

Pollinator Assemblages of an Underutilized Medicinal Tree (*Terminalia arjuna*): Diversity, Seasonality, and Conservation Needs

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Abstract: Pollination is a vital biological process that enables the reproduction of flowering plants, and insect pollinators play a crucial role in maintaining biodiversity and ecosystem stability. This study investigated the diversity of insect pollinators visiting the flowers of *Terminalia arjuna*, an important underutilized medicinal tree in the Mandi District of Himachal Pradesh, India. Insect samples were collected using hand nets during the flowering period from April to July in 2019-2021 and identified at the Zoological Survey of India, Kolkata. The results revealed that *T. arjuna* flowers attracted a diverse array of insects belonging to 5 orders, 9 families, and 23 species. Dipterans were the most diverse group, with ten species from three families: Syrphidae, Tachinidae, and Calliphoridae. Hymenopterans were followed by six species from the Apidae and Vespidae families. Lepidopterans were represented by three species from Pieridae and Nymphalidae, while Coleopterans had three species from Coccinellidae. A single Hemipteran species from the Largidae family was also recorded. These findings are consistent with previous studies on pollination mechanisms in other *Terminalia* species, which reported entomophilous pollination by various insect orders. The study highlights the importance of insect pollinators in the reproductive success of *T. arjuna* and underscores the need for conservation measures to protect these essential species and their habitats.

Keywords: Insect pollinators, *Terminalia arjuna*, biodiversity conservation, entomophilous pollination, Himachal Pradesh

1. Introduction

Pollination is a vital biological process that enables the reproduction of flowering plants by transferring pollen from the male anthers to the female stigma of flowers. This process is crucial for the development of fruits and seeds, thereby ensuring the survival of plant species. A diverse array of organisms, collectively known as pollinators, assist in this process. These include insects such as bees, butterflies, moths, and beetles, as well as birds and mammals like bats (Ollerron, 2011). Insect pollinators play a key role in maintaining biodiversity and ecological complexity through their interactions with plant species. By facilitating gene flow and cross-pollination, insect pollinators help sustain genetic diversity within plant populations, which in turn enhances ecosystem resilience and stability. Pollinators serve a dual purpose by supporting natural ecosystems and boosting agricultural productivity, with approximately 75% of global crop species benefiting to some extent from animal-assisted pollination (Klein *et al.*, 2007). Furthermore, the ecological services provided by insect pollinators extend to supporting habitats that benefit other wildlife, including birds and mammals that depend on fruits and seeds produced through pollination. Pollinators also contribute to the availability of plants used in medicine, clothing, and biofuels, underscoring their multifaceted ecological value (Potts *et al.*, 2010a). Their sensitivity to environmental changes, such as habitat fragmentation, pesticide exposure, invasive species, and climate change, makes them important bioindicators of ecosystem health. However, recent decades have witnessed alarming declines in pollinator populations due to human-induced factors like habitat destruction, excessive pesticide use, climate change, and new pathogens. These declines threaten global food security, ecosystem resilience, and

biodiversity conservation (Jamwal and Thakur, 2019; Potts *et al.*, 2010a). The significant reduction in pollinator abundance and diversity in recent years has raised global concerns, emphasizing the urgent need for conservation efforts to protect these keystone species and the services they provide (Goulson *et al.*, 2015). Consequently, there is an urgent need to implement conservation strategies that protect pollinator habitats, promote environmentally friendly agricultural practices, and increase public awareness of the ecological importance of pollinators. Extensive research has been conducted in India and abroad on commercial fruit crops, but there is limited information on underutilized medicinal fruit crops. With this in mind, we aimed to explore the diversity of the pollinator community of an essential underutilized medicinal tree, *Terminalia arjuna* (Roxb.) Wight and Arn., commonly known as the Arjuna tree. This deciduous species holds significant medicinal, ecological, and economic importance across India, including the state of Himachal Pradesh. Part of the Combretaceae family, this species typically thrives along riverbanks and in moist deciduous forest ecosystems, especially in the sub-montane regions of Himachal Pradesh at elevations up to 1200 meters. The tree is notable for its considerable height, reaching up to 25 meters, and its distinctive smooth, grey bark that peels off in large sheets. It also has simple, oblong leaves and small, yellowish-white flowers that bloom from April to July (Sharma *et al.*, 2012). The bark of *T. arjuna* is highly esteemed in traditional Ayurvedic medicine for its heart-protective properties and its effectiveness in treating cardiovascular conditions such as hypertension and hyperlipidemia (Dwivedi, 2007). The species is traditionally used for its wound-healing, anti-ulcer, and bone-setting properties, highlighting its essential role in indigenous healthcare systems. Ecologically, *T. arjuna* plays a significant role in soil stabilization and preventing riverbank

erosion, thereby enhancing the ecological integrity of riparian habitats in the region (Thakur and Dogra, 2016). However, increasing demand for its medicinal bark has led to unsustainable harvesting practices, posing a threat to natural populations. Consequently, conservation measures, including community-led afforestation and regulated harvesting protocols, are being advocated to ensure the sustainable management of this important species (Singh and Gupta, 2019).

2. Material and Methods

The present investigation was carried out on the diversity of various insect pollinators of *Terminalia arjuna* from District Mandi of Himachal Pradesh from April to July 2019 to 2021. Mandi district is centrally located in the Indian state of Himachal Pradesh, forming a vital part of the state's mid-Himalayan region. Geographically, it lies between 31°13'30" N to 32°04'22" N latitudes and 76°37'20" E to 77°23'15" E longitudes. Sweeps were made with a hand net throughout the flowering period of the crop at two-hourly intervals from the morning to the evening to observe the species diversity of insects. Captured insects were killed by using benzene and preserved as dry specimens, and were identified by the Zoological Survey of India, Kolkata.

3. Results and Discussion

Terminalia arjuna flowers attracted a wide variety of insects belonging to 5 orders, 9 families, and 23 species. Out of them, ten belong to the order Diptera, six to Hymenoptera, three to Coleoptera, three to Lepidoptera, and one to Hemiptera (Table 1, Figure 1, 2). Present studies revealed that Diptera were the major floral visitors comprising three families, viz., Syrphidae (*Episyrphus balteatus*, *Eristalis tenax*, *Eristalis cerealis*, *Eristalinus paria*, *Eristalinus arvorum*, Tachiniade (*Tachina sorbia*, *Phasia* sp., *Masicera* sp.), and Calliophoridae (*Calliphora vomitoria*, *Lucilia* sp.). They were followed in order of diversity by hymenopterans from two families viz., Apidae (*Apis cerana*, *Apis dorsata*, *Apis mellifera*, and *Ceratina* sp.) and Vespidae (*Parapolybia varia*, *Ropalidia brevita*), lepidopterans from two families viz., Pieridae (*Pieris canidia indica*) and Nymphalidae (*Aglais caschmirensis*, *Danaus chrysippus*), Coleopterans from one family viz., Coccinellidae (*Coccinella septempunctata*,

Oenopia kirbyi and *Harmonia dimidiata*) and one hemipteran from Largidae (*Physopelta gutta*).

The current findings are consistent with the observations of Raju *et al.* (2012), who noted that the flowers of *Terminalia pallida* were visited during the daytime by 33 insect species, including bees, wasps, bugs, flies, butterflies, and beetles. Gargi and Sinha (2017) reported entomophily in both *Terminalia belerica* and *Terminalia chebula*, identifying major flower visitors as *Apis indica*, *Chilomenes sexmaculata*, *Drosophila melanogaster*, *Solenopsis geminata*, and *Carpophilus hemipterus*. Their study indicates that the honey bee is the primary pollinator. Anoosha *et al.* (2018) examined the diversity of insect pollinators on *Terminalia bellirica* Roxb., finding that Dipterans were the most diverse group, followed by Hymenoptera and Coleoptera. In a study by Badoni and Arya (2022), it was found that dipteran species such as *Eristalis tenax*, *Episyrphus balteatus*, and *Eristalis cerealis* were the predominant insect pollinators for three medicinal Berberis plant species (*B. chitria*, *B. lycium*, and *B. asiatica*) in the Western Himalayas. In a similar vein, Madhu and Thakur (2023) observed that the flowers of *Valeriana jatamansi* Jones in the Shimla Hills attracted 51 species of insect pollinators, spanning five different orders and 12 families within the class Insecta. Among these, 33 species belonged to Diptera, four to Hymenoptera, nine to Lepidoptera, three to Coleoptera, and two to Hemiptera.

4. Conclusion

Terminalia arjuna is a medicinally very important fruit plant and is pollinated by a wide variety of insect pollinators. The diversity and abundance of both wild and managed insect pollinators are declining globally. So, the study on diversity and abundance of insect pollinators helps in their conservation for future. The study revealed that *T. arjuna* flowers attracted a wide variety of insects belonging to 5 orders, 9 families, and 23 species, with Dipterans being the major floral visitors, followed by Hymenopterans, Lepidopterans, Coleopterans, and Hemipterans. The findings align with previous studies on pollination mechanisms and insect pollinators of various *Terminalia* species, highlighting the importance of entomophily in the genus.



Figure 1: Pollinators of *Terminalia arjuna*

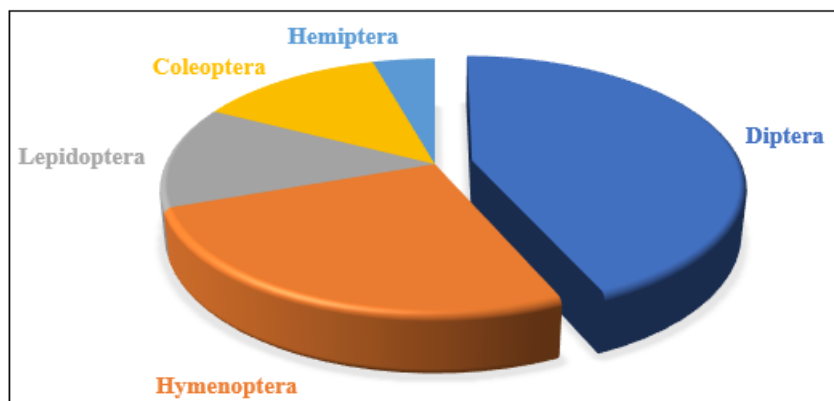


Figure 2: Diversity of Insect Pollinators of *Terminalia arjuna*

Table 1: Systematic list of insect pollinators *Terminalia arjuna* from District Mandi from different areas of Himachal Pradesh

Order	Family	Fauna
Hymenoptera	APIDAE	<i>Apis cerana</i> (Fabricius) <i>Apis dorsata</i> (Fabricius) <i>Apis mellifera</i> (Linnaeus) <i>Ceratina</i> sp.
	VESPIDAE	<i>Parapolybia varia</i> (Fabricius) <i>Ropalidia brevita</i> (Das and Gupta)
Diptera	SYRPHIDAE	<i>Episyrphus balteatus</i> (De Geer) <i>Eristalis tenax</i> (Linnaeus) <i>Eristalis cerealis</i> (Fabricius) <i>Eristalinus paria</i> (Bigot) <i>Eristalinus arvorum</i> (Fabricius)
	TACHINIADAE	<i>Tachina sorbia</i> (Walker) <i>Phasia</i> sp. <i>Masicera</i> sp.
	CALLIPHORIDAE	<i>Calliphora vomitoria</i> (Linnaeus) <i>Lucilia</i> sp.
Lepidoptera	PIERIDAE	<i>Pieris canidia indica</i> (Evans)
	NYMPHALIDAE	<i>Aglaia caschmirensis</i> (Kollar) <i>Danaus chrysippus</i> (Linnaeus)
Coleoptera	COCCINELLIADAE	<i>Coccinella septempunctata</i> (Linnaeus) <i>Oenopia kirbyi</i> (Mulsant) <i>Harmonia dimidiata</i> (Fabricius)
Hemiptera	LARGIDAE	<i>Physopelta gutta</i> (Burmeister)

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