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BREEDING OF THE GOLDEN-CROWNED KINGLET IN NORTHERN MINNESOTA

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During the summer of 1954 and 1957, and during spring and summer of 1955, 1956, and 1960, we studied the breeding biology of the Golden-crowned Kinglet (*Regulus satrapa*). This is apparently the first life history of this species ever completed. About 3788 h were spent in observation at the University of Minnesota's Biological Station at Itasca State Park, Minnesota.

Two pairs were intensively studied from the beginning of their first nesting cycle through the end of their second cycle (1955, 1956), two (1954, 1957) from incubation through the nestling period, and one (1960) through its first nesting cycle and part of the second. Spot observations were conducted daily at 12 other nests.

METHODS AND STUDY AREA

One of us generally observed activities at the nest from a blind, the other observed from the ground. We were in direct communication (talking or shouting distance) at each nest site during the period when kinglets started a second nest and still had nestlings in the first nest.

Kinglets allowed us to part branches and twigs hiding the nests from view to observe them from 30 cm away. All females at nests under intensive study allowed us to reach into the nest and pick them up. The female, and occasionally the male, visited us in the blind. When the adults blocked view of the nestling they were feeding, we could push them aside with a finger without unduly disturbing them. If they happened to be at the nest site when we weighed and measured eggs and nestlings, they flew into the blind, hopped around the scale, and even landed on us.

Nests under intensive study were observed from blinds on towers or tree platforms. Three nests were lowered from their original heights because it was not feasible to build towers or platforms high enough to observe them. (The distances lowered were 12.2, 3.04 and 1.82 m.) These nests were near the tree tops, so the tree was cut just below the nest site, and lowered to the desired height—as low at 2.7 m in one case. The first two nests were lowered at different increments over 3 days, but the third one was lowered only once. To retard drying out of foliage, the stem base was put in a bucket containing sand and water. In no case did nest-lowering disrupt the nesting cycle.

When the blind was on a neighboring tree, the tree top housing the nest was tied to the blind and pulled to within 30 cm. At the end of each observation period, these nests were untied.

All eggs, adults, and nestlings at nests under intensive study were marked with different colored acetate base paint. Adult females were

dabbed with a paint brush while they incubated or brooded the young; males as they fed mates or nestlings.

Eggs were marked and weighed a few hours after they were laid, and weighed again before they hatched to measure weight loss. Nestlings were marked in order to follow daily feather-tract development and weight gains.

Red squirrels (*Tamiasciurus hudsonicus*) were killed near nests under intensive study. They were the only rodents seen in the near vicinity of the nesting sites.

Habitat.—At Itasca, we found Golden-crowned Kinglet nests in spruce-tamarack bogs (14 nests), and in mixed stands (5 nests) dominated by balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), red pine (*Pinus resinosa*), with a few scattered tamarack (*Larix laricina*), paper birch (*Betula papyrifera*), aspen (*Populus tremuloides*), and jack pine (*Pinus banksiana*). A total of 49 days was spent locating nests (55% of our efforts in spruce-tamarack bogs and the remainder in the fir-spruce-pine habitat).

Three of the intensively studied nests were in the park. Prevalent in the understory were Bebb's willow (*Salix bebbiana*); bog birch (*Betula pumila*) (var.); red osier dogwood (*Cornus stolonifera*); and speckled alder (*Alnus rugosa*). The other three intensively studied nests were in the fir-spruce-pine habitat. Ground cover included blueberry (*Vaccinium angustifolium*); sourtop blueberry (*V. myrtilloides*); arrowwood (*Viburnum rafinesquianum*); serviceberry (*Amelanchier humilus*); spreading dog bane (*Apocynum androseamifolium*); and the common bracken fern (*Pteridium aquilinum* var. *latiusculum*). Dominant shrubs were honeysuckle (*Lonicera canadensis*), and wild sasparilla (*Aralia nudicaulis*). Black spruce (*Picea mariana*) were dominant in the bog study areas and ranged from 17–20 m in height. Tamaracks were primarily around the edges of the bog.

RESULTS

Vocalizations.—We found 3 major patterns or types of vocalizations of the Golden-crowned Kinglet during 5 seasons of study:

(1) Call notes
   A. Passive—1 to 5 "tse" notes on the same pitch.
   B. Active—same as "A" but louder, more rapid, and strident.
(2) Simple song—Series of up to 14 notes, with the first 2–5 on the same pitch, and the remainder ascending in less than half tone intervals; lasting up to 2 s.
(3) Complex song
   A. Included the simple song for the first part and a musical warble which dropped an octave or more in pitch for the second part; lasted up to 3 s.
   B. Same as "A," except the last part of the warble became chattery and harsh.
   C. Like "A," but much more melodious.

Passive call notes were used by the mating pair in (1) communicating with one another, (2) alerting the nestlings of their presence when the young failed to gape for food, (3) approaching the nest when feeding, and (4) locating and approaching fledglings for feedings. Active call notes were used when either adult was alarmed or distressed. They were used in the presence of avian and mammalian predators or cowbirds.

The simple song was used when a male kinglet proclaimed his territory directly to another male in a bordering territory. The female used the song to answer or call the male while she was on the nest or while she approached the nest from a period off the nest. Complex songs were used primarily for proclaiming territory, but were also used when red squirrels and Blue Jays (*Cyanocitta cristata*) were in the vicinity of the nest or near fledglings. Both sexes used the song during nest construction, especially when one bird was working materials into place, while the other was approaching the nest, or while it was awaiting its turn to get on the nest with nesting material. Complex song was often interspersed with simple song.

Singing was fairly constant during the nestling period and after the young fledged (first nesting). During late July and early August, less territorial singing took place, and the singing that was done seemed primarily for locating and feeding fledglings.

In comparing the amount of vocalizing done during different periods of the nesting cycle, the least amount took place during egg-laying; the most during incubation.

Territoriality.—Territory dimensions were determined by following the singing male and mapping his song perches. Lines connecting the outermost points were measured with a steel tape. Eleven territories were measured during our study. These measurements were then plotted on a map, and the enclosed area measured by dividing the areas into triangles and calculating their sizes.

Territories ranged in size from 0.9–2.5 ha, averaging 1.6 ha. The pair that maintained the largest territory (2.5 ha) had no competing kinglets bordering its territory.

Defense of the territory against invaders of its own species was performed primarily by the male, mainly through song. Physical combat between neighboring territorial males was observed only once.

Interspecific aggressive behavior was noted with the Blackburnian Warbler (*Dendroica fusca*), Black-throated Green Warbler (*Dendroica virens*), and Chipping Sparrow (*Spizella arborea*). These birds had nests within the territories of kinglets. Black-capped Chickadees (*Parus atricapillus*) and Boreal Chickadees (*P. hudsonicus*) were chased by both male and female kinglets when they landed on the kinglet's nesting tree.

Nest building.—At Itasca, Golden-crowned Kinglets regularly built 2 nests and raised 2 broods during a breeding season (we observed 15 nesting pairs). The Goldcrest (*Regulus regulus*) of northern Europe, considered conspecific with the Golden-crowned Kinglet, also has 2 broods in Fennoscandia (Palmgren 1932) and Norway (Haftron 1978a).

The average height of 19 nests we found in Itasca State Park was 15.3 m (range 8.2–19.6 m). Four were in white spruce, 3 in balsam fir, and 12 in black spruce (*Picea mariana*). All nests in black spruce and balsam fir were in the upper tree crowns, a few centimeters from the trunk. All but one of these nests rested on radiating twigs supported by branches which had been incorporated into the walls near the nest rim. The exception had no basal support; it was supported by twigs on the rim. Three nests in white spruce were suspended by the rims on radiating twigs, with no basal support.

If kinglets displayed a preference toward a compass point when building nests, it was to the east or southeast (11 nests east; 6 southeast; 1 southwest; 1 northwest). Prevailing winds at Itasca are westerly. All east and southeast nests on the leeward side were high in tree crowns. The nest on the exposed northwest side was lowest, and was only 5 m east of a windbreak of tall balsam fir.

All nests were so well protected by overhanging foliage that they weathered wind and rain and were never reached by sun. Haftron (1978b) found that during periods of heavy and/or long-lasting rain, the Goldcrest's nest cup sometimes gets wet. This was not so with kinglet nests. Even with torrential rains accompanied by strong winds, the nest remained dry. By nesting a few centimeters from the trunk in the black spruce and balsam fir, kinglet nests were free from any rain that might trickle down the trunk. The foliage was generally so dense around nests that they could not be seen from above or from nest level. We always had to part some of the twigs to observe nest activity. The 3 nests in white spruce trees were on the underside of long branches near the tips. They, too, were completely hidden from view from the top or at nest level, but could be partially seen from below.

The earliest nest building we observed was 18 May 1956. Robie Tufts found 2 nests just started in Nova Scotia, 10 April 1921, and Cordelia Stanwood found a half-finished nest near Ellsworth, Maine, 25 April 1912 (Bent 1949).

We collected 19 nests and found them to be made primarily of common locally available materials. Most nests contained lichens (*Parmelia sulcata, P. phypodes,* and *Usnea* sp.) scattered through the inner, bottom, and outer walls. The interior bases of the nests were lined with fine strips of paper birch bark, moss, lichen, deer hair, and feathers. The outer walls consisted chiefly of mosses (*Brachythecium solebrosum* and *Hypnum* sp.), spider web, cotton from cotton grass, parts of insect cocoons, and some unidentifiable brown-colored stringy-stretchable material.

Kinglet nests are deep cup-shaped, with the rims slightly arched inward. The nesting cavity is almost circular. Table 1 shows the mean nest dimensions for 5 nests before the eggs hatched and after the nestlings fledged. Five nests averaged 5 days to complete (range 4–6 days).

Contrary to Haftron (1978c), we observed courtship feeding on several occasions during nest construction. The male approached with food while the female was on the partially-completed nest; she responded by

TABLE 1. Mean dimensions for five Golden-crowned Kinglet nests shortly before the eggs hatched and after the nestlings fledged (cm).

	Before	After
Inside diameter	4.1	5.5
Outside diameter	7.5	9.7
Inside depth	4.0	3.2
Outside depth	7.7	5.1
Wall thickness	1.95	1.3

fluttering her wings and begging for food. She also pursued him in the neighboring trees around the nest, fluttering and gaping for food, while he gathered it. He would then turn and feed her.

Coition took place throughout nest building and the period of egg laying. The female instigated it by flattening out in the partially constructed nest or on twigs close to the nest while uttering call notes interspersed with the complex song. Her mate responded by singing a series of complex songs before mounting.

Eggs.—Six eggs in one of our nests averaged .59 g the day before they hatched (range .48–.66). Six eggs in another clutch, weighed immediately after the last egg was laid, averaged .77 g (range .59–.82 g). Five of these eggs averaged .63 g (range .25–.78) 14 days later. There was an average weight loss of .077 g. (The sixth egg did not hatch and weighed .27 g.) Haftron (1978d) weighed 13 fresh eggs of the Goldcrest and found a mean weight of .79 g.

Eight clutches (which were known to be complete) contained 9 eggs in the first nest. Of 6 complete second clutches, 4 had 9 eggs and 2 had 8 eggs. Haftron (1978c) concluded that 9.7 eggs is probably fairly close to the mean clutch size for the Goldcrest in northern Europe as a whole. This compares with 8.85 eggs (per 1st and 2nd clutch) for 14 nests of the Golden-crowned Kinglet at Itasca State Park.

Initiation dates for first clutches ranged from 12 May 1955 to 27 May 1960. The earliest date for the start of the second clutch (among those that were successful with their first clutch) was 22 June 1960; latest 1 July 1956.

Kinglets lay eggs early in the morning (between midnight and 0400 in 2 cases) on successive days until the clutch is complete. Haftron (1978c) found Goldcrest eggs were laid early in the morning on consecutive days. He learned the exact time of laying of 3 eggs on 1–3 July 1971 was 0249, 0246, and 0258.

Incubation.—Incubation was performed by the female only. All her nights were spent on the nest after the first egg was laid. Haftron (1978b) also found this true for the Goldcrest.

Through incubation, one female kinglet spent an average of 71% of her time each day on her first nest (nocturnal incubation not included). She began spending time on her eggs in the second nest after the seventh

egg was laid, and thereafter was on that nest 82% of the time. The average lengths of time per attentive period were 6.5 (range 4–38 min) and 6.3 min (range 2–22 min) respectively.

Weather conditions influenced attentiveness during incubation. Greatest attentiveness (81%) occurred when it had rained throughout the observation period (temperature 18°C). Least attentiveness (47%) occurred during the hottest day (temperature 35°C).

In 1955 a female began spending time on the nest after her second egg of a 9-egg clutch was laid. Five of the eggs hatched 19 days later; the remainder hatched over the following 3 days. A first-nesting female started incubating after her last egg (ninth) was laid, and the first 3 eggs hatched 15 days later; the remainder hatched over the next 2 days. A third female, second nesting, began incubating after the seventh of 8 eggs was laid.

No attentiveness was observed during either nesting cycle in 1956 until the last egg was deposited. At the first nest the first egg hatched 15 June, and the last 16 June, giving an incubation period of from 14–15 days. Using Nice's (1954) formula—the time from laying the last egg to the hatching of the last young—the incubation period would be 15 days. In her second nest, this same female kinglet was attentive 70% of the time after her seventh egg was laid 5 July. Her first egg hatched 20 July and the last one 21 July. Again, the incubation period would be 15 days. Haftron (1978a) found the Goldcrest's incubation period to be approximately 16 days for 3 clutches of eggs, and Palmgren (1959) states it is 15 days.

Female kinglets are very restless during incubation; changing directions every few seconds by turning from quarter to full turns or more. However, they will remain still for several minutes and even doze off to sleep.

During the first nesting of a pair, the female came in with a load of insects to "feed" her eggs on the 12th day of incubation. She repeated that type of behavior on the 12th and 13th day during second nest incubation. She shook the nest by alternately stamping her feet on the rim of the nest, as is typical of birds at nests with young. She gave rapid call notes; finally she ate the food. Haftron (1978a) also observed a female Goldcrest, who was incubating eggs in one nest and intermittently feeding young in another, trying to get her eggs to respond to food.

Hatching.—Hatching dates ranged from 4 June to 20 July. Eggs hatched at any time during day or night. In one nest 7 eggs hatched at 0805, 0837, 0939, 1250, 1355, 1505, and 1529. The eighth egg hatched the following day at 1530. In another nest all eggs hatched during the night and before 0700 on two consecutive days.

Egg shells were either eaten or removed by both parents. Unhatched eggs were never removed from the nest as far as we know. Eggs disappeared, but whether they hatched and the nestling died (and was then removed) was not known.

Nest stretching.—Nest stretching took place throughout incubation and

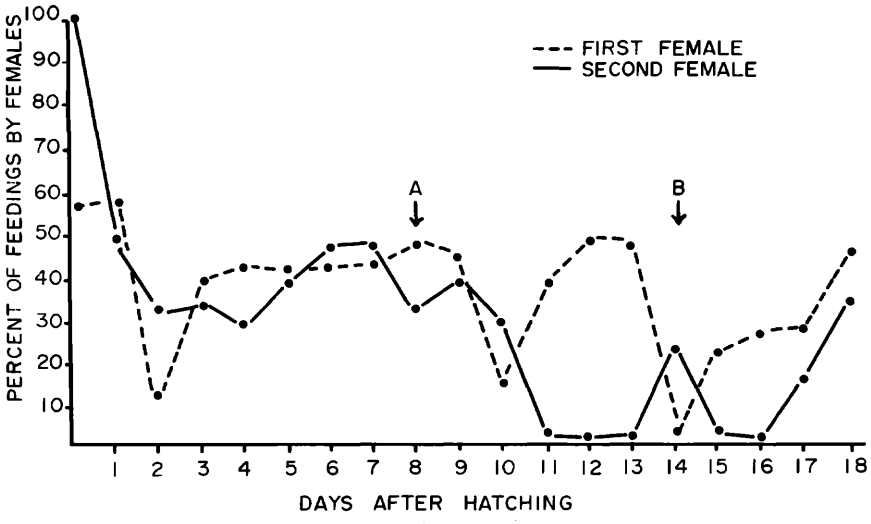

FIGURE 1. Comparative feeding by two first-nesting Golden-crowned Kinglet females. (A) indicates start of building of the second nest by both females. (B) indicates 1st egg laid in second nest of both females.

the nestling period and was done entirely by the female. One female (1956) stretched her nest beyond its limits. By the 24th day a hole appeared in the bottom of the nest, large enough for nestlings to fall through (oldest nestlings were 9 days old). The nest was 17.3 m from the ground, hanging like a pendulum from the underside of a black spruce that had no basal support. Three nestlings fell through the hole; 2 landed on limbs below the nest and the third on the ground. We patched the nest and returned the 3 that had fallen out. All nestlings survived and eventually fledged.

Feeding of nestlings.—Both parents fed nestlings, with the male doing the greater share early in the first nesting cycle, while the female spent part of the time brooding (male 62.5 and female 37.5%). When the nestlings were no longer brooded, her feeding visits increased. The female again fell behind when she started building her second nest (Fig. 1). Haftron (1978a) found that the male Goldcrest brought far more food to the young throughout the nesting cycle than the female. We observed this to be true of male kinglets.

Spiders were not accepted for food by the young. They were partially swallowed; then regurgitated. When this occurred, the parents tried to feed the spiders to other nestlings, who also rejected them.

The largest number of feeding visits made by a female during a 17-h period was 329 when her oldest nestlings were 14 days. She was taking care of the young by herself. The smallest number was zero while she built a second nest.

Two pairs started building a second nest 8 d after eggs began hatching

in the first nest, and laid eggs 6 d from the start of second nest construction (second nests were completed in 5 d; males did little work).

The first female greatly reduced her feeding visits 2 d after she began her second nest and again when she laid the first egg (Fig. 1). The second female greatly reduced her feeding visits on the third, fourth (no visits), and fifth days after beginning second nest construction, and again when her first egg was laid (Fig. 1).

Since both females left most of the feeding duties to their mates after they began building their second nests, overall low feeding percentages were to be expected.

Ambiguous behavior while attending temporally overlapping nests.—After one female kinglet began construction on her second nest, she showed ambiguous behavior between working on her new nest and feeding the young in the old nest. This was first observed on the fifth day of construction when she was lining the new nest. On 3 visits she fed the young nesting materials (deer hair, moss, lichen). The following day after she had deposited one egg in the new nest, she made 16 visits to her nestlings at the first nest, and on 4 of those she fed them nesting materials (feather, moss, lichens). She also removed deer hair, down, and moss from around the nestlings and stuffed it into the mouths of 2 nestlings who swallowed it. This type of behavior continued for 2 more days. Twice before her second nest was lined, she arrived with her bill loaded with insects and incorporated them into the nest wall.

Food.—During the nesting cycle, Golden-crowned Kinglets gathered food by foraging almost exclusively among the spruce, fir, and pine branches. We removed samples of insects from the bills of 2 pairs of adult kinglets before they fed nestlings. Alvah Peterson examined the collected matter (Table 2).

The food collected from the kinglets during the first nesting differed decidedly from that of the second brood. The kinglets must have collected what was readily available.

When one female shared feeding duties with her mate, she brought in tiny insects (winged and wingless), larvae, and some moths. After he disappeared, she brought primarily large Phalangida (daddy longlegs) and moths until the young fledged 5 days later, food items that, apparently, were most abundant and readily available in the immediate nesting area, but which probably had little food value since only 3 of 9 fledglings survived (Table 3).

Which nestling gets fed first.—Both parents tended to feed nestlings that were nearest to them. Of 294 feeding visits made by both parents to one nest over a period of 16 h, the nearest nestling was fed first 123 times; the farthest, 56 times; middle ones, 46; and others, 69 times.

In one nest after the male disappeared and the female assumed the exclusive role of feeding 9 nestlings, the "runt-of-the-litter" was crowded over to the opposite side of the nest from the approaching female and was seldom fed. Once it received no food for over a 3½ h period. It starved 2 days after the male disappeared, and was pushed to the nest

TABLE 2. Examples of food collected by two pairs of Golden-crowned Kinglets.

Food	Number			
	Larvae	Pupae	Nymphs	Adults
Insects				
Aphididae	9			12
Caddis fly				2
Chrysopidae	2			
Coccinellidae	6	1		
Corrodentia			3	2
Culicidae				1
Geometridae	11			
Hemiptera			2	
Lepidoptera		1		
Tipulidae				1
Lycaenidae	1			
Membracidae				1
Midge (*Chironomus*)				1
Miridae			1	
Pamphiliidae	1			
Phalaenidae	10			
Psocid			5	
Pupa (unknown)		1		
Syrphidae	15			
Trichoptera				1
Spiders (unknown)				5
Arachnida (long-legged) (*Tetragnatha elongata*)				2 1

bottom and trampled on by the other nestlings. When the male was still helping to feed nestlings, the female was observed digging the "runt" out from the bottom of the nest twice when it was 2 days old; twice at 5 days; once when it was 8 days.

TABLE 3. Number of Phalangids and insects fed nestlings by a female Golden-crowned Kinglet (male feeding included in parentheses for 18 July only).

Date	Time	Number of			% of Phalangids and moths in total feedings
		Phalangids	Moths	Other insects	
18 July[a]	0430–2030	1 (0)	18 (12)	269 (240)	6.5 (4.8)
19 July	0700–2000	121	55	134	56.7
20 July	0700–1600	191	36	136	62.5
21 July	0400–2100	271	58	265	55.4
22 July	0400–1200	141	22	143	53.3
23 July[b]	0700–1130	58	11	116	37.3

[a] Last day both parents fed nestlings.
[b] Nestlings fledged.

Nestling development.—Kinglets are completely naked when they hatch, except for tufts of down above the eyes and on the crown. They are about 2.6 cm long and have flesh-colored skin.

When nestlings are two days old, they emit their first sound ("tseek"), which is barely audible. At four days there is a trace of eye-opening. Sheaths begin to form on the sixth day. The first signs of feathers appear on the primaries, secondaries, and rectrices on the ninth day. Eyes are completely open on the twelfth day. They begin crawling in and out of the nest on the sixteenth day.

Nestlings weighed in 1956 gained from 5–7 times their hatching weight by the seventh day after hatching. The first nestling more than doubled its weight by the second day after hatching. The lightest nestling on the first day of hatching (.73 g), surpassed the weight of the heaviest one (1.03 g) on the seventh day after hatching.

Fledgling behavior.—About 2 days before the nestlings fledged, they crawled to and from the neighboring twigs and branches 30–60 cm away. After the first young fledged, within a matter of minutes, the remaining nestlings left the nest.

In 6 nests where nestlings were observed to fledge, the shortest time for the nest to empty was 15 min; the longest, 105 min. All young fledged before noon (the earliest at 0640, the latest, 1157). One nestling flew from a nest at 1639, just as the branch was moved to expose the nest for observation. However, the following morning, this nestling was back in the nest.

The majority of Golden-crowned Kinglets left the nest between 16–19 days after hatching. Of 46 nestlings whose ages were known, 2 fledged at 14 days, 2 at 15, 12 at 16, 2 at 17, 8 at 18, and 20 at 19 days. At one nest where nestlings fledged at 15–16 days old, they had been taken from the nest daily to check weight and feather tract development until they were 9 days old, and at 14 days for experiments; disturbances which may have triggered an earlier than normal departure. At another nest where nestlings fledged between 18–19 days, they were not handled as much nor as late in the nestling period. Haftron (1978a) found the nestling period for a pair of Goldcrests who double-brooded to be 17–22 days.

When the young left the nest, they flew horizontally to a tree 3–4 m from the nest, where they "tsipped" loudly and incessantly. Until all young had left the nest, both parents split feeding duties between the fledglings and the young still remaining in the nest, but tended to favor the nestlings with more feeding visits. Usually, within 1–2 h, the fledglings found one another by "tsipping," and they then gathered on the same limb in a tight row, spending most of their time preening between feeding visits by their parents. They were not observed preening one another.

Both adults fed fledglings the first day out of the nest, but thereafter, with the first brood, feeding was done almost exclusively by the male because the female was incubating on the second nest. Haftron (1978a)

found the same to be true with the Goldcrest. Kinglet eggs in the second nest hatched about the time the fledglings from the first nest became independent, enabling both parents to care for the newly hatched nestlings in the second nest. Twice for Goldcrest in Norway (Haftron 1978a) and once in Finland (Palmgren 1932), the first egg was laid in the second nest 3, 10, and 12 days respectively, before the first brood had left the nest. Goldcrest parents had to split their duties between the care of nestlings and fledglings.

Kinglet fledglings remained close to each other for the first 3–4 days after fledging. One family remained within 120 m of the old nesting site for the first 11 days out of the nest. They could easily be located within their territory, because while they perched on the same limb (about 10 m or more from the ground), they constantly "tsipped" while waiting to be fed.

Periodically, the male left his fledglings and fed his mate while she incubated at the second nest. She seldom visited the fledglings, but foraged for food nearby. After the nestlings fledged in the second nest, both parents shared almost equally in the feeding duties.

On the fifth day out of the nest, fledglings made their first attempts to get their own food by pecking in the foliage. (It took longer when nestlings fledged prematurely.) There was an increase in calling, not only among the fledglings, but also between them and the adults. The "tsipping" of the fledglings was almost like an adult "tse," but not quite so clear. The first signs of warbling took place, but the "tsees" and warble were run together.

Between the eighth and eleventh day out of the nest, the amount of foraging done on their own increased; they spent more time accompanying the adult while it foraged for their food.

Fledglings, between 12–16 days out of the nest, gathered a good deal of food for themselves, but still energetically pursued the adults for food. Their tails were sufficiently developed so that they were almost as capable of hovering in mid-air and maneuvering in flight as the adults. No feeding of fledglings by adults was observed after the young had been out of the nest 16–17 days.

Territorial singing largely ceased and territory boundaries faded after the nestlings in the second nest fledged.

Predation.—Predators most likely to find kinglet nests and destroy eggs or young were red squirrels, Blue Jays, and Gray Jays (*Perisoreus canadensis*). One raptor frequently seen in kinglet territories that might have been a threat to adult kinglets was the Sharp-shinned Hawk (*Accipiter striatus*).

One pair lost its nest to a predator after we had lowered it from 17.8 m to 2.4 m above the ground. Two red squirrels were feeding on cones 6 m away when we approached the nest to start our daily observations.

Another pair whose nest was lowered from its original height almost lost their second brood of 9 nestlings to red squirrels on several occasions. We shot 4 squirrels just as they were about to enter the nest. Two

other squirrels were killed when they leaped from the nesting tree to a neighboring one.

In another nest, Gray Jays were the prime suspects in killing 5 of 7 nestlings (the oldest being 16 days). As we were leaving our tree platform for the day, a flock of 7 Gray Jays invaded the area near the nest and were attacked by the adult kinglets. When we returned to the blind the next day, a dead, partially eaten young was in the nest. On a limb 3 m below the nest were two more partially eaten nestlings. A fourth dead nestling had been forced into a crack in the tree trunk .6 m below the nest. A fifth dead, partially eaten nestling was discovered in the moss 17.3 m below the nest. The last two escaped and were perched about 13 m up in a spruce, where the parents were feeding them.

Nest desertion.—Of the three desertions out of the 19 nests under study, all were apparently due to our activities. Two were during nest construction and one after the seventh egg was laid.

Nest success.—From 12 kinglet nests which contained a total of 102 eggs, 76 eggs (74%) hatched. Of 76 nestlings in 10 nests, 13 were taken by predators and 1 starved—a nestling success of 83%. Of 62 nestlings that fledged, 44 from 6 different families were followed; 38 reached the age of independence—a fledgling success of 86%.

The most frequent causes of reproductive failure among kinglets were predation, starvation, and failure of eggs to hatch. Starvation appeared to be the cause for the deaths of 6 nestlings in one nest where the female had to assume the feeding duties alone. Predators raided two nests and ate 13 of the 16 nestlings in them. Females of 2 different nests disappeared during the incubation period, leaving 2 clutches of 9 eggs each. Eight eggs in 6 different nests failed to hatch.

One egg that cracked contained a dead young which was not removed during our observation period, but the following day it was gone. Kinglets removed dead nestlings, but not unhatched eggs. However, when a 13-day-old nestling starved in another nest, the female made no attempt to remove it (the male had disappeared). The remaining 8 nestlings had outgrown the nest and spent most of the time in 2 or 3 tiers, completely covering the dead nestling.

Five young from one family died on the first day they fledged. They could not fly well enough to remain in the trees and were ignored by the adult female when they became grounded. (The adult male had disappeared during the latter part of the nestling period.) Starvation was believed to be the cause of their deaths.

Haftron (1978d) found that of 25 Norwegian Goldcrest nests, all containing eggs or young, 9 were robbed by predators or abandoned for unknown reasons. He did not record the clutch size nor the exact losses of eggs and young. By assuming a mean clutch size of 9.8 eggs (based on 13 Norwegian clutches known to be complete) and supposing that even from successful nests an average 2 eggs or young were lost, Haftron came up with a 50% fledging success.

We suspect that red squirrels, in Itasca, are the main predators of

Golden-crowned Kinglets and we strictly controlled the numbers of these rodents. We also saved nestlings that had fallen through nest bottoms. The success of reproduction for the Golden-crowned Kinglet is thus not likely as high as we observed compared to strictly natural conditions.

SUMMARY

We studied Golden-crowned Kinglets at Itasca State Park, Minnesota, in the summer of 1954 and 1957, and during the spring and summer months of 1955, 1956, and 1960. Nineteen nests were discovered, 18 of which contained eggs or young. It took about 5 d to build a nest. Nine eggs were laid in the first nests and 8 or 9 in the second. Incubation took approximately 15 d. Food consisted primarily of insects in various stages of development. We observed 44 of 62 nestlings that fledged and found an 86% success rate.

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