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Apis florea Fabricius: A small honey bee with major ecological, agricultural and therapeutic significance – A review

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Abstract
The red dwarf honey bee, *A. florea* Fabricius, is the smallest member of the genus *Apis* and is widely distributed across tropical and subtropical regions of Asia and the Middle East. Although considered a wild and non-domesticated species, *A. florea* plays a vital role in ecosystem functioning and agricultural sustainability due to its strong floral fidelity, efficient foraging behavior, and adaptability to diverse habitats. This review synthesizes current knowledge on the behavior, nesting ecology, floral calendar, foraging patterns, pollination efficiency, nutritional properties of honey, apitherapeutic potential and domestication attempts of *A. florea*. Evidence highlights its significant contribution to pollination of several crops such as coriander, fennel, aster, chamomile, cucurbits and oilseeds, where it enhances yield and quality parameters. Beyond pollination, *A. florea* produces nutritionally rich honey with high antioxidant, antimicrobial and probiotic properties, while venom-derived compounds such as melittin exhibit promising anticancer activity. Despite its ecological and economic importance, *A. florea* populations are declining due to habitat loss, predation, parasites, and insecticides application. Although full domestication remains challenging because of its open-nesting and absconding behavior, traditional management and semi-domestication approaches demonstrate potential for conservation-oriented utilization. Recognizing and conserving *A. florea* is essential for sustaining pollination services, biodiversity, and the therapeutic value of its bee products.

Keywords: *A. florea*, floral fidelity, Floral calendar, Apitherapy, Pollination, Comb

Introduction
Bees are a diverse group of insects that may exhibit either social or solitary modes of life and are classified under the order Hymenoptera. Worldwide, more than 17,000 species of bees have been documented, highlighting their remarkable diversity and establishing them as one of the most important and varied groups of pollinating insects. Honey bees are essential for ecosystem functioning and human welfare because of their key roles in pollination, biodiversity maintenance, economic support and environmental monitoring, emphasizing the importance of their conservation. Bee-produced honey is a natural sweetener recognized for its nutritional value and medicinal, antioxidant and antibacterial properties. In addition to honey, bees produce valuable by-products such as wax, propolis, royal jelly and pollen, which have extensive applications in medicine, cosmetics and various industries. Honey bees and flowering plants have co-evolved through a mutualistic relationship in which bees obtain nectar and pollen as food resources, while plants depend on bees for effective pollination (Gallai *et al*. 2009) [15]. The honey bee species found in India include the Rock bee (*Apis dorsata* Fabricius), Himalayan giant bee, (Apis laboriosa Smith), Indian bee (*Apis cerana indica* Fabricius), Red dwarf bee (*Apis florea* Fabricius), Black dwarf bee (*Apis andreniformis* Smith), Italian bee (*Apis mellifera* Linnaeus), Dammer bee, [*Tetragonula iridipennis* (Smith)]. There are a few more species like *Apis koschevnikovi Enderlein*, *Apis nigrocincta Smith* (Crane 2009) [8]. *A. cerana indica* and *A. mellifera* are commonly reared in artificial hives for honey production, yielding approximately 2-5 kg/comb/year and 35-40 kg/comb/year, respectively. In contrast, *A. florea*, *A. dorsata* and *A. laboriosa* are considered wild honey bee species and have not been fully domesticated. However, limited attempts to domesticate *A. florea* have shown partial success. The species most closely related to *A. florea* is *A. andreniformis* and together these two species are collectively referred to as dwarf honey bees (Crane 2009) [8].
Apis florea is the smallest among the major species of the genus *Apis*. It constructs a single, small exposed comb, usually attached to bushy vegetation, tree branches, or the corners of human dwellings. This species is predominantly distributed in plain regions and exhibits a strong tendency for swarming. *A. florea* is not commonly domesticated or managed under artificial conditions (Premika *et al*. 2024) [30]. The honey produced by this species is traditionally believed to possess medicinal properties, although its annual honey yield is relatively low, ranging from approximately 0.5 to 1.0 kg per colony per year (Abrol 2020) [1].
Compared to prior studies on other bee species, *A. florea* receives less attention from scientists. However, due to its vital role in pollination, ecological dynamics and impact on agriculture, this species is an intriguing subject for further research. This review paper aims to highlight all the aspects of *A. florea* in both natural and anthropogenic locations by exploring the biology, behaviour, nest architecture, division of labour, domestication, floral calendar and preference, foraging time, enemies, pollination efficiency, qualities of honey and their unique features.

Geographical distribution of *A. florea*

The geographical distribution of *A. florea* extends from the Middle East to Southeast Asia. In the Middle East, the species has been recorded from Saudi Arabia, the United Arab Emirates, Oman and parts of Iran. In Indian subcontinent, encompassing Pakistan, India, Nepal, Sri Lanka and Bangladesh. In Southeast Asia, *A. florea* occurs in several countries, particularly Myanmar, Thailand, Laos, Cambodia and Vietnam (Hepburn *et al*. 2005) [16].

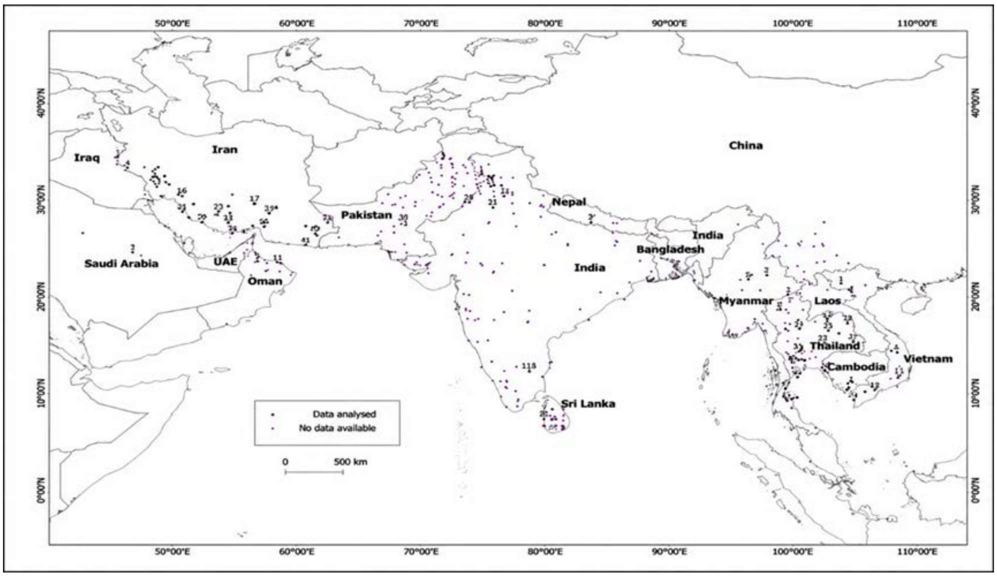

Fig 1: Geographical distribution of *A. florea* (Hepburn *et al*. 2005)

Taxonomic position of *A. florea*

The dwarf honey bee, *A. florea*, is a eukaryotic organism belonging to the Domain Eukaryota. It is classified under the Kingdom Animalia and the Phylum Arthropoda, characterized by jointed appendages and an exoskeleton. Within Arthropoda, it falls under the Class Insecta and the Order Hymenoptera, which includes bees, ants and wasps. The species is placed in the Suborder Apocrita, distinguished by a constricted waist and the Superfamily Apoidea, comprising bees and related insects. *A. florea* belongs to the Family Apidae and Subfamily Apinae. It is a member of the Genus *Apis*, which includes the true honey bees (Fabricius 1787).

Morphological features of *A. florea*

A. florea exhibits a compact and slender body form that is well adapted to its foraging and nesting habits. The head is small and rounded, densely covered with fine facial hairs that facilitate pollen adherence during floral visits. Prominently positioned on the head are a pair of large compound eyes accompanied by three ocelli, which together enhance light perception, motion detection and spatial orientation. The antennae are geniculate (elbowed) in structure, a characteristic feature of honey bees, providing increased flexibility and sensitivity for environmental perception and communication (Abrol 2020) [1]. The head is hypognathous, with mouthparts directed ventrally, an adaptation that supports efficient feeding on floral resources. The legs are highly specialized and show clear functional differentiation among the three pairs. The fore legs bear structures such as the eye brush and antenna cleaner, which are essential for grooming and maintaining sensory efficiency. The middle legs are equipped with a pollen brush and a tibial spur that assist in pollen manipulation. The hind legs are distinctly modified to form the corbicula, or pollen basket, enabling the efficient collection and transport of pollen during foraging activities (Abrol 2020) [1]. The abdomen is elongated and slender, marked by a characteristic pattern of alternating red and black bands that distinguishes *A. florea* from other honey bee species. Abdominal tergites I to VI are clearly visible. The entire body surface is covered with fine setae, enhancing the bee's capacity for pollen collection and retention (Abrol 2020) [1].

Fig 2: Dorsal and lateral views of *A. florea* (Trivedi 2022) [40]

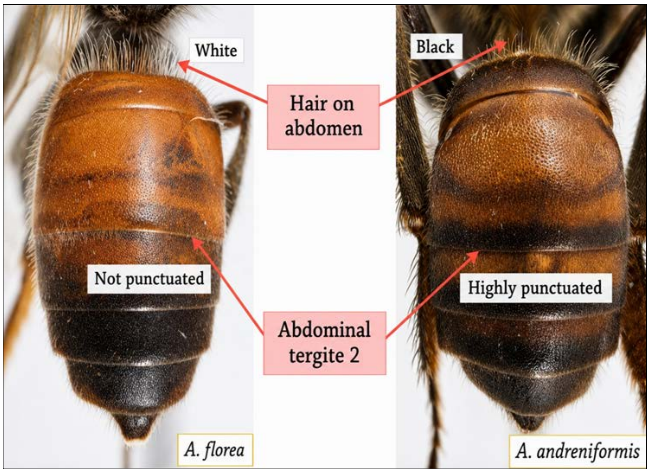

Fig 3: Diffrence between *A. flora* and *A. andreniformis* (Wang and Kong 1987)

Fig.3 Diffrence between *A. flora* and *A. andreniformis* (Wang and Kong 1987) [43] *Apis florea* and *Apis andreniformis* are closely related dwarf honey bee species that often appear superficially similar in size and general body form. One of the most prominent distinguishing features is observed on the hind tibia. In *A. florea*, the hairs covering the hind tibia are predominantly white, giving the leg a lighter and less contrasting appearance. In contrast, *A. andreniformis* possesses black hairs on the hind tibia, resulting in a noticeably darker and more contrasting coloration (Wang and Kong 1987) [43]. Further differentiation can be made by examining the abdominal tergites, particularly tergite II. In *A. florea*, the second abdominal tergite is smooth or weakly sculptured, lacking prominent punctuations. Conversely, in *A. andreniformis*, tergite II is distinctly and densely punctuated, giving the surface a textured or dotted appearance (Wang and Kong 1987) [43].

One of the most remarkable features of honey bees is their sophisticated communication system, first elucidated through the pioneering work of Karl von Frisch. Like other members of the genus *Apis*, *A. florea* employs dance communication to convey information about the location of food resources to nestmates. Two primary types of dances are observed in *A. florea*: the round dance and the waggle dance, each corresponding to the distance of the food source from the nest. The round dance is performed when floral resources are located at a short distance from the nest. This dance lacks directional information but effectively signals the presence of a nearby food source, stimulating other workers to search in the surrounding area. In contrast, the waggle dance is used when the food source is located farther away. This dance conveys precise information regarding both the direction and distance of the resource relative to the position of the sun. The orientation of the waggle run indicates the direction of the food source, while the duration and vigor of the waggle phase correlate with distance (Chhayani 2013) [7].

Nesting behaviour of *A. florea*

The hive of *A. florea* is typically an open-nesting, single comb constructed on low tree branches, hedges, house chimneys, empty cavities, or piles of dried sticks. Nest sites are usually well shaded and concealed within dense vegetation to reduce exposure to predators. Selection of nest height is closely associated with the height of surrounding host plants, enabling efficient foraging with minimal energy expenditure (Basavarajappa 2010) [3]. The nesting height of *A. florea* is generally observed at approximately 15 m above ground level (Wongsiri 1997) [44]. In urban environments, the nesting height of *A. florea* is most commonly reported to range between 0.5 and 10 m above ground level (Nagaraja and Rajagopal 1999) [21]. *A. florea* is considered to exhibit a faster nest-site selection process compared to *Apis mellifera* (Villa 2004) [42]. *Apis florea* identifies and selects new nesting sites through dance-based communication among colony members (Oldroyd *et al*. 2008) [22].

The process of selecting a nesting site begins when a scout bee discovers a potential location and inspects it thoroughly. She then returns to the swarm and performs dances if she finds the site suitable, prompting other scouts to re-inspect it. When enough bees approve the site, a quorum is reached, triggering the production of piping and stop signals that reduce further dancing. This coordinated communication ensures that the swarm reaches a unanimous decision. Once the signals spread, the swarm lifts off and relocates to the chosen site (Makinson *et al*. 2017) [19].

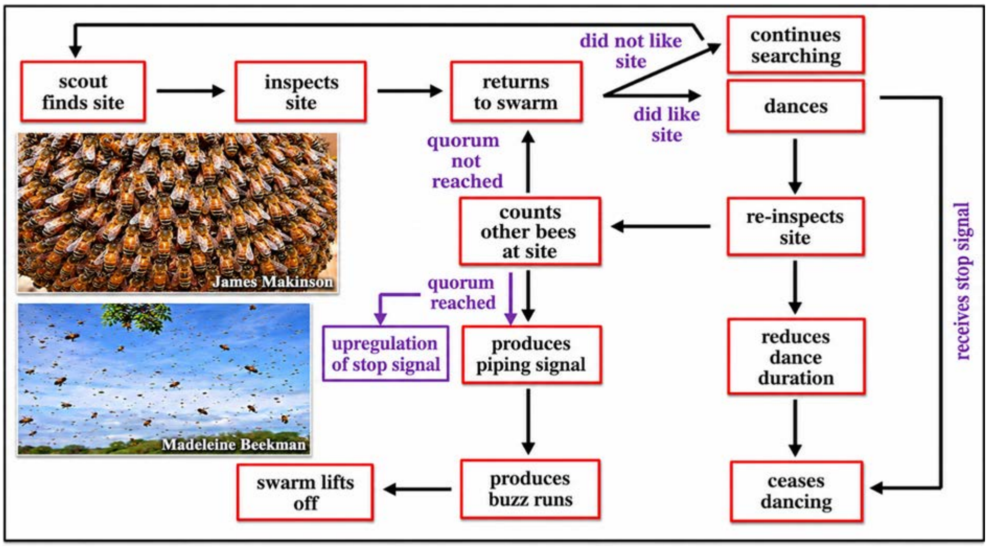

Fig 4: Nesting site selection process of *A. florea* (Makinson *et al*. 2017) [19]

The nesting sites of *A. florea* are influenced by environmental conditions, particularly the availability of woody vegetation and agroecosystem landscapes (Moritz 2010) [20]. Under tropical conditions, *A. florea* exhibits distinct nesting plant preferences, with trees serving as the primary nesting substrates. Among these, *Pongamia pinnata* shows the highest preference (17.4%), followed by species such as *Mangifera indica* and *Ceiba pentandra*. Shrubs, including Bougainvillaea and *Hibiscus rosa-sinensis* are used as nesting sites at moderate levels, while plants with low suitability are infrequently selected (Basavarajappa 2010) [3].

Nest architecture of *A. florea*

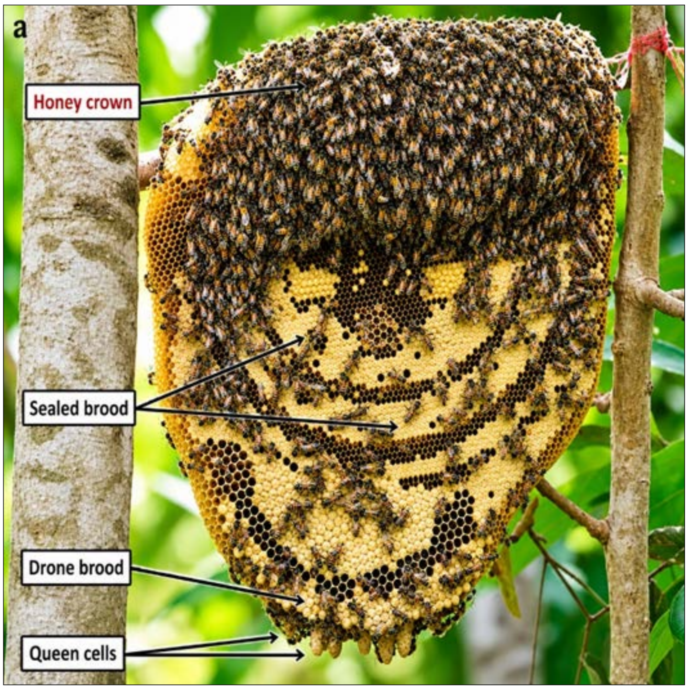

Fig 5: Comb architecture of *A. florea*

The comb of *A. florea* is constructed with characteristic hexagonal cells, initiated by laying a foundation of cells on the supporting surface at the nest base (Rinderer *et al*. 1996) [32]. The brood area shows a distinct organization, with worker brood arranged in concentric rings, giving the comb an overall circular appearance (Dawkins 2016) [10]. A protruding drone brood region is present at the lower portion of the comb. The largest, pear-shaped queen cells are oriented vertically and occur along the lower margin of the brood comb (Pirk 2004) [28].

Division of labour

The colony of *A. florea* shows a distinct caste system comprising the queen, workers, and drones (Crozier 1985) [9]. The queen is the only fertile female and maintains social organization through pheromonal control over worker reproduction. Workers are sterile females that perform both indoor duties (brood care, comb construction, food processing and nest maintenance) and outdoor duties (foraging, guarding and water collection) (Page and Gene 1991) [24]. Drones are fertile males whose sole role is reproduction, mating with the queen during mating flights and they do not participate in nest maintenance or foraging (Oldroyd *et al*. 1992) [23].

Foraging activity of *A. florea*

The foraging behaviour of *A. florea* closely resembles that of other honey bee species and is characterized by a high degree of floral fidelity, wherein individual foragers repeatedly visit the same plant species during a foraging bout. This behaviour enhances pollination efficiency and facilitates the production of relatively uniform honey types. Foraging activity typically commences during the early morning hours and gradually declines as light intensity and solar radiation decrease. Environmental factors such as sunlight, temperature and day length play a crucial role in regulating flight activity, with reduced foraging observed during low-light conditions. Compared to larger honey bee species, *A. florea* tends to spend longer durations on foraging trips. This extended foraging time is largely attributed to its smaller body size, which limits nectar and pollen carrying capacity. As a result, dwarf honey bees require additional time to collect sufficient floral resources to meet colony needs. The foraging range of *A. florea* is relatively short, with most foraging flights occurring within a distance of approximately 750 m from the nest. This restricted flight range promotes intensive exploitation of nearby floral resources. Consequently, the honey produced by *A. florea* colonies is often unifloral, reflecting dominance of a single flowering plant species within the foraging area (Abrol 2020) [1]. Foraging activity of *A. florea* on castor (*Ricinus communis*) follows a distinct diurnal pattern, with activity rising sharply after early morning and peaking during mid-morning (08:00-10:00 h). Thereafter, foraging gradually declines through midday and afternoon, reaching lower levels by evening (Li 2008) [22].

Floral calendar of *A. florea*

The floral calendar of *A. florea* indicates that the species utilizes a wide diversity of flowering plants throughout the year, reflecting its broad foraging spectrum under tropical and subtropical conditions (Basavarajappa 2010) [3]. *A.*

florea (the dwarf honey bee) mainly depends on a broad range of flowering plant families for both nectar and pollen, especially small, open and shallow flowers (Bhalchandra *et al*. 2014) [4]. Plant families such as Fabaceae, Euphorbiaceae, Asteraceae, Mimosaceae and Apocynaceae contribute substantially to nectar and pollen resources, forming the major floral base for colony sustenance. The availability of these floral resources across different seasons supports continuous foraging activity, colony growth and reproductive success, highlighting the ecological adaptability of *A. florea* in heterogeneous landscapes (Sajwani *et al*. 2014) [33].

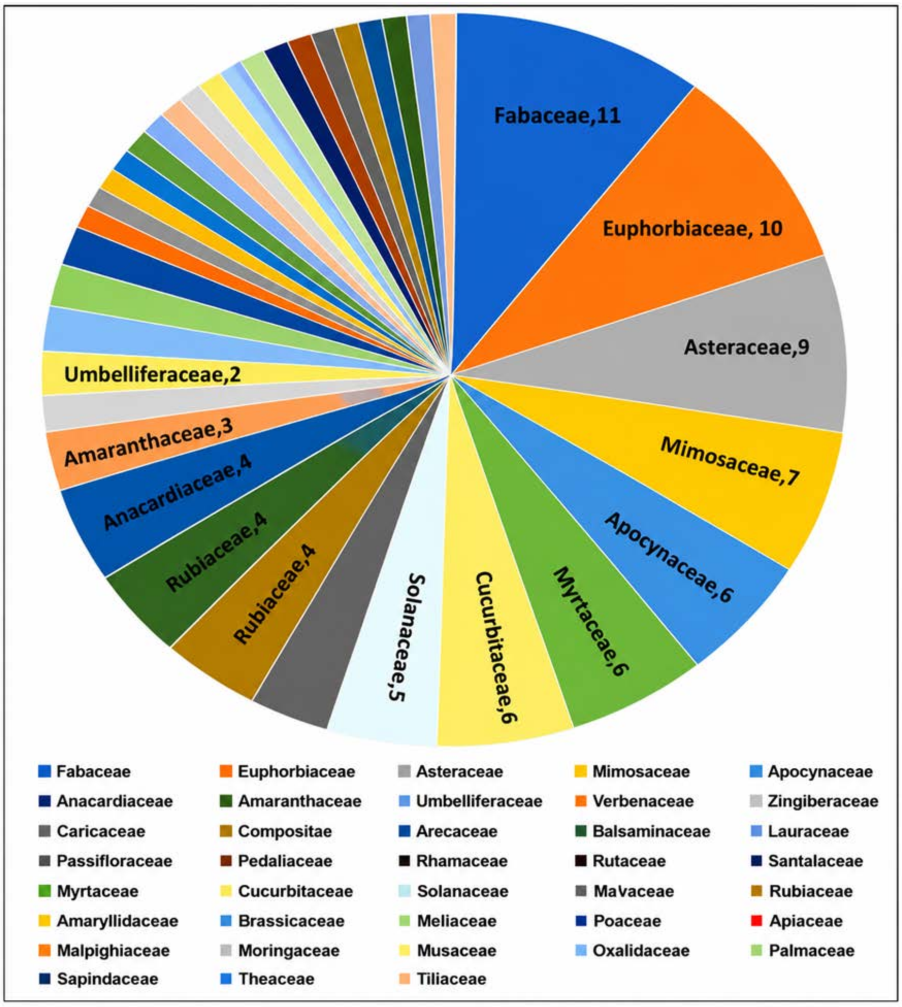

Fig 6: Floral preference of *A. florea* among different plant families. (Basavarajappa 2010) [3]

Importance of *A. florea*

1. In pollination

In pollination, coriander (*Coriandrum sativum*) during the rabi season, honey bees were the dominant pollinators, with *A. florea* contributing the highest visitation (≈42%), followed by *A. dorsata* (≈37%). Other insect groups such as stingless bees, butterflies, dipterans, beetles and syrphids played a minor role (Patil and Pastagia 2016) [27]. Similarly, on strawberry (*Fragaria ananassa*), honey bees dominated the pollinator assemblage, with *Apis cerana* (33%) and *A. florea* (31%) contributing the highest proportions, followed by *A. mellifera* (Abrol 2019) [2]. Abundance patterns on *Eruca sativa* and *Brassica rapa* showed that hymenopteran pollinators, particularly *Apis* species, were most active during mid-day hours (12:00-14:00 h). *Apis florea* recorded relatively higher abundance during peak periods, contributing about 25-50 per cent of total hymenopteran visits (Shakeel *et al*. 2019) [36]. On curry tree (*Murraya koenigii*), honey bees exhibited distinct diurnal foraging patterns, with peak activity during mid-day (12:00-14:00 h). *A. florea* showed the highest foraging rate (12.31 flowers min^{-1} $forager^{-1}$) and the highest mean visitation (11.1), surpassing other *Apis* species (Dhore 2020) [11]. In coriander, pollination by *A. florea* significantly enhanced yield attributes, recording the highest number of seeds per umbel (25.8), seeds per plant (232.4), seed size (5.03 mm^3) and test weight (13.6 g) compared to other pollination modes (Shwetha *et al*. 2020) [37]. In chamomile (*Matricaria chamomilla*), pollination involving *A. florea* resulted in improved yield attributes, including reduced capitulum drop (12.48%) and higher seed number per capitulum (67.53) with increased oil content (0.15%), compared to other treatments and the control (Shwetha *et al*. 2020) [37]. Pollination mode had a pronounced effect on fruit set and yield attributes of summer squash (*Cucurbita pepo*).

Treatments involving *A. florea* showed relatively higher fruit set (88%), fruit weight (833.6 g) and number of seeds per fruit (382) compared to other insect pollination treatments (Shwetha *et al*. 2020) [37]. Relative abundance studies on fennel (*Foeniculum vulgare*) showed that *A. florea* constituted the major share of floral visitors (92.6%), far exceeding other *Apis* species (Abrol 2025). Similarly, experiments with bee attractants on aster (*Callistephus chinensis*) indicated that *A. florea* responded more strongly than *A. cerana indica*, with the highest visitation recorded under sugar solution (10%) treatment (Chavan *et al*. 2025) [6]. Application of bee attractants markedly influenced seed yield parameters of aster (*Callistephus chinensis*). Sugar solution (10%) and jaggery solution (15%) resulted in higher number of seeds per flower (171.63 and 159.63), seed weight per flower (0.40 and 0.39 g) and seed yield (291.33 and 281.74 kg ha^{-1}), respectively, compared to other treatments. The enhanced yields are attributed to increased visitation of efficient pollinators, particularly *A. florea* (Chavan *et al*. 2025) [6]. Relative abundance studies on fennel (*Foeniculum vulgare*) indicated that *A. florea* was a prominent floral visitor (35.86%), followed by dipterans (*Lucilia sericata*) and hymenopterans such as *Polistes olivaceus* (Prajula *et al*. 2025) [29]. A similar pattern was observed on bitter gourd (*Momordica charantia*), where *A. florea* accounted for a substantial proportion (24%) of insect visitors alongside *A. cerana* and other pollinator groups (Layek *et al*. 2025) [17].

2. In nutrition

Biochemical analysis of *A. florea* honey samples revealed marked differences between raw and processed honey. Raw honey exhibited higher colour intensity, proline content (≈250 mg kg^{-1}), total protein (≈323 mg/100 g), flavonoids and phenolics compared to processed honey, indicating superior nutritional and antioxidant properties. These findings emphasize the nutritional value of raw honey derived from natural bee foraging systems (Vaghela and Reddy 2016) [41]. Antioxidant profiling further demonstrated higher bioactive potential in raw honey compared to processed samples. Raw honey, largely sourced from wild bees such as *A. florea*, exhibited greater ascorbic acid equivalent antioxidant capacity (≈16.6 mg/100 g), higher radical scavenging activity (≈53%) and comparable FRAP values. These results suggest that honey associated with *A. florea* contributes significantly to the antioxidant richness and functional nutritional quality of natural honey (Vaghela and Reddy 2016) [41]. Antioxidant activity of *A. florea* honey varied significantly across locations. Samples from Bushehr showed the highest ABTS (≈786 µg g^{-1}), FRAP (≈27 µg g^{-1}) and DPPH (≈625 µg g^{-1}) values, followed by Jahrom and Jiroft (Parichehreh *et al*. 2025) [25]. Physicochemical comparison of honey revealed distinct differences between *Apis florea* and *A. cerana*. *A. florea* honey contained higher levels of major sugars, particularly fructose and maltose, along with slightly higher moisture content and pH (Patel *et al*. 2025) [26]. Antioxidant activity in honey is primarily influenced by amino acids, with proline being a significant contributor rather than phenolic compounds (Taormina *et al*. 2001) [39]. The physicochemical properties of *A. florea* honey samples, i.e., the electrical conductivity of 0.823, free acidity of 11.56 meq/kg, lactose content of 4.81 meq/kg, proline content of 559.15 mg/kg and HMF (5, Hydroxy methyl furfural) content of 118.22 mg/kg. The lactose content is recorded higher in *A. florea* honey (Qamer *et al*. 2005) [31].

3. In apitherapy

Honey and venom derived from *A. florea* are also gaining attention in apitherapy, where their bioactive components are explored for potential therapeutic applications (Sattayawat *et al*. 2025) [34]. Apitherapeutic evaluation revealed strong antimicrobial activity of *A. florea* honey against *Helicobacter pylori*. This bacterium is a major gastric pathogen known to increase the risk of chronic gastritis, peptic ulcers and stomach cancer. Honey samples showed concentration-dependent inhibition, with maximum zones recorded at 100 per cent concentration, particularly from Bushehr (≈19.2 mm), supporting the therapeutic potential of *A. florea* honey in apitherapy (Parichehreh *et al*. 2025) [25]. Comparative studies on antibacterial activity of honey from different *Apis* species demonstrated notable inhibitory effects against pathogenic bacteria. Honey produced by *A. florea* showed strong activity against *Staphylococcus aureus* (≈23.8 mm) and *Pseudomonas aeruginosa* (≈26.5 mm), while *A. dorsata* honey was more effective against *Escherichia coli* (≈19.6 mm) (Yasmeen *et al*. 2025) [45]. Melittin peptides derived from *A. florea* venom have shown pronounced cytotoxic effects against lung cancer cell lines, including A549, NCI-H460 and NCI-H1975, in a dose-dependent manner. Significant reductions in cell viability were observed at higher concentrations, indicating strong anticancer potential. These findings support the emerging role of *A. florea* venom components as promising bioactive agents in apitherapy and cancer research (Sattayawat *et al*. 2025) [34]. The lactic acid bacterial community associated with *A. florea* honey is dominated by fructophilic species adapted to nectar- and honey-rich environments. *Lactobacillus kunkeei* occurs as the most prevalent LAB, contributing to antimicrobial defense, honey preservation, and bee health, while *L. plantarum* and *Enterococcus faecalis* add probiotic and fermentation-related functions (Seeley *et al*. 1982) [35].

Domestication of *A. florea*

Long-term monitoring revealed a sharp decline in *A. florea* colony numbers, decreasing from about 221 colonies in 1984 to nearly 53 colonies by 2011, indicating sustained population loss over three decades (Sihag, 2021) [38]. The observed trend highlights the urgent need for conservation-oriented management and the exploration of *A. florea* domestication or semi-domestication strategies to ensure its survival and sustained pollination services. In Oman, *A. florea* colonies have been managed effectively under traditional management practices (Dutton and Simpson 1977) [13]. They provide additional awareness for beekeeping practices (Dutton and Free 1979) [12]. Farmers collected wild colonies from mountain slopes and transferred them to man-made chambers or tree cavities for management. Several attempts have been reported in India to domesticate *A. florea*; however, these efforts have largely remained unsuccessful (Bhardwaj and Kapil 1980) [5]. Dwarf bees are rarely domesticated. The absconding habitat mainly deters the attempts to domesticate these bees. Little bee colonies never stay in the same place for a long time. In some areas, beekeepers make a ‘clip’ of split bamboo. After a wild colony is obtained, the honey section of the comb is removed for consumption (Abrol 2020). The remaining brood comb is placed in the clip and resuspended near the original location in the hope that the bees will reoccupy it. Although domestication is difficult, dwarf honey bees can be domesticated in low-cost hives for sustainable honey harvest and pollination of several field and orchard crops.

The nests can be cut from their nesting habitats and easily shifted to crop fields for planned pollination (Abrol 2020) [1].

Conclusion

Among all the major honey bee species, the red dwarf honey bee, *A. florea* is the smallest. It is found throughout the tropical and subtropical regions of Asia. The uniqueness of *A. florea* is typically building open, single-comb nests and strong floral fidelity. The broad floral calendar of *A. florea*, encompassing multiple plant families across seasons, reflects its wide foraging spectrum and strong ecological adaptability under tropical and subtropical conditions. It is a major pollinator in crops like coriander, fennel, aster, chamomile, summer squash, curry tree, niger and bitter gourd. Pollination by *A. florea* improves the quality and yield parameters. Beyond pollination, *A. florea* provide valuable products such as honey, wax, propolis, venom and royal jelly. Its raw honey not only possesses higher antioxidant, colour intensity, proline, protein and flavonoids but also shows antibacterial activity. Moreover, melittin isolated from venom of *A. florea* showed higher cytotoxicity against lung cancer cell lines. The continuing decline of *A. florea* populations highlights the need for conservation-focused management and alternative utilization approaches.

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