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Percentage abundance of castor pollinators under Haryana condition

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Abstract
An experiment was conducted at farm area of CCS Haryana Agricultural University, Hisar, Under Haryana condition in order to find out the % abundance of different insect pollinators of castor crop for two consecutive years of study. Based on the per cent diurnal abundance result of insect pollinators on flowers of *R. communis* cv. GCH-7 and DCH-177, hymenopterans were dominated as flower visitors of *R. communis* accounting more than 95 % of the total pollinators. Among them, four social bee species *viz.*, *A. florea* (49.22%), *A. cerana* (18.29%), *A. mellifera* (10.64%) and *A. dorsata* (6.73%) were considered to be principal pollinator species of castor while *Eristalinus* sp. (1.49%) was having least abundance per cent in GCH-7 hybrid. Similarily in DCH-177, *A. florea* (49.51%), *A. cerana* (19.32%), *A. mellifera* (11.49%) and *A. dorsata* (5.98%) were also considered to be principal pollinator species of castor while *Eristalinus* sp. (0.79%) was having least abundance per cent.

Keywords: Castor, *R. communis*, % abundance, pollinators

1. Introduction
Castor (*Ricinus communis* L.) commonly known as castor-bean, belongs to the spurge family Euphorbiaceae and locally known as arandi, It is an important non-edible oilseed crop, occupies the fifth position among the most commonly growing nine annual oilseed crops. At present, castor is cultivated in 30 different countries in tropical and warmer temperate regions throughout the world on a commercial scale (Anonymous, 2020) [3]. The major castor growing countries are India, China, Brazil, Africa, USA, and many other Asian countries (Melo *et al*., 2008) [10]. India is the largest producer of castor seed and meets most of the global demand for castor oil, contributing more than 60 per cent of the entire global production. Castor has tremendous potential as future industrial oilseed crop because of its high oil content (> 480 ml kg–1), potentially high yields (1250–2500 kg/ha), unique fatty acid composition (900 g/kg of ricinoleic acid), and ability to be grown under drought and saline condition (Severino *et al*., 2012) [15]. Honey bees, pollinators and flowering plants evolved a well-adjusted system of interdependence and such a relationship is one of the most significant events which have been started about 225 million years ago (Giannini *et al*., 2014) [8]. The conservation and management of insect pollinators are gaining importance day by day for which studies on pollinator's diversity, species richness and abundance are essential (Maiti and Maiti, 2011) [9]. So the first step is to identify the most important pollinators abundance and their percentage in order to examine their potential in pollinating different agricultural and horticultural crops.

2. Materials and Methods: For recording % abundance the most common (12) visitors of castor hybrids was taken into account. Observations were made on *R. communis* cv. GCH -7 and DCH -177 for consecutive two years *i.e.* 2018 and 2019. Experiment was conducted at Research Farm and Apicultural laboratory of Department of Entomology, CCS Haryana Agricultural University, Hisar. The abundance data collected at two hourly time intervals of the day, starting from 0600 to 1800 h and repeated at fortnightly intervals during the crop flowering period (August and September) was used to determine the diurnal abundance of different insect pollinators. The % diurnal abundance of insect visitors/pollinators were calculated on castor flowers. The following formula was used to know the per cent diurnal abundance of the individual insect species.

Relative abundance of "X" spp. = Number of visits of X spp./Total visits × 100

3. Results Discussions

3.1 Per cent diurnal abundance of insect visitors/pollinators on *R. communis* cv. GCH-7

The data depicted in (Table 1) indicated the clear variation between the two cropping years. The data demonstrated the dominance of hymenopterans as flower visitors and they were more abundant during 2019 as compare to 2018. During 2018, *A. florea* was observed to be the predominant species followed by *A. cerana*, *A. mellifera*, and *A. dorsata* with the mean per cent abundance of 51.47, 18.76, 9.12 and 6.01, respectively. Whereas *Vespa* sp., *Polistes* sp., *Camponotus* sp., *X. iridipennis*, *Calliphora* sp., *Eristalinus* sp., *M. bicolor* and *M. lanata* had low per cent abundance i.e. 0.65, 1.21, 1.47, 1.60, 1.73, 1.90, 2.46 and 3.67, respectively. While *A. dorsata*, *Polistes* sp., *M. lanata* and *Vespa* sp. no abundance were found during 0600-0800 h. No activities were recorded for *Polistes* sp., *M. lanata* and *Vespa* sp. during 1600-1800 h. Further, during 2019, the highest per cent abundance was of *A. florea* followed by *A. cerana*, *A. mellifera*, and *A. dorsata* which consisted of 46.98, 17.83, 12.15 and 7.45 per cent respectively, while *X. iridipennis*, *Eristalinus* sp., *Calliphora* sp., *Camponotus* sp., *Vespa* sp., *M. bicolor*, *M. lanata* sp. and *Polistes* sp. were the species with low per cent abundance consisted of 0.98, 1.08, 1.12, 1.45, 1.81, 2.53, 2.97 and 3.76 per cent respectively. No activity was found for *Polistes* sp. during 0600-0800 and 1600-1800 h.

Table 1: Per cent diurnal abundance of insect visitors/pollinators on flowers of *R. communis* cv. GCH-7 during 2018 and 2019

Sl. No	Insect visitor/ pollinators	Mean per cent relative abundance													Pooled abundance (%)
		2018							2019						
		0600-0800h	0800-1000 h	1000-1200 h	1200-1400 h	1400-1600 h	1600-1800h	Mean abundance (%)	0600-0800h	0800-1000 h	1000-1200 h	1200-1400 h	1400-1600 h	1600-1800h	Mean abundance (%)	
1.	*A. dorsata*	0.00 (0.00)*	6.58 (14.86)	6.14 (14.35)	6.72 (15.03)	6.83 (15.15)	6.80 (15.11)	6.01 (14.19)	7.49 (15.88)	8.23 (16.68)	7.07 (15.43)	6.73 (15.03)	8.08 (16.52)	8.26 (16.71)	7.45 (15.84)	6.73 (15.04)
2.	*A. cerana*	25.21 (30.14)	22.02 (27.98)	21.72 (27.78)	14.41 (22.31)	15.28 (23.01)	14.15 (22.10)	18.76 (25.66)	22.75 (28.49)	19.48 (26.19)	20.85 (27.17)	13.87 (21.86)	14.71 (22.56)	14.84 (22.66)	17.83 (24.98)	18.29 (25.32)
3.	*A. mellifera*	17.51 (24.74)	10.44 (18.85)	8.08 (16.52)	8.68 (17.13)	6.07 (14.27)	8.47 (16.92)	9.12 (17.58)	18.08 (25.16)	14.04 (22.00)	11.02 (19.38)	10.90 (19.28)	11.51 (19.83)	10.41 (18.82)	12.15 (20.40)	10.64 (19.04)
4.	*A. florea*	51.52 (45.87)	41.58 (40.15)	47.32 (43.47)	54.94 (47.84)	58.95 (50.15)	62.01 (51.95)	51.47 (45.84)	46.19 (42.81)	41.17 (39.92)	42.12 (40.46)	50.59 (45.34)	52.05 (46.18)	58.22 (49.73)	46.98 (43.27)	49.22 (44.55)
5.	*Polistes* sp.	0.00 (0.00)	1.71 (7.52)	1.66 (7.40)	1.45 (6.91)	0.66 (4.68)	0.00 (0.00)	1.21 (6.32)	0.00 (0.00)	4.58 (12.36)	4.44 (12.16)	4.69 (12.51)	4.19 (11.81)	0.00 (0.00)	3.76 (11.18)	2.49 (9.08)
6.	*X. iridipennis*	2.20 (8.53)	1.67 (7.42)	1.84 (7.79)	2.08 (8.29)	0.76 (5.00)	0.00 (0.00)	1.60 (7.26)	0.55 (4.25)	0.47 (3.91)	1.51 (7.07)	1.21 (6.32)	0.60 (4.44)	0.38 (3.55)	0.98 (5.67)	1.29 (6.52)
7.	*M. lanata*	0.00 (0.00)	5.00 (12.92)	3.95 (11.47)	4.10 (11.68)	3.65 (11.02)	2.42 (8.95)	3.67 (11.05)	0.62 (4.51)	2.94 (9.87)	3.24 (10.36)	3.25 (10.38)	3.34 (10.52)	3.21 (10.33)	2.97 (9.92)	3.32 (10.50)
8.	*Vespa* sp.	0.00 (0.00)	1.23 (6.36)	0.74 (4.93)	0.75 (4.98)	0.28 (3.06)	0.00 (0.00)	0.65 (4.62)	0.41 (3.68)	2.86 (9.74)	2.76 (9.56)	1.80 (7.72)	0.34 (3.35)	0.38 (3.55)	1.81 (7.73)	1.23 (6.37)
9.	*M. bicolor*	1.35 (6.68)	2.89 (9.80)	2.98 (9.95)	2.08 (8.29)	2.85 (9.72)	1.58 (7.23)	2.46 (9.03)	0.62 (4.51)	1.79 (7.69)	3.30 (10.46)	3.63 (10.99)	1.88 (7.88)	1.38 (6.74)	2.53 (9.16)	2.50 (9.10)
10.	*Camponotus* sp.	0.17 (2.36)	1.67 (7.42)	1.40 (6.80)	1.45 (6.91)	1.95 (8.02)	2.14 (8.41)	1.47 (6.96)	1.51 (7.06)	1.40 (6.79)	1.10 (6.02)	1.29 (6.52)	2.05 (8.24)	1.76 (7.62)	1.45 (6.91)	1.46 (6.94)
11.	*Calliphora* sp.	1.44 (6.89)	2.41 (8.94)	1.86 (7.84)	1.42 (6.84)	1.33 (6.62)	1.86 (7.84)	1.73 (7.55)	1.31 (6.56)	1.07 (5.95)	1.31 (6.56)	1.24 (6.39)	0.60 (4.44)	0.77 (5.02)	1.12 (6.08)	1.42 (6.84)
12.	*Eristalinus* sp.	0.59 (4.41)	2.85 (9.72)	2.32 (8.76)	1.93 (7.98)	1.38 (6.74)	0.65 (4.63)	1.90 (7.93)	0.48 (3.98)	2.01 (8.14)	1.31 (6.56)	0.80 (5.13)	0.68 (4.75)	0.46 (3.89)	1.08 (5.98)	1.49 (7.01)

*Figures in parentheses are angular transformed value

Factors	CD (P≤0.05)	SE(m)
Year	(0.033)	(0.012)
Insect visitor	(0.081)	(0.029)
Insect visitor × Year	(0.115)	(0.041)
Time	(0.057)	(0.021)
Year× Time	(0.081)	(0.029)
Insect visitor× Time	(0.198)	(0.071)
Insect visitor× Year ×Time	(0.281)	(0.101)

Pooled mean per cent abundance data of both the studied years also showed the dominance of *A. florea* (49.22%) followed by *A. cerana* (18.29%), *A. mellifera* (10.64%), *A. dorsata* (6.73%) and least abundance of *Vespa* sp., *X. iridipennis*, *Calliphora* sp., *Camponotus* sp., *Eristalinus* sp., *Polistes* sp., *M. bicolor* and *M. lanata* with the mean percentage abundance of 1.23, 1.29, 1.42, 1.46, 1.49, 2.49, 2.50 and 3.32 per cent respectively (Fig. 1). The highest and lowest percentage abundance was recorded for *A. florea* and *Vespa* sp. respectively. Results showed there was significant variation between years, insect visitors and different time interval. Interaction of insect visitors, time and year of study was also differed significantly.

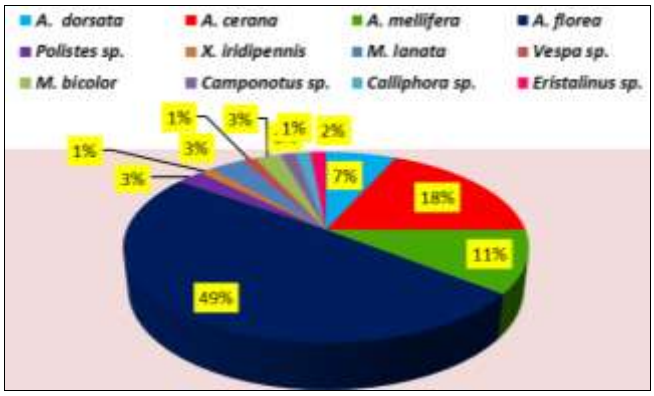

Fig 1: Mean per cent abundance (%) of insect visitors/pollinators on flowers of *R. communis* cv. GCH -7

Table 2: Per cent diurnal abundance of insect visitors/pollinators on flowers of *R. communis* cv. DCH-177 during 2018 and 2019

Sl. No	Insect visitor/ pollinators	Mean per cent relative abundance													
		2018							2019							Pooled abundance (%)
		0600-0800h	0800-1000 h	1000-1200 h	1200-1400 h	1400-1600 h	1600-1800h	Mean abundance (%)	0600-0800h	0800-1000 h	1000-1200 h	1200-1400 h	1400-1600 h	1600-1800h	Mean abundance (%)	
1.	*A. dorsata*	1.24 (6.40)*	3.13 (10.19)	3.93 (11.44)	5.40 (13.44)	6.01 (14.20)	6.12 (14.33)	4.35 (12.04)	3.51 (10.79)	7.74 (16.16)	7.84 (16.26)	7.56 (15.96)	9.16 (17.62)	9.10 (17.56)	7.61 (16.02)	5.98 (14.15)
2.	*A. cerana*	23.71 (29.14)	21.33 (27.50)	20.85 (27.17)	18.13 (25.20)	15.29 (23.02)	17.65 (24.84)	19.49 (26.20)	21.54 (27.65)	23.20 (28.80)	20.06 (26.61)	16.08 (23.64)	16.88 (24.26)	16.34 (23.85)	19.14 (25.94)	19.32 (26.07)
3.	*A. mellifera*	11.95 (20.22)	12.65 (20.84)	9.22 (17.68)	11.60 (19.91)	7.70 (16.11)	8.98 (17.44)	10.23 (18.65)	17.78 (24.94)	13.31 (21.40)	12.82 (20.98)	11.48 (19.81)	11.15 (19.51)	11.79 (20.08)	12.75 (20.92)	11.49 (19.81)
4.	*A. florea*	57.65 (49.40)	42.80 (40.86)	48.01 (43.86)	48.16 (43.94)	59.63 (50.55)	61.84 (51.85)	50.74 (45.42)	51.16 (45.66)	42.82 (40.87)	42.61 (40.75)	52.75 (46.58)	52.80 (46.60)	57.24 (49.16)	48.27 (44.01)	49.51 (44.72)
5.	*Polistes* sp.	0.00 (0.00)	6.02 (14.20)	5.73 (13.85)	5.58 (13.67)	3.36 (10.57)	0.00 (0.00)	4.44 (12.17)	0.00 (0.00)	1.01 (5.76)	1.96 (8.04)	1.74 (7.58)	4.16 (11.76)	0.00 (0.00)	1.22 (6.35)	2.83 (9.68)
6.	*X. iridipennis*	1.05 (5.89)	0.81 (5.15)	1.63 (7.33)	1.31 (6.58)	0.00 (0.00)	0.00 (0.00)	1.02 (5.79)	1.00 (5.74)	0.62 (4.51)	2.20 (8.52)	0.94 (5.55)	0.13 (2.04)	0.00 (0.00)	1.26 (6.44)	1.14 (6.13)
7.	*M. lanata*	0.57 (4.34)	3.93 (11.44)	2.28 (8.69)	3.39 (10.61)	2.80 (9.64)	1.12 (6.08)	2.59 (9.27)	0.63 (4.54)	3.06 (10.07)	2.12 (8.37)	2.55 (9.18)	1.87 (7.85)	0.97 (5.65)	2.10 (8.32)	2.34 (8.80)
8.	*Vespa* sp.	0.00 (0.00)	2.09 (8.30)	1.67 (7.44)	1.13 (6.10)	0.25 (2.89)	0.31 (3.17)	1.16 (6.18)	0.81 (5.18)	2.44 (8.99)	2.62 (9.32)	1.25 (6.41)	0.38 (3.54)	0.22 (2.71)	1.61 (7.28)	1.38 (6.75)
9.	*M. bicolor*	0.57 (4.34)	2.75 (9.54)	3.50 (10.78)	2.41 (8.93)	2.70 (9.46)	1.73 (7.57)	2.64 (9.35)	0.19 (2.48)	1.92 (7.96)	2.92 (9.84)	1.97 (8.08)	3.18 (10.27)	1.42 (6.84)	2.20 (8.53)	2.42 (8.95)
10.	*Camponotus* sp.	1.53 (7.10)	1.47 (6.96)	1.00 (5.73)	1.28 (6.49)	1.22 (6.35)	0.92 (5.50)	1.20 (6.30)	1.94 (8.01)	1.46 (6.95)	1.57 (7.20)	1.53 (7.11)	1.19 (6.26)	1.12 (6..07)	1.50 (7.04)	1.35 (6.67)
11.	*Calliphora* sp.	1.34 (6.64)	1.94 (8.01)	1.26 (6.45)	1.13 (6.10)	1.02 (5.79)	0.92 (5.50)	1.25 (6.42)	1.00 (5.74)	1.33 (6.63)	1.96 (8.04)	1.14 (6.14)	0.81 (5.15)	0.97 (5.65)	1.33 (6.62)	1.29 (6.52)
12.	*Eristalinus* sp.	0.29 (3.07)	1.09 (5.99)	0.95 (5.58)	0.47 (3.95)	0.15 (2.24)	0.00 (0.00)	0.60 (4.45)	0.38 (3.51)	1.11 (6.04)	1.33 (6.62)	1.01 (5.78)	0.68 (4.73)	0.60 (4.43)	0.98 (5.68)	0.79 (5.10)

*Figures in parentheses are angular transformed value

Factors	CD (P≤0.05)	SE(m)
Year	(0.035)	(0.013)
Insect visitor	(0.086)	(0.031)
Insect visitor × Year	(0.122)	(0.044)
Time	(0.061)	(0.022)
Year× Time	(0.086)	(0.031)
Insect visitor× Time	(0.211)	(0.076)
Insect visitor× Year ×Time	(0.298)	(0.107)

3.2 Per cent diurnal abundance of insect visitors/pollinators on *R. communis* cv. DCH-177

Per cent abundance data of DCH-177 during 2018 and 2019 indicated the same trend as GCH -7 (Table 2). During 2018, it was found that *A. florea* was the most abundant followed by *A. cerana*, *A. mellifera* and *A. dorsata*, with 50.74, 19.49, 10.23 and 4.35 per cent abundance, respectively whereas *Polistes* sp., *M. bicolor*, *M. lanata* sp., *Calliphora* sp., *Camponotus* sp., *X. iridipennis* and *Eristalinus* sp. with per cent abundance of 4.44, 2.64, 2.59, 1.25, 1.20, 1.16, 1.02 and 0.60 respectively. No abundance was recorded for *Polistes* sp. and *Vespa* sp. in the morning 0600-0800 h. Zero percentage abundance was documented for *Polistes* sp., *X. iridipennis* and *Eristalinus* sp. during 1600-1800 h.

During 2019, *A. florae* (48.27%) was also the most abundant one followed by *A. cerana* (19.14%), *A. mellifera* (12.75%) and *A. dorsata* (7.61%) and least abundance with the mean of *Eristalinus* sp. (0.98%), *Polistes* sp. (1.22%), *X. iridipennis* (1.26%), *Calliphora* sp. (1.33%), *Camponotus* sp. (1.50%), *Vespa* sp. (1.61%), *M. lanata* sp. (2.10%) and *M. bicolor* (2.20%). Pooled mean data on the per cent abundance also showed the peak activity of *A. florea*, *A. cerana*, *A. mellifera* and *A. dorsata*, with 49.51, 19.32, 11.49 and 5.98 per cent respectively. *Eristalinus* sp., *X. iridipennis*, *Calliphora* sp., *Camponotus* sp., *Vespa* sp., *M. lanata*, *M. bicolor* and *Polistes* sp. remained as least abundant species with per cent abundance of 0.79, 1.14, 1.29, 1.35, 1.38, 2.34, 2.42 and 2.83 (%), respectively (Fig. 2). Significant variation was noticed in between insect visitors, year of study and time interval, however their interactions also showed significant differences. These results are in line with Navatha and Sreedevi (2012) who stated that out of total visitors Apidea (75.57%) was the dominant family followed by Pieridae (5.36%), Formicidae (5.20%), Nymphalidae (4.80%) and Halictidae (4.36%) on castor crop., Akhtar *et al*. (2018) [2] stated that among all insect pollinators, *A. mellifera* as the predominant pollinator in mustard with 87.76 per cent abundance, whereas *A. florea* and *A. dorsata* had a low abundance of 1.11 and 0.98 per cent, respectively.

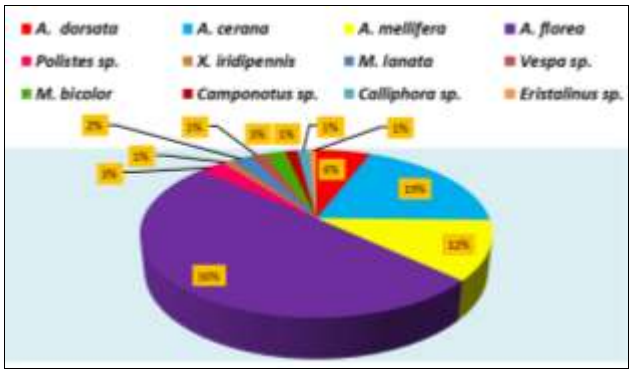

Fig 2: Mean per cent abundance (%) of insect visitors/pollinators on flowers of *R. communis* cv. DCH -177

Das and Jha (2018) reported that Hymenoptera was the most abundant visitors comprising 74.52% population out of which *A. mellifera* represented 35.18% followed by *A. cerana*

(23.11%), *A. dorsata* (12.00%) and *A. florea* (4.23%). However, Chaudhary (2001) also reported insects belonging to Apoidea (98.50%) as the major visitors in *B. juncea*. Among the social honey bee the little bee, *A. florea* was the most abundant (42.80%) followed by rock bee, *A. dorsata* (16.60%) whereas solitary bees constituted only 39 per cent of total visitors.

Abrol and Bajiya (2017) [1] found that *A. mellifera* was most abundant (28.09, 28.31%) on *B. napus* bloom followed by *A. cerana* (25.10, 25.48%), *A. dorsata* (18.00, 18.09%), *A. florea* (8.53, 7.90%) and *X. fenestrata* (5.55, 5.71%) during 2014-15 and 2015-16. Pudasaini *et al.* (2015) [13] also documented *A. mellifera* was most abundant one (36.34%); followed by *A. florea* (12.45%), *A. cerana* (11.14%), *A. dorsata* (5.68%), *Andrena* spp. (3.71%) and *Megachilus* spp. (0.66%). Atmowidi *et al*. (2007) [4] reported that the following three species, i.e. *A. cerana* (43.1%), *Ceratina* spp. (37%) and *A. dorsata* (8.4%) showed the greatest abundance on mustard. Nagpal (2016) recorded the maximum nectar foraging was recorded in case of *A. dorsata* (37.25%) followed by *A. florea* (36.08%), *A. cerana indica* (33.25%) and *A. mellifera* (31.63%) on *B. juncea*.

Vijaykumar (2011) [16] also observed that honey bee species were the most abundant pollinator i.e. 77.67% while other insect visitors were only 6.79% on sesame. Among the four honey bee species, the relative abundance of *A. cerana* was maximum (34.04%), followed by *A. florea* (29.00%), *A. dorsata* (14.63%), and non-*Apis* bees (15.54%). Rao (2019) [14] reported per cent abundance of different pollinator *viz., A. dorsata* (26.92%), *A. mellifera* (13.20%), *M. lanata* (12.58%), *A. florea* (7.44%), *A. cingulata* (1.02%), *X. iridipennis* (1.05%), *Compsomeriella* sp. (1.08%) and *Coelioxys* sp. (0.59%) on sesame. Dhurve (2008) also noted down that *A. dorsata* was the most abundant pollinator (37.23%) followed by *A. florea* (28.74%) and *A. cerana indica* (18.32%) in case of niger. Viraktamath *et al*. (2001) also recorded the abundance of *A. dorsata*, *A. mellifera*, *A. cerana*, and *A. florea* as 45.88, 10.81, 4.71 and 27.35 per cent, respectively.

4. Conclusion

Based on the per cent diurnal abundance data of insect visitors/pollinators on flowers of *R. communis* cv. GCH-7 and DCH-177, it was evident that the *Apis* sp. was in overwhelming and it was considered to be principal pollinator species of castor. Result indicated predominance abundance of hymenopterans visitors on *R. communis* flowers, hence it could be good indication presence of pollinators on castor crop and contributing their role on pollination.

5. References

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