ्नो नजरमाथी भर परेर नै नर फूल र स्त्री फूलमाथी बसेको अवलोकन गर्यो। स्त्री फूलमा किटपतङ्गको निम्ति कुनै रस अथवा आहार नभए पनि नर फूल झैं दुरुस्त देखिने हुनाले किटपतङ्ग झुकिपर स्त्री फूलमा बस्दा नर फूलबाट टिपेको परागको धुलो छरिन्छ, यसो हुँदा फूलमा परागण प्रक्रिया सम्भव भएको पाइन्छ।

DOI: <https://doi.org/10.11609/jott.4256.11.10.14328-14333>

Editor: A.J. Solomon Raju, Andhra University, Visakhapatnam, India.

Date of publication: 26 August 2019 (online & print)

Manuscript details: #4256 | Received 15 May 2018 | Final received 31 July 2019 | Finally accepted 05 August 2019

Citation: Gurung, S., A. Pradhan & A. Chettri (2019). Pollination in an endemic and threatened monoecious herb *Begonia satrapis* C.B. Clarke (Begoniaceae) in the eastern Himalaya, India. *Journal of Threatened Taxa* 11(10): 14328–14333. <https://doi.org/10.11609/jott.4256.11.10.14328-14333>

Copyright: © Gurung et al. 2019. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by adequate credit to the author(s) and the source of publication.

Funding: This research has been funded by the Department of Biotechnology (DBT), Government of India (Project No. BT/Env/BC/01/2010).

Competing interests: The authors declare no competing interests.

Author details: SUBHANKAR GURUNG is currently doing his PhD in the Department of Botany, Sikkim University, India. His interest lies in studying the reproductive biology of plants with special emphasis on understanding the role of pollinators. ADITYA PRADHAN, a PhD scholar and a Junior Project Fellow (JPF), is studying the diversity and distribution of the genus *Begonia* in Sikkim Himalayas. DR. ARUN CHETTRI is a plant taxonomist/ecologist who has worked extensively on plant diversity, taxonomy, ecology and conservation of threatened plants in different forests types in northeastern India, in particular in Sikkim.

Author contribution: Study designed by SG; Data collected by SG, AP; analysis of data done by AC, and SG wrote the manuscript.

Acknowledgements: The authors would like to thank the Department of Botany, Sikkim University for providing all the logistical support and laboratory facilities for this research. Our sincere thanks go to Dr. M.P. Thapa, guest faculty and Sailendra Dewan, research scholar, Department of Zoology and Dr. Somnath Dey, Department of Zoology, Darjeeling Government College for their assistance in helping us identify the pollinators. Lastly, we would like to thank the villagers for their cooperation and hospitality at Sumbuk.



INTRODUCTION

Male and female flowers provide different levels of rewards to the pollinators. In fact, some female flowers do not produce a pollinator reward and are actually pollinated by deceit (Willson & Ågren 1989; Ågren & Schemske 1991). Deceit pollination can be considered as an extreme case of unreliable signalling in plants since flowers do not offer any reward while they benefit from pollinator visitation (Renner 2006). Intersexual mimicry drives the pollinators to visit the female flowers that do not provide any reward (Little 1983; Ågren & Schemske 1991). Mimicry hypothesis suggests that plants that exhibit intersexual mimicry experience selective advantage when pollinators pay more visits to reward-less female flowers which resemble reward-providing male flowers (Ågren & Schemske 1991). Female flowers in many monoecious species of the genus *Begonia* may attract pollinators by mimicking conspecific male flowers in which bees mistakenly visit unrewarding female flowers (Vogel 1998; Wiens 1978; Ågren & Schemske 1991; Schemske & Ågren 1995; Corff et al. 1998). This hypothesis is based on the remarkable similarity between unrewarding female flowers and the pollen-rich male flowers (Ågren & Schemske 1991). Although, mimicry hypothesis and the behaviour of pollinators have been studied in some species of *Begonia* (Ågren & Schemske 1991; Castillo et al. 2002; Wyatt & Sazima 2011), no detailed study of such kind has been done in *Begonia satrapis* C.B. Clarke (Begoniaceae), an IUCN Red Listed Endangered herb of eastern Himalaya (Adhikari et al. 2018).

Little (1983) suggested that in floral mimicry hypothesis the mimic and the model floral displays are similar, and the pollinators mostly visit the model more often than the mimic. Accordingly, we tested this hypothesis by studying the floral display of male and female phase inflorescences and the pollinator behaviour in *B. satrapis*. The study addressed the following questions: (i) are there any differences between the size and morphology of male and female flowers? (ii) do pollinators discriminate between male and female flowers? (iii) what is the success rate of intersexual mimicry to deceive the pollinators to effect pollination?

MATERIALS AND METHODS

Study site

This study was conducted in a private forest in Sumbuk which falls in the Rangit Valley, South District, Sikkim, eastern Himalaya (27°06'18.90"N & 88°22'07.32"E, altitude 555m). The area experiences a maximum and minimum temperature of 26.9°C and 17.3°C, respectively, with an annual precipitation of 2,766mm. The study site comprises a sub-tropical type of forest where *B. satrapis* flourished in abundance along the margins of this forest which is close to human habitation. The forest surroundings comprised species of *Shorea robusta* C.F. Gaertn and *Schima wallichii* Choisy.

Statistical data analysis

Mann-Whitney U Test was performed to evaluate the difference in seed set rate in hand and open pollination of female flowers. Non-parametric t-test was used to evaluate the variation in morphological characters of male and female flowers. Data collected from different patches were pooled and subjected to a t-test to know whether the resulting variation levels are statistically significant or not. A t-test was performed between the open flowers and closed buds of both male and female flowers, respectively, to check if there is any chronological difference in the opening of male and female flowers.

Inflorescence sex ratio and floral morphology

A sample of 50 flowers, each for male and female sex, was used to record floral morphometrics. A sample of 50 plants was used to record the average number of male and female flowers produced in individual inflorescences. Anthesis schedule and flower lifespan were observed in the field itself.

Foraging activity and pollination

Pollinators were observed in three 3×1 m randomly chosen patches of *B. satrapis* which were reselected on 31 August, 1, 2 and 14 September 2017 (as per Ågren & Schemske 1991). The observation period for the day continued until the pollinators ceased to visit the flowers. Before making observations, number of open male and female flowers were counted within the monitored patch. A total of 1,013 open flowers were counted in each of the inflorescences of the monitored patch out of which 895 were male flowers and 118 were open female flowers. The foraging behaviour of pollinators that entered the patch was observed until they moved out

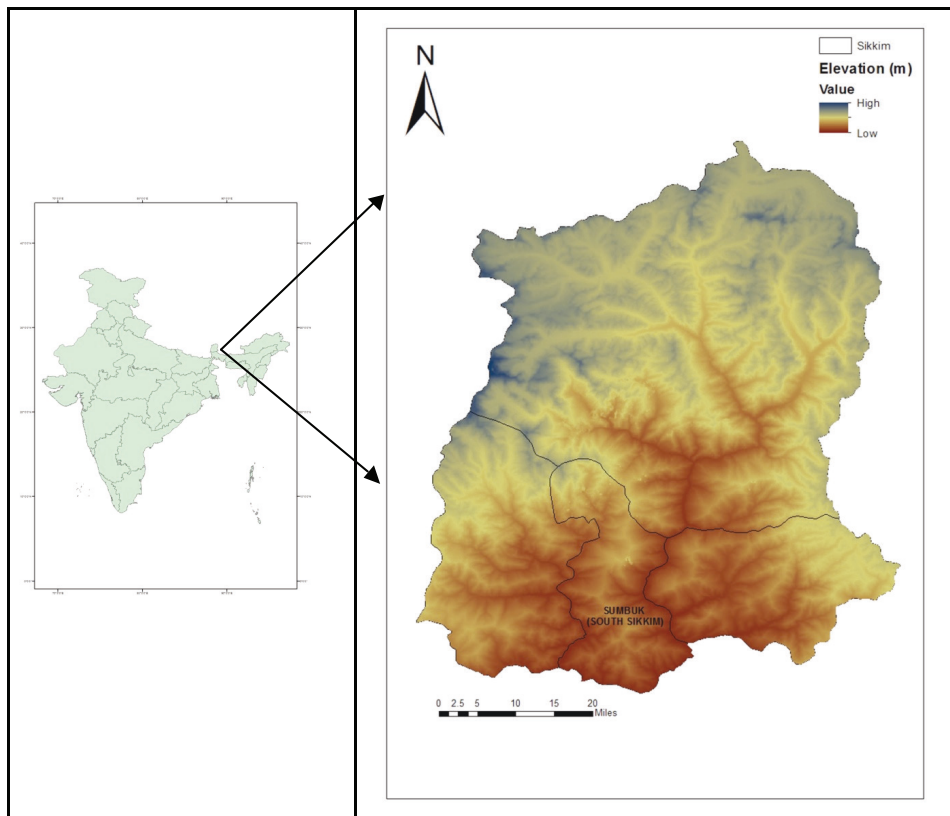


Figure 1. Study site in South Sikkim, the eastern Himalaya.

of it. The number of visits to both the male and female flower were recorded. The time spent on each flower was recorded with a stopwatch in each monitored patch (Male: N=50; Female: N=14). A minimum count of 50 visits to the flowers were kept mandatory in each monitored patch. To test if pollination occurs by wind, several of the buds (N=25) were bagged with mosquito nets which were made into small bags to exclude visitors in order to record the fruit and seed set rate. Similarly, another set of buds (N=25) were bagged and tagged with ribbons to test apomixis.

Apis florea and *Bombus breviceps* were the most frequent pollinators throughout this study. A few rare visits by two other unidentified bee species were noted. The observations were made only on *A. florea* and *B. breviceps* as other foragers visited the flowers rarely.

Hand pollination

Female buds (N=50) were bagged and tagged with a coloured ribbon a day before their anthesis and were hand pollinated on the following day. Hand pollination was performed by brushing the fresh dehisced anther against the stigma of a different plant. Similarly, female buds (N=50) were tagged with a different coloured

ribbon and were left for open pollination. The matured fruits were collected to record the number of seeds produced against the number of ovules produced per flower. The pollen limitation was estimated as the ratio of hand cross pollination to open pollination (Larson & Barrett 2000). The scale ranged from 0–100 where 0 indicated no pollen limitation to 100 indicating pollen limitation. All the tagged flowers could not be retrieved at the time of their collection due to anthropogenic activities at the study site.

RESULTS

Floral morphological details

The flowers of *B. satrapis* bloom during July–October. The flowers are open from 05.00–06.00 h. A female flower lasts for 7–9 days while a male flower lasts for almost 15 days. The inflorescence is a cymose with male and female flowers with pink tepals (Image 1). Male flowers comprise four tepals (2+2) while female flowers comprise five tepals (2+3). The outer tepals of male flowers were significantly longer (1.5 ± 0.24 vs. 1.2 ± 0.17 cm; $t=1.55e-09$, $p<0.05$) and wider



Image 1. *Begonia satrapis*: a—habitat | b—male flower | c—female flower | d—*Apis florea* | e—*Bombus breviceps*. © Subhankar Gurung.

(1.2 ± 0.16 vs. 1.0 ± 0.16 cm; $t=4.05e-04$, $p<0.05$) than those of the female flowers. In addition to the two large tepals, the inner tepals were significantly longer (1.2 ± 0.17 vs. 1.0 ± 0.18 cm; $t=1.46e-06$, $p<0.05$) than the female flowers while the inner tepal width showed no significant difference (0.6 ± 0.17 vs. 0.7 ± 0.19 ; $t=0.13$, $p<0.05$, NS) in both male and female flowers. The male flowers produced 34.9 ± 4.1 stamens which are 4.3 ± 0.8 mm in length. The anthers are rimose and each one produced $3,761.3 \pm 1,409.4$ pollen grains. The anther and stigma of a male and female flower are yellow in colour and are located in the centre of the flower respectively. *B. satrapis* is protandrous and exhibits temporal separation in the production of male and female flowers. The inflorescence was considered as a male phase inflorescence when a larger number of male flowers were open compared to the number of female flowers. The number of open male flowers produced per inflorescence was 3.36 ± 1.84 , $N=50$ and that of female flowers was 0.34 ± 1.17 , $N=50$. The number of open male flowers and closed male flower buds per inflorescence did not differ ($t=0.39$, $p>0.05$, NS) whereas difference was observed between open female flowers and closed female flower buds per inflorescence in a population ($t=0.0001$, $p<0.05$).

Foraging activity and pollination

During nine hours of observation on pollinators' behaviour on *B. satrapis* a total of 458 male and 14 female flowers were visited by *A. florea* and 100 male and seven female flowers were visited by *B. breviceps* inside the monitored patches (Image 1). The flowers were foraged by bees as and when they were open and continued foraging activity until 12.00h. *Apis florea* and *B. breviceps* showed strong preference to male flowers than female flowers (Table 1). The number of flower visits in the monitored patches by *A. florea* varied between male (91.6 ± 49.8) and female flowers (2.8 ± 2.2 ; $t=0.007$, $p<0.05$). Similarly, 107 flowers visited by *B. breviceps* varied between male (20 ± 8.3) and female flowers (1.4 ± 1.3 ; $t=0.005$, $p<0.05$). *A. florea* and *B. breviceps* spent more time on male flowers than on female flowers due to pollen collection activity (Table 2). *Apis florea* used their legs to remove the pollen while *B. breviceps* performed vibration to collect pollen. Both bee species discriminated female flowers after making first visit to them. The foraging activity of *A. florea* was slower than *B. breviceps* while there was no significant difference in time spent on male flowers ($t=0.31$, $p>0.05$, NS) and female flowers ($t=0.13$, $p>0.05$, NS) by both bee species.

Table 1. Number of *A. florea* and *B. breviceps* visits to male and female flowers of *B. satrapis*.

Patch	Number of flowers in a patch		Number of flowers visited			
	Male	Female	<i>A. florea</i>		<i>A. breviceps</i>	
			Male	Female	Male	Female
1	177	7	60	2	22	2
1	177	7	175	6	32	0
2	173	26	48	2	15	2
3	197	16	83	4	10	3
2	173	63	92	0	21	0

Table 2. Time (in seconds) spent on male and female flowers of *B. satrapis* by *A. florea* and *B. breviceps*.

Patch	<i>A. florea</i>		<i>B. breviceps</i>	
	Male	Female	Male	Female
	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD
1	4.9 \pm 3.4	0.7 \pm 0.3	1.1 \pm 0.6	1.4 \pm 0.1
1	4.6 \pm 2.9	0.4 \pm 0.1	1.2 \pm 0.7	-
2	3.1 \pm 2.4	0.6 \pm 0.3	1.9 \pm 1.2	1.0 \pm 0.2
3	5.4 \pm 3.2	0.7 \pm 0.6	2.0 \pm 1.6	1.0 \pm 0.1
2	2.5 \pm 1.4	-	1.4 \pm 0.7	-
	4.1 \pm 2.7	0.6 \pm 0.3	1.5 \pm 0.9	1.2 \pm 0.1

Note: The visits to flowers outside the patch were also considered for better results.

Hand pollination

Although fruit set was observed in both hand pollinated and open pollinated flowers, hand pollination between male and female flowers of different plants resulted in an increase in seed set (95.4 ± 8.1 , $N=17$) than open pollination (81.1 ± 17.2 , $N=17$) and showed a significant difference between the two ($U=0.001$, $p<0.05$). Fruit and seed set was absent in both wind pollination and apomixis. The estimated pollen limitation (1.17) indicated that the pollinators deposit adequate pollen in its natural environment.

DISCUSSION

B. satrapis is a monoecious species with both male and female flowers borne in the same inflorescence whose morphological characters varied significantly between male and female flowers in a population. The larger tepals of male flowers appear to be an adaptation to provide visual stimuli to pollinator bees to locate the flowers that provide the reward (Ågren

& Schemske 1991). The anthesis of male flowers prior to female flowers enable the pollinators to habituate themselves to the forage source and visit rewardless female flowers by deceit when available on the same or different inflorescences of the same or different conspecific plants. Similar observations were reported in *Jacaratia dolichaula* (Bawa 1980) where pollinators first encountered the rewarding male flowers and therefore, reduced the chances of discrimination of early flowering rewardless female flowers (Corff et al. 1998). The stigmas of female flowers are yellow and strongly resemble male flowers. The female flowers attract pollinators by mimicking male flowers (Wiens 1978; Ågren & Schemske 1991). The rimose anthers are grouped in large number which facilitate pollen collection by vibration (Wyatt & Sazima 2011). The two important foragers *A. florea* and *B. breviceps* showed more preference to the male flowers than the female flowers. This possibly could be because of the pollinators ability to recognize unrewarding flowers (Wyatt & Sazima 2011). It was observed that *A. florea* seemed diffident to collect pollen from a male flower immediately after its visit to a male flower. The lower rate of visitation and the hesitation shown in collecting pollen could be because of the lack of fragrance which has been experimentally proven to be an important aspect to encourage landing on a female flower (Lunau 1991; Schemske & Ågren 1995). Despite the negligible visits to a female flower a high seed set was observed in flowers left for open pollination which could be because of pollination by vibration (Wyatt & Sazima 2011). When a pollinator performs vibration while it visits a female flower by deception it transfers a large load of small and powdery pollen to the stigma (Wyatt & Sazima 2011). A single visit is adequate to deposit a large amount of pollen load to the stigma (Wyatt & Sazima 2011). Seed set in hand pollination was significantly higher than that of open pollination. The lack of pollen limitation, however, indicates that the pollinators are efficient in depositing pollen for successful seed set. Since wind pollination and apomixis are absent in *B. satrapis*, it becomes evident that it depends largely on pollinators for its successful sexual reproduction.

CONCLUSION

It is apparent from our study that the pollinators prefer to visit the polleniferous male flowers more than the rewardless female flowers. The imperfect discrimination by the pollinators by the number of

“mistaken” visits to female flowers, however, guarantees pollination by deceit. Further, abundant fruit and seed set indicate that pollinators are efficient in contributing to the production of fruit and seed in *B. satrapis*. The study indicates that *A. florea* and *B. breviceps* are the principal pollinators of *B. satrapis* and hence, this plant is melittophilous.

REFERENCES

- Adhikari, D., Z. Reshi, B.K. Datta, A. Chettri, K. Upadhaya, M.A. Shah, P.P. Singh, R. Tiwary, K. Majumdar, A. Pradhan, M.L. Thakur, N. Salam, S.H. Mir, Z.A. Kaloo & S.K. Barik (2018). Inventory and characterization of new populations through ecological niche modelling improve threat assessment. *Current Science* 114(3): 519–531. <https://doi.org/10.18520/cs/v114/i03/519-531>
- Ågren, J. & D.W. Schemske (1991). Pollination by deceit in a neotropical monoecious herb, *Begonia involucreta*. *Biotropica* 23: 235–241. <https://doi.org/10.2307/2388200>
- Bawa, K.S. (1980). Mimicry of male by female flowers and intrasexual competition for pollinators in *Jacaratia dolichaula* (D. Smith) Woodson (Caricaceae). *Evolution* 34: 467–474. <https://doi.org/10.2307/2408216>
- Castillo, R.A., C. Cordero & C.A. Domínguez (2002). Are reward polymorphisms subject to frequency- and density-dependent selection? Evidence from a monoecious species pollinated by deceit. *Journal of Evolutionary Biology* 15: 544–552. <https://doi.org/10.1046/j.1420-9101.2002.00425.x>
- Corff, J.L., J. Ågren & D.W. Schemske (1998). Floral display, pollinator discrimination and female reproductive success in two monoecious *Begonia* species. *Ecology* 79: 1610–1619.
- Larson, B.M.H. & S.C.H. Barrett (2000). A comparative analysis of pollen limitation in flowering plants. *Biological Journal of the Linnean Society* 69: 503–520.
- Little, R.J. (1983). A review of floral food deception mimics with comments on floral mutualism, pp294–309. In: Jones, C.E. & R.J. Little (eds.). *Handbook of Experimental Pollination Biology*. New York Press, New York, 558pp.
- Lunau, K. (1991). Innate flower recognition in bumblebees (*Bombus terrestris*, *B. lucorum*; Apidae): Optical signals from stamens as landing reaction releasers. *Ethology* 88: 203–214. <https://doi.org/10.1111/j.1439-0310.1991.tb00275.x>
- Renner, S.S. (2006). Rewardless flowers in Angiosperms and the role of insect cognition in their evolution, pp123–144. In: Waser, N.M. & J. Ollerton (eds.). *Plant-pollinator Interactions. From Specialization to Generalization*. University of Chicago Press, Chicago.
- Schemske, D.W. & J. Ågren (1995). Deceit pollination and selection on female flower size in *Begonia involucreta*: an experimental approach. *Evolution* 49: 207–214. <https://doi.org/10.1111/j.1558-5646.1995.tb05972.x>
- Vogel, S. (1998). Remarkable nectarines: structure, ecology, organophyletic perspectives IV. Miscellaneous cases. *Flora* 193: 225–248.
- Wiens, D. (1978). Mimicry in plants, pp365–403. In: Hecht, M.K., W.C. Steere & B. Wallace (eds.). *Evolutionary Biology*. Plenum Press, New York, 655pp.
- Willson, M.F. & J. Ågren (1989). Differential floral rewards and pollination by deceit in unisexual flowers. *Oikos* 55: 23–29. <http://doi.org/10.2307/3565868>
- Wyatt, G.E. & M. Sazima (2011). Pollination and reproductive biology of thirteen species of *Begonia* in the Serra Do Mar State Park, Sao Paulo, Brazil. *Journal of Pollination Ecology* 6: 95–107.





The Journal of Threatened Taxa (JoTT) is dedicated to building evidence for conservation globally by publishing peer-reviewed articles online every month at a reasonably rapid rate at www.threatenedtaxa.org. All articles published in JoTT are registered under [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/) unless otherwise mentioned. JoTT allows unrestricted use, reproduction, and distribution of articles in any medium by providing adequate credit to the author(s) and the source of publication.

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

August 2019 | Vol. 11 | No. 10 | Pages: 14247–14390
Date of Publication: 26 August 2019 (Online & Print)
DOI: 10.11609/jott.2019.11.10.14247-14390

www.threatenedtaxa.org

Editorial

Wildlife's Wonder Woman—Sally Raulston Walker (12 October 1944–22 August 2019)
– Sanjay Molur, Pp. 14247–14248

Communications

Species diversity and spatial distribution of amphibian fauna along the altitudinal gradients in Jigme Dorji National Park, western Bhutan
– Bal Krishna Koirala, Karma Cheda & Tshering Penjor, Pp. 14249–14258

The soft-release of captive-born Kaiser's Mountain Newt *Neurergus kaiseri* (Amphibia: Caudata) into a highland stream, western Iran
– Tayebe Salehi, Vahid Akmal & Mozafar Sharifi, Pp. 14259–14267

The status of waterbird populations of Chhaya Rann Wetland Complex in Porbandar, Gujarat, India
– Dhavalkumar Vargiya & Anita Chakraborty, Pp. 14268–14278

Diversity and temporal variation of the bird community in paddy fields of Kadharamangalam, Tamil Nadu, India
– Chaitra Shree Jayasimhan & Padmanabhan Pramod, Pp. 14279–14291

First videos of endemic Zanzibar Servaline Genet *Genetta servalina archeri*, African Palm Civet *Nandinia binotata* (Mammalia: Carnivora: Viverridae) and other small carnivores on Unguja Island, Tanzania
– Helle V. Goldman & Martin T. Walsh, Pp. 14292–14300

The identification of pika and hare through tricho-taxonomy (Mammalia: Lagomorpha)
– Manokaran Kamalakannan, Kailash Chandra, Joy Krishna De & Chinnadurai Venkatraman, Pp. 14301–14308

Palynological analysis of faecal matter in African Forest Elephants *Loxodonta cyclotis* (Mammalia: Proboscidea: Elephantidae) at Omo Forest Reserve, Nigeria
– Okwong John Walter, Olusola Helen Adekanmbi & Omonu Clifford, Pp. 14309–14317

Avitourism opportunities as a contribution to conservation and rural livelihoods in the Hindu Kush Himalaya - a field perspective
– Nishikant Gupta, Mark Everard, Ishaan Kochhar & Vinod Kumar Belwal, Pp. 14318–14327

Pollination in an endemic and threatened monoecious herb *Begonia satrapis* C.B. Clarke (Begoniaceae) in the eastern Himalaya, India
– Subhankar Gurung, Aditya Pradhan & Arun Chettri, Pp. 14328–14333

Multivariate analysis of elements from the microhabitats of selected plateaus in the Western Ghats, Maharashtra, India
– Priti Vinayak Aphale, Dhananjay C. Meshram, Dyanesh M. Mahajan, Prasad Anil Kulkarni & Shraddha Prasad Kulkarni, Pp. 14334–14348

Partner



Member



Short Communications

Diversity of butterflies of the Shettihalli Wildlife Sanctuary, Shivamogga District, Karnataka, India
– M.N. Harisha, Harish Prakash, B.B. Hosetti & Vijaya Kumara, Pp. 14349–14357

First record of two rare brachyuran crabs: *Drachiella morum* Alcock, 1896 and *Quadrella maculosa* Alcock, 1898 along the Tamil Nadu coast, India
– Chinnathambi Viswanathan, Sampath Goutham, Vijay Kumar Deepak Samuel, Pandian Krishnan, Ramachandran Purvaja & Ramachandran Ramesh, Pp. 14358–14362

Records of the Marbled Cat *Pardofelis marmorata* and the Asiatic Golden Cat *Catopuma temminckii* (Mammalia: Carnivora: Felidae) from the community forests surrounding the Dzükou Valley in Nagaland, India
– Bhavendu Joshi, Biang La Nam Syiem, Rokohebi Kuotsu, Arjun Menon, Jayanta Gogoi, Varun Rshav Goswami & Divya Vasudev, Pp. 14363–14367

Rediscovery of *Calanthe davidii* (Orchidaceae) after 11 decades in the western Himalaya, India
– Ashutosh Sharma, Nidhan Singh & Pankaj Kumar, Pp. 14368–14372

Notes

Range extension of the Gooty Tarantula *Poecilotheria metallica* (Araneae: Theraphosidae) in the Eastern Ghats of Tamil Nadu, India
– Kothandapani Raman, Sivangnanaboopathidoss Vimalraj, Bawa Mothilal Krishnakumar, Natesan Balachandran & Abhishek Tomar, Pp. 14373–14376

Some recent evidence of the presence of the Critically Endangered *Gyps* vulture populations in northern Shan State, Myanmar
– Sai Sein Lin Oo, Nang Lao Kham, Kyaw Myo Naing & Swen C. Renner, Pp. 14377–14380

Two new locations for the Vulnerable Black-necked Crane *Grus nigricollis* (Przhevalsky, 1876) (Aves: Gruiformes: Gruidae) in Arunachal Pradesh, India
– Rohan Krish Menzies, Megha Rao & Abhinav Kumar, Pp. 14381–14384

***Aquilaria malaccensis* (Malvales: Thymelaeaceae): a new host plant record for *Deudorix epijarbas cinnabarus* (Lepidoptera: Lycaenidae) in Malaysia**
– Kah Hoo Lau & Su Ping Ong, Pp. 14385–14387

Rediscovery of Nilgiri Mallow *Abutilon neelgerrense* var. *fischeri* T.K. Paul & M.P. Nayar (Malvaceae) after a century from southern India
– Varsha Vilasrao Nimbalkar, Arun Prasanth Ravichandran & Milind Madhav Sardesai, Pp. 14388–14390

Publisher & Host

