Sowls et al. (1978) reported large colonies (ca. 200,000) of storm-petrels between 160°W and 165°W; the birds I found on the Koyukuk River may have originated 1,000 km south, in the vicinity of those colonies.

Rivers are the only surface transportation corridors throughout most of interior Alaska, and observations are most numerous during September, the main hunting season. All the inland birds found have been on bodies of water, except Geist's (1939) birds, which were found dead 200 m from the Susitna River and the Dearborn specimen from Palmer. The Kogrukluk River specimen was feeding on insects from the water's surface. The specimen I collected was actively "feeding," but the crop contained only grass seeds that had been gathered off the river's surface. I did not examine the skull sutures for ossification, but there was no gonodal activity and no fat deposits. The second bird was seen later in the day, 2 km upstream from the first. These observations indicate that the storm-petrels on these rivers may seek "natural" habitat and attempt to find food.

I do not know of any inland records of Fork-tailed Storm-Petrels anywhere from North America (AOU 1983). For Leach's Storm-Petrel (*O. leucorhoa*), however, there are numerous coastal and inland records of storm-driven "wrecked" birds in North America and Europe (Palmer 1962). I believe that this disparity is because the northern Pacific distribution of the Fork-tailed Storm-Petrel places storm-driven birds in areas with fewer observers.

Based on recent records of inland Alaskan occurrences of the Fork-tailed Storm-Petrel, I believe that Nelson's and Geist's records should be accepted.

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DOUBLE BROODING BY AMERICAN KESTRELS IN CENTRAL MISSOURI

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Nearly all temperate-zone raptors raise only one brood per year; the time required for the complete breeding cycle occupies most of the period of suitable conditions (Newton 1977). Double brooding has been reported, however, for several species in extreme southern latitudes of the continental United States, including: the Harris' Hawk (*Parabuteo unicinctus*) in southern Arizona (Mader 1975), Common Caracara (*Caracara cheriway*; Bent 1937), Black-shouldered Kite (*Elanus caeruleus*; Pickwell 1930), Common Barn-Owl (*Tyto alba*; Marti 1968), and American Kestrel (*Falco sparverius*; Howell 1932) in Florida.

American Kestrels have successfully raised two broods in captivity (Porter and Wiemeyer 1970, 1972), but in the wild, this has been documented only in Florida (Howell 1932). Although Enderson (1960) reported a successful renesting in Illinois, he did not indicate whether or not the first nesting was successful. Stahlecker and Griese (1977) gave circumstantial evidence for a possible double brooding in a pair of kestrels in Colorado, while Black (1979) and Sutton (1979) speculated on the possibility that kestrels might double brood in Oklahoma.

Documentation of double brooding for temperate-latitude raptors would be of significance to wildlife researchers and managers, as it would augment information on annual productivity and nesting phenology. This paper reports the occurrence of double broods in a color-marked, wild population of American Kestrels in central Missouri. Clutch size, hatchability, nesting success, and behavioral differences between first and second nestings are analyzed.

STUDY AREA AND METHODS

The study area was 194 km² in central Boone County, Missouri. The area included the city of Columbia and suburbs (30 km²), as well as farmland interspersed with woodlots, old fields, meadows, streams, and lakes.

TABLE 1. Clutch size, hatchability, and fledging success of initial and second broods of American Kestrels in central Missouri.

	Initial brood						Second brood					
Year	No. of clutches	No. of eggs	$\bar{x}$	Young produced	Percent hatched	Young fledged	No. of clutches	No. of eggs	$\bar{x}$	Young produced	Percent hatched	Young fledged
1982	17	84	4.9	76	90.5	74	2	8	4.0	6	75.0	6
1983	36	192	5.3	161	84.0	160	12	48	4.0	35	73.0	35
Total	53	276	5.2	237	86.0	234	14	56	4.0	41	73.0	41

From September, 1981 through August, 1983, I captured 70 adult kestrels (38 males and 32 females) by using bal-chatri traps (Berger and Mueller 1959) and also noose-harnessed House Sparrows (*Passer domesticus*; Toland 1985). Most adult kestrels were caught from September through early March each year. Adults and 125 nestlings (60 males and 65 females) were individually marked with colored plastic jesses and/or painted U.S. Fish and Wildlife Service bands. I checked nests late in incubation and at intervals during the nesting stage. Nest sites were watched from distances of 50–100 m, using binoculars and a spotting scope, for a total of 1,210 h from 15 March through 30 August during 1981–1982 and 1982–1983. Observations were made during all daylight hours including as many full days as possible. Otherwise, half-day observations were alternated between morning and afternoon.

Kestrels nested in cavities in buildings, power poles, snags, and trees, as well as in some of 50 nest boxes which I placed in 1981–1982. From March, 1981 through August, 1982, my observations of 19 nesting pairs totaled 630 h. From March, 1982 through August, 1983, my observations of 39 nesting pairs totaled 580 h.

RESULTS AND DISCUSSION

Individually-tagged kestrels raised two broods at two of 17 (11.8%) nests in 1982 and at 12 of 36 (33%) nests in 1983. The 12 pairs which double-brooded in 1983 included two pairs which double-brooded in 1982. Both of these pairs nested in buildings. A concurrent increase in nest sites (30 boxes were erected for the first season and 20 more were added for the second year) and prey availability (microtines apparently increased from moderate densities during 1982 to very high densities in 1983) were probably important factors contributing to the increase of double brooding pairs during this study.

Although I did not quantify rodent population densities, personal observations and interviews with farmers throughout the study area indicated that voles (*Microtus* spp.) were abundant before and during the 1983 nesting season.

Distribution of nests and percentage of double brooding in nests other than boxes was similar for both years; two of 11 (18%) pairs had second broods in 1982, while three of 13 (23%) pairs were double-brooded in 1983. The distribution, density, and percentage of double brooding increased in nest boxes. In 1982, six pairs nested in 30 available boxes with no double brooding. In 1983, however, 23 pairs nested in 50 available boxes and nine (39%) pairs double-brooded.

The average size of second clutches was smaller than that of initial clutches, although the difference was not significant ($\chi^2 = 0.49$, $P > 0.05$, df = 1). First clutches averaged 4.9 eggs (4–6) in 1982 and 5.3 eggs (4–6) in 1983 (Table 1). All second clutches during both years contained four eggs.

The hatching success of initial clutches averaged 86% for the two years and was significantly higher than the average hatching success of 73% for second clutches ($\chi^2 = 5.73$, $P < 0.05$, df = 1). All but four nestlings fledged successfully during the study (Table 1), which resulted in overall nesting success rates (number of young to fledge divided by total number of eggs) of 85% for first nestings and 73% for second nestings.

In this study, only early breeders laid a second clutch after successfully raising a first brood. Of pairs whose first broods fledged during May, 80% laid second clutches and fledged second broods. Of pairs which fledged first broods in June, 25% raised second broods. No second broods were attempted by pairs whose first broods fledged in July. These data suggest a seasonal influence on kestrel productivity. Similarly, Bird and Lague (1982a) found an inverse relationship between clutch size and laying date in captive American Kestrels, with clutch size decreasing as the season progressed. They also found that later clutches had smaller eggs with thinner shells. Later clutches were also fewer, on average, than early ones laid by Eurasian Kestrels (*Falco tinnunculus*) in Europe (Cade 1982).

The lower hatchability of kestrel eggs of second clutches has been attributed to a seasonal decline in fertility of males (Bird and Lague 1982b). Bird and Lague (1977) found that, in captive kestrels in Canada, semen production peaked during the season at 13.5 h of daylight and declined significantly around the summer solstice, 21 June, at 15.75 h of daylight.

The mean fledging date for second broods in this study was 13 August. Fertilization probably averaged around 1 June (14.7 h of daylight). Clutch sizes and hatching success rates of early (mean fledging date 16 May) and late (mean fledging date 15 July) single broods were the same. Thus, a fertility decline in kestrels probably occurs during the approximately 30 days that separate late first-nesters from second-nesters in central Missouri (between 13.8 and 14.7 h of daylight).

The unpredictable and often inclement weather associated with March and early April in Missouri may increase the probability of nesting failures in the earliest nesters. Half (four of eight) of the clutches which failed were of pairs whose young would have fledged in May had they been successful. Of the four unsuccessful early nesting pairs, three did lay replacement clutches. Thus, while earlier initial clutches had the same number of eggs and hatching success as did later initial clutches, earlier-nesting kestrels appeared to have better nesting success in most respects, i.e., greater probability of raising second broods, laying replacement clutches, and higher mean number of young fledged per pair (7.20 vs. 4.37).

For their second broods, the kestrels used either alternative nest sites close to original nests, or the same nest cavity if alternative sites were not available. Of 14 pairs of kestrels which double brooded, eight re-used the original nest, while the other six used alternative sites which were 30–300 m ($\bar{x}$ = 135 m) from the original sites. Mader (1975) found several pairs of Harris' Hawks raising second broods in alternative nests within their own home ranges, at distances of 300–1,600 m of first nests. He also found that one pair laid a second clutch in the same nest before the nestling from the first clutch had fledged.

Kestrel pairs that produced two broods usually copulated again before their first brood had fledged. The mean number of days between fledging of the last nestling and initiation of the second clutch was six days (range 0–15).

In two nests, the first egg of the second clutch was laid on the same day that the last nestling of the first brood fledged. Porter and Wiemeyer (1972) reported that three captive kestrels began their second clutches 11, 12, and 14 days, respectively, after young of the first clutch had fledged. They also found that second clutches occasionally were laid before first-clutch young had fledged.

Young kestrels of first broods were dependent upon the adults for 10–14 days after they had fledged. At most nests, double brooding males brought food to first-brood fledglings as well as to their mates, who were incubating second clutches. The post-fledging dependency period, however, was shorter in first-brood fledglings than in either second-brood fledglings or fledglings from single-brooded birds ($\bar{x}$ = 4.5, range = 3–7 days).

Similarly, Mader (1977) found that when Harris' Hawks raised two broods in a year, the first brood reduced its ties to the adults and was not dependent on them while the second brood was being raised. When the second brood fledged, they were dependent for 2–3 months, as is characteristic of young from single-brood nests.

Both members of a pair became exceedingly inconspicuous during second nestings, in contrast to first nestings when one or both adults were usually perched within 20 m of the nest or delivering prey throughout the day. During the last two weeks of the nestling stage in first broods, females perched within 20 m of their nests an average of 28% of each day. Males perched within 20 m of the nest an average of 22% of each day during the fourth and last week of the nestling stage (Toland 1983). During this period, adults (especially females) were quick to defend against potential predators, including other raptors, corvids, wild and domestic carnivores, and people (Toland 1984).

During the raising of second broods, nests appeared to be abandoned from 08:00 to 19:00, except on cloudy or unseasonably cool days. Adults spent an average of only 6% of each day perched within 20 m of their nests during the last half of the nestling stage. They rarely attacked intruders of their territories at that time (Toland 1984). Adults were usually under the canopy of nearby trees, possibly seeking respite from the heat, especially in 1983, when daytime temperatures in July and August were consistently around 38°C. I did not see second-brood nestlings at the nest hole for several days before fledging, as I did those in first broods. Because females spent little time brooding second-clutch young, males did not need to call them out to transfer prey. Instead, females hunted even during incubation and early nestling stages.

Adult kestrels brought prey to first broods during all daylight hours, but especially during two peak periods—09:00–11:00 and 16:00–17:00—when 70% of the food was delivered (Toland 1983). I noted that most of the food for second broods was delivered between 06:00 and 07:30 and after 18:30.

The inconspicuousness of American Kestrels raising second broods may contribute to the lack of information regarding this phenomenon. My results indicate that, with the presence of adequate nesting sites and food supply, kestrels successfully raise two broods per year in central Missouri. The combination of food availability and weather conditions probably determines whether kestrels attempt to nest early enough to raise two broods in a season (Newton 1979). Warm, dry weather in early spring would also enhance hunting success and the body condition (fat and protein reserves) of females, critical requirements for egg development (Cavé 1968). In contrast, cold, wet spring weather increases energy demands and decreases hunting success in kestrels, which lowers the probability of successful reproduction (Cavé 1968). Thus, kestrels attempting to nest early in Missouri are faced with a dichotomy: a higher than average rate of nest failure if conditions are suboptimal or, if conditions are optimal, the reward of enough time in the season to successfully raise two broods.

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