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HD Zinzuvadiya

Ph. D. Scholar, Department of
Entomology, N. M. College of
Agriculture, NAU, Navsari,
Gujarat, India

LV Ghetiya

Associate Professor, Department
of Entomology, N. M. College of
Agriculture, NAU, Navsari,
Gujarat, India

Inventory of insect pollinators under agricultural landscape area of South Gujarat

HD Zinzuvadiya and LV Ghetiya

Abstract

The experiment was carried out through survey of insect pollinators under agricultural landscape area in the different districts of South Gujarat *i.e.* Bharuch, Narmada, Surat, Tapi, Navsari, The Dangs and Valsad during September 2017 to December 2019. The survey of insect pollinators of South Gujarat showed that 63 species of different insect pollinators were recorded which was belonging to three orders *viz.* hymenoptera, diptera and lepidoptera. The hymenoptera order found to be dominated with four families *viz.* halictidae (16 species), megachilidae (11 species), apidae (9 species) and xylocopidae (8 species) distributed into 20 genera and 44 species followed by diptera order with two families *viz.* syrphidae (9 species) and calliphoridae (1 species) distributed into eight genera and 10 species and lepidoptera order with six families *viz.* pieridae (3 species), nymphalidae (2 species), licaenidae (1 species), papilionidae (1 species), hesperiidae (1 species) and erebidae (1 species) distributed into nine genera and nine species. In the present study 20 species of hymenoptera, six species of diptera, and nine species of lepidoptera order were the most common as they were recorded in all districts of South Gujarat. Whereas, a species *i.e.* *Tetragonula iridipennis* reported from the Dangs district only. Fifty eight species of insect pollinators were reported for the first time from agricultural landscape area of South Gujarat.

Keywords: Pollinators, Inventory, Hymenoptera, Diptera, Lepidoptera

Introduction

Pollinators are important in 35 per cent of global crop production ^[1], and 70 per cent of major global crop species depend on animal pollination ^[2, 3]. In cultivated fields, more than 65 per cent of the crops are insect pollinated. Insect pollinators play an important role in improving the productivity of cross-pollinated crops. The role of pollinators in cross pollination of key agro-horticultural crops is well documented. The important insect pollinators include honey bees, butterflies, wasps, solitary bees (*Xylocopa*, *Andrena*, *Halictus*), bumblebees, stingless bees (*Trigona*, *Melipona*), dipterans flies (*Syrphus*, *Bombilius*) and some beetles. Insects mainly belonging to the orders of hymenoptera, lepidoptera, coleoptera, diptera, hemiptera, etc. are the most common and dominant pollinators in various regions. Among the insect, hymenopterans are highly evolved and constitute the most important group of pollinating insects. Even in hymenopteran bees belonging to the superfamily Apoidea containing an estimated 25000 described species including wasps, ants, chalcids, ichneumons, sawflies, etc. belonging to 250 genera and 11 families are regarded as the most important group of insect pollinators ^[4]. Insects are the pollinators of 80 per cent of all plant species in Europe, include diverse species of hymenoptera (bees, solitary species, bumblebees, pollen wasps and ants), diptera (bee flies, houseflies, hoverflies), lepidoptera (butterflies and moths), coleoptera (flower beetles), and other insects ^[5]. For tropical crops ^[6], provided a detailed list for 1330 species and compiled a list of potential breeding systems and pollinating taxa.

The objective of preparation of the general inventory of insect pollinators is to bring together information on the presence of various insect pollinators in the agroecosystem under South Gujarat. From the inventory of insect pollinators, one can find out rare and endangered species of insect pollinators in the region and thereby need for its conservation.

The information on the general inventory of insect pollinators is not found in a systematic form in the referred literature. Hence, an inventory of pollinators of South Gujarat was prepared in an organized form. The intensive collection of insect pollinators/foragers was done through an extensive survey from Bharuch, Narmada, Surat, Tapi, The Dangs, Navsari and Valsad districts of South Gujarat.

Corresponding Author:**HD Zinzuvadiya**

Ph. D. Scholar, Department of
Entomology, N. M. College of
Agriculture, NAU, Navsari,
Gujarat, India

The results obtained through the consolidated collection of a variety of insect pollinators are presented as general inventory of insect pollinators of South Gujarat.

Materials and Methods

Study area

The study was carried out in the different districts of South Gujarat *i.e.* Bharuch, Narmada, Surat, Tapi, Navsari, The Dangs and Valsad during September 2017 to December 2019. South Gujarat is situated in the south part of the Gujarat state in the coastal low land on the western part. The total geographic area of South Gujarat is 17,500 km². South Gujarat with coordinates: 21° 1702' N to 21° 4766' N (North latitude) and 72° 8013'E to 72° 8854'E (East longitude). It has a coastal line open to the Arabian Sea from West and is bounded by Middle Gujarat on the North and Maharashtra on Southern as well as Eastern parts. On the East, it is contiguous to The Dang district with forest and hilly evergreen as well as deciduous forest, revarian forest, mountains, water reservoirs, dams, ponds, plains, wetlands, canal areas, having alkaline soils, saline soils, and black fertile soils, etc.

Survey and collection of various pollinators were made in South Gujarat (Narmada, Bharuch, Surat, Tapi, Navsari, Valsad and The Dangs districts) through the random selection of agricultural landscape area under roving survey methods. The spot observations were followed by photography and collection from the different areas for their taxonomical studies based on morphological observations. The diurnal insect visitors of order hymenoptera, lepidoptera and diptera on flowers, from agricultural landscaping were observed during its peak activity period of the day (Mostly middle of the day). Species wise insect pollinators from crop flowers were recorded.

Verification of pollinators

Insect foraging on crop flowers was collected and examined for physical pollen loads (*i.e.* presence of pollen) on its body parts (*i.e.* legs, antennae, mouth parts, wings, abdominal tip, etc.) for its confirmation as a pollinator. For pollen observations, collected insects were observed under 10X magnifying glass for the presence of the pollen on its body, then insects were released in the same field from where they collected. At least 10 insects of all species were observed for presence of pollen on body and ≥ 30 per cent insects of the same species were found adequate pollen load on the body then that was considered as a pollinator. The habits, habitat and floral choice of pollinators were oversight in the study.

General inventory of insect pollinators

The collection of various pollinators was made in South Gujarat. Mostly, spot observation was done followed by photography and collection from the different areas for their taxonomical studies based on morphological characters. After

noting characteristics and observations the live pollinators were released in the environment from where they collected. The collected and preserved specimens of different pollinators were identified by sending samples to GKVK, Bengaluru.

The intensive survey and collection of various insect pollinators were made from entire South Gujarat (Narmada, Bharuch, Surat, Tapi, Navsari, Valsad and The Dangs districts) to strengthen the pollinators' list in the inventory of insect pollinators of South Gujarat. The information on the general inventory of pollinators of Gujarat was not found as single document in referred literature. Therefore, the checklists of pollinator for South Gujarat were compiled from available literature for comparison of insect pollinators reported with the present study.

Results and Discussion

General inventory of insect pollinators of South Gujarat

During the course of the present study, a total of 63 species of different insect pollinators was reported and an inventory of insect pollinators was attempted for the first time in South Gujarat. Sixty three species of insects were identified as pollinators through pollen carrying confirmation and results thus obtained was compared with the earlier work done in Gujarat Table 1.

The survey of insect pollinators of South Gujarat showed that 63 species of different insect pollinators were recorded which was belonging to three orders *viz.* hymenoptera, diptera and lepidoptera. As far as order wise distribution was concerned hymenoptera order found to be dominated with four families *viz.* halictidae, megachilidae, apidae and xylocopidae distributed into 20 genera and 44 species followed by diptera order with two families *viz.* syrphidae and calliphoridae distributed into eight genera and 10 species and lepidoptera order with six families *viz.* pieridae, nymphalidae, licaenidae, papilionidae, hesperiidae and erebidae distributed into nine genera and nine species.

Based on referred literature, only six species of insect pollinators have been reported from the Gujarat in the past. The same was compared with the insect pollinators observed during the present study. Fifty eight species of insect pollinators observed as a new record from South Gujarat (Table 1).

Very little work has been done in Gujarat with a list of only five insect pollinators in mango (Anon., 2020) [7], present study broadly strengthen the list of insect pollinators of South Gujarat. This is our first attempt of the preparation of an inventory of insect pollinators for South Gujarat. Considering the diverse kind of flora and geographic variations in South Gujarat, there is a great chance of increasing the number of insect pollinators in the inventory of South Gujarat. So, this study opens the pave for further research work on the biodiversity of insect pollinators in South Gujarat.

Table 1: General inventory of insect pollinators of South Gujarat

No.	Name of Insect pollinators	Family	Gujarat	Present study
I	Hymenoptera			
1	<i>Amegilla cingulata</i> (Fabricius, 1775)	Apidae	-	✓
2	<i>Amegilla confusa</i> (Smith, 1854)		-	✓
3	<i>Apis cerana indica</i> (Fabricius, 1793)		✓	✓
4	<i>Apis dorsata</i> (Fabricius, 1793)		✓	✓
5	<i>Apis florea</i> (Fabricius, 1787)		✓	✓
6	<i>Apis mellifera</i> (Linnaeus, 1758)		✓	-
7	<i>Tarsalia strobilanthae</i> (Baker, 1998)		-	✓

8	<i>Tetragonula laeviceps</i> (Smith, 1858)		✓	✓
9	<i>Tetragonula iridipennis</i> (Smith, 1854)		✓	✓
10	<i>Tetralonia elegans</i> (Smith, 1854)		-	✓
11	<i>Anthidium orientale</i> (Bingham, 1897)		-	✓
12	<i>Coelioxys capitatus</i> (Smith, 1854)		-	✓
13	<i>Coelioxys fuscipennis</i> (Smith, 1854)		-	✓
14	<i>Coelioxys sexmaculatus</i> (Cameron, 1897)		-	✓
15	<i>Lithurgus atratus</i> (Smith, 1853)			✓
16	<i>Megachile (Eutricharaea) hera</i> (Bingham, 1897)	Megachilidae	-	✓
17	<i>Megachile (Callomegachile) lerma</i> (Cameron, 1908)		-	✓
18	<i>Megachile bicolor</i> (Fabricius, 1781)		-	✓
19	<i>Megachile disjuncta</i> (Fabricius, 1781)		-	✓
20	<i>Megachile lanata</i> (Fabricius 1775)			✓
21	<i>Megachile stirostoma</i> (Cameron, 1913)		-	✓
22	<i>Braunsapis picitarsis</i> (Cameron, 1902)		-	✓
23	<i>Ceratina binghami</i> (Cockerell, 1908)		-	✓
24	<i>Ceratina hieroglyphica</i> (Smith, 1854)		-	✓
25	<i>Ceratina smaragdula</i> (Fabricius, 1787)		-	✓
26	<i>Xylocopa aestuans</i> (Linnaeus, 1758)	Xylocopidae	-	✓
27	<i>Xylocopa amethystina</i> (Fabricius, 1793)		-	✓
28	<i>Xylocopa fenestrata</i> (Fabricius, 1798)		-	✓
29	<i>Xylocopa latipes</i> (Drury, 1773)		-	✓
30	<i>Ceylalicus variegatus</i> (Olivier, 1789)		-	✓
31	<i>Halictus constrictus</i> (Smith, 1853)		-	✓
32	<i>Halictus fimbriatellus</i> (Vachal, 1894)		-	✓
33	<i>Halictus funebris</i> (Cameron, 1897)		-	✓
34	<i>Halictus gutturosus</i> (Vachal, 1894)		-	✓
35	<i>Halictus lucidipennis</i> (Smith, 1853)		-	✓
36	<i>Halictus rugolatus</i> (Smith, 1853)		-	✓
37	<i>Hoplonomia elliotii</i> (Smith, 1875)		-	✓
38	<i>Lasioglossum (Ctenonomia) serenum</i> (Cameron, 1897)	Halictidae	-	✓
39	<i>Lipotriches (Nomia) fervida</i> (Smith, 1875)		-	✓
40	<i>Lipotrichus fulvinerva</i> (Cameron, 1907)		-	✓
41	<i>Lipotrichus pulchriventris</i> (Cameron, 1897)		-	✓
42	<i>Nomia crassipes</i> (Fabricius, 1798)		-	✓
43	<i>Nomia iridescens</i> (Smith, 1858)		-	✓
44	<i>Pseudapis oxybeloides</i> (Smith, 1875)		-	✓
45	<i>Sphecodes fumipennis</i> (Smith, 1853)		-	✓
II	Diptera			
46	<i>Asarkina ericetorum</i> (Fabricius, 1781)		-	✓
47	<i>Eristalinus megacephalus</i> (Rossi, 1794)		-	✓
48	<i>Eristalinus quinquestriatus</i> (Fabricius, 1794)		-	✓
49	<i>Eristalis obliquus</i> (Weidemann, 1824)		-	✓
50	<i>Ischiodon scutellaris</i> (Fabricius, 1805)	Syrphidae	-	✓
51	<i>Mesembrius quadrivittatus</i> (Wiedemann, 1819)		-	✓
52	<i>Paragus serratus</i> (Fabricius, 1805)		-	✓
53	<i>Phytomia errans</i> (Fabricius, 1787)		-	✓
54	<i>Syritta orientalis</i> (Macquart, 1842)		-	✓
55	<i>Chrysomya megacephala</i> (Fabricius, 1794)	Calliphoridae	-	✓
III	Lepidoptera			
56	<i>Tirumala limniace</i> (Cramer, 1775)	Nymphalidae	-	✓
57	<i>Euploea core</i> (Cramer, 1780)		-	✓
58	<i>Eurema hecabe</i> (Linnaeus, 1758)		-	✓
59	<i>Cepora nerissa</i> (Fabricius, 1775)	Pieridae	-	✓
60	<i>Delias eucharis</i> (Drury, 1773)		-	✓
61	<i>Lampides boeticus</i> (Linnaeus, 1767)	Lycaenidae	-	✓
62	<i>Papilio demoleus</i> (Linnaeus, 1758)	Papilionidae	-	✓
63	<i>Pelopidas mathias</i> (Fabricius, 1798)	Hesperiidae	-	✓
64	<i>Amata passalis</i> (Fabricius, 1781)	Erebidae	-	✓

Species wise distribution of insect pollinators in different families

Species wise distribution of insect pollinators in different families from South Gujarat was worked out and classified as given in Table 2. During the present study a total of 63 species of different insect pollinators were recorded which was belonging to 12 families and 37 genera of the three orders viz. hymenoptera, diptera and lepidoptera. As far as order wise distribution is concerned hymenoptera order found to be dominated followed by diptera and lepidoptera order. However, as far as species wise distribution is concerned, in hymenoptera the family halictidae found to be abundant with 16 species (25.40%) under eight genera (21.62%) followed by megachilidae with 11 species (17.46%) under four genera (10.81%), apidae with nine species (14.29%) under five genera (13.51%) and xylocopidae with eight species (12.70%) under three genera (8.11%). While in the case of diptera the family syrphidae was found to be abundant with nine species (14.29%) under seven genera (18.92%) and less occurrence pollinating species in calliphoridae with one species (1.59%). In case of lepidoptera order, the family pieridae was found to be abundant with three species (4.76%) under three genera (8.11%) followed by nymphalidae with two species (3.17%) under two genera (5.41%) and less occurrence pollinating species in lycaenidae, papilionidae, hesperiidae and erebidae with one species in each (1.59%) (Table 2).

Table 2: Species distribution of insect pollinators in different families from South Gujarat

Order	Family	Genera		Species	
		Number	%	Number	%
1. Hymenoptera	Halictidae	8	21.62	16	25.40
	Megachilidae	4	10.81	11	17.46
	Apidae	5	13.51	9	14.29
	Xylocopidae	3	8.11	8	12.70
2. Diptera	Syrphidae	7	18.92	9	14.29
	Calliphoridae	1	2.70	1	1.59
3. Lepidoptera	Lycaenidae	1	2.70	1	1.59
	Pieridae	3	8.11	3	4.76
	Papilionidae	1	2.70	1	1.59
	Hesperiidae	1	2.70	1	1.59
	Nymphalidae	2	5.41	2	3.17
	Erebidae	1	2.70	1	1.59
03	12	37	100.00	63	100.00

Very little work has been done in South Gujarat with a list of only five insect pollinators out of 13 insect visitors of mango [7]. An earlier study revealed that family syrphidae was dominant amongst the flower-visiting flies of India (Mitra, 2010) [8]. Dhanyavathi (2009) [9] at Mysore reported 55 species in 16 genera under three families viz. apidae, halictidae and megachilidae of hymenoptera. Whereas, in lepidoptera order nymphalidae was the most specious family with 19 species followed by pieridae (7 species), lycaenidae (6 species), papilionidae (5 species), and hesperiidae (2 species) at South Indian West Coast Region (Balachandran *et al.*, 2014) [10]. Shivashankara *et al.* (2016) [11] at Uttarakhand also reported pollinators from hymenoptera, diptera and lepidoptera orders in coriander crop. Devi *et al.* (2017) [12] at Solan, Himachal Pradesh reported hymenoptera as a dominant pollinator's order. However, Saini *et al.* (2018) [13] recorded 49 species belonging to 12 genera under three families viz. apidae, halictidae, and megachilidae at Arunachal Pradesh. In contrast to present findings, Mitra (2010) [8] reported 116

species belonging to 16 families of diptera at Kolkata, whereas Choi and Jung (2015) [14] recorded 368 species in 115 families of seven orders to act as pollinators at South Korea. Apidae was found as the most abundant family with 76 per cent of the total bee individuals followed by halictidae at 14 per cent and megachilidae at 10 per cent at Kenya (Chiawo, 2017) [15]. Singh *et al.* (2017) [16] recorded thirty three insect species belonging to sixteen families of six orders, in which 11 species belong to order lepidoptera, 12 in hymenoptera, six in diptera, three in coleoptera and one in odonata in carrot crop at Hisar, Haryana. Scientists of different locations recorded pollinators from other insect orders too. But the present study focused only on three orders viz. hymenoptera, diptera and lepidoptera, therefore pollinators of other orders may not be looked out.

District wise distribution of the insect pollinators

Various insect pollinators species were observed extensively from the seven districts viz. Bharuch, Narmada, Surat, Tapi, Navsari, The Dangs and Valsad of South Gujarat during September 2017 to December-2019 to strengthen the inventory of the insect pollinators. The results thus obtained are presented along with their geographical status in Table 3.

The survey of insect pollinators covered all seven districts of South Gujarat. Looking to district wise distribution of insect pollinators, Navsari district ranked the first position with 62 species (98.41%), among them 43 species (97.73%) of hymenoptera, 10 species (100%) of diptera and nine species (100%) of lepidoptera. The Dangs and Narmada district constituted 60 species (95.24%) among them 41 species of hymenoptera (93.19%), 10 species (100%) of diptera and nine species (100%) of lepidoptera second rank, followed by Bharuch district constituted 49 species (77.78%) among them 32 species of hymenoptera (72.73%), eight species (80%) of diptera and nine species (100%) of lepidoptera. Whereas, Valsad district constituted 47 species (74.60%) of insect pollinators among them 30 species (68.19%) of hymenoptera, eight species (80%) of diptera and nine species (100%) of lepidoptera occupied the fourth position in South Gujarat. Subsequently, Surat district constituted 46 species (73.02%) of insect pollinators among them 31 species (70.45%) of hymenoptera, six species (60%) of diptera and nine species (100%) of lepidoptera acquired the fifth position. However, Tapi district presented by 45 species (71.43%) among which 28 species of (63.64%) hymenoptera, eight species (80%) of diptera, and nine species (100%) of lepidoptera (Table-3).

The descending order of districts of South Gujarat with the overall distribution of insect pollinators was recorded as Navsari > Narmada = The Dangs > Bharuch > Valsad > Surat > Tapi (Table-3).

In the present study, 20 species of hymenoptera, six species of diptera, and nine species of lepidoptera order were the most common as they were recorded in all districts of South Gujarat. Out of 44 species of insect pollinators of hymenoptera, 20 species viz. *A. cingulata*, *A. orientle*, *A. cerana indica*, *A. dorsata*, *A. florea*, *C. binghami*, *C. smaragdula*, *C. capitatus*, *C. fuscipennis*, *C. sexmaculatus*, *H. elliotii*, *L. atratus*, *M. hera*, *M. disjuncta*, *M. lanata*, *N. crassipes*, *T. laeviceps*, *X. aestuans*, *X. amethystina* and *X. fenestrata* were recorded from all districts of South Gujarat. While in the case of diptera; six species viz. *E. megacephalus*, *E. quinquestriatus*, *E. obliquus*, *I. scutalarris*, *M. quadrivittatus* and *P. serratus* were most common as they were recorded in all districts of South Gujarat. However, in

lepidoptera nine species were recorded in all districts of South Gujarat. They were *A. passalis*, *C. nerissa*, *D. eucharis*, *E. core*, *E. hecabe*, *L. boeticus*, *P. demoleus*, *P. mathais* and *T.*

limniace. Whereas, a species *i.e.* *Tetragonula iridipennis* reported from the Dangs district only.

Table 3: District wise distribution and species reachness of insect pollinators in South Gujarat

No.	Insect pollinators	Bharuch	Narmada	Surat	Tapi	Navsari	Valsad	The Dangs
I	Hymenoptera							
1	<i>Amegilla cingulata</i> (Fabricius, 1775)	✓	✓	✓	✓	✓	✓	✓
2	<i>Amegilla confusa</i> (Smith, 1854)	-	✓	-	✓	✓	-	✓
3	<i>Anthidium orientale</i> (Bingham, 1897)	✓	✓	✓	✓	✓	✓	✓
4	<i>Apis cerana indica</i> (Fabricius, 1793)	✓	✓	✓	✓	✓	✓	✓
5	<i>Apis dorsata</i> (Fabricius, 1793)	✓	✓	✓	✓	✓	✓	✓
6	<i>Apis florea</i> (Fabricius, 1787)	✓	✓	✓	✓	✓	✓	✓
7	<i>Braunsapis picitarsis</i> (Cameron, 1902)	✓	✓	-	-	✓	✓	✓
8	<i>Ceratina binghami</i> (Cockerell, 1908)	✓	✓	✓	✓	✓	✓	✓
9	<i>Ceratina hieroglyphica</i> (Smith, 1854)	-	✓	-	-	✓	✓	✓
10	<i>Ceratina smaragdula</i> (Fabricius, 1787)	✓	✓	✓	✓	✓	✓	✓
11	<i>Ceylalictus variegatus</i> (Olivier, 1789)	-	✓	✓	-	✓	-	✓
12	<i>Coelioxys capitatus</i> (Smith, 1854)	✓	✓	✓	✓	✓	✓	✓
13	<i>Coelioxys fuscipennis</i> (Smith, 1854)	✓	✓	✓	✓	✓	✓	✓
14	<i>Coelioxys sexmaculatus</i> (Cameron, 1897)	✓	✓	✓	✓	✓	✓	✓
15	<i>Halictus constrictus</i> (Smith, 1853)	✓	✓	✓	-	✓	✓	-
16	<i>Halictus fimbriatellus</i> (Vachal 1894)	-	✓	✓	-	✓	✓	✓
17	<i>Halictus funebris</i> (Cameron, 1897)	-	✓	✓	✓	✓	-	✓
18	<i>Halictus gutturosus</i> (Vachal, 1894)	✓	✓	-	-	✓	-	✓
19	<i>Halictus lucidipennis</i> (Smith, 1853)	-	-	✓	✓	✓	✓	✓
20	<i>Halictus rugolatus</i> (Smith, 1853)	✓	✓	-	✓	✓	-	✓
21	<i>Hoplonomia elliotii</i> (Smith, 1875)	✓	✓	✓	✓	✓	✓	✓
22	<i>Lasioglossum (Ctenonomia) serenum</i> (Cameron, 1897)	✓	-	✓	✓	✓	✓	✓
23	<i>Lipotriches (Nomia) fervida</i> (Smith, 1875)	✓	✓	-	-	✓	✓	✓
24	<i>Lipotrichus fulvinerva</i> (Cameron, 1907)	✓	✓	-	✓	✓	-	✓
25	<i>Lipotrichus pulchriventris</i> (Cameron, 1897)	-	✓	-	-	✓	-	✓
26	<i>Lithurgus atratus</i> (Smith, 1853)	✓	✓	✓	✓	✓	✓	✓
27	<i>Megachile (Callomegachile) lerma</i> (Cameron, 1908)	-	✓	-	-	✓	✓	✓
28	<i>Megachile (Eutricharaea) hera</i> (Bingham, 1897)	✓	✓	✓	✓	✓	✓	✓
29	<i>Megachile bicolor</i> (Fabricius, 1781)	✓	✓	✓	✓	✓	-	✓
30	<i>Megachile disjuncta</i> (Fabricius, 1781)	✓	✓	✓	✓	✓	✓	✓
31	<i>Megachile lanata</i> (Fabricius, 1775)	✓	✓	✓	✓	✓	✓	✓
32	<i>Megachile stirostoma</i> (Cameron, 1913)	-	✓	-	-	✓	✓	-
33	<i>Nomia crassipes</i> (Fabricius, 1798)	✓	✓	✓	✓	✓	✓	✓
34	<i>Nomia iridescens</i> (Smith, 1858)	-	✓	✓	-	✓	✓	✓
35	<i>Pseudapis oxybeloides</i> (Smith, 1875)	✓	✓	✓	-	✓	-	-
36	<i>Sphecodes fumipennis</i> (Smith, 1853)	✓	✓	-	✓	✓	-	✓
37	<i>Tarsalia strobilanthes</i> (Baker, 1998)	-	✓	✓	-	✓	-	✓
38	<i>Tetragonula iridipennis</i> (Smith, 1854)	-	-	-	-	-	-	✓
39	<i>Tetragonula laeviceps</i> (Smith, 1858)	✓	✓	✓	✓	✓	✓	✓
40	<i>Tetralonia elegans</i> (Smith, 1854)	✓	✓	-	-	✓	-	✓
41	<i>Xylocopa aestuans</i> (Linnaeus, 1758)	✓	✓	✓	✓	✓	✓	✓
42	<i>Xylocopa amethystina</i> (Fabricius, 1793)	✓	✓	✓	✓	✓	✓	✓
43	<i>Xylocopa fenestrata</i> (Fabricius, 1798)	✓	✓	✓	✓	✓	✓	✓
44	<i>Xylocopa latipes</i> (Drury, 1773)	✓	✓	✓	-	✓	-	✓
	Total of hymenopteran pollinators (A)	32	41	31	28	43	30	41
	Distribution of hymenopteran pollinators (%)	72.73	93.18	70.45	63.64	97.73	68.19	93.19
II	Diptera							
45	<i>Asarkina ericetorum</i> (Fabricius, 1781)	-	✓	-	-	✓	✓	✓
46	<i>Eristalinus megacephalus</i> (Rossi, 1794)	✓	✓	✓	✓	✓	✓	✓
47	<i>Eristalinus quinquestratus</i> (Fabricius, 1794)	✓	✓	✓	✓	✓	✓	✓
48	<i>Eristalis obliquus</i> (Weidemann, 1824)	✓	✓	✓	✓	✓	✓	✓
49	<i>Ischiodon scutellaris</i> (Fabricius, 1805)	✓	✓	✓	✓	✓	✓	✓
50	<i>Chrysomya megacephala</i> (Fabricius, 1794)	✓	✓	-	✓	✓	-	✓

Table 3: District wise distribution and species reachness of insect pollinators in South Gujarat

No.	Insect pollinators	Bharuch	Narmada	Surat	Tapi	Navsari	Valsad	The Dangs
51	<i>Mesembrius quadrivittatus</i> (Wiedemann, 1819)	✓	✓	✓	✓	✓	✓	✓
52	<i>Paragus serratus</i> (Fabricius, 1805)	✓	✓	✓	✓	✓	✓	✓
53	<i>Phytomia errans</i> (Fabricius, 1787)	-	✓	-	-	✓	✓	✓
54	<i>Syrirta orientalis</i> (Macquart, 1842)	✓	✓	-	✓	✓	-	✓
	Total of dipteran pollinators (B)	08	10	06	08	10	08	10
	Distribution of dipteran pollinators (%)	80.00	100.00	60.00	80.00	100.00	80.00	100.00
III	Lepidoptera							
55	<i>Amata passalis</i> (Fabricius, 1781)	✓	✓	✓	✓	✓	✓	✓
56	<i>Cepora nerissa</i> (Fabricius, 1775) (Common Gull)	✓	✓	✓	✓	✓	✓	✓
57	<i>Delias eucharis</i> (Drury, 1773) (Indian Jezebel)	✓	✓	✓	✓	✓	✓	✓
58	<i>Euploea core</i> (Cramer, 1780) (Common Crow)	✓	✓	✓	✓	✓	✓	✓
59	<i>Eurema hecabe</i> (Linnaeus, 1758) (Common Grass Yellow)	✓	✓	✓	✓	✓	✓	✓
60	<i>Lampides boeticus</i> (Linnaeus, 1767) (Pea Blue)	✓	✓	✓	✓	✓	✓	✓
61	<i>Papilio demoleus</i> (Linnaeus, 1758) (Lime Swallowtail)	✓	✓	✓	✓	✓	✓	✓
62	<i>Pelopidas mathias</i> (Fabricius, 1798) (Small Branded Swift)	✓	✓	✓	✓	✓	✓	✓
63	<i>Tirumala limniace</i> (Cramer, 1775) (Blue Tiger)	✓	✓	✓	✓	✓	✓	✓
	Total of lepidopteran pollinators (C)	09	09	09	09	09	09	09
	Distribution of lepidopteran pollinators (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	District wise Total Species (A + B + C)	49	60	46	45	62	47	60
	Overall distribution of insect pollinators (%)	77.78	95.24	73.02	71.43	98.41	74.60	95.24

Conclusion

The inventory of insect pollinators of agricultural landscaping of South Gujarat is prepared for the first time. Due to limitations of resources and time, the present list of insect pollinators in South Gujarat remained short. Thus, present findings open pave for further work for strengthening the inventory of insect pollinators of South Gujarat. The main pollinators viz. Rock bee (*A. Dorsata*), Indian bee (*A. cerana indica*) and little bee (*A. florea*) were abundantly available in all district of South Gujarat without showing its deficit. Based on present experiments, high valued useful inventory of insect pollinators of South Gujarat has been prepared for the first time in Gujarat. There is a great scope of updation of inventory of insect pollinators of Gujarat.

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