2-9-1997

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Abstract: Japanese macaques (Macaca fuscata) are old world monkeys that were introduced to Texas in 1972, and their population has since increased to over 800 individuals. Macaques are considered to be primarily vegetarian but will opportunistically forage on a variety of food items. Therefore, the objective of this study was to determine if macaques impact the nest success of bobwhite quail (Colinus virginianus). In June 1996, 20 artificial ground nests simulating those of bobwhite quail were placed randomly in areas with and without macaques. Nests were checked at 3-day intervals for 24 days and nest success was compared at each time interval between areas with and without Japanese macaques by Z-tests. The monkeys exhibited an immediate detrimental effect on nest success ($P = 0.051$), destroying or consuming 85% of the nests within the first 3 days and all the nests within 15 days. The combination of all native nest predators on the control area resulted in a compensatory effect regarding nest success ($P > 0.106$) for days 6 through 12. However, days 15 through 24 resulted in a lower nest success ($P = 0.074$) on areas with macaques. This study suggests that Japanese macaques could be an important predator of upland game bird nests.

Pages 151-155 *in* C. D. Lee and S.E. Hygnstrom, eds. Thirteenth Great Plains Wildl. Damage Control Workshop Proc., Published by Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

Key Words: depredation, Japanese macaque, Macaca fuscata, monkey, nests, predator

Texas has become the home of multiple species of exotic animals. Today, over 70 introduced species constituting over 200,000 animals can be found (Mungall 1994). Some introductions were made to benefit the exotic species by providing a sanctuary for propagation. Other introductions were made for human benefit, either for aesthetic reasons or for increased hunting opportunities. One rarely mentioned introduction of exotic animal in Texas is that of Japanese macaques (Macaca fuscata).

Japanese macaques are old world monkeys in the family Cercopthecidae. They are terrestrial and arboreal primates that typically inhabit forests, but can adapt quickly to new habitats (Rowell 1984). In 1972, a macaque troop at the Iwatayama Monkey Park on the slopes of Arashiyama near Kyoto, Japan, split into two groups (Lampe 1988). One group remained within the mountain sanctuary boundaries, while the other group moved into the suburbs of Kyoto. The latter group of 150 monkeys was relocated to Texas and has been used for anthropological research (Fedigan et al. 1986). The Texas population has increased from 150 to over 800 individuals in the 21 years since the macaques were

translocated. When the troop size was small, habitat alterations caused by the monkeys went unnoticed. However, this situation changed as the population of macaques increased.

Problems can occur when introducing exotic animals without having complete knowledge of the biology of the species, its habitat requirements, disease relationships, or its impact on native biota (Ables 1977). The introduction of a new species into a receiving area without conspecifics can create major ecological disturbances, such as out-competition and elimination of a resident competitor, the extermination of other species by predation, and widespread impact upon vegetation (Caldecott and Kavanagh 1988). The history of wildlife management contains multiple examples of the devastating effects exotic species can have on ecosystems. Such examples include the severe overgrazing effects that European rabbits (Oryctolagus cuniculus) had on the Australian continent (Frith 1973), the loss of avifauna on Guam due to the Brown Tree Snake (Boiga irregularis) (Savidge 1987), the direct and indirect effects of imported fire ants (Solenopsis invicta) on native wildlife in the southern United States (Summerlin and Green 1977), and to a less dramatic result, the effect of unregulated competition between native white-tailed deer (Odocoileus virginianus) and exotic ungulates in Texas (Baccus et al. 1985).

Research on the ecological implications of free-ranging exotics is needed to establish proper management guidelines for these species. To date, research is lacking concerning the effects of Japanese macaques on the South Texas ecosystem. Therefore, the objective of this study was to determine if macaques impact the nest success of bobwhite quail (Colinus virginianus). Bobwhite quail were chosen because they are an economically-important game bird in Texas (Guthery 1986).

METHODS

The study was conducted on the Burns Ranch near Dilley, Texas in LaSalle County during June 1996. Detailed topographical and climatological characteristics of the area are described in Cook (1984). The areas of interest were two 70-ha sites; one located near the center of the 13,640 ha ranch (monkey area) and the other site approximately 8.5 km away from the periphery of the first site (control area). Macaques remained at the first site throughout the study because of two permanent water structures within the area and because they were provisioned daily with fruits, vegetables, and Purina Monkey Chow (Ralston Purina Company, St. Louis, MO 63164). Plant communities of the study areas were dominated by dense stands of honey mesquite (Prosopis glandulosa) and Texas prickly pear (Opuntia lindheimeri). Potential native nest predators of the area included raccoons (Procyon lotor), opossums (Didelphis virginiana), striped skunks (Mephitis mephitis), coyotes (Canis latrans), ringtails (Bassariscus astutus), southern plains woodrats (Neotoma micropus), javelina (Dicotyles tajacu), rattlesnakes (Crotalus sp.), indigo snakes (Drymarchon corais), roadrunners (Geococcyx californicus), and a variety of hawks (Buteo sp.).

Twenty artificial ground nests simulating those of bobwhite quail were placed along transects in the center of the monkey and control areas. Nest locations were determined by walking a random number of meters (30 to 75 m) along the transect and then walking a random number of meters (0 to 10 m) perpendicular to the transect, either to the right or left of the transect line. A random number table was used to assign distances and direction (Steel and Torrie 1980); if the number along the transect was even then the perpendicular distance was measured to the right of the transect line, and if the number was odd then the perpendicular distance was measured to the left of the transect line. A map of each area was made to aid researchers in locating nests. Artificial ground nests consisted of one fresh, unwashed quail egg

placed in a slight depression of leaf litter in typical quail nesting habitat. Eggs were concealed with leaf litter. Eggs and nests were handled wearing latex gloves and transects walked wearing rubber boots to avoid leaving human scent. Nests were checked during mid-afternoons at 3-day intervals for 24 days. Macaques were provisioned away from the artificial nesting area to avoid their learning the location of individual nests. Nests that were depredated were not replaced. Nests remaining intact had their eggs replaced with a fresh egg every 6 days. Nest predators were identified by tracks at the nest site and with remotely-triggered cameras (TrailMaster Camera Systems, Goodson & Associates, Inc., Lenexa, KS 66215). Nests were considered successful if they remained intact throughout the 24-day period. Nest success was compared at each time interval between the monkey and control areas by a Z-test. Tests were considered to have biological significance at $\underline{P} < 0.10$ (Tacha et al. 1982).

RESULTS

Japanese macaques had an immediate detrimental effect ($\underline{P} = 0.051$) on nest success of bobwhite quail, destroying or consuming 85% of the nests within the first three days while the control area experienced a nest loss of 50% (Table 1). The combination of all native nest predators on the control area resulted in a compensatory effect regarding nest success ($\underline{P} > 0.106$) for days 6 through 12; the monkey and control areas had a 95% and 85% nest loss rate, respectively.

Table 1. Rate of artificial nest loss by introduced and native predators in areas with and without Japanese macaques during June 1996 in southern Texas.

	Nest loss[a]				
Day	Monkey area	(%)	Control area	(%)	$\underline{P}$-value[b]
0	0	(0)	0	(0)	--
3	17	(85)	10	(50)	0.05
6	18	(90)	15	(75)	0.11
9	18	(90)	15	(75)	0.11
12	19	(95)	17	(85)	0.14
15	20	(100)	18	(90)	0.07
18	20	(100)	18	(90)	0.07
21	20	(100)	18	(90)	0.07
24	20	(100)	18	(90)	0.07

[a]Number of artificial nests lost to predation ($\underline{n} = 20$).
[b]$\underline{P}$-values calculated by Z-tests.

However, days 15 through 24 resulted in a lower nest success (P = 0.074) on areas with macaques (Table 1). After the 24-day study period, only 10% of the nests on the control area remained intact while all nests in the monkey area were depredated. Japanese macaques were the only identifiable predator of nests in the area in which they were present. However, in the control area, which sustained a 90% nest failure rate, nests were preyed upon by raccoons (30%), opossums (10%), coyotes (10%), roadrunners (10%), ringtails (5%), woodrats (5%), and by undetermined predators (20%).

DISCUSSION

Japanese macaques did negatively impact the success of our simulated quail nests. Although we could not differentiate nest loss by macaques through predation from nests destroyed through curious behavior, the end result for bobwhite quail would remain the same; Japanese macaques can negatively impact quail by increasing nest loss.

Japanese macaques are considered to be primarily vegetarian but are known to forage on a variety of food items (Rowell 1984). We witnessed two occasions when a macaque located a nest and consumed the contents by placing the entire egg in its mouth, leaving only tracks as evidence of its presence. In contrast, nests placed in the control area that were destroyed by native predators often had eggshell fragments within 5 m of the nest site. Such depredation behavior has been documented for native predators (Hernandez 1996). Therefore, because we did not locate eggshell debris in the monkey area, it is possible that the majority of nests lost were from predation by macaques.

The introduction of macaques had a partial compensatory effect in regard to nest loss. Six native species were identified as nest predators in the control area. However, with the exception of one sighting of a rattlesnake, no other predators or predator signs were seen in the monkey area. Presently it is unknown whether macaques are interference or exploitative competitors with native predators.

We did experience a high nest loss in our control area. It is worthy to note that our study was conducted during an extended drought in South Texas. Slater et al. (1997) described a similar nest loss rate of artificial quail nests during drought conditions in western Texas.

The ecology of Japanese macaques in Texas is unknown. However, in Japan macaque troops are nomadic and typically travel 0.5 - 2.0 km/day in search of food (Izawa 1990). Group size varies from 15 - 200 individuals and troop territories range from 1 - 30 km^2 (van Hoff 1990). Where habitats have been altered, territories typically exceed 40 km^2 and macaques must travel greater daily distances to meet their dietary needs despite their generalist food habits (Izawa 1990). Therefore, due to their increasing population size and dietary requirements, Japanese macaques could expand their range and potentially cause widespread habitat alterations rather than localized changes.

Additional research is needed to understand the ecological ramifications caused by translocated primates. Such research is mandatory to establish proper management guidelines for this species.

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