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Foxglove, *Digitalis purpurea*: An Eco-feast Plant for Bumble Bee Conservation in the Northwestern Himalayas

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Abstract

Bumble bees (*Bombus* spp.) are key pollinators in the Himalayan ecosystem, but habitat degradation and scarcity of floral resources threaten their populations. Foxglove, *Digitalis purpurea,* an introduced plant with a deep corolla, is an important source of pollen and nectar for bees and harbours four species of bumble bees, *viz*. *Bombus haemorrhoidalis* Smith, *Bombus tunicatus* Smith, *Bombus simillimus* Smith, and *Bombus eurythorax* Wang in the Jammu region of the Northwestern Himalayas. The nest count and abundance of *B. tunicatus* and *B. simillimus* were significantly higher in patches with *D. purpurea* plantation ($p < 0.05$) as compared to control patches. The individuals of *B. tunicatus* and *B. simillimus* foraging on the flowers of *D. purpurea* were more vigorous in terms of body length and body weight ($p < 0.05$) as compared to the individuals foraging on other habitat patches. A strong positive correlation was found between the corolla lengths of the examined flower species and the tongue lengths of nectar-gathering bumble bees ($r = 0.89$). Besides, long-tongued *Bombus* species are attracted to flowers of *D. purpurea* due to the deep corolla and higher nectar production ($p < 0.05$). *D. purpurea* is recommended as an eco-feast plant for bumble bee conservation, and its planting in pollinator gardens will ensure efficient pollination by bumble bees. Hence, this study provides the first scientific evidence of the role *D. purpurea* plays in bumble bee conservation in the Indian Himalayas.

Introduction

Bumble bees (*Bombus* spp.) are important insect pollinators of flowering crops and wildflowers (Goulson, 2010). Long-tongued bumble bees have specifically evolved to feed on nectar from flowers with tubular, deep corollas. Their long proboscis enables them to effectively pollinate plant species that are inaccessible to pollinators with shorter tongues. They are therefore necessary for many long-corolla crops and wildflowers to reproduce successfully (Benton, 2006). From a conservation standpoint, long-tongued bumble bees are particularly important because plants with long corollas, such as crops and wildflowers, would otherwise receive insufficient pollination. Bumble bee conservation is crucial for sustaining food production, especially in the high elevations of the northwestern Himalayas, where they play a significant role in pollinating major cultivated and wildflower crops. To restore declining pollination services by bumble bees, the Government of India envisages creating pollination gardens, for which eco-feast plants for bumble bees need to be identified. The global decline in bumble bees threatens pollination services, but little is known about the eco-feast

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plants that sustain wild populations in the Himalayan region of India. The widespread loss of bumble bee species in the United Kingdom and in North America is a wake-up call for native bee species in India (Colla et al., 2012). Globally, this decline is attributed to the loss of floral resources, urbanization, land-use changes, deforestation, pests and pathogens, and abrupt habitat changes (Cameron et al., 2011). Since these bees are considered incredible pollinators of many commercially grown plants, they are being explored for commercial buzz pollination by Bio-Bee Biological Systems in Israel, for the protected cultivation of crops such as tomatoes, apples, almonds, kiwi, strawberries, and cucumbers in developed nations. In India, their distribution is primarily reported in the Himalayan hill and mountain ecosystems, and nearly 57 bumble bee species have been reported so far (Raina et al., 2024). No doubt their diversity is sustained, yet preliminary reports indicate that their foraging density and spatial distribution along the land gradient are declining rapidly in India. While information on their population decline is scarce, a recent report documents the shift of selective species to higher altitudes (Guleria, 2022). Given their immense importance, government initiatives to establish pollinator-friendly gardens are attracting scientists' attention in India. These gardens support insectary plants for bumble bees, providing nectar, pollen, and habitat for native bees, thereby sustaining pollinators essential to their conservation and survival.

Foxglove, *Digitalis purpurea*, a facultative biennial plant of the Plantaginaceae family, is widely grown above 1250 m above sea level in the union territory of J & K. It is an introduced plant in India, which is native to continental Europe and Britain, and has expanded its range into sub-continental areas over the last few decades (Willis et al., 2000). The genus name *Digitalis* was derived from the Latin word *Digitabulum*, meaning thimble or finger, which resembles the flower characteristics (Qualtrocchi, 2000). In the early 1880s, different attempts were made to grow *D. purpurea* in India as a regular crop of leaves for the most essential glucoside found in the plant, Digoxin, which is used in medicine. In the UK and other parts of Europe, previous investigations have found an association between long-tongued bumble bee species and *D. purpurea* and have also observed that as *D. purpurea* plant density increases, bumble bee visitation rate increases (Grindeland et al., 2005). In this context, we evaluated the role of *Digitalis purpurea* in sustaining native bumble bee populations in Jammu. We also investigated bumble bees' flower preference and studied the relationship between corolla lengths of the examined flower species and the tongue lengths of nectar-collecting bumble bees. Although the ecological significance of *D. purpurea* for bumble bees has been highlighted in European studies (Broadbent & Bourke, 2012). However, this work offers the first empirical assessment of its conservation potential in the Indian Himalayas, where habitat fragmentation threatens native *Bombus* species. We hypothesize that *D. purpurea* attracts a higher abundance of bumble bees with larger body size and elongated proboscises, owing to its deep corolla and abundant nectar rewards.

Materials and Methods

The investigation examined the visitation of native bumble bee species to the natural population of *Digitalis purpurea* in the Jammu region of the Northwestern Himalayas. The study was conducted on flowering patches in two habitats across four districts of the Jammu region from May to July over two years (2021-2022). Exploratory surveys were conducted in bumble bee hotspots in the Jammu region, viz. Nathatop (33.09º N, 75.24º E), Sanasar (33.12º N, 75.26º E), Thanthera (32.91º N, 75.72º E), and Chhatergala (34.15º N, 77.57º) (Figure 1b). Individuals of *Bombus* species were collected using an insect net for identification between 9:00 am and 5:00 pm (Williams, 2022).

During the survey, two habitat types were compared in a bumble bee hotspot to assess the impact of *D. purpurea* on bumble bee foraging behavior. The sampling design consisted of 20 independent patches representing the two habitat types, each approximately 500 m². Of these, ten patches were dominated by *D. purpurea* (≥ 70% floral coverage), and ten were control patches lacking *D. purpurea*. Each patch represented an independent experimental replicate. Within each patch, a single 1 m² quadrat (measured with a PVC quadrat frame) was randomly placed and visually surveyed for 5 minutes. All bumble bee visitors to open flowers within the quadrat were counted and identified, regardless of species.

In addition to foraging observations, bumble bee abundance and nest counts were observed in the open areas across both patch types. Further, to assess differences in bumble bee visitation patterns between habitat types, the relative proportion of visits was calculated for each bumble bee species. For each patch, the number of visits recorded for a given species was divided by the total number of bumble bee visits recorded within that patch, yielding the proportion of visits attributable to each species. To locate active bumble bee nests, foraging individuals were traced back to their nest entrances, and nest counts were carried out within a 500-meter radius of each patch. For each dependent variable, including bumble bee visitation rate, abundance, and nest counts, the sample size was $n = 10$, corresponding to ten independent patches in each treatment category.

Additionally, floral traits such as nectar concentration and corolla length were recorded for plants foraged by bumble bees in both habitats. To quantify nectar volume, five flower buds of each host plant were bagged in voile-cotton bags the day before anthesis to prevent pollinator access. Nectar sampling was carried out between 08:00 and 09:00 a.m., which coincided with whole flower opening and the onset of bee activity. Nectar was extracted from freshly opened flowers or intact flowers using a microcapillary of 90mm length, which was gently inserted at the base of the staminoids to allow capillary action to draw up the nectar (Hocking, 1953).

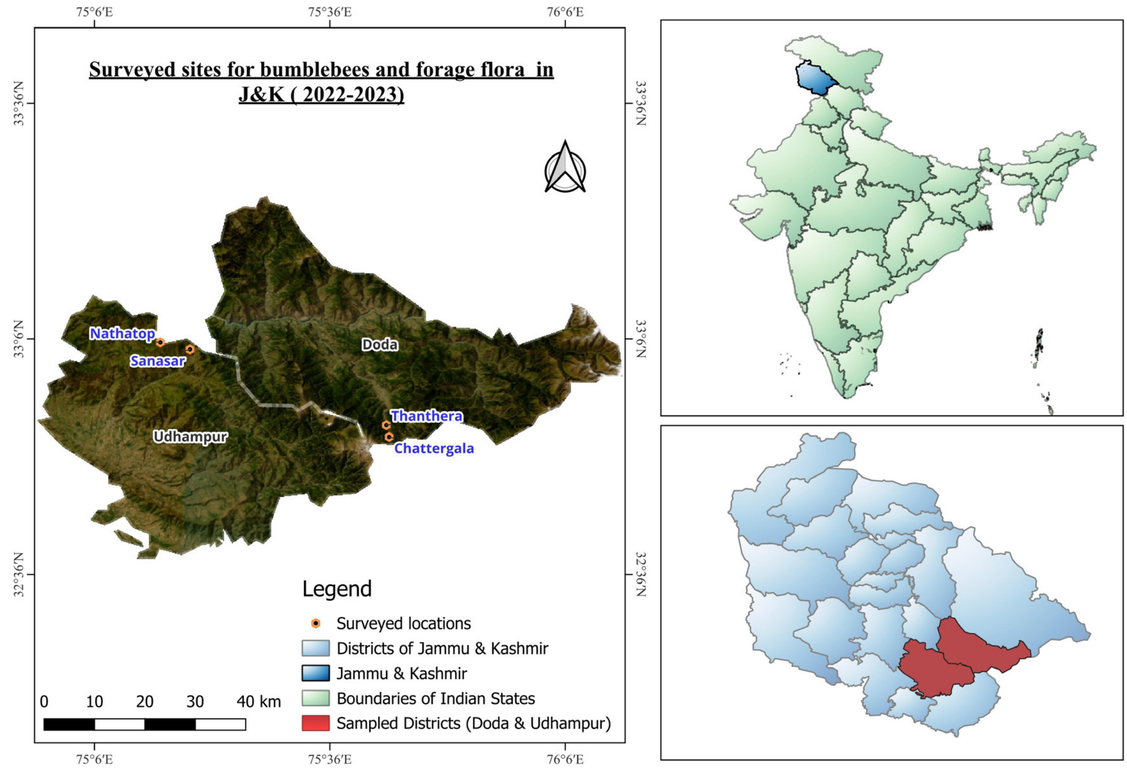

Fig 1. Survey locations in the Jammu region.

The nectar volume was estimated by measuring the length of the nectar column in micro capillary. Then, fresh flowers from different flower stalks were collected to measure corolla tube lengths using a vernier calliper or measuring scale. For morphological measurements, five individuals per species per site were collected using an entomological net. Bee specimens were euthanized using ethyl acetate and preserved for further morphological analysis. The body weight of foragers as well as bees collected from the nest's vicinity was measured by using an electronic balance. Further, morphological measurements like body length, *i.e.,* from the dorsal side of the head to the last segment of the abdomen, and the length of the proboscis or glossa out of the bee's mouth parts were measured using a stereomicroscope with an ocular micrometer in freshly caught bumble bees. The samples were pinned with entomological pins and identified to the family, genus, subgenus, and species levels using appropriate taxonomic keys and available literature (Williams, 2022).

Statistical Analysis

All data were analyzed using SPSS software (v26). We used a paired t-test to compare the mean number of nests, number of foragers, body weight, and proboscis length of foragers observed in the *D. purpurea* and control patches. The data on corolla length, nectar volume, and proboscis length of bumble bees were statistically analyzed using one-way ANOVA followed by Tukey's HSD post hoc test for comparison of means. The relationship between corolla length and proboscis length, nectar volume, body length, and body weight was examined using Pearson's correlation and regression equation.

Results

Our surveys identified four bumble bee species, viz. *Bombus haemorrhoidalis*, *Bombus tunicatus*, *Bombus simillimus,* and *Bombus eurythorax* foraging on flowers of *D. purpurea* (Figure 2). Among these bumble bee species, three species, viz. *B. haemorrhoidalis*, *B. tunicatus,* and *B. simillimus* were also observed foraging on alternative hosts such as *Strobilanthes* sp., *Impatiens balsamina, Cirsium falconeri,* and *Trifolium pratense* in control patches. The temperate *Bombus* species, i.e., *B. tunicatus*, *B. simillimus,* and *B. eurythorax,* were the main and frequent visitors of *D. purpurea*. While the first two species exhibited foraging plasticity by foraging on alternative host plants, *B. eurythorax* displayed exclusive floral fidelity to *D. purpurea*, relying entirely on this species for its nectar and pollen requirements.

The proportionate visitation rates of four bumble bee species to *Digitalis purpurea* differed significantly between the two flower patch conditions. Under both conditions, *B. tunicatus* and *B. simillimus* exhibited significantly higher visitation to floral resources, whereas *B. haemorrhoidalis* had a moderate visitation rate (Figure 3). However, nest counts of *B. tunicatus* ($F = 28.855$; df = 1,18; $p < 0.05$) and *B. simillimus* ($F = 22.407$; df = 1,18; $p < 0.05$) were significantly higher in patches of *D. purpurea* as compared to other patches,

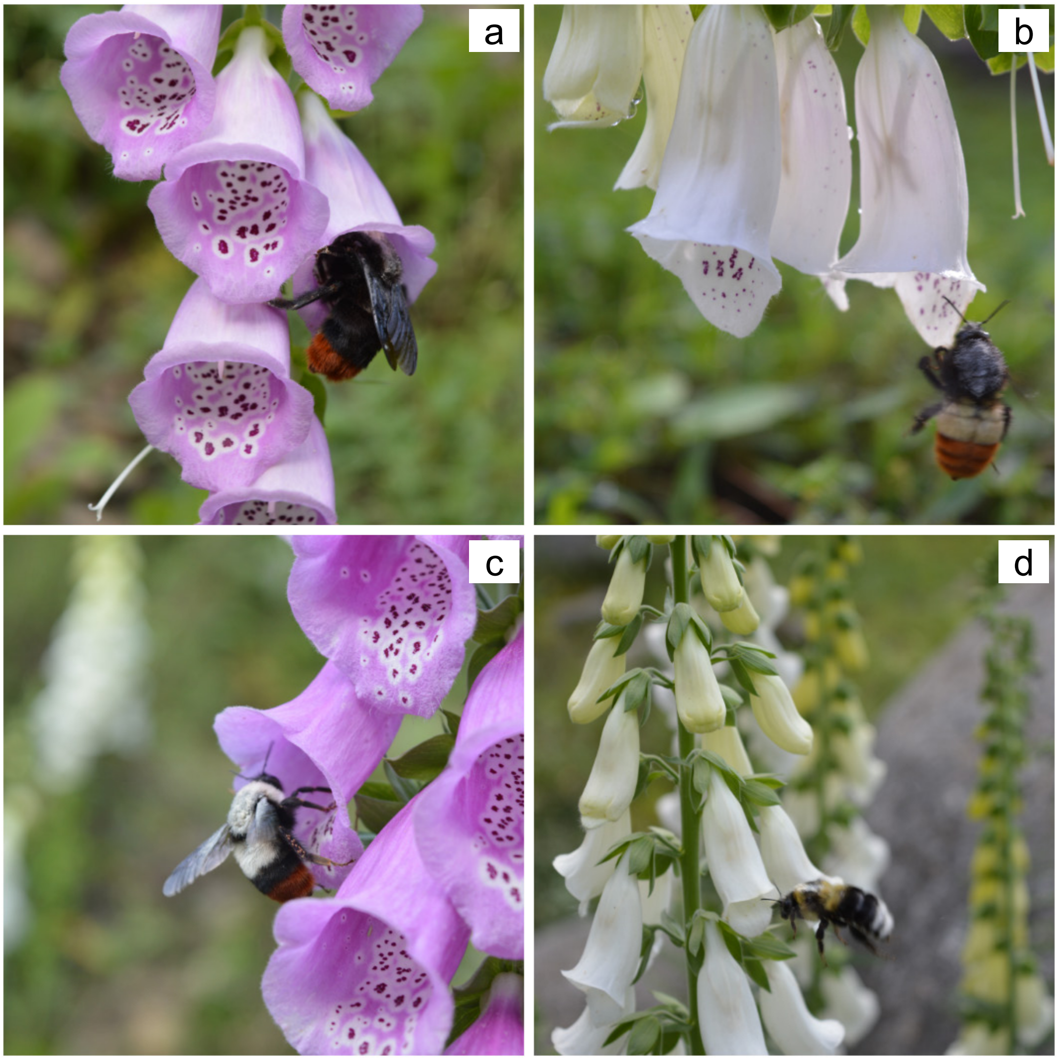

Fig 2. *Bombus* species visiting flowers of *Digitalis purpurea*: a) *Bombus simillimus*, b) *Bombus haemorrhoidalis*, c) *Bombus tunicatus*, d) *Bombus eurythorax.*

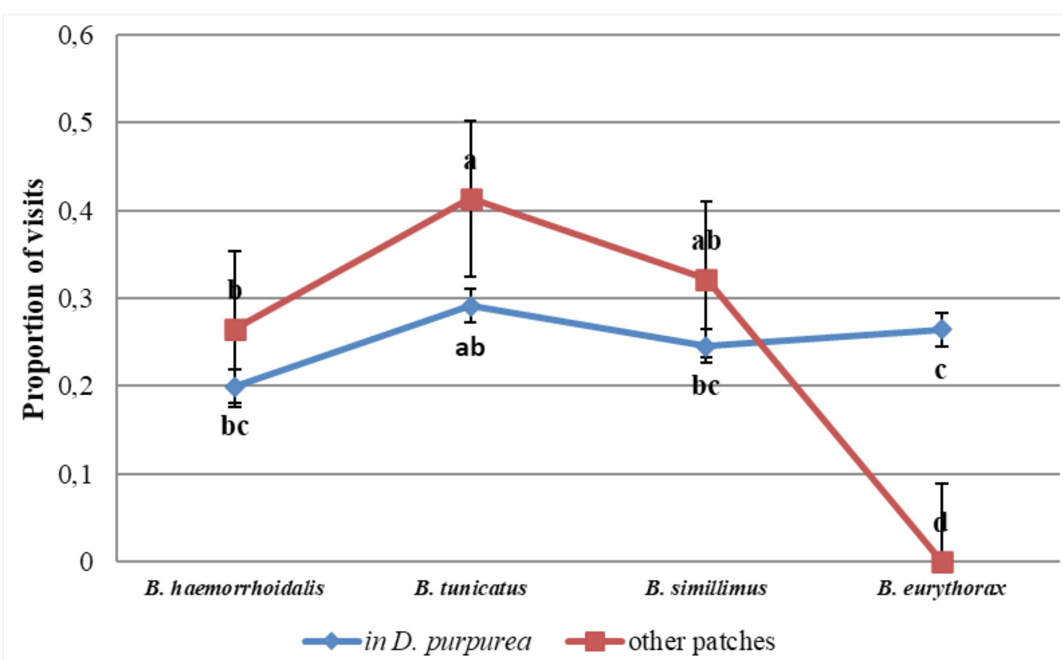

Fig 3. Relative proportion of visits of bumble bee species across *D. purpurea* and control patches.

while no significant difference in the number of nests of *B. haemorrhoidalis* in both habitats was observed. Nevertheless, *B. eurythorax* nests were recorded only within a vicinity (500 meters) of the *D. purpurea* plantation. A similar trend was recorded for the abundance of bumble bee foragers/m^2/5 min, wherein significantly higher numbers of individuals of *B. tunicatus* ($F = 26.780$; $df = 1,18$; $p < 0.05$) and *B. simillimus* ($F = 33.60$; $df = 1,18$; $p < 0.05$) were recorded in patches of *D. purpurea* as compared to patches having other host plants (Table 1).

Table 1. Nest count, number of foragers/m^2/5 min, body weight, and proboscis length observed in *D. purpurea* and control patches.

Bombus species	*B. haemorrhoidalis* (Mean ± SE*)	*B. tunicatus* (Mean ± SE*)	*B. simillimus* (Mean ± SE*)	*B. eurythorax* (Mean ± SE*)
Nests count				
D. purpurea patches	3.8 ± 0.24^{a}	6.7 ± 0.30^{b}	5.8 ± 0.32^{b}	4.0 ± 0.33^{a}
Control patches	1.5 ± 0.26^{b}	4.4 ± 0.30^{c}	3.9 ± 0.23^{c}	0.00^{a}
Number of foragers				
D. purpurea patches	7.4 ± 0.30^{a}	0.8 ± 0.41^{c}	9.1 ± 0.37^{b}	9.8 ± 0.41^{bc}
Control patches	5.2 ± 0.32^{b}	8.1 ± 0.31^{d}	6.3 ± 0.30^{c}	0.00^{a}
Body weight				
D. purpurea patches	0.44 ± 0.002^{b}	0.42 ± 0.002^{a}	0.46 ± 0.002^{d}	0.45 ± 0.002^{c}
Control patches	0.43 ± 0.002^{c}	0.39 ± 0.003^{b}	0.43 ± 0.003^{c}	0.00^{a}
Proboscis length				
D. purpurea patches	13.4 ± 0.16^{d}	10.6 ± 0.16^{a}	11.6 ± 0.16^{b}	12.3 ± 0.15^{c}
Control patches	12.3 ± 0.15^{d}	9.7 ± 0.15^{b}	10.5 ± 0.16^{c}	0.00^{a}

*Mean ± S.E. with different superscripts within the same row are significantly different at $p < 0.05$.

Since proboscis length is an important factor in determining the efficiency of nectar extraction by bumble bees' foragers, we observed that long-tongued bumble bees primarily partitioned their flower resources based on the relationship between proboscis length and corolla tube length. A strong positive correlation ($r = 0.89$; $R^2 = 0.80$; $p < 0.05$) was found between flower corolla lengths and the proboscis lengths of nectar-gathering bumble bees. Moreover, it was found that the individuals of *B. haemorrhoidalis* ($F = 24.20$; $df = 1,18$; $p < 0.05$), *B. tunicatus* ($F = 16.20$; $df = 1,18$; $p < 0.05$), and *B. simillimus* ($F = 22.22$; $df = 1,18$; $p < 0.05$) foraging on patches of *D. purpurea* had significantly longer proboscis length than individuals of same species foraging on other patches having no flowers of *D. purpurea*. Furthermore, corolla length also showed a significant positive correlation ($r = 0.94$; $R^2 = 0.89$; $p < 0.01$) with the nectar volume (Fig 4). Among the various hosts, it was found that the flowers of *D. purpurea* have the longest corolla length compared to the other preferred host plants by bumble bees ($F = 63.525$; $df = 4,35$; $p < 0.05$). Plants with deep corollas like *D. purpurea* ($F = 46.882$; $df = 4,35$; $p < 0.05$) also produced significantly higher amounts of nectar when compared to plants of other host species (Table 2).

It was found that individuals of *B. tunicatus* ($F = 52.20$; $df = 1,18$; $p < 0.05$) and *B. simillimus* ($F = 53.30$; $df = 1,18$; $p < 0.05$) foraging on flowers of *D. purpurea* were more vigorous in terms of body weight when compared to the individuals foraging on other patches, the difference being significant (Table 1). The same trend was observed in terms of body length, where individuals of *B. tunicatus* ($F = 2.437$; $df = 1,18$; $p < 0.05$) and *B. simillimus* ($F = 3.460$; $df = 1,18$; $p < 0.05$) foraging on flowers of *D. purpurea* were longer than individuals foraging on other patches. This showed that flowers of *D. purpurea* were preferred by large-sized bumble bees, including *B. eurythorax*. Further, corolla length ($r = 0.92$; $R^2 = 0.89$; $p < 0.05$) was found to strongly influence the body length of bumble bees. Along with body length, the body weight of bumble bees was also impacted by corolla length ($r = 0.94$; $R^2 = 0.85$; $p < 0.05$) (Figure 4).

Table 2. Corolla length and nectar volume per flower foraged by bumble bees.

S. No.	Host Plants	Corolla Length (mm) (Mean + SE)*	Nectar Volume (µl) (Mean + SE)*
1.	*Digitalis purpurea*	43.20 ± 0.35^{d}	17.75 ± 0.19^{d}
2.	*Strobilanthes sp.*	32.88 ± 2.55^{c}	12.25 ± 1.43^{c}
3.	*Impatiens balsamina*	24.25 ± 1.54^{b}	9.46 ± 0.25^{bc}
4.	*Cirsium falconeri*	18.62 ± 0.57^{ab}	4.07 ± 0.82^{a}
5.	*Trifolium spp.*	15.22 ± 0.35^{a}	7.03 ± 0.26^{ab}

*Mean ± S.E. with different superscripts within the same column are significantly different at $p < 0.05$.

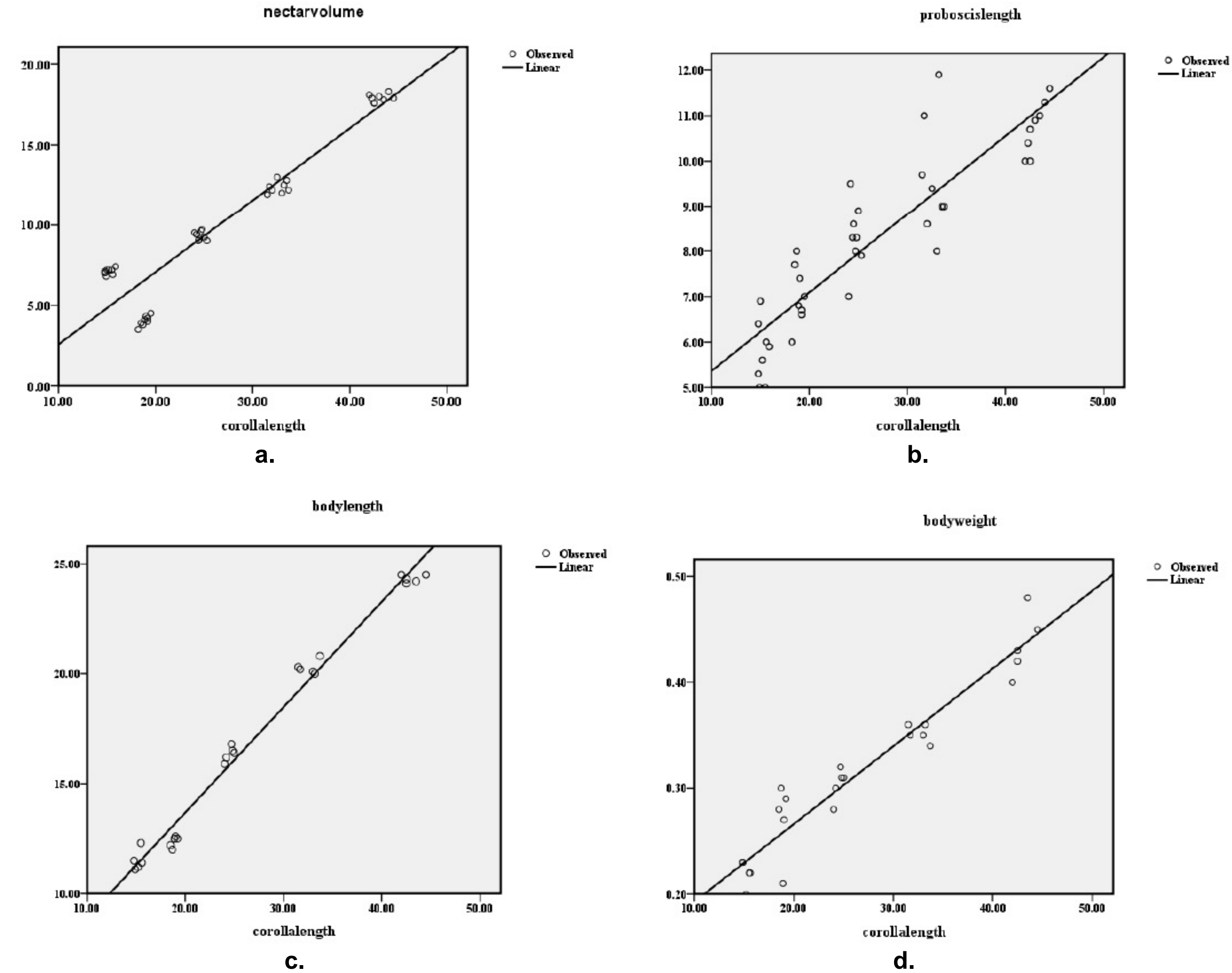

Fig 4. Regression analysis between corolla length against a) nectar volume, b) proboscis length, c) body length, and d) body weight.

Discussion

We recorded four bumble bee species visiting *D. purpurea* flowers, consistent with findings by Grindeland et al. (2005), who documented the presence of different bumble bee species visiting this plant, highlighting its attractiveness to *Bombus* species. The prevalence of long-tongued *Bombus* species as the primary visitors to *D. purpurea* is likely due to their adaptation to its long corolla (Broadbent & Bourke, 2012). This was because of the hindrance faced by the short-tongued bees in the collection of nectar from the flowers of *D. purpurea.* Apparently, the bumble bee species primarily partitioned their flower resources based on proboscis and corolla length (Stiles, 1975). For instance, long-tongued *Bombus* species were attracted to the flowers of *D. purpurea* because of copious nectar production that was attributed to the presence of large nectaries in deep corolla plants (Gomez et al., 2008). Owing to deep corollas, evaporation probably slowed down in this species, which retained higher nectar volume, leading to the predominance of long-tongued *Bombus* species (Grindeland et al., 2005; Pleasants, 1983). The deep corollas of *D. purpurea* were probably better handled by bumble bees of large size in terms of body length and body weight. Because of a higher amount of nectar, the mean foraging time of bumble bees on the flower of *D. purpurea* was higher than in other patches. The time required to visit a flower is affected by body weight, tongue length, corolla depth, and nectar volume (Harder, 1983). Thus, foraging on *D. purpurea* flowers saved the energy of long-tongued bumble bees and also fulfilled the nectar requirements in fewer visits as compared to bumble bees of other patches, where they have to take more visits to fulfil their nectar requirements.

The current findings highlight *D. purpurea* as a valuable floral resource across all bumble bee hotspot sites in the Jammu region. Nathatop, Sanasar, Thanthera, and Chhatergala. These hotspot sites have a higher abundance of *Digitalis* plants and support the highest bumble bee diversity and abundance. This result contrasts with the detrimental effects alien species have on native biota. Based on our research, *D. purpurea* appears to support local bumble bee populations without causing significant harm to native plant communities. Notably, *D. purpurea* was predominantly observed near water sources in microhabitats where native bumble bee-favored plants were largely absent. This suggests that its establishment does not include the displacement or competitive exclusion of native flora. The flowering period may supply vital foraging resources during seasonal gaps in native floral availability, and its deep, tubular blooms provide a rich nectar source that is especially well-suited to long-tongued bumble bee species. Given its seasonal bloom and compatibility with bumble bee foraging patterns, *D. purpurea* could be a useful supplemental plant in pollinator restoration initiatives. Therefore, we suggest using it cautiously in other areas, supported by long-term monitoring and site-specific ecological evaluations to ensure it aligns with regional biodiversity objectives. When introduced under carefully monitored, ecologically conscious conditions, *D. purpurea* helps sustain bumble bee populations, particularly in regions where pollinator populations are declining or flowers are scarce.

Consequently, the All India Coordinated Research Project on Honeybees and Pollinators is focusing on pollinator gardens, or bee hotels, as part of a broader strategy to support *in situ* conservation of pollinators. Identifying a key native, eco-feast plant that provides floral rewards and also supports pollinator diversity is crucial for the effective establishment of these gardens. These areas not only aid in conservation of bumble bee populations but also help in understanding their nesting behavior, which would further provide deeper, valuable insights into their artificial rearing and commercialization. Hence, our findings highlight *D. purpurea* as a potential eco-feast plant for bumble bees as it provides abundant rewards, i.e., pollen and nectar, while benefiting from adequate pollination in return.

Conclusion

The findings indicate that the Jammu region of the Northwestern Himalayas harbors a rich diversity of bumble bees that play a vital role in ecosystem services, particularly pollination, especially in high-altitude regions. The results also highlight the significance of *D. purpurea* as an important floral resource for long-tongued bumble bees. Its high nectar volume and deep corolla complement the morphological traits of long-tongued bees, enabling them to forage effectively and fulfil nectar requirements with fewer visits. In addition to supporting bumble bee foraging, *D. purpurea* may serve as a valuable seasonal resource during periods of floral scarcity. Hence, *D. purpurea* offers a practical option for pollinator gardens and restoration initiatives due to its suitability for native pollinators' requirements, especially in locations with limited resources or degradation. Given the ongoing decline in bumble bee populations, *D. purpurea* may be a valuable addition to conservation plans, such as those implemented by the All India Coordinated Research Project on Honeybees and Pollinators. Therefore, *D. purpurea* can be considered a potential "eco-feast" plant that provides abundant flower rewards in exchange for efficient pollination. Further, to enhance pollinator diversity and stability, its incorporation into pollinator-friendly landscapes should be promoted under carefully monitored, ecologically suitable conditions. Thus, it is concluded that *D. purpurea* holds promise not only as a medicinal plant but also as a valuable resource for the conservation of long-tongued bumble bees.

Authors' Contribution

A.G.: Conceptualization, software, writing-original draft, investigation, data curation, bumble bee identification.
R.K.G.: Methodology, supervision.
M.G.: Writing-review & editing, visualization.
N.S.: Formal analysis, resources.
K.B.: Validation, project administration.

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References

Benton, T. (2006). Bumblebees: the natural history & identification of the species found in Britain, Collins, London.

Broadbent, A. & Bourke, A. (2012). The bumblebee *Bombus hortorum* is the main pollinating visitor to *Digitalis purpurea* (Common Foxglove) in a UK population. Journal of Pollination Ecology, 8: 48-51. https://doi.org/10.26786/1920-7603(2012)10

Cameron, S.A., Lozier, J.D., Strange, J.P., Koch, J.B., Cordes, N., Solter, L.F. & Griswold, T.L. (2011). Patterns of widespread decline in North American Bumble bees. Proceedings of the National Academy of Science, 108: 662-667. https://doi.org/10.1073/pnas.1014743108

Colla, S.R., Gadallah, F., Richardson, L., Wagner, D., & Gall, L. (2012). Assessing declines of North American Bumble bees (*Bombus* spp.) using museum specimens. Biodiversity Conservation, 21: 3585-3595. https://doi.org/10.1007/s10531-012-0383-2

Gomez, J.M., Bosch, J., Perfectti, F., Fernández, J.D., Abdelaziz, M. & Camacho, J.P.M. (2008). Association between floral traits and rewards in *Erysimum mediohispanicum* (Brassicaceae). Annals of Botany, 101: 1413-1420. https://doi.org/10.1093/aob/mcn053

Goulson, D. (2010). Bumblebees: their behaviour, ecology and conservation. Oxford University Press, p 317.

Grindeland, J.M., Sletvold, N. & Ims, R.A. (2005). Effects of floral display size and plant density on pollinator visitation rate in a natural population of *Digitalis purpurea*. Functional Ecology, 19: 383-390. https://doi.org/10.1111/j.1365-2435.2005.00988.x

Guleria, A. (2022). Explaining the altitudinal gradient in bumble bee species with respect to historic and scientific data. M. Sc. Thesis, Sher-e- Kashmir University of Agricultural Sciences and Technology Jammu, Jammu and Kashmir, India.

Harder, L.D. (1983). Flower handling efficiency of Bumble bees: morphological aspects of probing time. Oecologia, 57: 274-280. https://doi.org/10.1007/bf00379591

Hocking, B. (1953). The intrinsic range and speed of flight of insects. Transactions Royal Entomological Society London, 104: 223-345.

Pleasants, J.M. (1983). Nectar production patterns in *Ipomopsis aggregate* (Polemoniaceae). American Journal of Botany, 70: 468-1475. https://doi.org/10.1002/j.1537-2197.1983.tb10850.x

Qualtrocchi, U. (2000). CRC world dictionary of plant names. CRC Press, New York, USA.

Raina, R.H., Kumar, K., Pathak, P., Jangid, T., Choudhary, P., Parrey, A.H. & Sharma, I. (2024). Bumblebees: Diversity, Role in Pollination Ecology, Threats, and Conservation. In: Insect Diversity and Ecosystem Services: Volume 1: Importance, Threats, Conservation, and Economic Perspectives. 1st Edn., CRC Press, Taylor and Francis group, India.

Stiles, F.G. (1975). Ecology, flowering phenology, and humming-bird pollination of some Costa Rican *Heliconia* species. Ecology, 56: 285-301. https://doi.org/10.2307/1934961

Williams, P.H. (2022). The Bumble bees of the Himalaya: An Identification Guide. Abc taxa.

Willis, A.J., Memmott, J. & Forrester, R.I. (2000). Is there evidence for the post invasion evolution of increased size among invasive plant species. Ecology Letters, 3: 275-283. https://doi.org/10.1046/j.1461-0248.2000.00149.x