Bee-Eating Birds (Coraciiformes: Meropidae) Reduce Virgin Honey Bee Queen Survival during Mating Flights and Foraging Activity of Honey Bees (*Apis mellifera* L.)

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Abstract- This study investigated bee-eating bird (Coraciiformes: Meropidae) predation on virgin honeybee queens in Saudi Arabia. The study also subsequently documented the effect of bird predation on colony strength, and foraging activity. Data were collected during 2011. The results indicated that bee-eating birds reduced flight survival. Eighty percent of 30 queens successfully mated when bee-eaters were not present in the apiary, when bee-eaters were present, only 46.67% of 30 queens successfully mated. Data also indicated no significant difference in the number of frames covered with adult bees in honey bee colonies during presence and absence of bee-eaters (6.3 and 6.8 frames of bees/colony, respectively) and frames of brood (3.0 and 2.8 frames of brood/colony, respectively. No significant difference was detected in the number of foraging honey bee workers gathering pollen from plant flowers when bee-eating birds were present or absent. This study also found that, bee-eating birds can affect the number of foragers gathering ground pollen and sugar syrup from dishes placed on distance (10, 75 and 150 meter) from the hives entrances.

Keywords- *Apis mellifera*, bee-eaters, Meropidae, queen mating, queen losses, colony strength, foraging activity, pollen gathering.

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1 INTRODUCTION

Bee-Eating Birds are widely distributed, and many beekeepers regard them as serious pests. Most of them are migratory species that spend part of the year in apiaries preying on honeybees before moving to another area. However, during their presence in the apiary they produce specific sounds that honey bees can recognize causing them to stay in their hives.

The European bee-eater (*Merops apiaster*) is a widely distributed species, although mainly locally abundant, in arid and semi-arid areas [1], [2] where it usually selects sandy cliffs in wadis. It is one of the few bird species with the ability to modify the habitat by digging long burrows where it breeds, therefore fitting to the definition of allogenic engineer {proposed by[3]}. They are migratory, diurnal birds that spend most of their time foraging for food. It is common to see them sitting at a perch scanning for prey. They, fly out to catch a prey item and then return to the perch to subdue and consume it [4]. These birds are often found nesting in colonies, but may also nest singly as well.

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The Green Bee-eater (*M. orientalis*) like other species in the genus, bee-eaters predominantly eats flying insects, especially bees, wasps and ants. They catch their prey in the air by sorties from an open perch and can sometimes be nuisance to beekeeping [5]. [6] stated that the Green Bee-eater is a near passerine bird in the bee-eater family. It is resident but prone to seasonal movements depending on rainfall patterns and is found widely distributed across sub-Saharan Africa from Senegal and Ethiopia, the Nile valley, western Arabia and Asia from India to Vietnam. They also added that, they are the main insect eaters found in grassland, thin scrub and forests, and they are often found far from water. Riverside habitats were found to support high populations in southern India (157 birds per square kilometer) dropping off to 101 per km² in agricultural areas and 43-58 per square km near human habitations [7]. They are usually seen in small groups and often roost communally in large numbers (200-300 birds). The birds move excitedly at the roost site and call loudly, often explosively, and disperse before settling back to the roost tree [8].

The relationship between bee-eaters and *Apis* sp. is complicated. The majority of the 24 species of bee-eaters are known to feed mainly on honey bees (*Apis mellifera*), and they constitute an important component of the bird's diet [9], [10]. [11] stated that migratory species of bee-eaters prey on bees in an apiary for a period of time and then move on to another locality. However, beekeepers- in many parts of the world have problems with birds preying on bees in apiaries used for queen rearing and mating [12], [13], [14], [5]. [15] stated that Bradfield's swift caught honey bees (*A. mellifera*) in flight near a hive. He also reported that eight swifts at a time were noticed taking bees that appeared to be returning to the hive after foraging flights.

Other *Merops* species are known sometimes to be important predators of *A. cerana*, *A. florae* and *A. dorsata* [16], *Andrena* sp. and *Anthophora* sp [17], and bumble bees, *Bombus* sp. [18], [16]. The bee-eaters sometimes consume large numbers of hornets, *Vespa* sp., and bee-wolves *Philanthus* sp. [16]; Coleoptera, Dermaptera, Diptera, Lepidoptera, Odonata, nematodes (Torquatoides balanocephala) and other bee predators, and in such circumstances, they may be of benefit to beekeeping [4], [18], [17], [19]. [5] stated that *M. apiaster* feed on flying insects and can sometimes be nuisance to bee-keepers. Their preferred prey was mostly beetles followed by hymenopterans. Orthopterans appear to be avoided [20]. They are sometimes known to take crab spiders [21]. [16] gave a list of all insects (over 300 species) that have been recorded as prey of the European bee-eater and discussed quantitative data for 17 *Merops* species. His results concluded that honeybees constituted from 15 to 25% of the prey and the diet of *M. apiaste*r included30% honeybees and 21% bumble bees. He also found that *Merops* species sometimes consume large numbers of *Vespa*, *Philanthus*, and other bee predators. Meanwhile, [17] made an analysis of 100 *M. apiaster* pellets and found that out of 1864 prey items identified, 1290 were honeybees (69%), 26 were *Andrena* sp., three were *Anthophora* sp., and there were 168 unidentified bees. The remaining prey consisted of 13.8% Coleoptera, 3% Diptera, 2% non-apid Hymenoptera, and less than 1% Odonata, Lepidoptera and Dermaptera. [19] studied bee-eaters at sites in southern and central Slovakia. Samples of pellets and food remains revealed the presence of 1786 prey objects from over 160 insect species. Although diet diversity was high, honey bees were (28.2-42.4%) and bumble bees, *Bombus* spp. (16.1-39.5%), constituted the main part of the diet at all sites. It also concluded that of the honey bees (*A. mellifera*) caught, 53.5% were drones and 46.5% were workers.

European bee-eaters' diet consists of bees ranging in size from large to small (Hymenoptera), but also includes dragonflies (Odonata) and other flying insects [22], [23].

Analysis of active European bee-eaters' nests detected several species of mites (chicken mites, tropical fowl mites) and larvae of Diptera, beetles (Tenebrionidae), and moths and butterflies (Lepidoptera) [2].

Foraging activities of honeybees on different flowering plants were studied by [24], [25], [26], [27], [28]. [29] found that foraging activity of worker honey bees was significantly higher at 8 am than 10 pm in the Central Region of Saudi Arabia.

The aim of the present study is to answer an important question that has fascinated both scientists and beekeepers, and that question is Do bee-eating birds affect the mating of virgin queens in mating apiaries, and do they affect the colony strength and foraging activities of honey bees during their activities in the apiaries?.

2 MATERIALS AND METHODS

2.1 Experimental Design

Experiment was carried out on native honey bee colonies (*A. mellifera jementica* Ruttner) during 2011 at the Queen Rearing and Honey Bee Nuclei production belong to Agricultural Extension Department, Ministry of Agriculture, Kingdom of Saudi Arabia.

2.2 Mating of virgin queens during presence and absence of bee-eaters

Sixty virgin queens in sixty honey bee mating nuclei were used for this experiment. Each nucleus contained two frames of brood and two honey-pollen combs. The adult bee workers covered four frames on both sides. One day after preparing the nuclei, newly emerged sister virgin queens were introduced individually to the nuclei. The nuclei were examined to destroy any natural queen cells and to release the virgin queens for flying and mating. Sugar syrup (1:1) was provided to feed the nuclei continuously. Inspection on nuclei was made daily to observe mating process and the occurrence of eggs in the comb. The numbers of virgin queens were kept at 60 by introducing newly emerged virgin queens to honey bee nuclei that lost their queens during introduction. The 60 nuclei with virgin queens were randomly divided into two groups; each group had 30 nuclei as follows:

a- The first group was divided during the presence of bee-eaters in the apiaries in April, 2011; the queens were released three days after dividing for queen mating.
b- The second group was divided during absence of bee-eaters from the apiaries in May, 2011; and the queens were released three days after dividing for queen mating.

The number of mated and lost queens for each group was recorded.

2.3 Honey bee colony strength during presence and absence of bee-eaters

Twenty honey bee colonies were selected for studying colony strength during presence and absence of bee-eaters. Each colony contained five frames of bees and two frames of brood. Mean numbers of frames covered with adult bees and frames of brood were estimated and recorded at end of the experiment.

2.4 Pollen foraging activity during presence and absence of bee-eaters

Twenty honey bee colonies were selected for studying foraging activity for gathering pollen from plant flowers during presence and absence of bee-eaters. Foraging activity was estimated by counting all the returning workers (foragers) loaded with pollen grains that entered to their hives during ten minutes of observation. The counts were repeated three times during presence of bee-eaters in the apiaries on April 5, 12 and 19, 2011 and during their absence from the apiaries on May 15, 22 and 29, 2011.

2.5 Foraging activity for gathering ground bee-pollen placed on different distances during presence and absence of bee-eaters

Ground bee-pollen was spread out onto flat aluminum plates, each plate measured (50 cm in diameter and 4 cm depth). Twelve plates were divided into three groups, and each group contained four plates. The plates in each group were placed in a line at the east side of the apiary (in front of the entrances of the bees hives), and the distance between each plate in each group in each row was 20 meters. The first group was placed at a distance of 10 meters in front of the apiary, the second one was placed at 75 m and the last one was placedon150 m. The ground bee-pollen was added continually during this experiment, the numbers of honey bee workers that gathered ground bee-pollen on their body-hair and on their legs were counted on the plates for five minutes three times/day (7, 11 am and 5 pm). This process was repeated three times during the presence of bee-eaters in the apiaries on October 2, 9 and 16, 2011 and during their absence from the apiary on November 5, 12 and 19, 2011.

2.6 Foraging activity for gathering sugar syrup placed on different distances during presence and absence of bee-eaters

Sugar syrup (1:1) was prepared and added continuously during this experiment in plastic dishes (40 cm in diameter and 16 cm depth) supplied with wood sticks to float on the syrup to keep honey bees from drowning in the syrup. Twelve dishes were divided into three groups, and each group contained four dishes. Dishes were placed in a line in east side of the apiary; the distance between each dish in each group in each row was 20 m. The first group was placed at a distance of 10 m in front of the apiary, the second group was placedon75 m and the last one was placed at distance of150 m. The numbers of workers gathering sugar syrup from the dishes were counted for five minutes three times/day (7, 11 am and 5 pm).This process was repeated three times during presence of bee-eaters in the apiaries (October 2, 9 and 16, 2011), and during their absence from them (November 5, 12 and 19, 2011).The dishes with sugar syrup were placed on stands to protect them from ants, crawling insects and other animals.

2.7 Data Analysis

All data were analyzed using SAS PROC GLM ver. 9.1.3 [30]. ANOVA tests were performed to calculate P-values, and Least Significant Difference (LSD) tests (α: 0.05) were performed for means separation.

3 RESULTS

3.1 Mating of virgin queens during presence and absence of bee-eaters

Data illustrated in Fig. (1) indicated that bee-eaters negatively affected the mating of virgin queens. The number and percentage of queen mating were significantly higher during absence of bee-eaters from the apiaries (24 and 80%) than that occurred during their presence in the apiary (14 and 46.67%).The data also indicated that out of sixty virgin queens; six queens were lost through mating flights during absence of bee-eaters from the apiary; meanwhile, 16 queens were lost through mating flights during the presence of bee-eaters in the apiary.

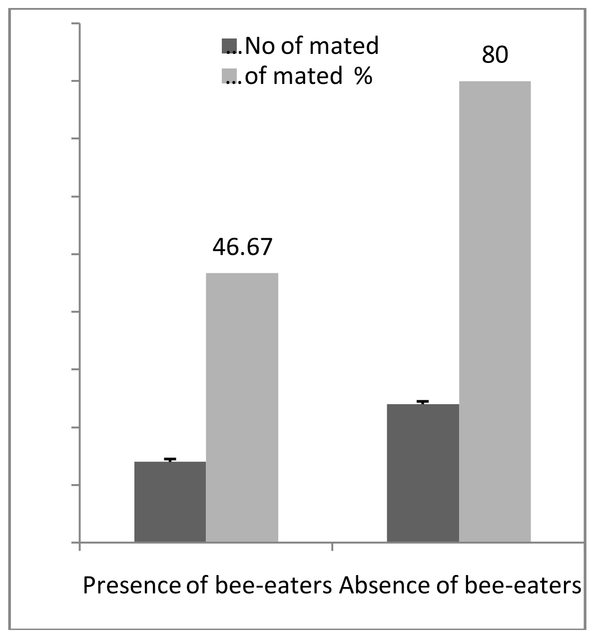

Fig (1): Number and Percentage of mated queens during presence and absence of bee-eaters

3.2 Honey bee colony strength during presence and absence of bee-eaters

Data presented in Table (1) indicated that no significant difference was found in frames covered with adult bees and frames of brood in honey bee colonies during presence and absence of bee-eaters. The mean number of frames of bees was (6.30.18 and 6.8±0.16 frames of bees/colony) during the presence and absence of bee-eaters, respectively, and the mean numbers of frames of brood were (3.0±0.00 and 2.83±0.16 frames of brood/colony) during presence and absence of bee-eaters, respectively.

TABLE 1

Mean number of frames of bees and frames of brood during presence and absence of bee-eaters from the apiaries (Means ± S.E).

Aspects	Frames of bees	Frames of brood
Presence of bee-eaters	6.33 ± 0.18a	3.000 ± 0.00a
Absence of bee-eaters	6.83 ± 0.16a	2.833 ± 0.16a
L.S.D. at 0.05	0.599	0.371

N= 10; within column, means followed by the same letters are not significantly different

3.3 Pollen foraging activity during presence and absence of bee-eaters

Table (2) showed that there was no significant difference in number of honey bee workers (foragers) entered their colonies loaded with pollen grains through the three inspection periods during presence and absence of bee-eaters. The mean number of foragers entered their colonies loaded with pollen grains was (108.3±17.18 and 147.00±20.67; 223.0±26.27 and 203.8±26.86, and 168.0±0.00and 132.0±0.00 forager/colony), during presence and absence of bee-eaters through the first (F= 1.25, df= 19, P> 0.01), second (F= 0.67, df= 19, P> 0.01), and third (F= 1.87, df= 19, P> 0.01) duration, respectively.

TABLE 2

Mean number of foraging honey bee workers entered their colonies loaded with pollen grains three durations during presence and absence of bee-eaters from the apiaries (Means ± S.E)

Aspects	No. of incoming bee workers loaded with pollen grains		
	1st duration	2nd duration	3rd duration
Presence of bee-eaters	108.33 ± 17.18a	223.00 ± 26.27a	168.00 ± 17.40a
Absence of bee-eaters	147.00 ± 20.67a	203.80 ± 26.86a	132.00 ± 15.21a
L.S.D. at 0.05	66.061	99.509	58.588

N= 10; within column, means followed by the same letters are not significantly different

3.4 Foraging activity for gathering ground bee-pollen placed on different distances during presence and absence of bee-eaters

Data in Table (3) showed that bee-eaters sometimes negatively affected gathering ground bee pollen and sometimes not. In the first inspection duration, on distance 10 m from the hives entrances, the number of bee workers gathered ground pollen from the plates was significantly higher during absence of bee-eaters (7.67±0.88, 16.67±1.20 and 23.00±1.16 worker/plate) than it was during presence of them in the apiary (4.00±58, 5.67±0.67 and 16.00±1.16 worker/plate) at 7, 11 am and 5 pm, respectively. The same trend was obtained on distance of 75 and 150 m at 11 am and 5 pm, where the number was (11.67±0.67 and 18.67±0.88, and 10.67±1.67 and 18.00±2.52 worker/plate) during absence of bee-eaters as compared with (5.00±0.00 and 11.33±1.45, and 3.00±0.58 and 10.33±0.33 worker/plate) during their presence on 75 and 150 m at 11 am and 5 pm, respectively. No significant difference was found during their presence and their absence on distance of 75 and 150 m at 7 am.

In the second inspection duration the bee-eater seemed to be weren't affect the foraging activity for gathering ground bee-pollen placed on different distances, where there was no significant difference in number of workers gathered ground bee-pollen on distance 10, 75 and 150 m at 7, 11 am and 5 pm. except on distance 150 m at 5 pm it was significantly higher during absence of bee-eaters than it was during their presence (27.00±1.53 and 11.67±0.33 worker/plate), during absence and presence of bee-eaters, respectively, (F= 96.18, df= 11, P< 0.01).

In the third inspection duration the mean number of honey bee workers recorded gathering ground bee-pollen was significantly high during presence of bee-eaters in the apiaries on distance 10, 75 and 150 m at 7 am and 5 pm. Meanwhile, it was significantly high during their absence from the apiaries on distance 10 and 75 m at 11 am, but no significant difference was found in ground bee-pollen gathering during presence and absence of bee-eaters on distance 150 m at 11 am (6.00±0.58 and 8.00±1.16 worker/plate), during presence and absence of bee-eaters, respectively (F= 2.40, df= 11, P> 0.01) (Table 3).

TABLE 3

Mean number of bee workers gathered ground bee-pollen placed on different distances (10, 75 and 150 meters) from the hives entrances, three times/day (7, 11 am and 5 pm) during presence and absence of bee-eaters from the apiaries (Means ± S.E)

Duration	Distance	No. of bee worker gathered ground bee-pollen					
		7 am		11 am		5 pm	
		Presence	Absence	Presence	Absence	Presence	Absence
1st duration	10 m	4.00 ± 0.58b	7.67 ± 0.88a	5.67 ± 0.67b	16.67 ± 1.20a	16.00 ± 1.16b	23.00 ± 1.16a
		(2.927)		(3.816)		(4.534)	
	75 m	5.67 ± 0.67a	5.33 ± 00.67a	5.00 ± 0.00b	11.67 ± 0.67a	11.33 ± 1.45b	18.67 ± 0.88a
		(2.6177)		(1.851)		(4.719)	
	150 m	7.33 ± 0.88a	7.67 ± 0.33a	3.00 ± 0.58b	10.67 ± 1.67a	10.33 ± 0.33b	18.00 ± 2.52a
		(2.6177)		(4.897)		(7.048)	
2nd duration	10 m	12.67 ± 1.20a	14.33 ± 1.77a	11.33 ± 1.86a	13.00 ± 2.08a	24.00 ± 1.16a	24.67 ± 0.67a
		(5.926)		(7.743)		(3.702)	
	75 m	11.00 ± 0.58a	9.00 ± 1.16a	9.00 ± 1.16a	5.33 ± 0.88a	18.67 ± 1.45a	21.00 ± 1.00a
		(3.584)		(4.034)		(4.897)	
	150 m	9.67 ± 1.20a	11.33 ± 0.88a	7.33 ± 0.88a	6.67 ± 1.45a	11.67 ± 0.33b	27.00 ± 1.53a
		(4.139)		(4.719)		(4.341)	
3rd duration	10 m	36.33 ± 1.77a	22.00 ± 1.73b	11.67 ± 0.33b	21.00 ± 1.16a	34.33 ± 1.77a	16.67 ± 0.6b
		(6.864)		(3.337)		(5.235)	
	75 m	18.67 ± 1.20a	10.67 ± 0.67b	8.33 ± 0.33b	14.67 ± 1.33a	22.67 ± 0.33a	13.33 ± 0.88b
		(3.816)		(3.816)		(2.618)	
	150 m	20.33 ± 0.33a	10.00 ± 0.00b	6.00 ± 0.58a	8.00 ± 1.16a	23.33 ± 1.20a	12.67 ± 2.03b
		(0.926)		(3.584)		(6.544)	

N= 12; values between brackets are L.S.D. at 0.05
Within row, pairs of means followed by the same letters are not significantly different

3.5 Foraging activity for gathering sugar syrup placed on different distances during presence and absence of bee-eaters

As shown in Table (4) through the first inspection duration no significant difference was found in mean number of honey bee workers recorded gathering sugar syrup placed on distance 10, 75 and 150 m at 7am during presence and absence of bee-eaters. Meanwhile, this number was significantly higher during absence of bee-eaters from the apiaries on distance 10 and 75 m at 11 am and 5 pm, where the mean number was (706.67±14.55 and 449.33±12.25, and 509.00±8.51 and 202.67±2.67 worker/dish), as compared with (505.33±4.38 and 327.33±12.68, and 344.00±3.66 and 142.67±6.37 worker/dish) during their presence in the apiaries at 11 am and 5 pm, respectively. On the other hand the mean number of foragers workers for gathering sugar syrup was significantly higher during presence of bee-eaters on 150 m at 11 am and 5 pm (252.00±5.20 and 229.67±6.65 worker/dish) (F= 34.13, df= 11, P< 0.01) as compared with (206.33±5.85 and 201.00±4.59 worker/dish) (F= 12.62, df= 11, P< 0.05).

In the second inspection duration the mean number of foragers workers for gathering sugar syrup was significantly high during absence of bee-eaters at 7 am on distance 10 m (595.67±10.35 worker/dish), as compared with (498.33±13.03 worker/dish) during presence of bee-eater (F= 34.30, df= 11, P< 0.01). On distance 75 m no significant difference was found in sugar syrup gathering during presence and absence of bee-eaters (122.67±3.27 and 113.67±3.18 worker/dish), respectively (F= 3.39, df= 11, P> 0.01). Meanwhile it was significantly higher during presence of bee-eaters at 7 am on distance of 150 m (177.33±6.37 and 120.33±4.34 worker/dish), during presence and absence of bee-eaters, respectively (F= 54.86, df= 11, P<0.01). At 11 am the sugar syrup gathering was significantly higher during presence of bee-eaters on distance 10 m (722.33±14.90 and 596.67±8.83 worker/dish), during presence and absence of bee-eaters (F= 52.78, df= 11, P<0.01), and on distance 75 m (512.33±19.23 and 413.00±6.03 worker/dish) (F= 24.36, df= 11, P< 0.01). On distance 150 m it was significantly higher during absence of bee-eaters from the apiary (113.00±3.22 worker/dish), as compared with (67.00±2.00 worker/dish) during their presence (F= 53.17, df= 11, P< 0.01). At 5 pm the syrup gathering was significantly higher during presence of bee-eaters on distance 10 m (415.67±9.15 and 325.67±12.21 worker/plate), during presence and absence of bee-eaters, respectively (F= 34.88, df= 11, P< 0.01), and on 150 m (175.67±3.18 and 151.00±1.16 worker/dish) (F= 53.17, df= 11, P< 0.01). Meanwhile, no significant difference in number of foragers workers gathering sugar syrup during presence and absence of bee-eaters on distance 75 m (217.33±3.72 and 196.00±8.73 worker/dish) (F= 5.07, df= 11, P> 0.05).

In the third inspection duration at 7 am, the mean number of workers recorded gathering sugar syrup was significantly high during absence of bee-eaters on distance 75 m (114.00±1.00 and 60±2.89 worker/dish) (F= 312.43, df= 11, P <0.01), and on150 m (101.67±1.77 and 48.33±3.85 worker/dish) during absence and presence of bee-eaters, respectively (F= 159.01, df= 11, P< 0.01), meanwhile no significant difference was found in foragers workers for gathering sugar syrup during presence and absence of bee-eaters on distance 10 m (420.67±31.24 and 353.33±8.83 worker/dish) (F= 4.31, df= 11, P> 0.01). At 11 m, it was significantly high during absence of bee-eaters on distance 10 m (497.67±2.85 and 435.33±20.13 worker/dish) (F= 9.43, df= 11, P< 0.05) and on 75 m (208.67±5.79 and 148.33±6.02 worker/dish) (F= 52.33, df= 11, P< 0.05) during absence and presence of bee-eaters,

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respectively, while it was significantly higher during presence of bee-eaters on distance 150 m (124.33±3.39 and 104.33±3.53 worker/dish) during presence and absence of bee-eaters, respectively (F= 16.74, df= 11, P< 0.05).

TABLE 4

Mean number of bee workers gathered sugar syrup placed on different distances (10, 75 and 150 meters) from the hives entrances, three times (7, 11 am and 5 pm), during presence and absence of bee-eaters in the apiaries (Means ± S.E)

Duration	Distance	No. of bee worker gathered sugar syrup					
		7 am		11 am		5 pm	
		Presence	Absence	Presence	Absence	Presence	Absence
1st duration	10 m	221.00 ± 15.00a	196.00 ± 6.51a	505.33 ± 4.38b	706.67 ± 14.55a	327.33 ± 12.68b	449.33 ± 12.25a
		(45.339)		(42.127)		(48.902)	
	75 m	110.00 ± 1.16a	98.33 ± 6.07a	344.00 ± 3.06b	509.00 ± 8.51a	142.67 ± 6.37b	202.67 ± 2.67a
		(17.14)		(25.091)		(19.147)	
	150 m	210.33 ± 6.13a	198.67 ± 9.25a	252.00 ± 5.20a	206.33 ± 5.85b	229.67 ± 6.65a	201.00 ± 4.59b
		(30.778)		(21.704)		(22.404)	
2nd duration	10 m	498.33 ± 13.03b	595.67 ± 10.35a	722.33 ± 14.90a	596.67 ± 8.83b	415.67 ± 9.15a	325.67 ± 12.21b
		46.144		48.027		42.31	
	75 m	122.67 ± 3.27a	113.67 ± 3.18a	512.33 ± 19.23a	413.00 ± 6.03b	217.33 ± 3.72a	196.00 ± 8.73a
		(13.57)		(55.883)		(26.307)	
	150 m	177.33 ± 6.37a	120.33 ± 4.34b	67.00 ± 2.00b	113.00 ± 3.22a	175.67 ± 3.18a	151.00 ± 1.16b
		(21.366)		(10.511)		(9.393)	
3rd duration	10 m	420.67 ± 31.24a	353.33 ± 8.83a	435.33 ± 20.13b	497.67 ± 2.85a	205.00 ± 5.57a	209.67 ± 5.24a
		90.034		56.371		21.226	
	75 m	60.00 ± 2.89b	114.00 ± 1.00a	148.333 ± 6.02b	208.67 ± 5.79a	167.00 ± 2.00a	124.333 ± 4.64b
		(8.482)		(23.156)		(14.005)	
	150 m	48.33 ± 3.85b	101.67 ± 1.77a	124.33 ± 3.39a	104.33 ± 3.53b	113.00 ± 2.52b	125.67 ± 3.18a
		(11.743)		(13.570)		(11.259)	

N= 12; values between brackets are L.S.D. at 0.05
Within row, pairs of means followed by the same letters are not significantly different

At 5 pm no significant difference found in mean number of foraging workers for gathering sugar syrup during presence and absence of bee-eaters on distance 10 m (205.00±5.57 and 209.67±5.24 worker/dish) (F= 4.31, df= 11, P>0.05). It was significantly high during presence of bee-eaters on distance 75 m (167.00±2.00 and 124.33±4.64 worker/dish) during presence and absence of bee-eaters, respectively (F= 71.55, df= 11, P<0.01). Meanwhile, it was significantly high during absence of bee-eaters on distance 150 m (113.00±2.52 and 125.67±3.18 worker/dish) (F= 9.76, df= 11, P< 0.05) (Table 4).

4 DISCUSSION

In the Central Region of Saudi Arabia there are three migratory species of bee-eating birds (Coraciiformes: Meropidae) that attack honey bees near apiaries, these species are; European bee-eater (*Merops apiaster* Linnaeus 1758); Olive bee-eater (*Merops superciliosus* Linnaeus 1766) and Green bee-eater (*Merops orientalis* Latham 1802), these species are found in the apiaries two times during the year, in spring and in autumn [31].

The current data show that the bee-eaters negatively affected queen mating, where the number and percentage of queen mating were significantly higher during absence of bee-eaters from the apiaries as compared with when they were present. These findings agree with data obtained by [32], [12], [13], [18] revealed that the prey species were generally more than 10 mm in length, and found that bee-eaters select their prey according to size and mode of flight, and data obtained by [33] found no virgin queens were lost during mating flights in February but up to 40% were lost in April, October and November, and queen mating success varied from 92% to less than 18% depending on predation by birds (*Merops* sp), and data obtained by [34] stated that European bee-eaters cause significant damage to a hive if they prey upon the queen, and [35] found that the birds that preyed on drones were widely distributed and not in a specific way.

Our results also indicated that the bee-eaters did not significantly affect honey bee colony strength and foraging activity for gathering pollen from flowers, since no significant differences were found in numbers of frames covered with adult bees, frames of brood, or in collecting pollen grains from lowers during presence or absence of bee- eaters. However, collection of ground pollen and sugar syrup placed at different distances from the hives entrances resulted in variable results. These findings are in agreement with the findings of [18] reared a pair of European bee-eaters and described adult foraging behavior. In an examination of pellets from the nest, 855 prey items were found, of which bumble bees were the commonest (44.1% of total), followed by honeybees (27.5%), beetles (9.0%) and wasps (7.0%) [16] found that honeybees constituted from 15 to 25% of the prey and the diet of *M. apiaster* [36] recorded 10 bird species from eight families belonging to three orders attacking agricultural crops in Northern Iraq included the bee-eaters, *M. supercili osuspersicus* and *M. apiaster*, and [37] found that the maximum number of workers found in the stomach of bee-eater was only 25 individuals.

Our findings do not agree with [31] stated that serious losses result from the activities of birds, and from [17] made an analysis of 100 *M. apiaster* pellets and found that honeybees were 69% of their diet, and [19] who studied samples of pellets and food remains of bee-eaters and found that honey bees were 28.2-42.4% of their diet. He also found that of the honey bees (*A. mellifera*) caught, 53.5% were drones and 46.5% workers, [38] reported that the bee-eaters may be particularly dangerous to the beekeeping operation because of the tendency of some species to attack bees in an apiary in flocks of up to 250 birds [4] found that *M. pusillus* feeds close to the ground as a flycatcher, returning to a perch after each feeding attempt, and that their food remains showed that the diet in the breeding season consisted of a wide variety of insects 4.5-35 mm long; 57% were Hymenoptera, of which 57% were Apoidea (mainly honeybees and Trigona), and the remainder were mostly Coleoptera, Diptera and Odonata, and data by [5] who found that the green bee-eater *M. orientalis orientalis* prey upon foraging honey bees (*A. mellifera*) in large numbers near an apiary during the dearth period and were seen near the foraging sites of the bees in the flowering period. He also found that the prey efficiency of the birds capture was exceptionally high near the apiary, and concluded that the bee-eater a serious predator of honey bees.

We conclude that serious honey bee losses can occur due to predation of bee-eating birds feeding near apiaries. Their feeding is particularly hazardous to queens taking their mating flight. We also conclude that queen rearing apiarist should avoid establishing mating apiaries in areas frequented by bee-eating birds.

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