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Growth Rate and Relocation Movements of Common Nighthawk (*Chordeiles minor*) Nestlings in Relation to Age

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ABSTRACT.—Relocation by dependent young is a survival strategy that occurs among a wide range of taxa. The Common Nighthawk (*Chordeiles minor*) lays its eggs on bare substrate and, once hatched, nestlings may relocate to new sites daily. We located and monitored eight Common Nighthawk nests in Grand Teton National Park, Wyoming, quantified inter-use-site distances in relation to nestling age, and calculated a nestling growth rate curve. Common Nighthawk nestlings grow in a nearly linear fashion. Nestlings moved up to 48 m in a single day and larger, older nestlings tended to move greater distances between daily use-sites. Received 2 December 2011. Accepted 25 June 2012.

Life history traits, including successful predator avoidance behaviors by young, which promote juvenile survival, should increase an organism's fitness and be favored by natural selection (Roff 1992). Relocation of dependent offspring to increase the probability of survival is a tactic that occurs in a broad range of taxa. However, the ability of the non-precocial young of most avian species to change their location is limited, primarily due to construction of often elaborate, stationary nests where they are fed and brooded by adults (Collias and Collias 1984, Podulka et al. 2004). Relocation of young birds to limit predation risk, while reasonable, is poorly documented. Moreover, the details of this strategy in avian species rearing dependent young remain largely unknown.

Many species of nightjars (Caprimulgidae) have semi-precocial nestlings hatched from eggs laid on bare ground (Holyoak 2001) without creating any nest structure. Anecdotal observations suggest Common Nighthawks (*Chordeiles minor*)

move their eggs and coax their pre-fledge, semi-precocial nestlings to move in response to disturbance both by potential predators and microhabitat disturbances such as pooling water (Pickwell and Smith 1938; Fowle 1946; Rust 1947; Sutton and Spencer 1949; Dexter 1952, 1961; Weller 1958; Brigham et al. 2011). However, factors influencing the distance and frequency of pre-fledging chick movements are unclear. We tested the hypothesis that nighthawk nestlings' movements between daily use-sites increase with offspring age. We also calculated a Common Nighthawk nestling growth rate curve using, for the first time, measurements obtained from multiple chicks and broods.

METHODS

Study Area and Field Techniques.—Our study occurred during May–August 2010 within sagebrush (*Artemisia* spp.) flats in Grand Teton National Park, northwestern Wyoming. Elevation ranged from ~1,950 to 2,012 m and sites were dominated by mountain big sagebrush (*A. tridentata vaseyana*). Nighthawk nests were located by chance during systematic searches for nests of shrub and ground-nesting passerines.

Common Nighthawk nests and use-sites were checked daily between 1400 and 2000 hrs MST, barring inclement weather. We navigated to the most recent known daily use-site using a handheld global positioning system (GPS) and attempted to relocate nestlings by initially searching within a 10-m radius from that point. We returned to the most recent known use-site if the nestlings were not relocated during the initial 10-m radius search and walked four 50 m by 50 m quadrants centered at the last known use-site, effectively searching an area of 1,000 m². We repeated the quadrant search on each of the 2 days following the initial disappearance of the nestlings and assumed the nest was no longer active or had moved out of our search radius if we were still unable to locate the brood. We flushed the brooding female upon

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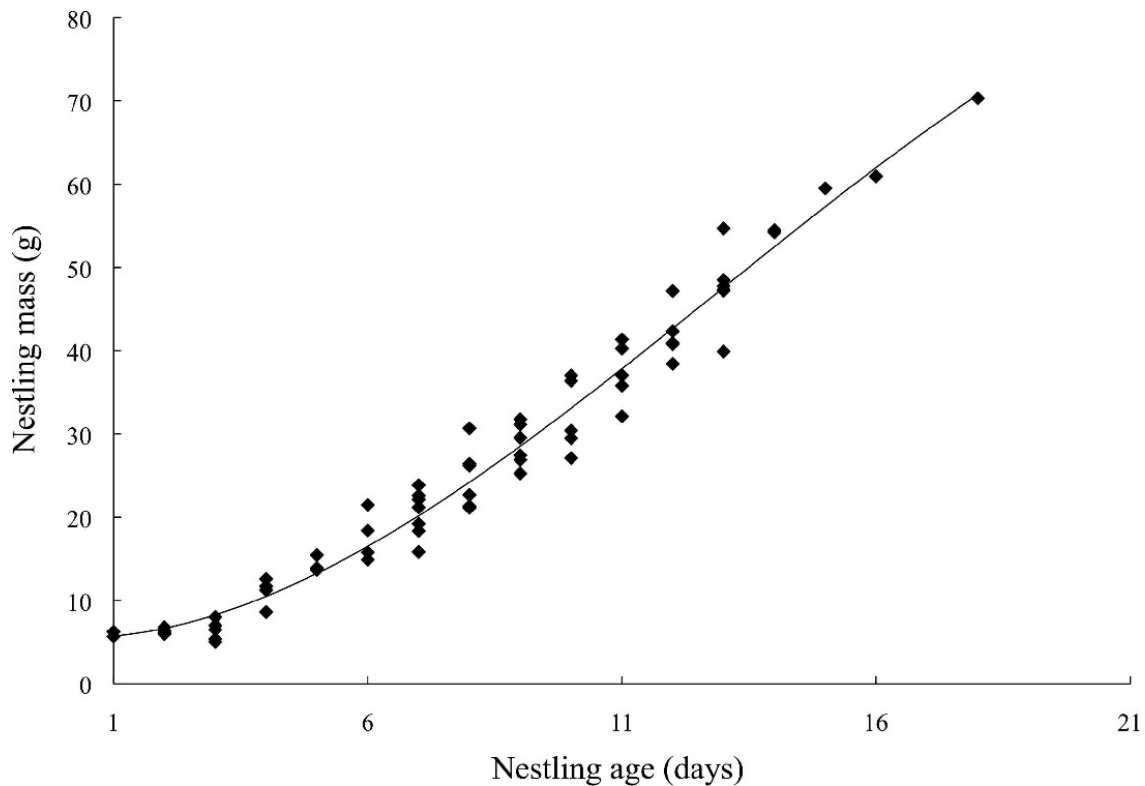


FIG. 1. Growth rate curve ($y = -0.0103x^3 + 0.3956x^2 - 0.1698x + 5.5$; $R^2 = 0.97$) demonstrating growth patterns of Common Nighthawk nestlings. Data were derived from 71 measurements of 10 Common Nighthawk nestlings (3–11 measurements per nestling) from six different nests in Grand Teton National Park, Wyoming, 2010.

relocating a new daily use-site, and followed her (usually ~ 15 m) until she ceased her injury display and left the area so she would not return while we handled the nestlings. We marked the new use-site using a handheld GPS. We paced off the straight-line distance between sequential use-sites if they were < 15 m apart. We used GPS locations to measure the straight-line inter-use-site distance if the new site was relocated > 15 m from the previous.

We considered the age of a brood to be the age of the first-hatched nestling. Nestling body masses were obtained during each visit using a portable electronic balance (± 0.005 g) that was recalibrated following each relocation. We marked the underside of the feet of the first hatched nestling, for nests with two nestlings, using a non-toxic permanent marker. Marks were reapplied as needed prior to fledging. We replaced nestlings where they were found and watched them until they assumed a stationary, cryptic posture.

We collected video of a single nest-site relocation by placing a camouflaged video camera within 5 m of an active use-site and recorded

brooding and movement activity from 1800 to 2100 hrs MST.

Statistical Analyses.—We calculated mean use-site movement distances for each nestling age and evaluated polynomial regressions before selecting a cubic regression due to the high correlation coefficient and correspondence with our observations of nestling movement tendencies. We fit a cubic polynomial curve to the nestling growth data because it maintained the linear nature of the curve while allowing for a biologically accurate representation of slower nestling growth both early and late in the nestling stage. We used one-tailed independent sample *t*-tests to assess significance ($\alpha = 0.05$ for all tests) of the correlation coefficients of the growth curve and movement data. We performed a two-tailed, paired sample *t*-test to assess whether hatch order within clutches influenced nestling growth rates.

RESULTS

Eight nest sites were found during incubation and included in analyses. One brood was discovered during the nestling stage but was omitted

TABLE 1. Means (\pm SE), ranges, and sample sizes of nestling movements of Common Nighthawks within three age classes in Grand Teton National Park, Wyoming, 2010.

Age (days)	Daily nestling movement (m)		<i>n</i>
	Mean \pm SE	Range (m)	
1–5	1.57 \pm 0.43	0–4	15
6–10	6.88 \pm 0.96	0–14	16
11+	16.25 \pm 3.39	5–48	14

from analyses due to our inability to relocate subsequent use-sites. We observed one case in which an egg of a two-egg-clutch was crushed by an ungulate and the remaining viable egg moved 0.5 m from the original nest site. It is unclear whether the egg was moved purposefully by the adult in response to the disturbance or if it was inadvertently moved by the adult flushing during or after the disturbance event (Jackson 2007). We did not record any occurrences of egg movement at any other nests ($n = 7$).

A growth rate curve (Fig. 1) was derived from 71 measurements of 10 nestlings from six different broods. Nighthawk nestlings grew in a nearly linear fashion ($r^2 = 0.97$, $t = 48.6$, $df = 68$, $P < 0.001$). Common Nighthawk eggs hatch asynchronously; however, across broods, second-hatched nestlings weighed significantly more than the older nestlings at the same age ($t = 3.17$, $df = 14$, $P = 0.007$).

Forty-five measurements ($n = 6$ nests) of nestling-stage movements were obtained from nestlings that ranged in age from 1 to 18 days. Older nestlings were more likely to move longer distances in a day ($r^2 = 0.66$, $t = 9.16$, $df = 43$, $P < 0.001$; Table 1, Fig. 2). We observed two cases in which a likely predation attempt was made on two different broods and in both cases the nestlings moved nearly twice as far in comparison to the largest previous site relocations (9 to 18 m, and 11 to 21 m). In the first case, a nestling was observed to be severely injured, presumably due to a predation attempt. In the second case, one nestling was depredated.

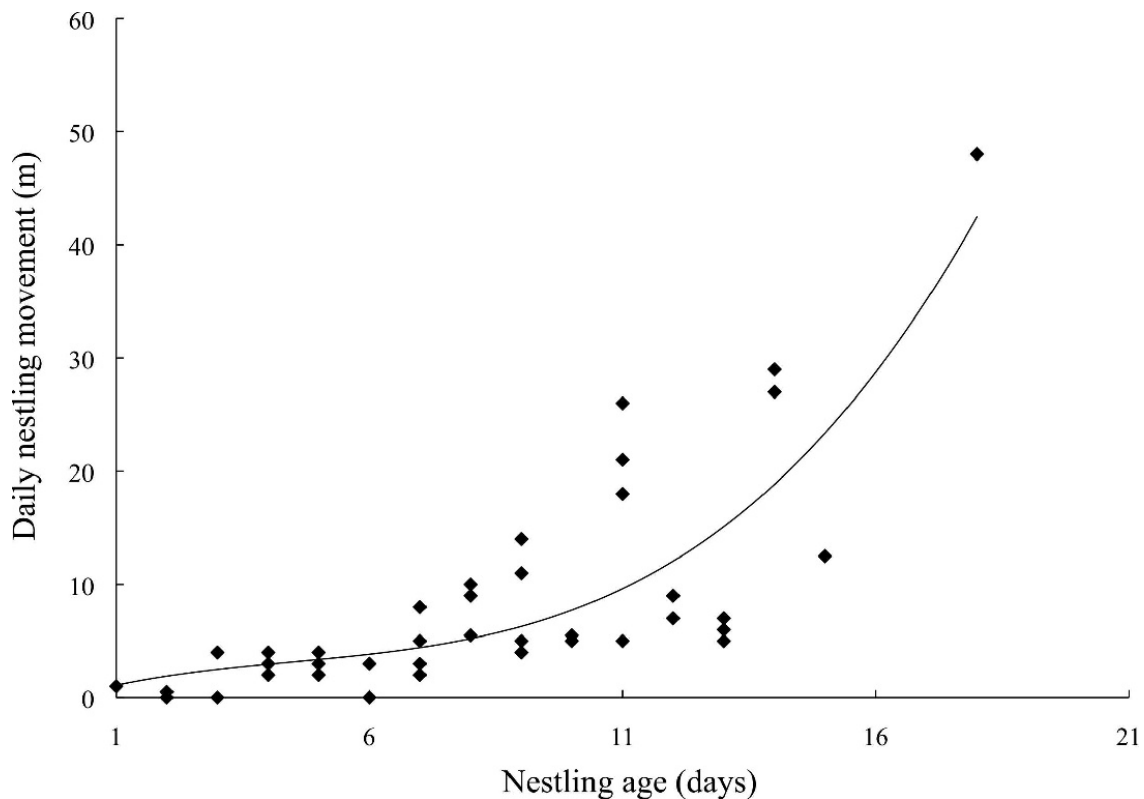


FIG. 2. Common Nighthawk nestling movements as a function ($[y = 0.0138x^3 - 0.1868x^2 + 1.2665x]$; $R^2 = 0.66$) of chick age. Measurements ($n = 45$) were collected for nests with 1 to 18 day-old young in Grand Teton National Park, Wyoming, 2010.

DISCUSSION

Nighthawk nestlings moved greater distances between daily use-sites as nestlings increased in age. Chicks of 1–5 days of age moved no more than 4 m a day from their previous use-site. However, nighthawk nestlings regularly relocated greater distances after day 5 between daily use-sites, although short-range movements (~ 5 m) were recorded throughout the nestling period (Table 1). Common Nighthawk feet and legs are poorly adapted for ambulation and these physical limitations may explain the reduced range of movement observed during the early nestling stage. However, that short movements (~ 5 m) occurred even for young >11 days of age suggests there are likely other factors influencing nestling movement. We recognize that by regularly visiting the use-sites and handling young we initiated disturbance that could have influenced nestling movements. However, all nest visits were conducted similarly and there was still a clear movement distance pattern with respect to nestling age. Our limited observations ($n = 2$) of nestling movements following severe disturbances (partial predation, and a serious injury likely due to attempted predation) suggest there may be a relationship between the severity of disturbance and the distance nestlings move. Common Nighthawks may be able to differentiate between more severe disturbance events and lesser ones, although our protocol did not allow us to test this hypothesis.

Which microhabitat features are important for nest and use-site selection and inter-use-site movement routes remains unclear as are the specific cues that elicit nestling movements. We were unable to discern any aural or visual cue that prompted the nestlings to follow the female parent from the nest based on our video footage of a use-site relocation. However, nestlings began to stir and commence movement after the female parent stopped brooding and began walking away from the nestlings, suggesting that adults may be responsible for use-site selection at least while the nestlings are young (≤ 5 d).

The growth rate of nestling nighthawks is comparable to reports for other young nightjars such as Australian Owlet-nightjars (*Aegotheles cristatus*) (Brigham and Geiser 1997) and Common Poorwills (*Phalaenoptilus nuttallii*) (Csada and Brigham 1994). Similarities in nest predation pressure and life history strategies have been invoked to explain similarities in growth rates of songbird species (Remes 2006) and may explain

the general likeness between the growth rates of these nightjars. Common Nighthawk nestlings overcame asymmetrical masses associated with asynchronous hatching within several days of hatching unlike Common Poorwill nestlings, which are reported to take up to 14 days to reach equivalent masses (Csada and Brigham 1994). We did not observe feeding behaviors of Common Nighthawk nestlings or adults and are unable to comment on the potential role of food availability and quality. However, selection may favor parents with two equally developed nestlings that are able to relocate similar distances.

Understanding the nature of nestling relocation has important implications for future survey efforts, evaluation of reproductive success, and population analyses. Common Nighthawk nests are difficult to find and often just as difficult to relocate. Having a general guideline for nighthawk nestlings' movement potential will allow for more certainty in identifying nest fates in future studies. Daily nest survival rates and fecundity estimates would also be improved. Our nestling growth rate curve will provide a basis for comparison across other ecological contexts. Developing a better understanding of diverse nestling behaviors in birds and other taxa enriches our understanding of natural histories and important selective pressures shaping life history strategies.

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