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Effect of Bee Attractants on Bee Activities and Production of Bottle Gourd

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Authors' contributions

This work was carried out in collaboration among all authors. Author LTH designed the study, wrote the protocol, performed the statistical analysis, wrote the first draft of the manuscript. Author JM framed the research work, designed the study, analysis of the study, draft finalization of the manuscript. Author SB identification of pollinator species, designed the study, draft finalization of the manuscript. Author BS managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field investigation was carried out to study the effect of bee attractants on pollinator activity and the production of bottle gourd. The experiment was conducted at Horticulture Farm, Sriniketan during Kharif 2022 in a randomized block design with three replications. The treatment consists of

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eight indigenous bee attractants (jaggery solution @ 10%, sugar solution @ 10%, sugarcane juice solution @ 10%, honey solution @ 10%, cumin seed oil @ 0.5%, fennel seed oil @ 0.5%, dill seed oil @ 0.5% and rose water), and control. A total of 15 insect and non-insect species belonging to 10 families and 6 orders were found visiting the bottle gourd flowers during the experiment. Peak bees' activity was observed around 11 AM to 2 PM. Bee attractants increased the bee population irrespective of treatments and time intervals (on spray day and two consecutive days after spray). The effect of bee attractants was more pronounced on *Apis cerena indica* (Indian Bee) than on *Melipona sp.* (Stingless bee). In most cases Jaggery @ 10% spray attracts maximum honeybees regardless of different times and days after spray, followed by sugar solution (10%) and rose water. Jaggery @ 10% plots showed the early emergence of male (49.3) and female flowers (57.0) and also the days to male to female flowering (7.7). Application of jaggery @ 10% showed maximum number of fruits per plot (29.3), fruit length (8.1cm), fruit diameter (15.9cm) and fruit yield per plot (32.4kg). Maximum fruit yield ha^{-1} (216q) was registered in 10% jaggery-treated plots, followed by sugar solution (10%) treated plots (213.2q). Fragrant oils (cumin, fennel and dill seed oil), honey, rosewater and sugarcane juice-treated plots showed mixed responses for yield traits but mostly were superior to the control. Application of jaggery (10%) or sugar (10%) solution thrice (at 30%, 50% and 75% flowering stage) can be suggested to the bottle gourd growers of the Red and Laterite Zone of West Bengal for yield enhancement.

Keywords: Bee attractants; honeybee; stingless bee; bottle gourd; yield.

1. INTRODUCTION

Cucurbits are widely produced vegetables all over India. One of the most significant cucurbitaceous vegetable crops grown in both rainy and summer seasons is the Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.; 2n=22]. It is also called white-flowered gourd or calabash. Bottle gourd is a well-liked cooking vegetable cultivated throughout India. Apart from that, it is frequently used to treat diarrhea, constipation, and indigestion. Moreover, it has cooling, relaxing, and diuretic effects. Bottle gourd shell has been used since pre-historic times. Water bottles, bowls, musical instruments, and decorative ornaments are all made from dried bottle gourds.

Cucurbit flowers are often monoecious, meaning that they produce male and female flowers at separate internodes on the same plant. In bottle gourds, blossoms typically begin 40– 50 days after seeding. The white flowers of bottle gourd possess five sepals and five petals. Anthesis occurs between 17:00 and 20:00 hours, and the blooms open at night. On the day of anthesis and into the following morning, the pollen is still alive. As male and female floral structures do not coexist on the same flower, cucurbitaceous plants rely heavily on insects for pollination. Pollen transmission from flower to stigma is therefore crucial for fruit production. In order to boost yield and enhance the qualitative and quantitative characteristics of the crop, honeybees must be used strategically and effectively in order to achieve the necessary pollination.

Bee pollination increases crop yield and improves the quality and quantity of seed and fruit yield. The use of pollinators, particularly honeybees, is regarded as one of the most cost-effective and environmentally friendly methods of increasing the yield of cross-pollinated crops (Free, 1970; Pal and Bhattacharya 2023). Many studies have consistently confirmed that good pollinator management can increase yield levels by 100 to 150 percent in cucurbitaceous crops (Melnichenko and Khalifman, 1960).

Any substance used to lure bee pollinators to the target crop in order to maximize pollination and productivity is referred to as a bee attractant. These attractants can be used to pollinate the target crop at crucial times. The three primary categories of bee attractants are those based on food, pheromones, and botanical origin. Glucose, maltose, sucrose, lactose, protein, fat, minerals, vitamins, and gluconic acid are the major ingredients in food-based attractants. Bee-Line, Bee Lure, Bee-Q, and other commercial items are a few examples. Large Indian farming communities need to be informed about the potential advantages of using indigenous attractants to increase production in an environmentally responsible manner. As there is very little information available on the impact of pollination on the quality and quantity of bottle gourd, the experiment was conducted to study the effect of different bee attractants on the

production of bottle gourd along with the pollinator fauna and their relative abundance on bottle gourd.

2. MATERIALS AND METHODS

The experiment was conducted at the Horticulture Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal in the kharif season of 2022-23. The experiment was conducted in randomized block design with 3 replications consisting of eight treatments viz. jaggery @ 10% (T_1), sugar solution @ 10% (T_2), sugarcane solution @10% (T_3), honey solution @10% (T_4), rose water (T_5), dill seed oil @ 0.5% (T_6), cumin seed oil @ 0.5% (T_7) and fennel seed oil @10% (T_8). Jaggery, sugar, sugarcane juice, honey and rose water were purchased from the local market and Cumin, fennel and dill seed oil purchased from Moksha Lifestyle Products, Delhi. Bottle gourd seeds cv. Sathi 2 were sown in a plot size of 5 m x 3 m, with 8 pits being dug on opposite sides of each plot and an irrigation channel of 0.6 m length running through the pits for intense irrigation. The pits were 60 cm apart to allow for healthy growth and development of plants. Nine different types of bee attractants were used and sprayed three times on the crop at the flowering stage (30%, 50% and 75% flowering). Distilled water was sprayed in the control plot. In each plot, a five-minute visitation by the honeybee and stingless bee species, from 7 to 8 a.m., 9 to 10 a.m., 11 a.m. to 12 p.m., and 1 to 2 p.m., was counted. Data were gathered on the day of the treatment, and consecutive two days after the treatment for the three sprays. Data was gathered and the average was calculated. After being time-wise averaged, the mean of all the observations was then subjected to statistical analysis for inference and evaluated in relation to the crop's ability to bring various pollinator species, including bees, beetles and other pollinators. The identification of the various pollinator species was conducted at the Department of Agricultural Entomology, Institute of Agriculture, Visva-Bharati, Sriniketan. Additionally, effects of these attractant on bottle gourd yield parameters viz number of days taken to male and female flowering from sowing, number of fruits/plots, fruit length (cm), fruit diameter (cm) and fruit yield/ha (q) is obtained by using fruit yield per plot.

3. RESULTS AND DISCUSSION

3.1 List of Pollinating Agents Visiting Bottle-Gourd Flowers

A total of 14 insects from 9 families and 5 orders (Fig. 1 and Table 1) were observed in the experimental plots. A predatory spider namely Green lynx spider was also noticed visiting the bottle gourd field very infrequently. Most pollinators that visited bottle gourd blooms were Hymenoptera, followed by Coleoptera and other pollinators. Though the green lynx spider was found to visit Bottle Gourd plants only occasionally their role as pollinator could not be ascertained.

Shrivastava and Shrivastava (1991) reported 23 species of insects visiting cucurbitaceous crops belonging to the families Hymenoptera, Hemiptera, Thysanoptera, Lepidoptera, Diptera, and Coleoptera in Rewa (India).

Table 1. Visit of different pollinating agents on bottle gourd flowers

Sl. No	Order	Family	Species
1	Hymenoptera	Apidae	*Apis cerana indica*
2			*Apis mellifera*
3			*Melipona sp.*
4			*Xylocopa latipes*
5		Vespidae	*Vespula vulgaris*
6			*Delta sp.*
7	Coleoptera	Chrysomelidae	*Aulacophora foveicollis*
8		Coccinellidae	*Coccinella sp.*
9	Hemiptera	Coreidae	*Cletus sp.*
10		Pentatomidae	*Stink bug*
11		Pyrrhocoridae	*Dysdercus cingulatus*
12	Lepidoptera	Papilionidae	*Papilio sp.*
13	Odonata	Libellulidae	*Pantala flavescens*
14			*Diplacodes trivalis*
15	Araneae	Oxyopidae	*Peucetia viridans*

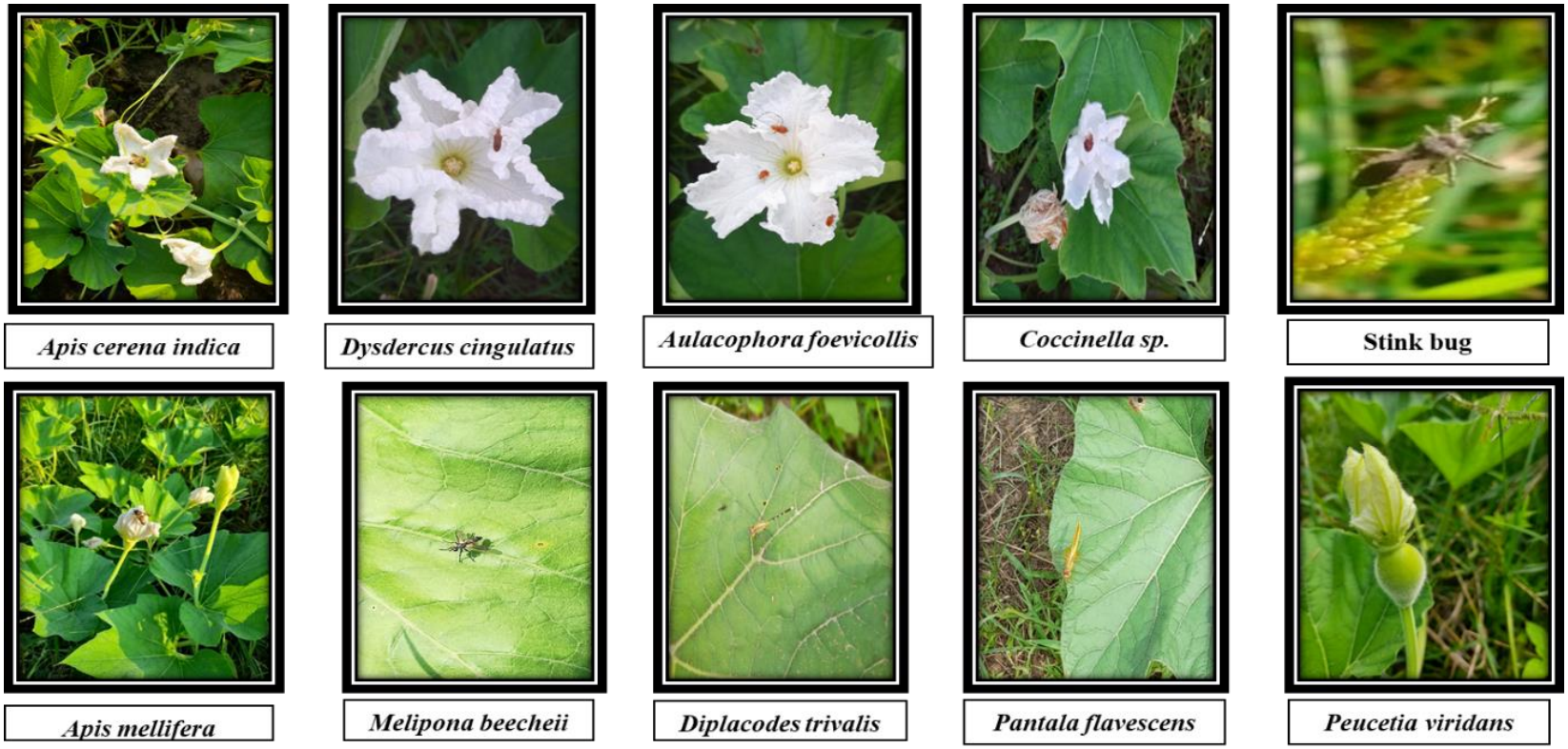

Fig. 1. Photographs of different pollinating agents on bottle gourd flowers

Srikanth (2013) reported more than 20 species of floral visitors in bottle gourd with a higher proportion of hymenopterans as major pollinators. Whereas Prajapati et al. (2022) reported the order Coleoptera to be dominant followed by Hymenoptera, Lepidoptera, Hemiptera, and Diptera. On the contrary, Alury (1992) studied that high frequency of bee foraging visits attracts the cryptically coloured green lynx spider, *Peucetia viridans*, which is in conformity with our findings.

3.2 Effect of Bee Attractants on the Production of Bottle Gourd

It was found that the jaggery treated plots showed early emergence of male and female flower (49.3, 57.0) respectively. It also took very less duration from male to female flower appearance (7.7) as compared to the other plots as is depicted in Table 2. The plants imposed with the same treatment produced the maximum number of fruits/plots (29.3). Whereas sugar, sugarcane juice and rose water showed similar results, being statistically similar and at par with the jaggery solution treated plots.

On the other hand, plots treated with only distilled water (i.e. Control) gave the minimum number of fruits/plots (17.0) yield. The treatments with foliar application of honey solution, fennel seed oil and dill seed oil had no effect on increasing the fruit numbers and were at par with the control.

With regards to the Fruit length (cm) it was observed that the treatments with solution of jaggery, sugar, rose water and sugarcane produced maximum fruit length like 8.1,7.8, 7.8 and 7.7 cm respectively, which was also statistically similar to each other. On the other hand, spraying with only distilled water (i.e. Control) gave minimum fruit length of 7.3 cm. The treatment with cumin, fennel seed oil, honey solution and dill seed oil also had no effect on increasing the fruit length and were also statistically at par with the control.

The average fruit diameter recorded was 14.2 cm and the maximum fruit diameter (15.9 cm) was obtained with jaggery solution-imposed treatment. Spraying with sugarcane juice and dill seed oil gave minimum fruit diameter of 13.6 cm. The treatment involved spraying with sugar solution, rose water, cumin seed oil, fennel seed oil and honey solution also had no effect on increasing the fruit diameter.

The average fruit yield/ha recorded was 168.8 q. It was found that the plants sprayed with the solution of jaggery (216 q) and sugar (213.2 q) produced the maximum number of fruit yields/ha, which were statistically similar to each other. On the other hand, the treatment where only distilled water was sprayed gave the minimum number of fruit yield/ha (115.5 q).

The results obtained in the study are in conformity with Lingappa et al. (1999) who reported an increase of 21.80 and 31.80 percent in the number of fruits formed and total yield, respectively when bee attractants were sprayed twice on watermelon**.** Dinesh (2003) reported that spraying of bee attractants in cucumber recorded a significantly greater number of fruits (15.61 fruits/plant vs 7.42 and 3.34 without bees, respectively) and fruit weight (126.11 g/fruit). Jayaramappa et al. (2011) demonstrated an increase in the number of fruits per plant (12.57 percent), number of fruits per plot (8.73 percent), fruit length (8.64 percent) and fruit weight (01 percent) compared to open pollination (control) in ridge gourd. According to Wankhede et al. (2018) jaggery solution 10% produced the highest net yield (69.55.q/ha) compared to open pollination without spray (51.44 q/ha) and PWI (50.66 ha) in cucumber. Wankhede et al. (2018) observed a higher seed yield in cucumber in jaggery @10% treated plots. Increased yield due to the application of bee attractants was reported by Mane (2003) in coriander, Nidagundi (2004) in bitter gourd, Srikanth (2012) in bottle gourd, Anita et al. (2012) in guava, Manchare et al. (2019) in ridge gourd and Jailyang (2022) in kiwi.

3.3 Effect of Bee Attractants on the Population of Honeybees (@ 30%, 50% and 75% Flowering)

In this experiment, nine different locally available bee attractants were used to spray on the bottle gourd flowers. These bee attractants were sprayed three times during the experiment period (@ 30%, 50% and 75% flowering) and observations were recorded on the population of *Apis cerena indica* and *Melipona sp.* at different intervals of time such as 7-8 am, 9-10 am,11-12 noon and 1-2 pm during the spray day, one day after spray and two days after spray.

Table 2. Effect of bee attractants on the production of bottle gourd

Treatments	Days to first male flower formation	Days to first female flower formation	Days to male to female flower	Number of Fruits/plots	Fruit Length (cm)	Fruit diameter (cm)	Yield (q/ha)
Control	60.7	72.7	12.3	17.0	7.3	13.8	115.5
Jaggery	49.3	57.0	7.7	29.3	8.1	15.9	216.0
Sugar	51.7	61.0	9.3	27.3	7.8	14.7	213.2
Sugarcane	53.0	62.0	9.0	24.7	7.7	13.6	181.8
Honey	49.3	60.0	10.7	21.7	7.5	13.8	174.4
Rose water	67.0	76.7	9.7	25.0	7.8	14.3	185.9
Cumin seed oil	53.0	67.0	14.0	22.7	7.6	14.0	170.2
Fennel seed oil	52.7	65.3	12.0	22.0	7.6	13.9	129.9
Dill seed oil	56.0	66.7	10.7	21.7	7.5	13.6	131.9
Mean	54.7	65.4	10.6	23.5	7.7	14.2	168.8
S.E. m (±)	0.7	0.9	1.1	1.8	0.1	0.4	1.5
CD (P=0.05)	1.9	2.7	3.2	5.1	0.4	1.2	4.3
CV (%)	2.1	2.4	18.1	12.9	2.8	5.0	15.1

Table 3. Effect of bee attractants on the population of *Apis cerena indica and Melipona sp.* after the three sprays (@ 30%, 50% and 75% flowering)

Treatments	*Apis cerena indica*			*Melipona sp.*		
	On the spray day	One day after spray	Two days after spray	On the spray day	One day after spray	Two days after spray
Control	2.81	2.78	3.08	2.58	2.58	2.28
Jaggery	3.36	3.53	3.25	2.97	3.06	3.03
Sugar	3.33	3.31	3.00	2.89	2.81	3.06
Sugarcane	2.81	3.03	2.86	2.53	2.72	2.53
Honey	2.94	3.14	3.06	2.69	2.81	2.58
Rose water	2.89	3.19	2.92	2.56	2.86	2.36
Cumin seed oil	2.64	3.06	3.08	2.56	2.72	2.53
Fennel seed oil	2.89	2.86	2.97	2.72	2.64	2.69
Dill seed oil	2.69	3.33	2.97	2.31	2.67	2.53
Mean	2.93	3.44	3.02	2.65	2.76	2.62
S.E. m (±)	0.14	0.11	0.11	0.06	0.09	0.08
CD (P=0.05)	0.40	0.32	NS	0.18	NS	0.24
CV (%)	8.17	6.08	6.42	4.08	5.72	5.38

3.3.1 Effect of bee attractant on the population of *Apis cerena indica* (On the day of spray, One day after spray and Two days after spray)

The average number of *Apis cerena indica* that visited on the spray day during all three sprays was significantly different among the treatments. Treatment variation was also observed for the bee visit. Data revealed that the maximum number of *Apis cerena indica* (3.36 bees/5m^2/5 minute) observed were on plots treated with jaggery followed by sugar-treated plots (3.33 bees/5m^2/5 minute). Minimum number of bee visits was recorded in the dill seed oil-treated plots (2.69 bees/5m^2/5 minute) and the remaining treatments were statistically at par with the dill seed oil.

Data on one day after the spray revealed that there was an overall increase in most of the cases of bee activity in the entire experimental field. The average number of *Apis cerena indica* visited the bottle gourd blooms on one day after the spray during all the three sprays increased than the previous day (i.e. on the day of spray). Treatment variation was also observed for the bee visit. Application of jaggery @10% led to attracting the maximum number of *Apis cerena indica* (3.53/5m^2/5 minute), which was superior to other treatments. The second and third best treatments were dill seed oil (3.33/5m^2/5 minute) and sugar @10% (3.31/5m/5 minute) respectively. The minimum number of bees visited in control plots (2.78 bees/5m^2/5 minute), was poorer than all other treatments. Sugarcane, cumin and fennel seed oil which were statistically at par with the dill seed oil.

Effects of bee attractants two days after spray, during all three sprays as evidenced by the average number of bees that visited the bottle gourd bloom on the two days after spray were statistically insignificant among the treatments, i.e. *Apis cerena indica* did not show any preference to either treated or untreated plots as all the treatments were at par with each other.

3.3.2 Effect of bee attractant on the population of *Melipona sp.* (On the day of spray, One day after spray and Two days after spray)

The average number of *Apis cerena indica* that visited on the spray day during all three sprays was significantly different among the treatments. Treatment variation was also observed for the bee visit. Data revealed that the maximum number of *Melipona sp.* observed were on plots treated with jaggery (2.97 bees/5m^2/5 minute) followed by sugar-treated plots (2.89 bees/5m^2/5 minute). The minimum number of bee visits was recorded in the dill seed oil-treated plots (2.31 bees/5m^2/5 minute).

Data on one day after the spray revealed that there was an overall increase in most of the cases of bee activity in the entire experimental field. The average number of *Melipona sp*. also increased than the previous day (i.e. on the day of spray) but data revealed that the average population of *Melipona sp*. during all sprays was statistically non-significant.

The average number of *Melipona sp*. that visited on two days after spray during all three sprays was significantly different among the treatments. Data revealed that the maximum number of *Melipona sp*. (3.06 bees/5m^2/5 minute) observed were on plots treated with sugar followed by jaggery-treated plots (3.03 bees/5m^2/5 minute). The minimum number of bee visits was recorded in the control plots (2.28 bees/5m^2/5 minute) and the rose water treated plots were statistically at par with the control.

In the present experiment, in most cases, Jaggery @ 10% attracted the greatest number of bees (*Apis cerena indica*) followed by the treatment with sugar solution @10%. On the other hand, the number of *Melipona* sp. increased but was not that effective in pollination after spraying bee attractants in most cases. Dinesh (2003) and Nidagundi (2004) reported that spraying of cacambe (10%), jaggery (10%), and Bee-Q (1.25%) had a significant influence in attracting a greater number of pollinators in cucumber and bitter gourd respectively. Jaggery and sugar solution increased the activity of phagostimulation (Hosamani et al, 2020), which may be the reason for the higher activity of bees on jaggery/sugar solution application.

4. CONCLUSION

Bee attractants were effective in enhancing the number of pollinators, especially honey bees on bottle gourd flowers, and also for increasing the production of bottle gourd. The number of honey bees visiting the bottle gourd plot has increased after spraying of attractants, on the day of spray and one & two days after spray. Among different hours of the day, maximum honeybees' activity was found around midday at 11-2 PM. The effect

of bee attractants was more pronounced on *Apis cerena indica* than *Melipona sp.* For most of the studied traits, spraying of jaggery@10% solution was observed as the best treatment and showed maximum honeybee population in most of cases at 1st, 2nd and 3rd sprays (@ 30, 50 and 75% flowering) regardless of different hours and days after spray. 10% sugar solution and rosewater treated plots often responded favorably and par with each other. Jaggery plots showed the early emergence of male and female flowers and also the days to male to female flowering. The highest fruit yield/ha was registered in plots treated with jaggery @ 10% followed by sugar solution (10%) and rose water-treated plots. Fragrant oils (cumin, dill and fennel seed oil) and rose water treated plots showed mixed responses for yield traits but mostly were superior to control. Plots treated with jaggery solution, followed by sugar solution and rosewater-treated plots mostly registered superior values which suggest enhanced phagostimulation activities of the pollinators.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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