eree for critical review of the manuscript, and R.C. Rope for providing aerial photographs of the study area.

LITERATURE CITED

BENNETT, C.M. 1990. Streamflow losses and ground-water level changes along the Big Lost River at the Idaho National Engineering Laboratory, Idaho. U.S. Geological Survey, Denver, Colorado. Report 90-4067.

CRAIG, T.H. 1977. Raptors of the Idaho National Engineering Laboratory site. M.S. thesis, Idaho State University, Pocatello, ID U.S.A.

———. 1979. The raptors of the Idaho National Engineering Laboratory site. IDO-12089. U.S. Department of Energy, Idaho Falls, ID U.S.A.

——— AND C.H. TROST. 1979. The biology and nesting density of breeding American Kestrels and Long-eared Owls on the Big Lost River, southeastern Idaho. *Wilson Bull.* 91:50–61.

HANSEN, R.W. AND L.D. FLAKE. 1995. Ecological relationships between nesting Swainson's and Red-tailed Hawks in southeastern Idaho. *J. Raptor Res.* 29:166–171.

KORPIMÄKI, E. 1992. Diet composition, prey choice, and breeding success of Long-eared Owls: effects of multiannual fluctuations in food abundance. *Can. J. Zool.* 70:2373–2381.

——— AND K. NORRDAHL. 1991. Numerical and functional responses of Kestrels, Short-eared Owls, and Long-eared Owls to vole densities. *Ecology* 72:814–826.

MARKS, J.S. 1986. Nest-site characteristics and reproductive success of Long-eared Owls in southwestern Idaho. *Wilson Bull.* 98:547–560.

———, D.L. EVANS, AND D.W. HOLT. 1994. Long-eared Owl (*Asio otus*). *In* A. Poole and F. Gill [EDS.], The birds of North America, No. 133. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists Union, Washington, DC U.S.A.

SAUER, J.R., J.E. HINES, I. THOMAS, J. FALLON, AND G. GOUGH. 2000. The North American breeding bird survey, results and analysis 1966–1999. Version 98.1, USGS Patuxent Wildlife Center, Laurel, MD U.S.A. www.mbr.nbs.gov/bbs.html.

STONE, M.A.J., L.J. MANN, AND L.C. KJELSTROM. 1993. Statistical summaries of streamflow data for selected gaging stations on and near the Idaho National Engineering Laboratory, Idaho, through September 1990. U.S. Geological Survey. Report 92-4196.

Received 27 October 2000; accepted 3 March 2001
Associate Editor: Cole Crocker-Bedford

J. Raptor Res. 36(1):77–81

BEHAVIORAL AND PHYSICAL DEVELOPMENT OF A NESTLING CRESTED EAGLE (*MORPHNUS GUIANENSIS*)

DAVID F. WHITACRE[1]
The Peregrine Fund, 5668 West Flying Hawk Lane, Boise, ID 83709 U.S.A.

JUVENTINO LOPEZ AVILA AND GREGORIO LOPEZ AVILA
Fondo Peregrino, Parque Nacional Tikal, Flores, Petén, Guatemala

KEY WORDS: *Crested Eagle*; Morphnus guianensis; *nestling*; *behavior*; *development*; *nesting biology*; *tropical*.

Rates of physical and behavioral development in nestling birds are key aspects of avian life histories (Starck and Ricklefs 1998). Details of the growth and development of many falconiforms are lacking. One such poorly known species is the Crested Eagle (*Morphnus guianensis*). Although this is the second largest of widespread Neotropical forest eagles, virtually all that is known concerning the species' nesting biology and behavior is based on a single nest (Bierregaard 1984).

We studied nesting biology, behavior, and diet at two nests of Crested Eagles in Guatemala's Petén lowlands Most results are presented elsewhere (Whitacre et al. in press a, D. Whitacre unpubl. data). Here we describe the progression of behavioral and physical development in a single wild nestling, and present a growth curve and behavioral notes from a captive-reared nestling.

STUDY AREA AND METHODS

We studied two Crested Eagle nests. Nest No. 1 (1994) was 7 km south of Tikal National Park, and nest No. 2

[1] E-mail address: dwhitacre@peregrinefund.org

Table 1. Behavioral and physical development of a Crested Eagle nestling at Tikal, Guatemala.

NESTLING AGE (DAYS)	DEVELOPMENTAL FEATURE FIRST NOTED ON THIS DAY
0	Chick mostly immobile; holds head up for brief moments; ate only three bites during all-day watch.
7	Chick moves around more.
9	Chick attempts to shuffle on horizontal tarsi toward female.
16	Chick moves more easily across the nest, shuffling on its tarsi, falling at times; moves into shade provided by female and tree limbs; makes preening motions.
17	Makes preening motions several times; raises hind end to defecate, with most of mutes falling outside nest.
18	Chick attempts to stand, with the aid of its wings.
23	Stands briefly on nearly straightened legs rather than over horizontal tarsi; takes faltering steps, though still without legs fully extended; noticeably more active than during prior week, but still spends much time sprawled out, sleeping.
24	Wing-stretching behavior, repeatedly.
25	Chick responds to distant Keel-billed Toucan (*Ramphastos sulfuratus*) vocalizations by looking in that direction. When male arrives at nest, chick walks toward male, flapping wings, bites at prey, and drags prey around nest. Chick attempts, unsuccessfully, to eat in the female's absence; becomes motionless when several Brown Jays (*Cyanocorax morio*) approach the nest.
26	When male arrives with prey, chick vocalizes and attempts to seize prey; feather shafts emerging on chick's head and wings.
37	Chick stands firmly on straightened legs and flaps wings as in flight exercise.
38	Chick stands solidly several seconds at a time; stands up to defecate.
39	When a Black Vulture (*Coragyps atratus*) flies over the nest, both chick and adult female extend wings and vocalize.
40	Chick jumps as it flaps in place—increasingly common thereafter.
44	Feathers appearing on nestling's wings.
45	First time chick wet from rain, the female absent.
46	Chick is so large that the female cannot completely cover it.
51	Nestling stands for up to 2 min, but spends most of time lying in the nest; fed in small bites by the female; female still broods and shelters the chick from sun and rain.
52	Chick remains standing for 6 min; walks away from female, remains in the sun for several min.
53	Chick remains standing for 17 min. When female arrives at nest, chick spreads its wings and erects its feathers in apparent threat display. Chick first seen to mantle with wings spread over prey brought by male; moves nest material around with its beak.
54	Chick again manifests a defensive display, looking upward with wings spread and beak open, although we cannot see what elicits this response. Hereafter, chick often responds to vultures in this fashion. Chick stands for 38 min, is unsuccessful at feeding itself.
58	Chick extends its wings and calls loudly when a pair of White Hawks (*Leucopternis albicollis*) soars over.
59	Chick lowers head and spreads its wings when two helicopters pass overhead; in subsequent days, airplanes repeatedly elicit this response, sometimes accompanied by gaping of the beak and erected plumage. Chick stands for >2 hr; is wet from rain, as the female spends a good portion of the day away; afterwards, chick spreads its wings in the sun. Chick first seen to tear off and eat a few bites on its own, though with difficulty.
65	Chick jumps and flaps frequently; pounces on and seizes a stick (nest material) with its talons.
72	Chick weighs 1630 g (ca. adult female mass); wing chord is 245 mm, total length 450 mm, and wingspan 870 mm; eyes are dark gray, feet buffy yellowish, and cere, facial skin, and beak black.
80	Chick often feeds on its own.

Table 1. Continued.

NESTLING AGE (DAYS)	DEVELOPMENTAL FEATURE FIRST NOTED ON THIS DAY
81	Adult female begins remaining away from nest most of time and periodically brings prey to the nest. Chick adept at plucking prey and feeding itself. Chick now weathers frequent heavy rains on its own.
92	On 28 August, chick equipped with a backpack radiotransmitter. Chick weighs 1697 g, wing chord is 400 mm, total length 590 mm, and wingspan 1140 mm.
93	Chick pouncing, seizing and pecking at nest material and prey remains and exercising wings more frequently and vigorously; commonly jumps, flapping, from rim to rim of the nest, and periodically tugs at the antenna of its radiotransmitter. When wet from rain, the nestling often spreads its wings in the sun.
100	Chick frequently moves nest material around with its bill; practice hunting and flapping have reached a fever pitch.
114	On 19 September, nestling flies around within nest tree and to other trees; fledged at 109–114 d of age (in nest at age 108 d).

(1995) was near the center of the park. Tikal National Park is a tropical lowland site at 17°N latitude in Guatemala's Petén Department. Tikal's environment is described by Schulze and Whitacre (1999). Because nest No. 1 failed prior to hatching, we report here on observations at nest No. 2, which produced one fledgling. We discovered nest No. 2 on 8 May 1995, while the adults were incubating. The nest was 16.4 m high in a live Jobillo tree (*Astronium graveolens*). At a similar height in a tree 74 m from the nest, we built a wooden observation platform, using poles cut from the forest, a 1.2 × 0.6 m piece of plywood, and baling wire. Construction of the platform took several hours during three days, from 8–10 May. The Crested Eagles gave no indication of being disturbed by the construction process.

On 11 May we began dawn-to-dusk observations, usually 13–14 hr in duration, using a spotting scope. We logged 979.3 hr of observation on 83 d; observation periods averaged 11.8 hr in duration. We observed this nest during the last three weeks of the incubation period and until the chick fledged at 109–114 days of age. Using a backpack arrangement and 6 mm teflon ribbon, we placed an 18 g radiotransmitter (216 KHz; Holohil Systems Ltd., Carp, Ontario) on the juvenile once it neared fledging age. We monitored the radio-tagged fledgling until 16 mo of age, when we ended fieldwork.

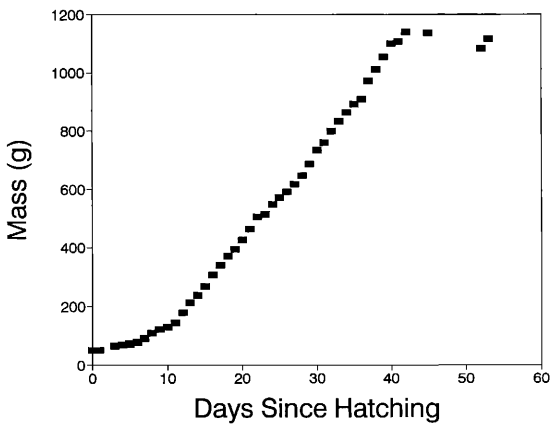

Figure 1. Mass gain of hatchling male Crested Eagle (band number = 220107) in the Oklahoma City Zoological Park. Data from zoo records, courtesy of Barbara Howard.

RESULTS

The nestling, later judged by size to be a female, was not hatched as of 26 May and was very tiny and weak the morning of 29 May; we estimated she hatched 28 May, which was designated as day 0. The chick's physical and behavioral development during the 114 d brood-rearing period are described in Table 1.

Post-Fledging Period. At first, the fledgling returned to the nest to sleep and receive prey, but within a few days it spent little time in the nest, flying frequently between various trees up to 100 m from the nest, and returned to the nest mainly to receive prey from the adults At this time, the female often fed the chick, bill to bill. With radiotelemetry, we followed the fledgling to the age of nearly 16 mo, when she still remained dependent on the adults. Unlike some other raptor species at Tikal, the fledgling did not indulge in protracted food-begging while adults were away from the nest area, but rather, it called mainly when they approached. At least as late as day 141 (16 October), the female still occasionally fed the chick bit-by-bit when she delivered prey.

Data on a Captive-reared Nestling. Because no growth curves are available for wild birds, here we report data for a male (surgically sexed) hatched at the Oklahoma City Zoo (Fig. 1). This male weighed 51 g on hatching day, showed essentially linear mass gain after two weeks, and stabilized at ca. 1117 g at age 42–53 d (Fig. 1). Allowing 5–10% additional mass gain thereafter (Newton

1979:120, T. Cade pers. comm.), its predicted adult weight is ca. 1170–1230 g. At 21 days, this chick's talons were beginning to turn from white to gray, and covert feathers were emerging from quills. At four weeks, primary feathers were emerging from sheaths and at six weeks the chick was very alert and interested in his surroundings. On day 51 he stood in the nest, on day 72 he sat on the nest rim, and on day 76 he was found on the floor and returned to the nest. On day 94 the primaries were hard-penned, though the tail was still growing. On day 103, the chick flew across the room to another perch, and two days later was flying about the room (B. Howard pers. comm.).

DISCUSSION

Developmental mileposts accord closely between the captive-reared and wild chicks. Both were able to stand for some time during their seventh week, and both made their first significant flights at 103–114 days. The Crested Eagle nestling at Tikal developed at a slower rate than did Ornate Hawk-Eagle (*Spizaetus ornatus*) nestlings (Whitacre et al. in press b), which in turn developed more slowly than did Black Hawk-Eagle nestlings (*S. tyrannus*; Whitacre et al. in press c). We observed chicks first standing up for prolonged periods at 5 wk in the Black Hawk-Eagle, during the seventh week in the Ornate Hawk-Eagle, and at 8 wk in the Crested Eagle. Chicks first flapped in place vigorously at 4 wk in the Black Hawk-Eagle, 5 wk in the Ornate Hawk-Eagle, and during the seventh week in the Crested Eagle. The age at which we noted chicks first able to feed themselves was less variable; this occurred at 8 wk in the Black Hawk-Eagle and during the ninth week for both the Ornate Hawk-Eagle and Crested Eagle. A Black Hawk-Eagle chick first walked out onto limbs near the nest early in the fourth week and did so commonly by the end of the fourth week. We observed this behavior at 9 wk in the Ornate Hawk-Eagle and 16 wk in the Crested Eagle. First flights within the nest tree were observed during the eighth week for the Black Hawk-Eagle, the tenth week in the Ornate Hawk-Eagle, and at 16 wk in the Crested Eagle. Fledging from the nest tree took place during the tenth week in the two hawk-eagles and at 16 wk in the Crested Eagle.

The relative speed of development of the above three species accords with their relative body sizes. Black Hawk-Eagles (most rapid to develop) are also smallest, with mean adult female mass of 1115 g (Whitacre et al. in press c). Ornate Hawk-Eagles, with intermediate rate of development, are intermediate in size, with females averaging 1450 g (Whitacre et al. in press b). Crested Eagles, slowest to develop, have a mean adult female mass of about 1850 g (Whitacre et al. in press a).

The nestling periods of these two Crested Eagles (103–105 d for the captive bird and 109–114 d for the wild bird) are notably long for a raptor of this size. The Crested Eagle falls well above the curve relating nestling period to female mass in a wide range of falconiforms (Newton 1979:119). Indeed, the nestling period we documented is equivalent to that of the Philippine Eagle (*Pithecophaga jefferyi*), Crowned Hawk-Eagle (*Stephanoaetus coronatus*), and Martial Eagle (*Polemaetus bellicosus*), all substantially larger birds than the Crested Eagle (Newton 1979:344). It is unclear why the Crested Eagle should have a nestling development period as long as these larger tropical eagles. Further data are needed in order to more confidently estimate the duration of the nestling period in *Morphnus*.

RESUMEN.—Se observó dos nidos de Aguila Monera *Morphnus guianensis* en Petén, Guatemala. Reportamos sobre el desarrollo comportamiento de un polluelo. También presentamos datos sobre el crecimiento y comportamiento de un juvenil en cautiverio. La juvenil silvestre, una hembra, eclosionó aproximadamente 28 Mayo, designado día 0. La primera vez que observamos el polluelo arreglarse las plumas fue en día 16; en día 17 defecó hacia la orilla del nido, y siempre lo hizo así después. Día 18 intentó pararse por primera vez, y en día 23 pudo pararse brevamente. En día 24 estiró las alas de manera estereotípica. A partir del día 25, respondió agresivamente cuando el macho trajo presa, y a especies tal como buitres. A partir del día 37 el polluelo logró pararse por un buen rato, y batió las alas en ejercicio. En día 59, logró alimentarse ella mismo por primera vez, y quedó parada por dos horas. Cuando el polluelo tenía 81 días, la hembra adulta empezó a ausentarse la mayor parte del día, supuestamente cazando, y trajo presas al nido periodicamente. A partir del día 93, el polluelo frecuentemente saltó, aleteando, de una orilla del nido a la otra, manejaba palitos del nido en su pico, y las atacaba con las garras como que fueran presa. Entre días 109 y 114, voló fuera del árbol del nido por primera vez, pero siguió regresando al árbol del nido para recibir presas. Usando radio-telemetría, seguimos la juvenil hasta 16 meses de edad, cuando terminamos el estudio. En aquella fecha, la juvenil quedaba todavía dependiente en los adultos. Hacemos comparaciones entre la rapidez de desarrollo del Aguila Monera, el Aguilucho de Penacho (*Spizaetus ornatus*), y el Aguilucho Negro (*S. tyrannus*). El desarrollo del juvenil de *Morphnus* fue lento en comparación con otros rapaces de igual tamaño.

[Traducción de los autores]

ACKNOWLEDGMENTS

This is an offering of The Peregrine Fund's Maya Project; we are grateful to the many individuals and foundations that provided funding for that project. We are grateful to Barbara Howard for providing records for Crested Eagles at the Oklahoma City Zoological Park and to R. Bierregaard, J. Bednarz, and an anonymous reviewer for helpful comments on the manuscript.

LITERATURE CITED

BIERREGAARD, R.O., JR. 1984. Observations of the nesting biology of the Guiana Crested Eagle (*Morphnus guianensis*). *Wilson Bull.* 96:1–5.

NEWTON, I. 1979. Population ecology of raptors. T. & A.D. Poyser, Berkhamsted, U.K.

SCHULZE, M.D. AND D.F. WHITACRE. 1999. A classification and ordination of the tree community of Tikal National Park, Petén, Guatemala. *Bull. Fla. Mus. Nat. Hist.* 41:169–297.

STARCK, J.M. AND R.E. RICKLEFS. 1998. Avian growth and development: evolution within the altricial-precocial spectrum. Oxford University Press, Oxford, U.K.

WHITACRE, D. F., J. LÓPEZ AVILA, AND G. LÓPEZ AVILA. In press a. Crested Eagle (*Morphnus guianensis*). *In* D.F. Whitacre (ED.), Raptors of the maya forest: ecology of a neotropical raptor community. Cornell University Press, Ithaca, NY U.S.A.

———, J.A. MADRID M., H.D. MADRID M., R. CRUZ E., C J FLATTEN, AND S. FUNES A. In press b. Ornate Hawk-Eagle (*Spizaetus ornatus*). *In* D. Whitacre (ED.), Raptors of the maya forest: ecology of a neotropical raptor community. Cornell University Press, Ithaca, NY U.S.A.

———, J. LÓPEZ A., G. LÓPEZ AVILA, S. FUNES AVILA, C J FLATTEN, AND J.A. MADRID M. In press c. Black Hawk-Eagle (*Spizaetus tyrannus*). *In* D. Whitacre (ED.), Raptors of the maya forest: ecology of a neotropical raptor community. Cornell University Press, Ithaca, NY U.S.A.

Received 2 December 2000; accepted 30 October 2001

J. Raptor Res. 36(1):81–84

SPRING WEATHER AND BREEDING SUCCESS OF THE EURASIAN KESTREL (*FALCO TINNUNCULUS*) IN URBAN ROME, ITALY

LUCA SALVATI[1]
Piazza F. Morosini 12, I-00136 Rome, Italy

KEY WORDS: *Eurasian Kestrel*; Falco tinnunculus; *breeding success*; *weather conditions*; *urban habitats*; *Mediterranean areas.*

The breeding biology of the Eurasian Kestrel (*Falco tinnunculus*) has been well-studied in northern and central Europe mainly focusing on the influence of prey fluctuations on clutch size and productivity (e.g., Village 1990, Plesnik and Dusík 1994, Valkama et al. 1995) as well as on the influence of weather conditions on timing of breeding (Kostrzewa and Kostrzewa 1990, 1991). In Mediterranean Europe, few studies addressed these aspects (Gil-Delgado et al. 1995) and relevant accounts on kestrel breeding success are by Rizzo et al. (1993), Gil-Delgado et al. (1995), Fargallo et al. (1996), and Avilés et al. (2000). Here, I provide data on the breeding success of kestrels in two different habitats of Rome, central Italy, through 5 yr. I studied between-year differences in breeding success in relation to spring weather and I compare my results with data collected 15 yr earlier from the same population (Sommani 1986).

STUDY AREA AND METHODS

I conducted fieldwork from March 1996–July 2000 in Rome, Latium, central Italy (41°53′N, 12°28′E). The area is characterized by developed areas, urban parks, open-lands (mainly dry pastures and cereal crops), and small oak woods (mainly *Quercus ilex*). The two census plots included one strictly urban area (inner city) and one suburban, built-up area (Appia Antica park). Breeding density was 1.9 pairs/km^2 (N = 86 pairs) in the urban area and 0.6 pairs/km^2 (N = 34 pairs) in the suburban area (Salvati et al. 1999). For census procedure to locate breeding pairs see Salvati et al. (1999, 2000).

Nests were monitored weekly from the pre-incubation period. Visits were increased to 2–3 d intervals during the nesting period. Laying date for each nest was determined by subtracting the mean incubation period of the species (28 d; Avilés et al. 2000) from the hatching date Hatching date was determined taking into account that all eggs hatch in 4 d (Avilés et al. 2000). Fledging date was defined as the first day when all fledglings leave the nest. Young generally stay for 5–10 d in the vicinity of the nest using perches previously frequented by the parents, but rarely come back to the nest during daylight (Komen and Myer 1989, Bustamante 1994). As the interval of nest visits was 2–3 d, an error of ±1 d should be assigned to fledging date. Clutch size and laying date were recorded for a subsample of breeding pairs, because many nests were inaccessible for an exact count of eggs or chicks during the early stages of breeding (Salvati et al. 1999). I measured percent egg productivity as the number of fledglings in a nest divided by the total number of eggs laid in that nest. Breeding parameters for the years 1979–85 were obtained through the same technique from Sommani (1986).

As weather variables, I used mean monthly rainfall and

[1] E-mail address: picoidesmajor@yahoo.com