*J. Adv. Sci. Edu. Res.* **2021: 2: 34-117**, ISSN: 2583-0155 (ONLINE)

https://doi.org/10.56253/JASER.2.1.2021.36-118
Pubished: 25.12.2021(http://jaser.rkmvccrahara.org/)

# Plant Pollinator Co-ordination in Ornithophily – a Review

Shuvam Sengupta,1 Subhrajyoti Mallick,2 Sayan Bhowmick,3 Aritra Mondal,4 Kundan Dutta,5 Achintya Chattopadhyay.6 *

1-6 Center for Insect Taxonomy and Pollinator Research, Ramakrishna Mission Vivekananda Centenary College (Autonomous), Rahara, Kolkata-700118, West Bengal, India.

****For Correspondence: drachatto@yahoo.com***

**Abstract:**

Plant-bird interaction is directly related to the food habit, foraging andnesting behaviour of birds and pollination, seed dispersal in plants. Ornithophilous plants are pollinated by birds, who are specialized to collect nectar and pollen. Thus both plants and birds developed their adaptive characters, making pollination a success. However, such adaptive characters are variable in different plants and bird pollinators. Pollination syndrome has provided an understanding of the evolution and adaptation of birds and the floral traits. Present review contains general and specific pollination characteristics of both plants and their pollinator bird species. Observations by different workers on 89 species of plants and 108 species of pollinating/ flower visiting birds could be noted of which 58 species of plants and 84 species of associatedbirds were recorded from India. Gap areas in research on ornithophily in India have been discussed.

**Key Words:** Ornithophily, Syndrome, Interaction, Pollination.

## Introduction:

Pollination is the important reproductive phenomenon in angiosperms that is successfully implemented through effective mutual relationship between flowers and their pollinators. Specific patterns of structure and function of the flowers and their pollinators are called pollination syndromes which are flower traits evolved by natural selection imposed by the pollinators that culminated in convergent evolution (Raju, 2010). Pollination syndromes help to understand the mechanism of floral diversification (Fenster et al., 2004). The prediction of

pollination syndromes usually involves specialized flowers, such as tubular flowers having nectar, employing a group of effective pollinators (Castellanos et al., 2003; Wilson et al., 2004; Muchhala, 2006; Pauw, 2006; Rodríguez-Rodríguez and Valido, 2008).

**Birds:**

Birds are one of the most isolated groups of animals in the modern world. They are widely distributed, occupy a variety of ecological niches and vary in size from small hummingbirds to ostriches (Brusatte et al., 2015). More than 10,400 species of birds have been recorded globally (Gill et al., 2020). About 5,966 species of passerines and 4,027 species of non-passerines exhibit their geographic distributional variations (Jetz et al., 2014). Till now India reported 1275 bird species, covering 26 Orders and 111 Families (Bayani and Satose, 2020) and this included 79 bird species as endemic to India (Jathar and Rahmani, 2006).

**Pollination:**

Bird pollination is energetically expensive for plants, yet it occurs only when birds can mediate optimal patterns of pollen flow and seed set, where nectar acts as an inducement (Stiles, 1978).Birds are homeotherms and large in size which increases their energy needs (Stiles, 1978). Therefore, plants with bird-pollinated flowers put more energy into production of large quantities of dilute nectar, the main reward of pollinators (Cronk and Ojeda, 2008; Roitman et al., 2002). Nectar's sugar concentrations of ornithophilous flowers range between 20-26% with extremes between 10-34% (Pike and Waser, 1981; Stiles and Freeman, 1993; Proctor et al., 1996; Baker, 1975). To serve the energy needs of avian pollinators' plants often produce larger flowers (Cronk and Ojeda, 2008). Along with nectar, food tissues also serve as nutritive rewards to different pollinators but its presence is rare in the Angiosperms (Simpson and Neff, 1981; Roitman et al., 2002).

Pollination being mutuality, plants are the major benefactors along with the birds. The potential mobility of birds is probably higher than insects (Ruschi, 1949; Stiles, 1973; Stiles and Wolf, 1979). This combined with high energy needs, result in birds visiting several widely scattered nectar sources on a single foraging bout which is highly beneficial for plants (Stiles, 1978). Because of high energy needs, birds must continue to forage under inclement conditions where other pollinators remain inactive and have low population densities. Thus birds are more dependable pollinators in high altitude or dry environments, isolated islands and the areas with frequent cold or rainy conditions (Cronk and Ojeda, 2008; Stiles, 1971,

1973; Cruden, 1972; Van der Pijl and Dodson, 1966; Stiles, 1978; Dupont et al., 2004; Micheneau et al., 2006). Birds with spatial memories, can remember the location of flower patches from year to year (Bené, 1946). So the floral environment becomes more fine-grained in space and time for birds than insects (Stiles, 1978). Pollens usually get attached on the forehead, beak, face and chin feathers of a bird (Ford et al., 1979). Bills being evolutionarily labile structures, birds can enter into species-specific morphological coadaptations with flowers to a greater extent than bats (Stiles, 1978).

Overall, bird pollination must be regarded as an expensive system that is only advantageous when the high energy investment from plants is repaid from birds as pollinators in terms of favorable pollen flow patterns and high seed set (Stiles, 1978).

**Ornithophily and its syndrome:**

Ornithophily is the term used for bird-pollination. General pollination syndromes of ornithophilous plants are unscented flowers characterized by their bright, often contrasting colours, dilute nectar and landing platform (Raju, 2010).

**Floral adaptations in ornithophily:**

There are four broad types of floral adaptations of bird pollinated plants: 1. attraction mechanisms; 2. exclusion mechanisms; 3. protection mechanisms and 4. pollination mechanisms (Grant and Grant, 1968).

**Attraction mechanisms-**

- Attractive floral displays with a combination of contrasting colours, like red, orange, yellow etc.
- Copious amounts of nectar (Cronk and Ojeda, 2008).

**Exclusion mechanisms-**

- Some flowers are difficult for insects to work but easy for hummingbirds. Example- pendant flowers (*Aquilegia formosa*).
- Long-exserted stamens are recurved to block entrance to the tube in *Trichostema lanatum*. (Cronk and Ojeda, 2008).

**Protection mechanisms-**

- Birds being potentially destructive pollinators, mechanical strength is provided by the formation of sclerenchyma or collenchyma tissue in various floral parts for protection.

- Separation of ovary and nectaries by the sheathing of ovary by a staminal tube or by a stalked or inferior ovary.
- Groove formed by the corolla to guide birds' beaks to the nectary without causing damage to the corolla providing direct protection to the ovary (Cronk and Ojeda, 2008).

**Pollination mechanisms-**

- Zygomorphic flowers tend to place pollen on the top of the visiting bird's beak or head (Cronk and Ojeda, 2008).

More than 1,600 species in eight bird families have special adaptations– slender curved beaks and tufted or tubular tongues (Meeuse, 2020). Birds do not use their olfactory system to find food and have very strong eyesight, which captures red light frequencies in the electromagnetic spectrum very efficiently (Meeuse, 2020).

Pollinating birds are larger than insects, so have a greater rate of body metabolism in comparison. This is why birds have to take a greater amount of nectar per individual than an insect (Meeuse, 2020).

Pollinator/visitor birds from the world and India with their host plant species along with their morphological and behavioural adaptive characters, as recorded by different workers are summarized in table-1 and table-2 below —

**Table- 1: World bird pollinators and associated plants with syndromes**

| Sl. no. | Bird species | Pollination adaptations in birds | Plant species | Pollination syndromes in plants | References |
|---|---|---|---|---|---|
| | **Family-** Nectariniidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 1 | Orange-breasted sunbird (*Nectarinia violacea* (Linnaeus, 1766)) | Nectarivorous, attracted by bright colour polymorphism, curvature of the beak helps in nectar collection. | *Erica plukenetii* | Strongly curved tubular flowers and thicker stems, very viscid corolla tube, probably to prevent nectar and pollen thieving by insects. Red flowers are relatively well represented and have high incidence of bi or tricolour. | Rebelo et al., 1985; Siegfried et al., 1985 |
| | | Specific characters in association with this plant, not found. | *Lachenalia luteola* | Single inflorescence comprising a raceme of approximately 10 tubular yellowish-green flowers. | Turner and Midgley, 2016; Duncan, 2012 |

| | | | | | |
|---|---|---|---|---|---|
| 2 | Malachite sunbird (*Nectarinia famosa* (Linnaeus, 1766)) | Attracted by the bright colour of the flowers, birds come for nectar, collect it sitting on the ground, thereby transferring copious pollen on their beaks between male and female inflorescence. | *Cytinus sanguineus* | Bright-red colouration, flowers are at the soil level, copious production of nectar and the absence of floral scent keeps the insect and rodent pollinators away. | Hobbhahn and Johnson, 2015 |
| | | Specific characters in association with this plant, not found. | *Hyobanche sanguinea* | Bright red colouration, vertically oriented flowers grown in contact with soil, arranged in tight inflorescence which is perchless and with a significant amount of nectar. | Turner and Midgley, 2016 |

| | | | | | |
|---|---|---|---|---|---|
| | | Birds forage from the centre of the inflorescence and their crowns pick up the pollens, as they are presented towards the centre of the inflorescence. | *Protea roupelliae* | The plant has dark pink flower bracts, diurnal flowering, lack of odour and large quantities of dilute nectar. Pollens are presented on the side of stigma facing the centre of the inflorescence in newly opened flowers. | Hargreaves et al., 2004; Faegri and Van der Pijl, 1979; Beard, 1993 |
| | | Nectar feeder and has a long narrow curved bill. | *Chasmanthe floribunda* | Nectar containing long corolla tubes, bright orange in colour. | Geerts and Pauw, 2009 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | Crimson sunbird (*Aethopyga siparaja* (Raffles, 1822)) | All general features of a sunbird. Specific characters not found. | *Camellia petelotii* | The normally pendulous flowers are cup shaped, with shiny yellow, waxy petals and dozens of stamens with orange anthers. The outer whorl of filaments forms a tube. | Sun et al., 2017 |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Olive sunbird (*Cyanomitra olivacea* (Smith, 1840)) | Perch on the petioles of the densely arranged leaves or hover in front of the flower and stick the beak deep into the flower tube to suck the nectar. They have a beak size that can be inserted deep into the flowers and deflect the trigger appendage which leads to a rolling movement of the style and pollen gets deposited onto the beak. | *Megaphryniu m trichogynum* | Large vertically arranged, yellow and red coloured hanging flowers with elongated floral tubes and large quantities of low concentrated nectar. Flowers have a trigger-like appendage of the hooded staminode which on touching springs the style forward. Plants bear simultaneously open flowers, decreasing the energy-consuming movements of the birds. | Ley and Claßen-Bockhof, 2009; Vogel, 1954; Westerkamp, 1990 |

| | | | | | |
|---|---|---|---|---|---|
| | | Same as above | *Ataenidia conferta* | Large white vertical flowers and vertically arranged red bracts collect rainwater as an important water supply for birds. Plants have simultaneously open flowers, decreasing the energy-consuming movements of the birds, also the flowers have a trigger-like appendage of the hooded staminode which on touching springs the style forward. | Ley and Claßen-Bockhof, 2009; Vogel, 1954; Westerkamp,1990 |

| | | | | | |
|---|---|---|---|---|---|
| | | To access the nectar cup the birds perch on the anther-sheath. They depress the petals, to open the flaps of the anther-sheath and expose the pollen which readily adhere to the bird's feet. | *Strelitzia nicolai* | The horizontal petals are fused along their base to form anther-sheath which contains the stamens. The flaps of the anther-sheath expose thin filaments bearing long anthers with white sticky pollen. Their third petal, forms a shield over the nectar "cup" which comprises the fused bases of three petals. | Frost and Frost, 1981 |
| 5 | Grey sunbird (*Nectarinia veroxii* (Smith, 1831)) | Same as above | *Strelitzia nicolai* | Already mentioned | Frost and Frost, 1981 |
| 6 | Collared sunbird (*Anthreptes collaris* (Vieillot, 1819)) | Same as above | *Strelitzia nicolai* | Already mentioned | Frost and Frost, 1981 |

| | | | | | |
|---|---|---|---|---|---|
| 7 | Long-billed spider hunter (*Arachnothera robusta* Müller and Schlegel, 1845) | To reach the nectar they have a long and thick curved bill. | *Amylotheca duthieana* | Flowers are cylindrical and reddish orange in colour. The lobe and corolla are short and the lobes are reflexed. In stamens tension causes the tubular corolla to split along the petal junctions to form window-like fenestrae. | Yumoto et al., 1997 |
| 8 | Little spiderhunter (*Arachnothera longirostra* (Latham, 1790)) | Long bills and tongues to suck nectar from flowers, thereby helping in pollination. | *Trithecanthera sparsa* | Flowers are yellow and corolla is of intermediate shape. They lack odour, nectar guides and lips. | Yumoto et al., 1997 |

| | | | | | |
|---|---|---|---|---|---|
| | | Same as above | *Trithecanthera xiphostachys* | Flowers have long corolla and lobes, lack odour, nectar guides and lips and pink coloured. The bright colour and long corolla of inflorescence attract pollinating birds from a long distance. | Yumoto et al., 1997 |
| | | Having long-billed, as the entrance of the corolla tube are tightly blocked up by stamen and stigma that inhibit the entrance of other pollinators except birds. | *Hornstedtia conica* | Fusiform spikes are born on stout peduncles at a height of 30-70 cm above the ground. They are compactly bound with large red bracts. One or two flowers are born on a spike. The corolla tube is very long and curved. | Kato et al., 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | | Same as above | *Phaeomeria fulgens* | Long scapes bear the head of inflorescence at a height of 30-50 cm above the ground. Stamen and stigmata tightly block the slender corolla tube that inhibits the insertion of bee's proboscis. | Kato et al., 1993 |
| 9 | Cameroon sunbird (*Cyanomitra oritis* (Reichenow, 1892)) | Small in size, with long beaks and hovering ability. | *Impatiens frithii* | Red coloured flowers with long-spurred and bucciniform lower sepals. | Janeček et al., 2015; Grey-Wilson, 1980; Janeček et al., 2011 |
| 10 | Southern double-collared sunbird *(Cinnyris chalybea* (Linnaeus, 1766)) | Feeds on nectar, having a short narrow curved bill. | *Erica versicolor* | Nectar containing, in short corolla tubed flowers. | Geerts and Pauw, 2009 |

| | | | | | |
|---|---|---|---|---|---|
| 11 | Mrs. Gould's sunbird (*Aethopyga gouldiae* (Vigors, 1831)) | Not found | *Rhododendron clementinae* | Rosaceous to pink coloured flowers, large and open type inflorescence. | Huang et al., 2017 |
| 12 | Grey-chinned sunbird or green sunbird (*Anthreptes rectirostris* (Shaw, 1812)) | In search of abundant nectar, insert beaks through the fenestrae without perching and have ease of collecting nectar due to open flowers. | *Plicosepalus kalachariensis* | Open type flowers having abundant nectar, tubular corolla split along the petal junctions forming window-like fenestrae, curvature of corolla tube is connected with more specialized fenestral structure. | Feehan, 1985 |

| | | | | | |
|---|---|---|---|---|---|
| 13 | Amethyst sunbird (*Chalcomitra amethystina* (Shaw, 1812)) | Nectarivorous, curved beak helps in collection of nectar, attracted by the bright colour polymorphism. | *Delonix regia* | Large flowers, with four spreading scarlet or orange-red petals up to 8 cm long, fifth petal is slightly larger and spotted with yellow and white. Appear in corymbs and at the ends of branches. The pods are green and flaccid when young and turn dark-brown and woody. | Du Puy et al., 1995 |
| | **Family-** Trochilidae | | | | |
| 14 | Hummingbird | Maneuvers during the collection of nectar and small body size helps in accessibility. | *Burmeistera tenuiflora* | Highly exposed flowers, bright red colouration keeps insect pollinators away and nectar is produced nocturnally. | Muchhala, 2003; Van der Pijl, 1961 |
| | | Nectar feeder, with long tongue. | *Aquilegia* sp. | Bright in colour with floral spurs and contains nectar. | Whittall and Hodges, 2007 |

| | | | | | |
|---|---|---|---|---|---|
| 15 | Anna's hummingbird (*Calypte anna* (Lesson, 1829)) | Smallest of birds, most species measuring 7.5–13 cm in length, with longer beaks, allowing more effective reach into crevices of tall flowers for nectar. | *Ipomopsis aggregata* | Trumpet-shaped flowers that are especially thin and one-inch long. The corolla opens out at the tip to five pointed lobes. Inside are a few red stamens and bright yellow anthers. | Cronk and Ojeda, 2008 |
| 16 | Rufous hummingbird (*Selasphorus rufus* (Gmelin, 1788)) | Smallest of birds, with longer beaks, allowing more effective reach into crevices of tall flowers for nectar. | *Fritillaria suberosa* | The flowers are usually solitary, nodding and bell-shaped with bulbs that have fleshy scales, resembling those of lilies. | Cronk and Ojeda, 2008 |
| | **Family-** Ploceidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 17 | Cape weaver (*Ploceus capensis* (Linnaeus, 1766)) | With streaked olive-brown upperparts and a long pointed conical bill. | *Strelitzia reginae* | At an average of over 6 feet tall, flowers are produced on a stiff stem that rises above the foliage and are contained in orange and blue, boat-shaped bracts to produce a lovely effect in any landscape. | Cronk and Ojeda, 2008 |
| | **Family-** Pycnonotidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 18 | Chinese bulbul (*Pycnonotus sinensis* (Gmelin, 1789)) | Not found | *Eriobotrya japonica* | Flowers are pale, fragrant and with a sufficient amount of nectar, attracting bird pollinators. The stamens curl inwards when young, unbending progressively from outside to inside. At the base of the calyx the perigynous flower has nectaries whose nectar is deposited onto the shallow hypanthium. | Fang et al., 2012; Ford, 1985; Ollerton et al., 2009a |
| | **Family-** Zosteropidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 19 | Taiwan yuhina (*Yuhina brunneiceps* Ogilvie-Grant, 1906) | This generalist passerine has larger body size than specialist birds and with shorter but wider bills. Bill length and half of the crest approximately matches the elongated gynoecium of *A. acuminatus*. | *Aeschynanthus acuminatus* | Odourless red flowers having narrow corolla tubes with copious (61 μL), highly diluted (7%) hexose-dominant nectar. The corolla lacks the landing platform so birds can only hover or perch from adjacent stems or branches. The narrow corolla tubes help to deposit pollen onto the exact position of bird bodies. | Chen et al., 2019; Cronk and Ojeda, 2008; Pellmyr, 2002; Stiles, 1978; Corlett, 2004; Chang et al., 2013 |
| | **Family-** Leiotrichidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 20 | White-eared sibia (*Heterophasia auricularis* (Swinhoe, 1864)) | This generalist passerine has larger body size than specialist birds and with shorter but wider bills. Brush-tipped tongues specialized to quickly collect nectar via capillarity. | *Aeschynanthus acuminatus* | Already mentioned | Chen et al., 2019; Cronk and Ojeda, 2008; Pellmyr, 2002; Stiles, 1978; Corlett, 2004; Chang et al., 2013 |
| 21 | Grey-cheeked fulvetta (*Alcippe morrisonia* Swinhoe, 1863) | Same as above | *Aeschynanthus acuminatus* | Already mentioned | Chen et al., 2019; Cronk and Ojeda, 2008; Pellmyr, 2002; Stiles, 1978; Corlett, 2004; Chang et al., 2013 |
| | **Family-** Meliphagidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 22 | Western spinebill (*Acanthorhynchus superciliosus* Gould, 1837) | During flower penetration, downward directed nectary spurs fit to the curved beak of the bird and it stays on the ground as perching is not allowed by the plant. | *Utricularia menziesii* | Red coloured large flowers with hexose dominated nectary spur, directed downward that can withstand contact with a hard beak. | Lowrie, 2013; Płachno et al., 2019 |
| 23 | Honeyeater | Not found | *Mirbelieae* sp. | Not found | Joseph et al., 2014 |
| | **Family-** Psittacidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 24 | Golden-winged parakeet (*Brotogeris chrysopterus* (Linnaeus, 1766)) | They insert its pointed beak through the petal's imbrications, thereby effectively contacting the pore-like stigmas, pollinating flowers. | *Moronobea coccinea* | Flowers are pinkish-coloured, robust, odourless, providing a perching site. During anthesis, petals are flexible and form a pseudotube enclosing the anthers and the flowers do not open fully. | Vicentini and Fischer, 1999; Westerkamp, 1990; Proctor et al., 1996; Bittrich and Amaral, 1996 |
| | **Family-** Phylloscopidae | | | | |
| 25 | Canary Islands chiffchaff (*Phylloscopus canariensis* (Hartwig, 1886)) | To access nectar, birds occasionally hang upside down from the flower. | *Canarina canariensis* | Flowers are large, robust, orange-reddish in colour, bell-shaped and lack odour. | Ollerton et al., 2009b; Bramwell and Bramwell, 2001; Proctor et al., 1996 |

**Table- 2: Indian pollinator and visitor birds with associated plants syndromes**

The following table depicts total pollinator and visitor Indian birds and associated plants with respective syndromes. In this table P= the plant is associated with the respective bird for pollination and V= the bird visits theflower as reported till now.

| Sl. no. | Bird species | Pollination adaptations in birds | Plant species | Pollination syndromes in plants | References |
|---|---|---|---|---|---|
| | **Family**-<br>Nectariniidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 1. | Purple sunbird (*Nectarinia asiatica* (Latham, 1790)) | Elongated gently decurved beak that helps to harvest the deep-seated nectar from the flowers. They press down the keel (carina) so the stiff pistil and the staminal tube emerge through the tip of the keel and rub against the body parts, mainly crown. | *Butea monosperma* (P) | Plants have bright reddish-orange coloured flowers with diurnal anthesis and abundant nectar whose production is confined to the period during which the stigma is receptive. Nectar is protected deep into the keel and requires a special foraging effort. Stamens and anthers are placed at different heights in the staminal tube. Anthers are arranged in such a way that it maximizes pollen presentation when nectar is consumed from the opening of the keel. | Tandon et al., 2003; Faegri and van der Pijl, 1979 |

| | | | | | |
|---|---|---|---|---|---|
| | | Legitimately probe flowers for nectar by their slightly curved bill. In this process they contact the sex organs of the flower by upper side of the bill and forehead. | *Anisomeles malabarica* (P) | Flowers are purple, fragrant and bilabiate with a small upper lip and a broader and wider downwardly bending lower lip. At the upper part of the corolla the anthers are oriented downward. | Raju, 2008 |
| | | Same as above | *Anisomeles indica* (P) | Flowers are bilabiated by a small upper lip and a broader and wider downwardly bending lower lip. The anthers are downwardly oriented in the upper part of corolla. They are purple coloured and have a fragrance. | Raju, 2008 |

| | | | | | |
|---|---|---|---|---|---|
| | | Same as above | *Acanthus ilicifolius* (P) | Flowers have a cartilaginous corolla tube with a three liped lower lobe that makes a landing place for pollinators and the upper lobe shelters the stamen and stigma. They are pink coloured, odourless and bilabiate. | Raju, 2008 |

| | | | | | |
|---|---|---|---|---|---|
| | | Same as above | *Bruguiera gymnorrhiza* (P) | Flowers are red coloured, odourless and tubular in shape. The anthers with curved filaments develop tension and push against the petals which serve as an enclosing pouch with two stamens. Triggered by the visitors, the petal margins of the flower unzip and flow apart which catapult the loose pollen towards the center of flower by releasing the stamens. | Raju, 2008 |

| | | | | | |
|---|---|---|---|---|---|
| | | Birds probed the flowers directly, contacting the stamens and stigma lying at the tip of the upper lip by their bill and forehead, affecting pollination. | *Helicteres isora* (P) | Flowers are large, tubular in shape and odourless. The corolla of the flower is quite robust and it holds the nectar in the tubular side. On the day of anthesis their colour is bluish grey, light red on the second day and deep red on the third day, this colour change mainly attracts the birds. | Raju, 2008 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Leucas aspera* (P) | Flowers are zygomorphic with faint scent, the lower lip of the corolla tube acts as the area of advertisement. Copious amount of nectar is present in the tubular corolla. The filaments and anthers are partly fused with the upper lip of the corolla tube. | Kulloli et al., 2011 |
| | | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Pyrus pashia* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Prunus* sp. (P) | Not found | Narang et al., 2000 |
| | | Not found | *Bauhinia variegate* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Punica granatum* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Bignonia venusta* (P) | Not found | Narang et al., 2000 |
| | | Feed on extrafloral nectaries located at the base of leaf petiole. During nectar consumption, heads, shoulders and feathers contact the flowering inflorescences in the leaf axils. They probe for extrafloral nectar on individual plants by hopping from branch to branch and contact flowering inflorescences. | *Acacia sinuate* (P) | Not found | Raju and Rao, 2002 |

| | | | | | |
|---|---|---|---|---|---|
| | | Act as pollinators as well as robbers depending upon the quantum of available nectar. While probing the flowers from the front, their bill contacts the stigma and anthers dorsally. | *Leonotis nepetifolia* (P) | Long internodes with spinous whorls of scarlet–orange coloured flowers. The upper lip of the flower is densely wooly in nature | Kulloli et al., 2011 |
| | | Not found | *Woodfordia floribunda* (P) | Plant produces non-fleshy, dry, thin walled, dehiscent capsules. The capsules, by being inside the calyx tube, were found to be attractive to certain birds. | Raju, A. J. S., 2005 |

| | | | | | |
|---|---|---|---|---|---|
| | | While probing flowers for nectar, birds release stamens and stigma from the beak-shaped keel petals and contact them on their beak and forehead. | *Butea superba* (P) | Diurnal anthesis, robust odourless flowers with high amounts of nectar and bright orange-scarlet corolla. Stamens and stigma away from the nectar location. Deeply placed, well-protected nectar and ovary. The standard petal curves downwardly for easy probing. | Raju and Rao, 2007 |
| | | Not found | *Sonneratia caseolaris* (V) | Not found | Pandit and Choudhury, 2001 |
| | | Not found | *Aegiceras corniculatum* (V) | Not found | Pandit and Choudhury, 2001 |
| 2 | Purple-rumped sunbird (*Nectariniazeylonica* (Linnaeus, 1766)) | Same of purple sunbird with *B. ceiba* | *Anisomeles malabarica* (P) | Already mentioned | Raju, 2008 |

| | | | | | |
|---|---|---|---|---|---|
| | | Same of purple sunbird with *A. indica* | *Anisomeles indica* (P) | Flowers are bilabiated by a small upper lip and a broader and wider downwardly bending lower lip. The anthers are downwardly oriented in the upper part of corolla. They are purple coloured and have a fragrance. | Raju, 2008 |
| | | Same of purple sunbird with *L. nepetifolia* | *Leonotis nepetifolia* (P) | Flowers are orange-scarlet, odourless and they are bilabiated by well-developed curved upper lip and poorly developed tripartite glabrous lower lip. | Raju, 2008 |
| | | Same of purple sunbird with *A. ilicifolius* | *Acanthus ilicifolius* (P) | Already mentioned | Raju, 2008 |

| | | | | | |
|---|---|---|---|---|---|
| | | Same of purple sunbird with *B. gymnorrhiza* | *Bruguiera gymnorrhiza* (P) | Already mentioned | Raju, 2008 |
| | | Same of purple sunbird with *H. isora* | *Helicteres isora* (P) | Already mentioned | Raju, 2008 |
| | | Not found | *Leucas aspera* (P) | Already mentioned | Kulloli et al., 2011 |
| | | They feed the extrafloral nectaries located at the base of leaf petiole. They probe for extra-floral nectar on individual plants by hopping from branch to branch and contact with flowering inflorescences. | *Acacia sinuate* (P) | Not found | Raju and Rao, 2002 |
| | | Not found | *Woodfordia floribunda* (P) | Already mentioned | Raju, A. J. S., 2005 |

| | | | | | |
|---|---|---|---|---|---|
| | | Same of purple sunbird with *B. superba* | *Butea superba* (P) | Already mentioned | Raju and Rao, 2007 |
| | | Birds species used the shoot or inflorescence axis for perching and probed flowers from front and laterally strike stamens and stigma to collect nectar resulting in effective pollination. | *Gmelina arborea* (P) | Flowers are large, short-stalked, bisexual, odourless and zygomorphic, calyx is tubate and five-lobed at the tip, corolla is brownish-yellow. Stamens lie close to the upper lip, but extend beyond the lower lip and stand within the length of the central petal of the lower lip. | Raju and Rao, 2006 |
| | | Not found | *Sonneratia caseolaris* (V) | Not found | Pandit and Choudhury, 2001 |
| | | Not found | *Aegiceras corniculatum* (V) | Not found | Pandit and Choudhury, 2001 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | Sunbird | Landing on the branches, pushes the beak into the flowers to collect nectar and stored water from cup-shaped calyxes. Birds have a rough beak surface where pollen grains are adhered by this process. | *Bombax ceiba* (P) | Flowers are adapted by the presence of hard flower-wall, cup-shaped calyx, stiff filaments, well-protected ovary, abundant nectar, good capillary system bringing nectar up or preventing its flowing out of a deep tube or spur and absence of odour. | Bhattacharya and Mandal, 2000 |
| 4 | Crimson sunbird (*Aethopyga siparaja*(Raffles, 1822)) | Not found | *Hibiscus mutabilis* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Bignonia venusta* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Woodfordia floribunda* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Loten's Sunbird (*Nectarinia lotenia*(Linnaeus, 1766)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| 6 | Small sunbird (*Nectarinia minima* (Sykes, 1832)) | Not found | *Hibiscus rosa-sinensis* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Helicteres isora* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Sesbania grandiflora* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Sophora* sp.(P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Lonicera leschenaultii* (P) | Not found | Subramanya and Radhamani, 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Woodfordia fruticosa* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Russelia equisetifolia* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Quamoclitco cinea* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Duranta plumieri* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Stachytarpha ta indica* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Stachytarpha ta mutabilis* (P) | Not found | Subramanya and Radhamani, 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Bougainvillea spectabilis* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Elytranthe parasitica* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Scurrula parasitica* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Helixanthera obtusatus*(P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Lorantus obtusatus*(P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Helixanthera intermedia*(P) | Not found | Subramanya and Radhamani, 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Dendrophthoe memecylifolius*(P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Dendrophthoe neelgherrensis* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Macrosolen parasiticus* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Taxillus recurvus* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Taxillus cuneatus* (P) | Not found | Subramanya and Radhamani, 1993 |
| | **Family**-Sturnidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 7 | Common myna (*Acridotheres tristis* (Linnaeus, 1766)) | Approach flowers by landing on the racemes. After landing, they drink the liquid rewards. While doing so, they contact the stamens and stigma with the underside of their beak and body. | *Spathodea campanulata* (P) | Provides calyx, water and nectar for pollinators. Flowers are showy, scarlet, large and bell-shaped. Gamopetalous corolla with short tube at base and widens gradually towards the mouth. Bright yellow with red streaks inside the corolla. The inflorescence is panicle, compact and almost erect in position. The panicles arise at the terminal part of the branches. | Rangaiah et al., 2004 |
| | | Same of sunbird with *B. ceiba* | *Bombax ceiba* (P) | Already mentioned | Bhattacharya and Mandal, 2000 |
| | | Same of purple sunbird with *H. isora* | *Helicteres isora* (P) | Already mentioned | Raju, 2008 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Butea monosperma* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Eucalyptus globulus* (P) | Not found | Narang et al., 2000 |
| | | Same of purple sunbird with *B. superba* | *Butea superba* (P) | Already mentioned | Raju and Rao, 2007 |
| 8 | Pied myna (*Sturnus contra* (Linnaeus, 1758)) | Same as above | *Bombax ceiba* (P) | Already mentioned | Bhattacharya and Mandal, 2000 |
| 9 | Brahminy myna (*Sturnia pagodarum* (Gmelin, 1789)) | Not found | *Erythrina suberosa* (P) | To provide suitable perches for foraging birds, flowers occupy only the distal half of the inflorescence axis and the inflorescence is oriented horizontally providing a standard place for probing. | Raju and Rao, 2004; Baker et al., 1983 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Woodfordia floribunda* (P) | Already mentioned | Raju, A. J. S., 2005 |
| 10 | Bank myna (*Acridotheres ginginianus* (Latham, 1790)) | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Not found | *Woodfordia floribunda* (P) | Already mentioned | Raju, A. J. S., 2005 |
| 11 | Indian myna (*Acridotheres tristis* (Linnaeus, 1766)) | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| 12 | Jungle myna (*Acridotheres fuscus* (Wagler, 1827)) | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Butea monosperma* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Helicteres isora* (P) | Not found | Manikandan and Kunhikannan, 2016 |
| 13 | Spot-winged starling (*Saroglossa spiloptera*(Vigors, 1831)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Woodfordia floribunda* (P) | Not found | Narang et al., 2000 |
| 14 | Chestnut-tailed starling (*Sturnus malabaricus*(Gmelin, 1789)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Butea monosperma* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Woodfordia floribunda* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Helicteres isora* (V) | Flowers are bright red in colour, tubular in shape with wide floral tube. | Richard et al., 2011 |
| 15 | Hill myna (*Gracula religiosa* Linnaeus, 1758) | Not found | *Bombax ceiba* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Helicteres isora* (P) | Not found | Subramanya and Radhamani, 1993 |
| | **Family-** Timaliidae | | | | |
| 16 | Tawny-bellied babbler (*Dumetia hyperythra* (Franklin, 1831)) | Same of sunbird with *B. ceiba* | *Bombax ceiba* (P) | Already mentioned | Bhattacharya and Mandal, 2000 |

| | | | | | |
|---|---|---|---|---|---|
| 17 | Pin-striped tit-babbler (*Macronus gularis* (Horsfield, 1822)) | Same as above | *Bombax ceiba* (P) | Already mentioned | Bhattacharya and Mandal, 2000 |
| 18 | Yellow-breasted babbler (*Macronous gularis* (Horsfield, 1822)) | Not found | *Bombax ceiba* (P) | Bright red coloured flowers attract bird pollinators from quite a far distance and helps to avoid bee pollination. The size and tip location of floral cups at branches facilitate the birds' easy accessibility. Ample amount of nectar serves as great energy resources for birds in dry conditions. | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| 19 | Red-capped babbler (*Stachyridopsis ruficeps* (Blyth, 1847)) | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |

| | | | | | |
|---|---|---|---|---|---|
| 20 | Common babbler (*Turdoides caudate* (Dumont, 1823)) | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| 21 | Rosy pastor (*Pastor roseus* (Linnaeus, 1758)) | Not found | *Bombax ceiba* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Bombax insigne* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Erythrina verigata* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Butea monosperma* (P) | Not found | Subramanya and Radhamani, 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Careya arborea* (P) | Not found | Subramanya and Radhamani, 1993 |
| 22 | Scimitar babbler (*Xiphirhynchus superciliaris* Blyth, 1842) | Not found | *Bombax ceiba* (P) | Not found | Subramanya and Radhamani, 1993 |
| 23 | Yellow-eyed babbler (*Chrysomma sine nse* (Gmelin, 1789)) | Not found | *Bombax ceiba* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Bombax insigne* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Erythrina varigata* (P) | Not found | Subramanya and Radhamani, 1993 |
| | **Family-** Pycnonotidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 24 | Red-vented bulbul (*Pycnonotus cafer* (Linnaeus, 1766)) | Same of sunbird with *B. ceiba* | *Bombax ceiba* (P) | Already mentioned | Bhattacharya and Mandal, 2000 |
| | | Same of purple sunbird with *H. isora* | *Helicteres isora* (P) | Already mentioned | Raju, 2008 |
| | | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Woodfordia floribunda* (P) | Already mentioned | Raju, A. J. S., 2005 |
| | | Not found | *Butea monosperma* (V) | Papilionaceous flowers are large with bright orange-red colouration with ample amounts of nectar, showing diurnal anthesis. | Tandon et al., 2003 |

| | | | | | |
|---|---|---|---|---|---|
| 25 | Red-whiskered bulbul (*Pycnonotus jocosus* (Linnaeus, 1758)) | Same of purple sunbird with *H. isora* | *Helicteres isora* (P) | Already mentioned | Raju, 2008 |
| | | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| | | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Same of purple-rumped sunbird with *G. arborea* | *Gmelina arborea* (P) | Already mentioned | Raju and Rao, 2006 |
| | | Not found | *Spathodea Campanulata* (V) | Flowers are bright red in colour, tubular in shape with wide floral tube | Richard et al., 2011 |

| | | | | | |
|---|---|---|---|---|---|
| 26 | Black-headed yellow bulbul (*Pycnonotus melanicterus*(Gmelin, 1789) | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| | | Not found | *Woodfordia floribunda* (P) | Already mentioned | Raju, A. J. S., 2005 |
| 27 | Himalayan bulbul (*Pycnonotus leucogenys*(Gray, 1835)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Woodfordia floribunda* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Prunus cerasoides* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Prunus* sp. (P) | Not found | Narang et al., 2000 |
| | | Not found | *Xylosma longifolium* (P) | Not found | Narang et al., 2000 |
| 28 | Black bulbul (*Hypsipetes leucocephalus*(Gmelin, 1789)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| 29 | White-browed bulbul (*Pycnonotus luteolus* (Lesson, 1841)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Butea monosperma* (V) | Already mentioned | Tandon et al., 2003 |
| | **Family-** Zosteropidae | | | | |
| 30 | Indian white-eye (*Zosterops palpebrosus* (Temminck, 1824)) | Same of purple sunbird with *B. gymnorrhiza* | *Bruguiera gymnorrhiza* (P) | Already mentioned | Raju, 2008 |
| | | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Woodfordia floribunda* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Ougenia oojeinensis* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Prunus cerasoides* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Prunus* sp. (P) | Not found | Narang et al., 2000 |
| | | Not found | *Pyrus pashia* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Leptodermis lanceolatus* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Schefflera wallichana* (P) | Flowers are open disc shaped and brownish red in colour and opened with exposed nectar. | Richard et al., 2011 |
| | | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| | | Not found | *Butea monosperma* (V) | Already mentioned | Tandon et al., 2003 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Sonneratia caseolaris* (V) | Not found | Pandit and Choudhury, 2001 |
| | | Not found | *Aegiceras corniculatum* (V) | Not found | Pandit and Choudhury, 2001 |
| | **Family-** Leiotrichidae | | | | |
| 31 | Jungle babbler (*Turdoides striatus* (Dumont, 1823)) | Same of purple sunbird with *H. isora* | *Helicteres isora* (P) | Already mentioned | Raju, 2008 |
| | | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Butea monosperma* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| 32 | Grey sibia (*Heterophasia gracilis* (Horsfield, 1840)) | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| 33 | Rufous sibia (*Heterophasia capistrata*(Vigors, 1831)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |
| 34 | White-headed babbler (*Turdoides affinis* (Jerdon, 1845)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| | **Family-** Dicruridae | | | | |
| 35 | Black drongo (*Dicturus macrocerus* (Vieillot, 1817)) | Same of purple sunbird with *H. isora* | *Helicteres isora* (P) | Already mentioned | Raju, 2008 |

| | | | | | |
|---|---|---|---|---|---|
| | | To reach nectar it cut the anterior part of the standard petal. | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| 36 | North Indian black drongo (*Dicrurus adsimilis* (Bechstein, 1794)) | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| 37 | Hair-crested drongo *(Dicrurus hottentottus* (Linnaeus, 1766)) | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |

| | | | | | |
|---|---|---|---|---|---|
| 38 | Greater racket-tailed drongo *(Dicrurus paradiseus* (Linnaeus, 1766)) | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| | | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| 39 | Drongo (*Dicurus* sp.) | Not found | *Helicteres isora* (P) | Flowers are bright red in colour, tubular in shape with wide floral tube. | Richard et al., 2011 |
| 40 | Grey drongo (*Dicrurus leucophaeus*Vieillot, 1817) | Nectarivorous with beak size (25-28mm) larger than visitor birds. | *Helicteres isora* (P) | Red coloured and tubular shaped flower with a robust corolla and absence of odour. | Shantaram, 1996; Faegri and Pijl, 1978 |
| 41 | White-bellied drongo (Dicrurus caerulescens (Linnaeus, 1758)) | Nectarivorous with beak size (22-27mm) larger than visitor birds. | *Helicteres isora* (P) | Odourless red coloured tubular shaped flower with a robust corolla. | Shantaram, 1996; Faegri and Pijl, 1978 |

| | | | | | |
|---|---|---|---|---|---|
| | **Family-** Muscicapidae | | | | |
| 42 | Magpie-robin (*Copsychus saularis* (Linnaeus, 1758)) | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| 43 | Pied Bushchat (*Saxicola caprata* (Linnaeus, 1766)) | Not found | *Woodfordia floribunda* (V) | Not found | Raju, A. J. S., 2005 |
| | **Family-** Fringillidae | | | | |
| 44 | Common rosefinch (*Carpodacus erythrinus* (Pallas, 1770)) | Not found | *Erythrina suberosa* (P) | Already mentioned | Raju and Rao, 2004; Baker et al., 1983 |
| | | Not found | *Woodfordia floribunda* (P) | Not found | Narang et al., 2000 |
| | **Family-** Falconidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 45 | Oriental hobby (*Falco severus* Horsfield, 1821) | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| | **Family-** Cuculidae | | | | |
| 46 | Indian cuckoo (*Cuculus micropterus* Gould, 1838) | Not found | *Bombax ceiba* (P) | Already mentioned | Lunau et al., 2011, Bergamo et al., 2016; Raju et al., 2005; Khanduri and Kumar, 2016 |
| | **Family-** Psittaculidae | | | | |
| 47 | Alexandrine parakeet (*Psittacula eupatria*(Linnaeus, 1766)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| 48 | Plum-headed parakeet (*Psittacula cyanocephala*(Linnaeus, 1766)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| | | Not found | *Butea superba* (V) | Already mentioned | Raju and Rao, 2007 |
| 49 | Blue-winged parakeet (*Psittacula columboides* (Vigors, 1830)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| 50 | Rose-ringed parakeet (*Psittacula krameri* (Scopoli, 1769)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| | | Not found | *Butea monosperma* (V) | Already mentioned | Tandon et al., 2003 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Butea superba* (V) | Already mentioned | Raju and Rao, 2007 |
| 51 | Blossom-headed parakeet (*Psittacula cyanocephala* (Linnaeus, 1766)) | Not found | *Helicteres isora* (V) | Red coloured and tubular shaped flower with a robust corolla and absence of odour. | Shantaram, 1996; Faegri and Pijl, 1978 |
| 52 | Indian lorikeet (*Loriculus vernalis* (Sparrman, 1787)) | Same of purple-rumped sunbird with *G. arborea* | *Gmelina arborea* (P) | Already mentioned | Raju and Rao, 2006 |
| | **Family-** Corvidae | | | | |
| 53 | Large-billed crow (*Corvus macrorhynchos* Wagler, 1827) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |
| 54 | Red-billed blue magpie (*Urocissa erythrorhyncha*(Boddaert, 1783)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| 55 | Indian treepie (*Dendrocitta vagabunda* (Latham, 1790)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| | | Not found | *Butea monosperma* (V) | Already mentioned | Tandon et al., 2003 |
| 56 | House crow (*Corvus splendens*Vieillot, 1817) | Not found | *Butea monosperma* (P) | Not found | Subramanya and Radhamani, 1993 |
| | **Family-** Monarchidae | | | | |
| 57 | Flycatcher (*Muscicapa* sp.) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Woodfordia floribunda* (P) | Not found | Narang et al., 2000 |
| | **Family-** Phylloscopidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 58 | Grey-hooded warbler (*Seicercus xanthoschistos* (Gray and Gray, 1847)) | Not found | *Ougenia oojeinensis* (P) | Not found | Narang et al., 2000 |
| | **Family-** Paridae | | | | |
| 59 | Great tit (*Parus major* Linnaeus, 1758) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| 60 | Yellow cheeked tit (*Machlolophus spilonotus* (Bonaparte, 1850)) | Same of purple-rumped sunbird with *G. arborea* | *Gmelina arborea* (P) | Already mentioned | Raju and Rao, 2006 |
| | **Family-** Passeridae | | | | |
| 61 | House sparrow (*Passer domesticus*(Linnaeus, 1758)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| | | Not found | *Erythrina indica* (P) | Not found | Narang et al., 2000 |

| | | | | | |
|---|---|---|---|---|---|
| 62 | Russet sparrow (*Passer rutilans*(Temminck, 1836)) | Not found | *Bombax ceiba* (P) | Not found | Narang et al., 2000 |
| 63 | Yellow throated sparrow (*Gymnoris xantho collis* (Burton, 1838)) | Not found | *Bombax ceiba* (P) | Not found | Subramanya and Rdhamani, 1993 |
| | | Not found | *Bombax insigne* (P) | Not found | Subramanya and Rdhamani, 1993 |
| | **Family-** Chloropseidae | | | | |
| 64 | Gold-fronted leafbird (*Chloropsis aurifrons* (Temminck, 1829)) | Nectarivorous with beak size (22-25mm) larger than visitor birds. | *Helicteres isora* (P) | Red coloured and tubular shaped flower with a robust corolla and absence of odour. | Shantaram, 1996; Faegri and Pijl, 1978 |
| | | Same of purple sunbird with *B. superba* | *Butea superba* (P) | Already mentioned | Raju and Rao, 2007 |

| | | | | | |
|---|---|---|---|---|---|
| | **Family-** Megalaimidae | | | | |
| 65 | Large-green barbet (*Megalaima viridis*(Boddaert, 1783)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| | **Family-**Oriolidae | | | | |
| 66 | Black-headed Oriole (*Oriolus xanthornus* (Linnaeus, 1758)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| 67 | Golden oriole (*Oriolus oriolus* (Linnaeus , 1758)) | Not found | *Bombax ceiba* (P) | Not found | Subramanya and Rdhamani, 1993 |
| | | Not found | *Bombax insigne* (P) | Not found | Subramanya and Rdhamani, 1993 |
| | | Not found | *Erythrina varigata* (P) | Not found | Subramanya and Rdhamani, 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | **Family-** Dicaeidae | | | | |
| 68 | Tickell's flowerpecker (*Dicaeum erythrorhyncho* (Latham, 1790)) | Same of purple-rumped sunbird with *G. arborea* | *Gmelina arborea* (P) | Already mentioned | Raju and Rao, 2006 |
| | | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| | | Not found | *Woodfordia floribunda* (V) | Not found | Raju, A. J. S., 2005 |
| 69 | Thick-billed flowerpecker (*Dicaeum agile* (Tickell, 1833)) | Not found | *Helicteres isora* (V) | Not found | Manikandan and Kunhikannan, 2016 |
| 70 | Nilgiri flowerpecker (*Dicaeum concolor* Jerdon, 1840) | Not found | *Hibiscus rosa-sinensis* (P) | Not found | Subramanya and Radhamani, 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Sesbania grandiflora* (P) | Not found | Subramanya and Radhamani, 1993 |
| | **Family-** Acrocephalidae | | | | |
| 71 | Blyth's reed warbler (*Acrocephalus dumetorum* Blyth, 1849) | Not found | *Helicteres isora* (V) | Already mentioned | Shantaram, 1996; Faegri and Pijl, 1978 |
| | **Family-** Motacillidae | | | | |
| 72 | Indian Pipit (*Anthus novaeseelandiae*( Gmelin, 1789)) | Not found | *Woodfordia floribunda* (V) | Not found | Raju, A. J. S., 2005 |
| | | Same of purple sunbird with *B. superba* | *Butea superba* (P) | Already mentioned | Raju and Rao, 2007 |
| | **Family-** Meropidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 73 | Small bee-eater (*Merops orientalis* Lathm, 1801) | Same of purple sunbird with *B. superba* | *Butea superba* (P) | Already mentioned | Raju and Rao, 2007 |
| | **Family-** Aegithinidae | | | | |
| 74 | Common iora (*Aegithina tiphia* (Linnaeus, 1758)) | Not found | *Sonneratia caseolaris* (V) | Not found | Pandit and Choudhury, 2001 |
| | **Family-** Cisticolidae | | | | |
| 75 | Common tailorbird (*Orthotomus sutorius* (Pennant, 1769)) | Not found | *Sonneratia caseolaris* (V) | Not found | Pandit and Choudhury, 2001 |
| | **Family**-Picidae | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 76 | Black-rumped flameback (*Dinopium benghalense* (Linnaeus, 1758)) | Not found | *Erythrina variegate* (P) | Not found | Subramanya and Rdhamani, 1993 |
| 77 | Brown-capped pigmy woodpecker (*Dendrocopos nanus* Vigors, 1832)) | Not found | *Butea superba* (V) | Already mentioned | Raju and Rao, 2007 |
| | **Family-** Laniidae | | | | |
| 78 | Rufous-backed shrike (*Lanius schach* Linnaeus, 1758) | Not found | *Erythrina variegate* (P) | Not found | Subramanya and Rdhamani, 1993 |
| | **Family-** Cisticolidae | | | | |
| 79 | Tawny-flanked prinia (*Prinia subflava* (Gmelin, 1789)) | Not found | *Bombax ceiba* (P) | Not found | Subramanya and Radhamani, 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Bombax insigne* (P) | Not found | Subramanya and Radhamani, 1993 |
| 80 | Ashy prinia (*Prinia socialis* Sykes, 1832) | Not found | *Calycopteris floribunda* (P) | Not found | Subramanya and Radhamani, 1993 |
| | **Family-** Turdidae | | | | |
| 81 | Eurasian blackbird (*Turdus merula* Linnaeus, 1758) | Not found | *Bombax ceiba* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Bombax insigne* (P) | Not found | Subramanya and Radhamani, 1993 |
| | | Not found | *Erythrina suberosa* (P) | Not found | Subramanya and Radhamani, 1993 |

| | | | | | |
|---|---|---|---|---|---|
| | | Not found | *Erythrina subumbrans* (P) | Not found | Subramanya and Radhamani, 1993 |
| | **Family-** Ploceidae | | | | |
| 82 | Baya weaverbird (*Ploceus philippinus* (Linnaeus, 1766)) | Not found | *Bombax insigne* (P) | Not found | Subramanya and Radhamani, 1993 |
| | **Family-** Estrildidae | | | | |
| 83 | White-throated munia (*Lonchura malabarica* (Linnaeus, 1758)) | Not found | *Erythrina verigata* (P) | Not found | Subramanya and Radhamani, 1993 |
| 84 | White-backed munia (*Lonchura striata* (Linnaeus, 1766)) | Not found | *Erythrina verigata* (P) | Not found | Subramanya and Radhamani, 1993 |

**Discussion:**

Ornithophilous plants develop some specific patterns of structure and function of the flowers to attract their bird pollinators. Among 100 families of flowering plants worldwide,

ornithophily is present in some 65 angiosperm families as evolutionary succession from bee-pollinated precursors. (Cronk and Ojeda, 2008).

These types of flowers are expert at attracting birds by brilliant colours and modifications of corolla (Meeuse, 2020). About 2,000 species of birds visit flowers more or less regularly to feed on nectar and pollen (Meeuse, 2020). Some plants adapt to this pollination process because birds are efficient pollinators even in inclement and adverse climatic conditions. Bird pollination is advantageous when high energy expenditure from plants is repaid from birds in terms of favorable pollen flow and high seed set.

It is apparent from table-1 and table-2 that, birds' have some general pollination adaptive features - they are all nectarivorous, have straight slender or curved beaks that can be long or short depending on flower characteristics and have a relatively strong attraction to bright colours. General ornithophilous syndromes for plants include odourless, bright coloured flowers with copious amount of dilute nectar and often providing perching sites for birds by adaptive modifications of corolla.

Pollination adaptations of 25 bird species of 9 families from the world, associated with 31 plant species have been recorded in this study. Subramanya and Radhamani (1993) reported 58 pollinator birds from 16 families from India. In this review work, it is found that 84 species of birds are visitors to 58 species of flowers, of which 69 species from 28 families has been confirmed as bird pollinators and pollinator status of other 15 species of birds, visiting flowers of 5 species of plants could not be confirmed yet. Further study is therefore found necessary. Reports on tight relations of a plant species on a single pollinator bird species for ensured pollination are found lacking.

Sazima et al. (2001) and Dellinger et al. (2014) reported that glistening, sugar-containing jelly pellets of *Combretum lanceolatum* and staminal appendages of *Axinaea* (Melastomataceae) attract birds, but the identities of the concerned bird species have not been reported.

In the event of a strong bonding between a flowering plant species and its pollinator bird, a decrease in bird abundance may produce a corresponding decrease in the associated plant abundance and that may have a feedback effect on the bird species (Garcia, 2016). Endemic bird species have restricted distribution and are therefore more susceptible to anthropogenic threats than non-endemic species and may be more threatened to extinction (Pouteau et al., 2022). It is found that 53.3%, 28.6% and 28% of endemic birds of the Eastern Himalayas, Western Ghat and Indo Burma biodiversity hotspots in India are already

threatened with extinction (Karmakar et al., 2010). In depth study on the role in pollination of the endemic birds of India is therefore felt necessary.

Studies in India on ornithophily are found to be scanty and incomplete. Consolidated work with respect to 1) plant bird association 2) ornithophilous modifications in the flowers with respect to their pollinators 3) plants with specificity in ornithophily 4) involvement of endemic birds of India in pollination 5) ecological services rendered by the pollinating birds, particularly in high altitudes and economic importance of ornithophily, are found to be lacking in India.

Intensive studies on the Indian species of plants and their avian pollinators are therefore needed for a better understanding of the plant-bird pollination ecology.

**Conflict of interest:**

The authors declare no conflict of interest over research and publication of this document.

**Acknowledgements:**

The authors express their sincere thanks to the Principal of Ramakrishna Mission Vivekananda Centenary College, Rahara, revered Swami Kamalasthananda Maharaj for giving the opportunity of this review work. We are also grateful to Dr. Bulganin Mitra and Dr. Sujoy Pal for their advice and support.

**Author's contribution:**

Each author has equal contribution in preparing the manuscript. The sixth author has supervised this review work.

**References:**

Baker, H. 1975. Sugar concentration in nectars from hummingbird flowers. *Biotropica,* 7: 37-41.

Baker, H. G., Bawa, K. S., Frankie, G. W. and Opler, P. A. 1983. *Tropical rain forest ecosystems*. Elsevier Scientific Publishing Company.

Bayani, A. and Satose, V. 2020. Classification of Indian Birds. In: *Birds of India,* v. 2.17. Indian Foundation for Butterflies.

Beard, J. S., 1993. *The Proteas of tropical Africa*. Kangaroo Press.

Bené, F. 1946. Feeding and related behaviors of hummingbirds. *Mem. Boston Nat. Hist. Soc.,* 9: 403-481.

Bergamo, P. J., Rech, A. R., Brito, V. L. G. and Sazima, M. 2016. Flower colour and visitation rates of *Costus arabicus* support the 'bee avoidance' hypothesis for red-reflecting hummingbird-pollinated flowers. *Funct Ecol*, 30: 710–720.

Bhattacharya, A. and Mandal, S. 2000. Pollination biology in *Bombax ceiba* Linn. *Current science,* 79: 1706-1712.

Bittrich, V. and Amaral, M. C. E. 1996. Pollination biology of *Syrnphoniaglobulifera* (Clusiaceae). *Plant Syst. Evol.,* 200: 101-110.

Bramwell, D. and Bramwell, Z., 2001. *Wild flowers of the Canary Islands*. Editorial Rueda.

Brusatte, S. L., O'Connor, J. K. and Jarvis, E. D. 2015. The Origin and Diversification of Birds. *Current Biology*, 25: 888-898.

Castellanos, M. C., Wilson, P. and Thomson, J. D. 2003. Pollen transfer by humming-birds and bumblebees, and the divergence of pollination modes in *Penstemon*. *Evolution,* 57: 2742–2752.

Chang, Y. M., Lin, H., Hatch, K. A., Yao, C. and Shiu, H. 2013. Brush-tipped Tongue Structure of the Taiwan Yuhina (*Yuhina brunneiceps*) and White-eared Sibia (*Heterophasia auricularis*). *Wilson J. Ornithol.,* 125: 204–208.

Chen, K. H., Lu, J. Y. and Wang, C. N. 2019. Effective pollination of *Aeschynanthus acuminatus* (Gesneriaceae) by generalist passerines, in sunbird-absent East Asia. *Scientific Reports*, 9: 17552.

Corlett, R. T. 2004. Flower visitors and pollination in the Oriental (Indomalyan) Region. *Biol. Rev.,* 79: 497–532.

Cronk, Q. and Ojeda, I. 2008. Bird-pollinated flowers in an evolutionary and molecular context. *Journal of Experimental Botany,* 59(4): 715-727.

Cruden, R. V. V. 1972. Pollinators in high-elevation ecosystems: Relative effectiveness of birds and bees. *Science,* 176: 1439-1440.

Dellinger, A. S., Penneys, D. S., Staedler, Y. M., Fragner, L., Weckwerth, W. and Schonenberger, J. 2014. A specialized bird pollination system with a bellows mechanism for pollen transfer and staminal food body rewards. *Current Biology,* 24(14): 1615-1619.

Du Puy, D. J., Phillipson, P. B. and Rabevohitra, R. 1995. The genus *Delonix* (Leguminosae: Caesalpinioideae: *Caesalpinieae*) in Madagascar. *Kew Bulletin,* 50(3): 445-475.

Duncan, G. 2012. The genus *Lachenalia.* Kew Publishing.

Dupont, Y. L., Hansen, D. M., Rasmussen, J. T. and Olesen, J. M. 2004. Evolutionary changes in nectar sugar composition associated with switches between bird and insect pollination: the Canarian bird-flower element revisited. *Functional Ecology,* 18: 670–676.

Faegri, K. and Pijl, V. 1978. *The Principles of Pollination Ecology.* Pergamon Press.

Faegri, K. and Van der Pijl, L., 1979. *The principles of pollination ecology*. Pergamon Press.

Fang, Q., Chen, Y. Z. and Huang, S. Q. 2012. Generalist passerine pollination of a winter-flowering fruit tree in central China. *Annals of Botany,* 109: 379 –384.

Feehan, J. 1985. Explosive flower opening in ornithophily: a study of pollination mechanisms in some Central African Loranthaceae. *Botanical Journal of the Linnean Society,* 90(2): 129–144.

Fenster, C. B., Armbruster, W. S., Wilson, P., Dudash, M. R. and Thomson, J. D. 2004. Pollination syndromes and floral specialization. *Annual Review of Ecology Evolution and Systematics,* 35: 375-403.

Ford, H. A. 1985. Nectarivory and pollination by birds in southern Australia and Europe. *Oikos,* 44: 127-131.

Ford, H. A., Paton, D. C. and Forde, N. 1979. Birds as pollinators of Australian plants. *New Zealand Journal of Botany,* 17: 509-519.

Frost, S. K. and Frost, P. G. H. 1981. Sunbird Pollination of *Strelitzia nicolai*. *Oecologia,* 49: 379-384.

García, D. 2016. Birds in Ecological Networks: Insights from Bird-Plant Mutualistic Interactions. *Ardeola,* 63(1): 151-180.

Geerts, S. and Pauw, A. 2009. Hyper-specialization for long-billed bird pollination in a guild of South African plants: the Malachite Sunbird pollination syndrome. *South African Journal of Botany*, 75: 699-706.

Gill, F., Rand, A. L. and Storer, R. W. 2020. Bird. *Encyclopedia Britannica*. https://www.britannica.com/animal/bird-animal. Accessed 12 October 2020.

Grant, K. A. and Grant, V., 1968. *Hummingbirds and their flowers*. Columbia University Press.

Grey-Wilson, C., 1980. *Impatiens of Africa*. A. A. Balkema.

Hargreaves, A. L., Johnson, S. D. and Nol, E. 2004. Do floral syndromes predict specialization in plant pollination systems? An experimental test in an "ornithophilous" African Protea. *Oecologia*, 140: 295–301.

Hobbhahn, N. and Johnson, S. D. 2015. Sunbird pollination of the dioecious root parasite *Cytinus sanguineus* (Cytinaceae). *South African Journal of Botany*, 99: 138–143.

Huang, Z. H., Song, Y. P. and Huang S. Q. 2017. Evidence for passerine bird pollination in Rhododendron species. *AoB PLANTS,* 9(6): plx062.

Janeček, S., Bartoš, M. and Njabo, K. Y. 2015. Convergent evolution of sunbird pollination systems of Impatiens species in tropical Africa and hummingbird systems of the New World. *Biological Journal of the Linnean Society*, 115: 127-133.

Janeček, Š., Patáčová, E., Bartoš, M., Padyšáková, E., Spitzer, L. and Tropek, R. 2011. Hovering sunbirds in the Old World: occasional behaviour or evolutionary trend. *Oikos,* 120(2): 178–183.

Jathar, G. A. and Rahmani, A. R. 2006. Endemic Birds of India. *Buceros,* 11 (2 & 3): 1-53.

Jetz, W., Thomas, G. H., Joy, J. B., Redding, D. W., Hartmann, K., and Mooers, A. O. 2014. Global Distribution and Conservation of Evolutionary Distinctness in Birds. *Current Biology*, 24: 919–930.

Joseph, L., Toon, A., Nyári, Á. S., Longmore, N. W., Rowe, K. M. C., Haryoko, T., Trueman, J. and Gardner, J. L. 2014. A new synthesis of the molecular systematics and

biogeography of honeyeaters (Passeriformes: Meliphagidae) highlights biogeographical complexity of a spectacular avian radiation. *Zoologica Scripta*, 43(3): 235-248.

Karmakar, S., Bhattacharya, T. and Karmakar, S. 2010. The status of endemic birds in three Indian hot spots: A review of available data.*Science and Culture*, 76(11–12): 524-528.

Kato, M., Itino, T. and Nagamitsu, T. 1993. Melittophily and Ornithophily of Long-tubed Flowers in Zingiberaceae and Gesneriaceae in West Sumatra. *Tropics*, 2(3): 129-142.

Khanduri, V. P. and Kumar, K. S. 2016. Reproductive effort and success in *Bombax ceiba* L. in a tropical forest of Mizoram, Indo-Burma region of North-East India. *Braz. J. Bot*, 40(1): 157-166.

Kulloli, S. K., Chandore, A. N. and Aitawade, M. M. 2011. Nectar dynamics and pollination studies in three species of Lamiaceae. *Current Science*, 100(4): 509-516.

Ley, A. C. and Claßen-Bockhoff, R. 2009. Pollination syndromes in African Marantaceae. *Annals of Botany*, 104(1): 41-56.

Lowrie, A., 2013. *Carnivorous plants of Australia Magnum Opus*. Redfern Natural History.

Lunau, K., Papiorek, S., Eltz, T. and Sazima, M. 2011. Avoidance of achromatic colours by bees provides a private niche for humming birds. *J Exp Biol*, 214: 1607–1612.

Manikandan. P. and Kunhikannan, C. 2016. Avian flower visitors of *Helicteres isora* L. a deciduous forest species in Thathengalam forest of Kerala in Western Ghats. *Int. J. Adv. Res. Biol. Sci.*, 3(10): 171-176.

Meeuse, B. J. D. 2020. Pollination. *Encyclopedia Britannica*. https://www.britannica.com/science/pollination/Birds. Accessed 12 October 2020.

Micheneau, C., Fournel, J. and Pailler, T. 2006. Bird pollination in an angraecoid orchid on Reunion Island (Mascarene Archipelago, Indian Ocean). *Annals of Botany*, 97: 965–974.

Muchhala, N. 2003. Exploring the boundary between pollination syndromes: bats and hummingbirds as pollinators of *Burnmeistera cyclostigmata* and *B. tenuiflora* (Campanulaceae). *Oecologia*, 134: 373-380.

Muchhala, N. 2006. The pollination biology of Burmeistera (Campanulaceae): specialization and syndromes. *American Journal of Botany,* 93: 1081–1089.

Narang, M. L., Rana, R. S.and Prabhakar, M. 2000. Avian Species Involved in Pollination and Seed Dispersal of Some Forestry Species in Himachal Pradesh. *The journal of the Bombay Natural History Society,* 97(2): 215-222.

Ollerton, J., Alarcón, R. and Waser, N. 2009a. A global test of the pollination syndrome hypothesis. *Annals of Botany,* 103: 1471-1480.

Ollerton, J., Cranmer, L., Stelzer, R. J., Sullivan, S. and Chittka, L. 2009b. Bird pollination of Canary Island endemic plants. *Naturwissenschaften,* 96: 221–232.

Pandit, S. and Choudhury, B. C. 2001. Factors affecting pollinator visitation and reproductive success in *Sonneratia caseolaris* and *Aegiceras corniculatum* in a mangrove forest in India. *Journ. Tropical Ecology,* 17: 431-447.

Pauw, A. 2006. Floral syndromes accurately predict pollination by a specialized oil-collecting bee (*Rediviva peringueyi*, Melittidae) in a guild of South African orchids (Coryciinae). *American Journal of Botany,* 93: 917–926.

Pellmyr, O., 2002. Pollination by Animals. In: *Plant Animal Interactions: An Evolutionary Approach*. pp. 157–184. Wiley-Blackwell.

Pike, G. H. and Waser, N. M. 1981. The production of diluted nectar by hummingbird and honeyeater flowers. *Biotropica*, 13: 260–270.

Płachno, B. J., Stpiczyńska, M., Świątek, P., Lambers, H., Miranda, V. F. O., Nge, F. J., Stolarczyk, P. and Cawthray, G. R. 2019. Floral micromorphology of the bird-pollinated carnivorous plant species *Utricularia menziesii* R.Br. (Lentibulariaceae). *Annals of Botany*, 123: 213-220.

Pouteau, R., Brunel, C., Dawson, W., Essl, F., Kreft, H., Lenzner, B., Meyer, C., Pergl, J., Pyšek, P., Seebens, H., Weigelt, P., Winter, M., and van Kleunen, M. 2022. Environmental and socioeconomic correlates of extinction risk in endemic species. *Diversity and Distributions,* 28: 53–64.

Proctor, M., Yeo, P. and Lack, A., 1996. *The natural history of pollination*. Timber Press.

Raju, A. J. S. 2005. Passerine bird pollination and seed dispersal in *Woodfordia floribunda* Salisb. (Lythraceae), a common low altitude woody shrub in the Eastern Ghats forests of India. *Ornithological Science*, 4: 103–108.

Raju, A. J. S. 2010. Pollination biology: Aspects and Prospects. *Journal of Palynology*,46: 85-96.

Raju, A. J. S. and Rao, S. P. 2002. Pollination ecology and fruiting behaviour in *Acacia sinuata* (Lour.) Merr. (Mimosaceae), a valuable non-timber forest plant species. *Current Science*, 82(12):1466 - 1471.

Raju, A. J. S. and Rao, S. P. 2004. Passerine bird pollination and fruiting behaviour in a dry season blooming tree species, *Erythrina suberosa* Roxb. (Fabaceae) in the Eastern Ghats forests, India. *Ornithol Sci*, 3:139 - 144.

Raju, A. J. S. and Rao, S. P. 2006. Pollination by bees and passerine birds and seed dispersal by monkeys in the white teak *Gmelina arborea* Roxb., a commercially important timber tree species in the Eastern Ghats. *Current Science*, 90(2): 232-236.

Raju, A. J. S. and Rao, S. P. 2007. Passerine bird-pollination in the dry season blooming *Butea superba* Roxb. (Fabaceae) in the eastern ghats. *Journal of the Bombay Natural History Society*, 104(1): 120-121.

Raju, A. J. S., 2008. Some bird-pollinated flowers of forest tracts of Andhra Pradesh, India. In: *Bioresources conservation and management*. pp. 129-146. Today and Tomorrow's Printers and Publishers.

Raju, A. J. S., Rao, S. P. and Rangaiah, K. 2005. Pollination by bats and birds in the obligate outcrosser *Bombax ceiba* L. (Bombacaceae), a tropical dry season flowering tree species in the Eastern Ghats forests of India. *Ornithological Science*, 4(1): 81-87.

Rangaiah, K., Rao, P. and Raju, A. J. S. 2004. Bird-pollination and fruiting phenology in *Spathodea campanulata* Beauv. (Bignoniaceae). *Beitr. Biol. Pflanzen*, 73: 395-408.

Rebelo, A. G., Siegfried W. R. and Oliver, E. G. H. 1985. Pollination syndromes of *Erica* species in the south-western Cape. *S. Afr. J. Bot*., 51(4): 270-280.

Richard, P. S. S., Muthukumar, S. A. and Malleshappa, H. 2011. Relationship between floral characters and floral visitors of selected angiospermic taxa from Kalakad Mundanthurai Tiger Reserve, Southern Western Ghats, India. *Indian Forester*, 137(8): 962-975.

Rodríguez-Rodríguez, M. C. and Valido, A. 2008. Opportunistic nectar-feeding birds are effective pollinators of bird-flowers from Canary Islands: experimental evidence from *Isoplexis canariensis* (Scrophulariaceae). *American Journal of Botany*, 95: 1408–1415.

Roitman, G. G., Sérsic, A. N., Cocucci, A. A. and Montaldo, N. H. 2002. Flower food tissues as reward for pollinating birds. *Bol. Soc. Argent. Bot.*, 37(1-2): 71-77.

Ruschi, A. 1949. A polinização realizada pelos Trochilideos a sua área de alimentação e o repovoamento. *Bol. Mus. Biol. Prof. Mello-Leitão*, 2: 1-51.

Sazima, M., Vogel, S., do Prado, A. L., de Oliveira, D. M., Franz, G. and Sazima, I. 2001. The sweet jelly of *Combretum lanceolatum* flowers (Combretaceae): a cornucopia resource for bird pollinators in the Pantanal, western Brazil. *Plant Systematics and Evolution*, 227(3): 195-208.

Shantaram, V. 1996. Visitation patterns of birds and butterflies at a *Helicteres isora* Linn. (Sterculiaceae) clump. *Current Science*, 70(4): 316- 319.

Siegfried, W. R., Rebelo, A. G. and Prys-Jones, R. P. 1985. Stem thickness in *Erica* plants in relation to avian pollination. *Oikos*, 45(1): 153-155.

Simpson, B. B. and Neff, J. L. 1981. Floral rewards: alternatives to pollen and nectar. *Ann. Missouri Bot. Card.*, 68: 301-322.

Stiles, F. G. 1971. Time, energy, and territoriality of the Anna hummingbird. *Science*, 171: 818-821.

Stiles, F. G. 1973. Food supply and the annual cycle of the Anna hummingbird. *Univ. Calif. Publ. Zool.*, 97: 109.

Stiles, F. G. 1978. Ecological and Evolutionary Implications of Bird Pollination. *Amer. Zool*., 18: 715-727.

Stiles, F. G. and Freeman, C. E. 1993. Patterns in floral nectar characteristics of some bird-visited plant species from Costa Rica. *Biotropica*, 25: 191–205.

Stiles, F. G. and Wolf. L. L. 1979. The ecology and evolution of a lek mating system in the Long-tailed Hermit hummingbird. *Amer. Ornith. Monogr.*, 27: iii-78.

Subramanya, S. and Radhamani, T. R. 1993. Pollination by birds and bats. *Current Science,* 65(3): 201-209.

Sun, S. G., Huang, Z. H., Chen, Z. B. and Huang, S. Q. 2017. Nectar properties and the role of sunbirds as pollinators of the golden-flowered tea (*Camellia petelotii*). *American Journal of Botany,* 104: 468-476.

Tandon, R., Shivanna, K. R. and Ram, H. Y. M. 2003. Reproductive Biology of *Butea monosperma* (Fabaceae). *Annals of Botany,* 92: 1-9.

Turner, R. C. and Midgley, J. J. 2016. Sunbird-pollination in the geoflorous species *Hyobanche sanguinea* (Orobanchaceae) and *Lachenalia luteola* (Hyacinthaceae). *South African Journal of Botany*, 102: 186–189.

Van der Pijl, L. 1961. Ecological aspects of flower evolution. II. Zoophilous flower classes. *Evolution,* 15(1): 44–59.

Van der Pijl, L. and Dodson, C. H., 1966. *Orchid flowers, their pollinators and evolution*. University of Miami Press.

Vicentini, A. and Fischer, E. A. 1999. Pollination of *Moronobea coccinea* (Clusiaceae) by the Golden-Winged Parakeet in the Central Amazon. *Biotropica,* 31(4): 692-696.

Vogel, S. 1954. Blütenbiologische Typen als Elemente der Sippengliederung dargestellt anhand der Flora Südafrikas. *Botanische Studien,* 1: 1–338.

Westerkamp, C. 1990. Bird-flowers: hovering versus perching exploitation. *Botanica Acta,* 103(4): 366–371.

Whittall, J. B. and Hodges, S. A. 2007. Pollinator shifts drive increasingly long nectar spurs in columbine flowers. *Nature,* 447(7145): 706–712.

Wilson, P., Castellanos, M. C., Hogue, J. N., Thomson, J. D. and Armbruster, W. S. 2004. A multivariate search for pollination syndromes among penstemons. *Oikos,* 104: 345–361.

Yumoto, T., Itino, T. and Nagamasu, H. 1997. Pollination of Hemiparasites (Loranthaceae) by spider hunters (Nectariniidae) in the Canopy of a Bornean tropical rain forest. *Selbyana,* 18(1): 51-60.