International Journal of Botany Studies
www.botanyjournals.com
ISSN: 2455-541X
Received: 22-05-2021, Accepted: 07-06-2021, Published: 22-06-2021
Volume 6, Issue 3, 2021, Page No. 761-766

Natural insecticide plants: *Tephrosoria Purpurea* (L.) *Pers* and *Trichodesma amplexicaule Roth* in ecological relationship with hymenopteran pollinators in the Thar desert of Rajasthan, India

Ghanshyam Kachhawa[1], Santosh Kumar Charan[1*], Rishikesh Meena[2]
[1] Assistant Professor, Department: Zoology, University of Rajasthan, Jaipur, Rajasthan, India
[2] Assistant Professor, Department of Botany, University of Rajasthan, Jaipur, Rajasthan, India

Abstract
To estimate the ecological relationship of wild weeds with Hymenopteran pollinator experiments were conducted on *Tephrosoria purpurea* (L.) *Pers* and *Trichodesma amplexicaule Roth.* These plants are natural insecticides in nature so have the great economical importance in the study area. A sum of 17 bees species have been observed on *Tephrosoria purpurea* and Apidae family has been observed as the most abundant family followed by Megachilidae, Halictidae and Andrenidae. *Trigona iridipennis Smith* was reported as the most abundant bee while *Megachile bicolor (Fab)* as the least abundant bee. A sum of 15 bee species has been reported on *Trichodesma amplexicaule* on the day of observation. Apidae family was observed as most abundant family while Halictidae family observed as least abundant. *Trigona iridipennis Smith* was highest reported on both of the plants. Foraging rate has been observed in term of number of flowers visited by bees per minute in the different time intervals of the day. It was observed that peak foraging was observed in the noon between 10 hrs and 15 hrs when there were low humidity and high temperature as compared to morning (before 10 hrs) and afternoon (15 hrs). Result expressed a great relationship between activity of bees and abiotic factors of ecosystem. *Apis florea* and *Nomia elliotii Smith* were observed as the most frequent visitors on *Tephrosoria purpurea* while *Andrena spp* was observed as least frequent bee during the peak foraging time. On the other hand Apis dorsata and Megachile femorata Smith bees have been observed as most frequent visitors on *Trichodesma amplexicaule and Nomia elliotii Smith* as the least frequent bee.
Foraging activity of bees in different time intervals of the day was statically analyzed by ANOVA. Result indicated that Null Hypothesis cannot be accepted because of P-Value were less than level of significance in both the cases. Experimental plants were found to be important for the survival of bee fauna in the stressful conditions of Thar Desert by providing pollen and nectar for nutrition.

Keywords: bees, foraging rate, hymenoptera, nectar, pollinators

Introduction
Natural insecticide plants are the plants which are able to repel mosquito that works as a vectors of many diseases. *Tephrosoria purpurea (L) Pers* is one of such plant. Plants from Tephrosoria genus synthesize rotenoids, rotenone, rotenolone and Tephrosin phytochemicals that have strong insecticidal activities [1]. *Tephrosoria purpurea (L) Pers* is a branched, sub-erect, perennial wasteland weed which is found in poor soil of the Thar Desert. It leaves are stipulated and triangular in shape. Axillary inflorescence is found with purple-whitish flowers of about 4-8.5 mm length [2]. It is locally called as Masa, Sharpunka, Bisoni, Sarphonk or Biyani. It is a member of Fabaceae family of order Fabales and Tribe-Millettieae. Tephrosin retinoid chemical is found in the seeds and leaves of this plant which can paralyze fishes; hence it is commonly called as Fish poison [3]. African tribal used this plant in curing animals bitten by snakes [4].It is cultivated in the Rajasthan state as green manure which has been found capable in reducing soil salinity and maintaining PH of soil [5]. *Trichodesma amplexicaule Roth* is spreading branched and erected perennial weed with bisexual flowers. It is locally called as Chhota kulpha or Indian borage. It is a member of Boraginaceae family of Boraginales order of clade-Asterids. The Actinomorphic symmetrical flower of *Trichodesma amplexicaule* has separate sepals, light pinkish corolla, 5 stamens which makes a cone around style of carpel [6]. This plant contains Flavonoids, Triterpenes, Tannins and Saponins [7]. Plants have a great ecological relationship with different kind of insects. Plants provide nutrients to the insects in the form of pollen and nectar and insects provide pollination service to plants for the success of cross-breeding [8]. Transfer of pollen grains (Gamete carrier) from male reproductive organ (anther of stamen) to the female reproductive part (stigma of carpel) is referred to as pollination [9].
Pollination is essential for the formation of seed set, fruit set and the survival of plants. Pollination occurs by wind (anemophilous) or insects (Entomophilous) in the cross-pollinating plants [10]. Insect makes the 'Buzzing sound' by vibrating their wings to dislodge pollen grains from the anther. Buzzing sprinkles the pollens on the furry body of bees [11]. It was reported that bees and flowering plant have co-evolved during the course of Phylogentetic development and these are highly dependent on each other specially the entomophilius plants [12, 13, 14]. Pollination is indispensable for the maintenance of ecosystem by balancing biodiversity. Hymenopteran pollinators are very important in Insecta class as it is the larger order which comprises bees, wasps, ants and sawflies. In this paper, study has been specially confined to super family Apoidea which is a major group within Hymenoptera order. Apoidean bees are responsible for the pollination not only in the cultivated crops [15] but also wild plants [16].

Material and Methods

In the north-western part of India, the Thar Desert is the largest arid region and it is the world's 17th largest desert. It is located at the 27ºN71ºE coordinates in India and Pakistan. It's going to the Indomalayan realm of the earth. Its maximum 85% part is found in India, which is present in the Rajasthan, Punjab, Haryana and Gujarat states of India [17]. Annual rainfall is scarce and limited to around 300-350 mm. May and June months have been measured as the hottest months when temperatures rise to 48-50ºC. These unique geographical conditions make this ecosystem more special for the study of the plant-insect ecological relationship. Mean relative humidity has been observed from 36% to 83% in April and August respectively. On the day of observation, insect were collected from the hand-sweeping net from 6 hours to 18 hours. The collected specimens were stored in an ethyl acetate insect killing bottle in the field. Insects were spread on entomological board and collected in the entomological boxes after pinning at the thorax. Under the stereo-zoom microscope, insects were examined and described by the most authentic entomological literature. Abundance of insect pollinators have been measured in the morning, noon, afternoon and mean of abundance has been taken in the estimation of diversity of insect pollinators. Number of visits per minute by the bees on the respective plants was calculated to establish bee-plant relationship. The effect of time duration on the bees has been analyzed by ANOVA testing by MS Excel 2019.

Result and Discussion

Tephrosia purpurea (L.) is a perennial branched weed that is belonging to Fabaceae family of Fabales order. It was observed that *Tephrosia purpurea (L.)* plant showed anthesis during the month of August and September after the first monsoon rain in the study area. It was observed as one of the most common weed in the desert of Thar which provides nutrition to the wild bees. A sum of 17 bee species from four different families i.e. Apidae, Halictidae, Andrenidae, Megachilidae were reported on the *Tephrosia purpurea (l.)* plant (Table 1). Apidae family was observed as the most abundant family with 11 different bee species and a total of 190 bees from Apidae family have been captured in the study area. A sum of 43 bees has been captured belonging to Megachilidae family while the Andrenidae family was the least abundant. Bees from Apidae family provided great contribution in the pollination service which is showing great Bee-plant ecological relationship. It was reported that plant and bees are interdependent on each other [18].It was also found that *Trigona iridipennis Smith* from Apidae family as a most abundant Hymenopteran while *Megachile bicolor (Fab.)* as the least frequent visitor on the plant. It was noticed that Honey bee is not always suitable for all kind of plants in all conditions [19, 20]. Native bees and solitary bee were found to be able to pollinate wild plants. Bees are very indispensible for the survival of terrestrial ecosystem by providing pollination service.

Trichodesma amplexicaule Roth is an erect perennial weed about 15-18 cm height with bisexual flowers. This plant is belonging to Boraginaceae family of Boraginales order. It was observed that this plant showed anthesis during the months of August and October. This weed has been found as spatially clustered and widely distributed in the western Rajasthan state of India. A sum of 15 bee species from three different families i.e. Apidae, Halictidae and Megachilidae were observed on *Trichodesma amplexicaule Roth* (Table 2). Bees from Apidae family were the most frequent visitors. Apidae family was reported as the most abundant family (09 species) followed by Megachilidae (04 species) and Halictidae (02species) family. A maximum 164 bees were observed from Apidae family followed by Megachilidae (40 bees) and Halictidae (16 species) during the field study. *Trigona iridipennis Smith* was found as the most abundant bee while Nomia *oxybeloides Smith* as the least abundant bee on *Trichodesma amplexicaule Roth.* It was found that abundance and diversity of Hymenopteran pollinators in the field enhance the crop yield which is showing great plant-bee ecological relationship. *Trigona iridipennis* Smith was observed as the most abundant visitor on the *Tephrosia purpurea (L.) and Trichodesma amplexicaule Roth* plants. Bees visit on the both plants were observed in the different time intervals of the day as morning (before 10 hrs), noon (between 10 hrs-15 hrs) and afternoon (after 15 hrs). It was found that bees visited very frequently in the noon in term of number of flower visited per minute (Fig. 1). Number of flowers visited per minute by a bee can be represented as foraging rate of bee. Foraging rate was highest in the noon as compare to morning (before 10 hrs) and afternoon (after 15 hrs) because of climatic factors. Peak foraging was noticed in the noon because of low humidity and high temperature. It is showing that ecological parameters impact on pollination service and bee- plant ecological relationship. *Apis florea* and *Nomia elliotii Smith* were observed as the most frequent visitors on the *Tephrosia purpurea (L.) Pers*. *Andrena spp* was observed as the least frequent visitor during the peak foraging time of the day (Table 3). *Trigona iridipennis Smith, Apis florea* and *Nomia elliotii* were noticed as main pollinators of *Tephrosia purpurea (L.)* because *Trigona iridipennis Smith* was the most abundant but *Apis florea* and *Nomia elliotii* were the most frequent visitors on the plant. *Ceratina sexmaculata* bee was the most frequent visitor (14 flowers visited/ minute) following by *Apis dorsata* and *Megachile femorata Smith* while the *Thyreus mucorea* and *Megachile cephalotes Smith* as the least frequent visitors (07 flowers visited/ minute) during the peak foraging time between 10 hrs and 15 hrs on the observation day (Table 4). *Trigona iridipennis Smith*, *Apis dorsata* and *Megachile femorata Smith* were noticed as the major pollinators on the *Trichodesma amplexicaule Roth* because of *Trigona iridipennis Smith* was the most abundant while *Apis dorsata* and *Megachile femorata Smith* were the most frequent visitor on this plant. Peak foraging was noticed in the noon in the case of *Trichodesma amplexicaule Roth* (Fig.2). Foraging activity of bees on the both plants with time duration of the day was statically analyzed by ANOVA testing.

It was found that there is significant difference in visit of bees in different time intervals. P- Value 1.49E-08 estimated less than level of significance (0.05) and F crit value 3.190727 observed less than F value for the *Tephrosia purpurea (L.) Pers* (Table 5). P-value 6.45E-09 estimated less than level of significance (0.05) and F crit value 3.219942 calculated less than F value for *Trichodesma amplexicaule Roth.* Results concluded that Null Hypothesis cannot be accepted.

Table 1: Bee diversity on *Tephrosia purpurea (L.) Pers*

Sr.	Insect pollinators	Systematic Position	Abundance
1	*Apis florea*	Family- Apidae, Sub-family-Apinae, Tribe- Anthophorini	06
2	*Apis dorsata*	Family- Apidae, Sub-family-Apinae, Tribe- Anthophorini	04
3	*Amegilla zonata Linn.*	Family- Apidae, Sub-family-Apinae, Tribe- Anthophorini	12
4	*Amegilla niveocincta*	Family- Apidae, Sub-family-Apinae, Tribe- Anthophorini	07
5	*Xylocopa fenestrata (Fab)*	Family- Apidae, Sub-family-Xylocopinae, Tribe- Xylocopini	11
6	*Xylocopa latipes*	Family- Apidae, Sub-family-Xylocopinae, Tribe- Xylocopini	10
7	*Xylocopa amethystina (Fab)*	Family- Apidae, Sub-family-Xylocopinae, Tribe- Xylocopini	14
8	*Ceratina sexmaculata*	Family- Apidae, Sub-family-Xylocopinae, Tribe- Xylocopini	23
9	*Braunsapis mixta Smith*	Family- Apidae, Sub-family-Xylocopinae, Tribe- Allodapini	08
10	*Trigona iridipennis Smith*	Family- Apidae, Sub-family-Apinae, Tribe- Meliponini	89
11	*Thyreus ramosus*	Family- Apidae, Sub-family-Apinae, Tribe- Melectini	06
12	*Nomia elliotii Smith*	Family- Halictidae, Sub-family- Nomiinae	34
13	*Andrena spp*	Family- Andrenidae, Sub-family-Andreninae,	14
14	*Icteranthidium saltatore Nurse*	Family- Megachilidae, Sub-family-Megachilinae, Tribe- Anthidini	14
15	*Megachile coelioxysides Bingham*	Family- Megachilidae, Sub-family- Megachilinae, Tribe- Megachilini	16
16	*Megachile gathela Cameron*	Family- Megachilidae, Sub-family- Megachilinae, Tribe- Megachilini	09
17	*Megachile bicolor (Fab)*	Family- Megachilidae, Sub-family- Megachilinae, Tribe- Megachilini	04

Table 2: Bee diversity on *Trichodesma amplexicaule Roth*

Sr.	Insect pollinators	Systematic position	abundance
1	*Apis florea*	Family- Apidae, Sub-family-Apinae, Tribe- Anthophorini	11
2	*Apis dorsata*	Family- Apidae, Sub-family-Apinae, Tribe- Anthophorini	06
3	*Amegilla fallax Smith*	Family- Apidae, Sub-family-Apinae, Tribe- Anthophorini	24
4	*Amegilla niveocincta Smith*	Family- Apidae, Sub-family-Apinae, Tribe- Anthophorini	12
5	*Xylocopa amethystina*	Family- Apidae, Sub-family-Xylocopinae, Tribe- Xylocopini	09
6	*Ceratina sexmaculata*	Family- Apidae, Sub-family-Xylocopinae, Tribe- Xylocopini	13
7	*Ceratina viridissima*	Family- Apidae, Sub-family-Xylocopinae, Tribe- Xylocopini	27
8	*Trigona iridipennis Smith*	Family- Apidae, Sub-family-Apinae, Tribe- Meliponini	52
9	*Thyreus mucorea*	Family- Apidae, Sub-family-Apinae, Tribe- Melectini	10
10	*Nomia elliotii Smith*	Family- Halictidae, Sub-family- Nomiinae	14
11	*Nomia oxybeloides Smith*	Family- Halictidae, Sub-family- Nomiinae	02
12	*Icteranthidium sinapinum Cockerell*	Family- Megachilidae, Sub-family-Megachilinae, Tribe- Anthidini	13
13	*Megachile cephalotes Smith*	Family- Megachilidae, Sub-family- Megachilinae, Tribe- Megachilini	18
14	*Megachile femorata Smith*	Family- Megachilidae, Sub-family- Megachilinae, Tribe- Megachilini	05
15	*Megachile bicolor (Fab)*	Family- Megachilidae, Sub-family- Megachilinae, Tribe- Megachilini	04

Table 3: Number of bee visits on *Tephrosia purpurea (L.) Pers*

Sn.	Bee species	Number of flowers visited/ minute		
		Before 10 hrs	Between 10-15 hrs	After 15 hrs
1	*Apis florea*	4	12	5
2	*Apis dorsata*	5	10	7
3	*Amegilla zonata Linn.*	3	9	4
4	*Amegilla niveocincta*	2	7	4
5	*Xylocopa fenestrata (Fab)*	4	11	6
6	*Xylocopa latipes*	2	6	3
7	*Xylocopa amethystina (Fab)*	3	8	6
8	*Ceratina sexmaculata*	1	4	3
9	*Braunsapis mixta Smith*	0	5	1
10	*Trigona iridipennis Smith*	3	6	2
11	*Thyreus ramosus*	2	8	5
12	*Nomia elliotii Smith*	4	12	6
13	*Andrena spp*	1	3	0
14	*Icteranthidium saltatore Nurse*	3	8	5
15	*Megachile coelioxysides Bingham*	1	5	0
16	*Megachile gathela Cameron*	3	7	4
17	*Megachile bicolor (Fab)*	2	6	3

Table 4: Number of bee visits on *Trichodesma amplexicaule Roth*

Sn.	Bee species	Number of flowers visited / minute		
		Before 10 hrs	Between 10-15 hrs	After 15 hrs
1	*Apis florea*	5	11	6
2	*Apis dorsata*	6	13	8
3	*Amegilla fallax Smith*	3	8	5
4	*Amegilla niveocincta Smith*	4	9	5
5	*Xylocopa amethystina*	5	10	7
6	*Ceratina sexmaculata*	7	14	10
7	*Ceratina viridissima*	6	12	9
8	*Trigona iridipennis Smith*	5	11	7
9	*Thyreus mucorea*	3	7	5
10	*Nomia elliotii Smith*	2	6	3
11	*Nomia oxybeloides Smith*	4	9	6
12	*Icteranthidium sinapinum Cockerell*	3	8	3
13	*Megachile cephalotes Smith*	2	7	4
14	*Megachile femorata Smith*	5	13	7
15	*Megachile bicolor (Fab)*	4	11	5

Table 5: Analysis of flowers visited/ minute by the bees in different time intervals of the day

Null Hypothesis 1: Number of visits of bees on *Tephrosia purpurea (L.) Pers*						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	236.5098	2	118.2549	26.84919	1.49E-08	3.190727
Within Groups	211.4118	48	4.404412			
Total	447.9216	50				
Null Hypothesis 2: Number of visits of bees on *Trichodesma amplexicaule*						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	F crit
Between Groups	252.9333	2	126.4667	30.54985	6.45E-09	3.219942
Within Groups	173.8667	42	4.139683			
Total	426.8	44				

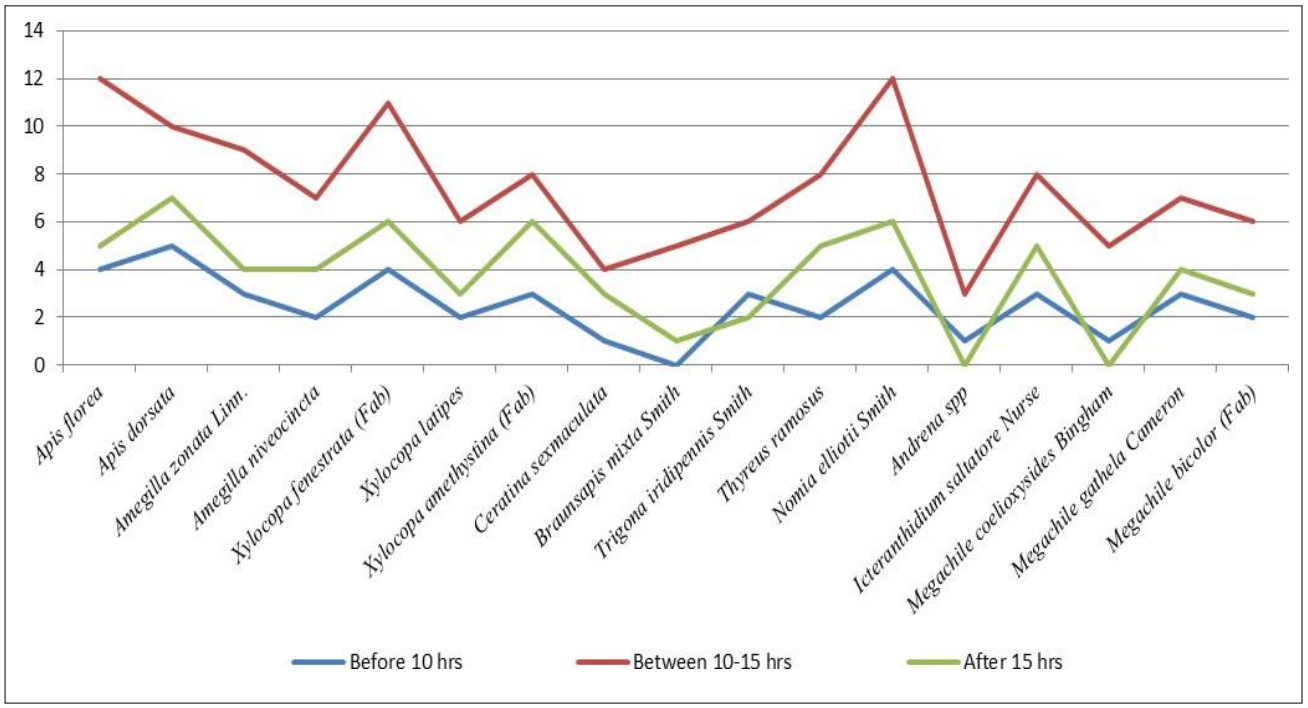

Fig 1: Average number of bee visits on Tephrosia *purpurea (L.) Pers*

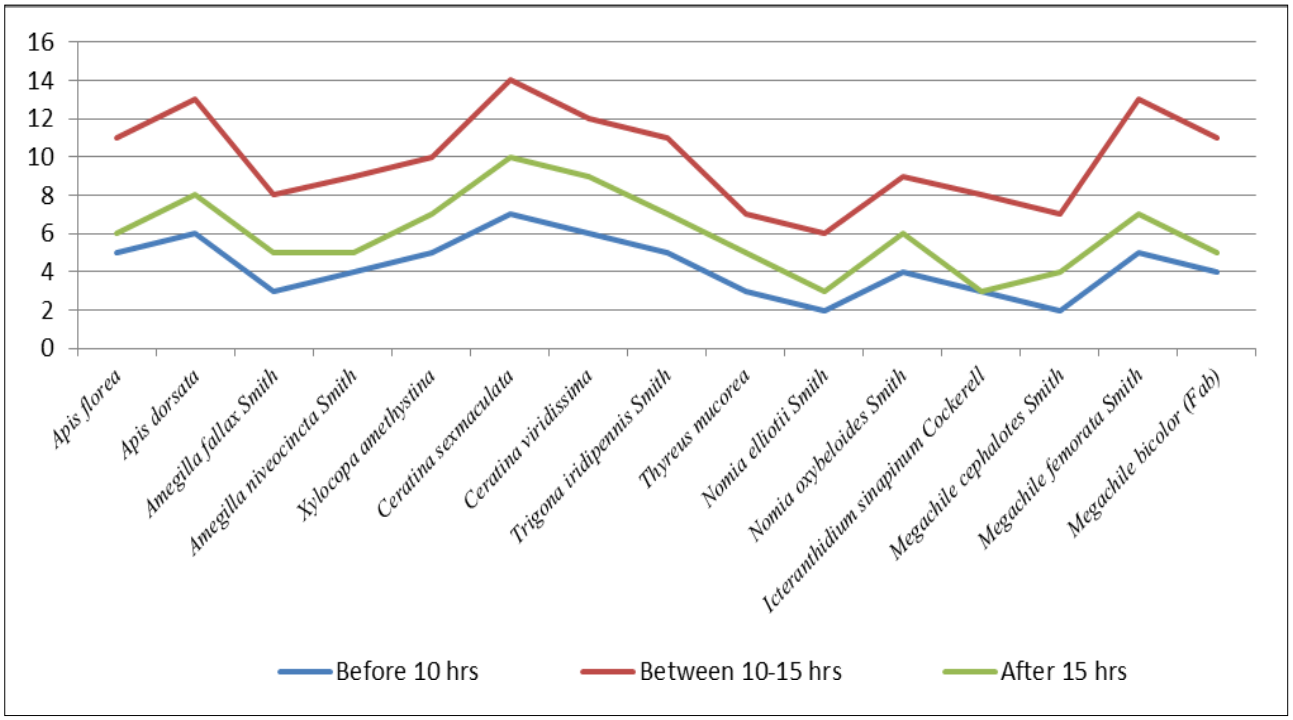

Fig 2: Average number of visits by the bees on the plant *Trichodesma amplexicaule*

Conclusion

Tephrosoria purpurea (L) *Pers* and *Trichodesma amplexicaule Roth* plants are the natural insecticidal plants so these plants have great economic importance in the western Rajasthan. These plants showed great ecological relationship with Hymenopteran pollinators in the study area. Plant and bees benefited to each other for the survival and showed ecological relationship with abiotic factors (temperature and humidity) that was expressed as differential foraging activity with the distinct time intervals of the day. These plants provide nutrition to the bees in the ecosystem when cultivated crops are not available and bees help the cultivated crops to produce great yield.

Acknowledgment

The authors are highly grateful to U.G.C. (University Grant Commission, New Delhi) for providing financial assistance to corresponding author (Project sanctioned letter No. and Date: F.30-91/2015 dated 30/03/2015). The authors are also thankful to Dr. Jagdish Saini, Research associate, Department of Hymenoptera, Zoological Survey of India, Kolkata, India for technical assistance in the identification of bees.

References

1. Zhang P, Qin D, Chen J and Zhang Z. Plants in the genus Tephrosia: Valuable resources for Botanical Insecticides. Insects,2020:11:721.
2. Dalwadi PP, Patel JL, Patani PV. Tephrosoria purpurea Linn (Sharpunkha, wild indigo): A review on phytochemistry and pharmacological studies, Indian J. Pharm. Biol. Res,2014:2:108.
3. Ahmad VU, Ali Z, Hussanini SR, Iqbal F, Zahid M, Abbas M *et al*. Flavonoids of *Tephrosia purpurea*. Fitoterapia,1999:70(4):443-445.
4. Heuze V, Thiollet H, Tran G, Hassoun P, Lebas F. Ahuhu (Tephrosia purpurea). Feedipedia. A programme by INRA, CIRAD, AFZ and FAO, 2018.
5. Patil PV, Huger S, Nanjappaiah HM, Kalyane N, Chowdhry M. 'Phytopharmacology of Tephrosia purpurea Linn: An Overview', Pharmacologyonline, 2011:3:1111-1140.
6. Ahmed T, Sarwar GR, Ali T, Qaiser M. Buzz-pollination in Trichodesma indicum (L) R.BR. (Boraginaceae). Pakistan Journal of Botany, 1995:27(1):93-99.
7. Shankar KR, Gurjar C, Rajalakshmi VG, Joshi NH. Pytochemical investigations of plant Trichodesma indicum. Biomedical and Pharmacology Journal, 2008:1(2):453-456.
8. Free. Pollination in the tropics. Beekeeping and Development, 1999, 51-67.
9. Stern RK. Introductory plant biology. William C. Brown Publisher, New York, USA, 1994. ISBN: 978-0697257734. 608.
10. McGregor SE. Insect pollination of cultivated crop plants. Agriculture handbook No. 496. USDA, ARS, Washington, 1976, 411.
11. Buchmann SC. Buzz pollination in angiosperms. In handbook of experimental pollination biology (C E Jones and RJ Little Eds.). Van Nostrand Reinhold, New York,1983:1:73-114.
12. Suryanarayan MC. Honey- flower relationship. Bulletin of Botanical survey of India,1986:28(1):55-62.
13. Velthius HHW. Pollen digestion and the evolution of sociality in bees. Bee world,1992:73(2):77-89.
14. Hargasim O. Bee as pollinators of entomophilies crops,1974:55(4):137-140.
15. Klein AM, Vaissiere B, Cane JH *et al*. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society of London Series Biological sciences,2007:274:303-313.
16. Burd M. Batemans principle and plant reproduction: the role of pollen limitation in fruit and seed set. Botanical Review,1994:60:83-139.

17. Sharma KK, Mehra SP. The Thar of Rajasthan (India): Ecology and conservation of a desert ecosystem. Fauna ecology and conservation of the Great Indian Desert. Springer, Berlin Heidelberg, 2009. ISBN: 978-3-540-87408-9. 221.
18. Free. Pollination in the tropics. Beekeeping and Development,1999:51:67.
19. Batra SWT. Biology of Lasioglossum (Evylaeus) matieanense (Bluthgen) [Hymenoptera: Halictidae], the predominant pollinating bee in orchards at high altitude in the Great Himalaya of Garhwal, U.P., India. Proceeding of the Entomological Society of Washington,1997:99:162-170.
20. Cane JH (1997). Ground-nesting bees: the neglected pollinator resource for agriculture. Acta Hort,1997:37:309-324.
21. Moustafa HZ, Salem MS. Influence of three insecticides from three different groups on Pectinophora gossypiella (Saund.)(Lepidoptera: gelechiidae). International J. of Entomol. Research. 2019;4:127-31.