common shortly after hatching and more frequent on small breeding territories than on larger ones (Hunt and Hunt 1976). In our study, the high incidence of young, dead chicks near their own nest at the Lighthouse suggests a higher risk there due to neighbor proximity. This is consistent with the observation that gulls nesting at high density fledge (on average) fewer chicks than pairs in low density areas (Butler and Trivelpiece 1981). However, while neighbor-interference was less frequent among the lower density Canada Furnace pairs, the pairs there apparently suffered excessive loss of mobile chicks because of easy access by humans and dogs to the mainland nesting location.

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Nest-site selection and breeding biology of the Chipping Sparrow.—Despite its extensive breeding range (Godfrey, The Birds of Canada, Natl. Mus. Can. Bull. 203, 1966) and frequent habit of nesting in man-made clearings, few studies of the breeding biology of the Chipping Sparrow (*Spizella passerina*) have been published. This study examines several aspects of Chipping Sparrow biology (e.g., chronology of the nesting cycle, breeding success, and nestling growth), and emphasizes relationships between nesting success and components of nest-site selection, such as nest height and orientation.

Study site and methods.—The study was done from 25 May–15 July 1981 and 25 May–8 July 1982 in Algonquin Provincial Park, Nipissing District, Ontario. Algonquin Park lies on the southern edge of the Canadian Shield in a transition zone between conifers typical of more northerly regions and southern hardwoods. White spruce (*Picea glauca*), white pine (*Pinus strobus*), and balsam fir (*Abies balsamea*) are dominants in the study area (see Maycock, Ecology 37:846–848, 1956, for a complete description of the local vegetation).

We located nests by observing adults during nest construction and by searching in suitable habitats. Nests were visited daily between 17:00 and 20:00. In 1981, nestlings were marked on their tarsi with a felt pen for individual identification, and each day we measured nestling weight, tarsus length (from tibiotarsus-tarsometatarsus joint to hallux), bill length (from anterior edge of nares to tip of culmen), and bill width (at anterior edge of nares). Adult measurements were based upon 30 specimens from Ontario in the collection of the Royal Ontario Museum (no difference between the sexes).

After the young had fledged, the heights of the nest and nest tree were measured or estimated, and orientation of each nest (i.e., the side of the tree in which it was built), was recorded. The nest was then collected and its composition analyzed.

For each nest, the percentage cover of each plant species within 1 m of the nest (including nest tree) was estimated. Nearby trees were characterized by the point-quarter method (Smith, Ecology and Field Biology, 3rd ed., Harper and Row, New York, New York, 1980). Within each quadrant, the distance from the nest to the nearest tree over 1 m tall was measured, the tree identified, and its height measured or estimated. (The nest tree was not included in the analysis.) A minimum height of 1 m was used because this was the lower

TABLE 1
VEGETATION AT CHIPPING SPARROW NEST-SITES

Tree species nearest to nests[a]	No. quadrants[b]	% frequency
White spruce (*Picea glauca*)	38	45
Trembling aspen (*Populus tremuloides*)	9	11
Balsam fir (*Abies balsamea*)	7	8
White pine (*Pinus strobus*)	7	8
Choke cherry (*Prunus virginiana*)	7	8
Red pine (*Pinus resinosa*)	4	5
Red maple (*Acer rubrum*)	2	2
Sugar maple (*Acer saccharum*)	2	2
Total	76	89
Plant species with the highest mean percent covers within 1 m of nests[c]	**Mean % cover**	**% frequency**
White spruce	39	91
Grass species (mostly *Danthonia spicata*)	20	82
Hairy-cap moss (*Polytrichum* sp.)	9	45
Blueberry (*Vaccinium angustifolium*)	6	45
Red pine	6	6
Balsam fir	5	14

[a] The following occurred in one quadrant only: *Alnus rugosa, Amelanchier* sp., *Betula papyrifera, Corylus cornuta, Pinus banksiana, Salix* sp., *Sambucus pubens,* and unidentified dead. In four quadrants there were no trees within 100 m of the nests.

[b] Four quadrants/nest.

[c] Mean percent of bare ground was 5%, and its percent frequency was 23%.

limit to heights of nest trees in this study, i.e., trees taller than 1 m were considered potentially suitable for nesting.

Nestling growth rates are described quantitatively using the method of Ricklefs (Ecology 48:978–983, 1967). All means are given ±1 standard deviation (SD). Statistical significance was set at $P < 0.05$.

Arrival on breeding grounds, pair formation, and nest initiation.—The first Chipping Sparrows were noted in Algonquin Park during the last week of April each year (pers. obs.; R. G. Tozer, pers. comm.). Most of the population arrived during the first week of May, at which time males were seen singing from conspicuous perches, usually in white spruce or balsam fir.

Territorial disputes occurred frequently in mid-May but declined progressively thereafter. Disputes included chases during which resident males sang short phrases in flight as they closely pursued conspecific intruders. By late May most adults were paired and spent considerable time foraging on the ground along the edges of wooded areas, gravel roads, and parking lots.

We observed 15 copulations, all of which occurred on tree branches. In contrast, Walkinshaw (Wilson Bull. 56:193–205, 1944a) reported that copulation generally occurred on the ground. On two occasions copulation immediately followed territorial disputes, with the resident male returning to his mate after chasing away an intruder.

The modal date of nest initiation, calculated by direct observations or back-dating, was

TABLE 2

CLUTCH-SIZES AND NESTING SUCCESS OF CHIPPING SPARROWS

	1981	1982	Combined	P
Clutch-size $\bar{x}$	3.8	4.3	4.0	NS[a]
SD	0.6	0.5	0.6	
N	10	7	17	
range	3–5	4–5	3–5	
% eggs hatched[b]	65.4 (36/55)	80 (24/30)	70.6 (60/85)	NS[c]
% nests hatching ≥ 1 young	66.7 (10/15)	85.7 (6/7)	72.7 (16/22)	NS[c]
% young fledged of those hatched	72.2 (26/36)	100 (24/24)	83.3 (50/60)	<0.005[c]
% nests fledging ≥ 1 young	53.3 (8/15)	85.7 (6/7)	63.6 (14/22)	NS[c]

[a] Mann-Whitney *U*-test.

[b] Losses due to predation.

[c] *G*-test.

31 May. This date calculation includes our data and an additional 15 Chipping Sparrow nests from Algonquin Park (Ontario Nests Records Scheme). A few nests which were started through early July presumably were replacement clutches; we have no evidence of double-brooding.

Nest-site selection.—Nineteen of the 22 nests (86.4%) were placed in white spruce, and one each was in eastern hemlock (*Tsuga canadensis*), balsam fir, and red pine (*Pinus resinosa*). Although white spruce also predominated in the sample of tree species nearest the nest tree (Table 1), its frequency of occurrence was only 45.2%. The difference between frequency of occurrence of white spruce and its use as a nesting substrate by Chipping Sparrows was significant ($G = 12.49$, 1 df, $P < 0.001$). The analysis assumes that the trees around nests are a random sample of trees in the immediate area. Thus, the birds selected white spruce as the nest tree, rather than nesting in species of trees according to their relative abundance in the immediate habitat.

The median height of nest trees was 2.5 m (range = 1.1–13.7 m). This height did not differ significantly from nearby trees (Mann-Whitney *U*).

The most common trees in the vicinity of nests and the dominant plants within 1 m of nests (Table 1) are typical early secondary successional species in well-drained areas in Algonquin Park. These species are characteristic in areas which have been disturbed by fire (Martin, Ecol. Monogr. 29:187–218, 1959), as well as by man. This supports the idea that the dramatic increase in edge habitats and open areas associated with European man's arrival in North America may have permitted Chipping Sparrows to greatly increase in numbers (Stull, U.S. Natl. Mus. Bull. 237, Pt. 2, 1968:116).

The mean height of nests was 1.1 ± 0.6 m (range = 0.4–2.5 m), which generally agrees with findings of others (e.g., Stull 1968; Tate, Diss. Abstr. Int. 34B:1982–B, 1973; Buech, J. Field Orn. 53:363–369, 1982).

Nest characteristics.—Nest construction required 4 days. Although we did not make detailed observations on division of labor, both sexes in each of two pairs were seen gathering material and incorporating it into their nests. In contrast, Stull (1968) and Walkinshaw (1944a; Bird-Banding 23:101–108, 1952), reported that only females built nests. Furthermore, in other species of *Spizella,* only females have been observed building the nest (e.g.,

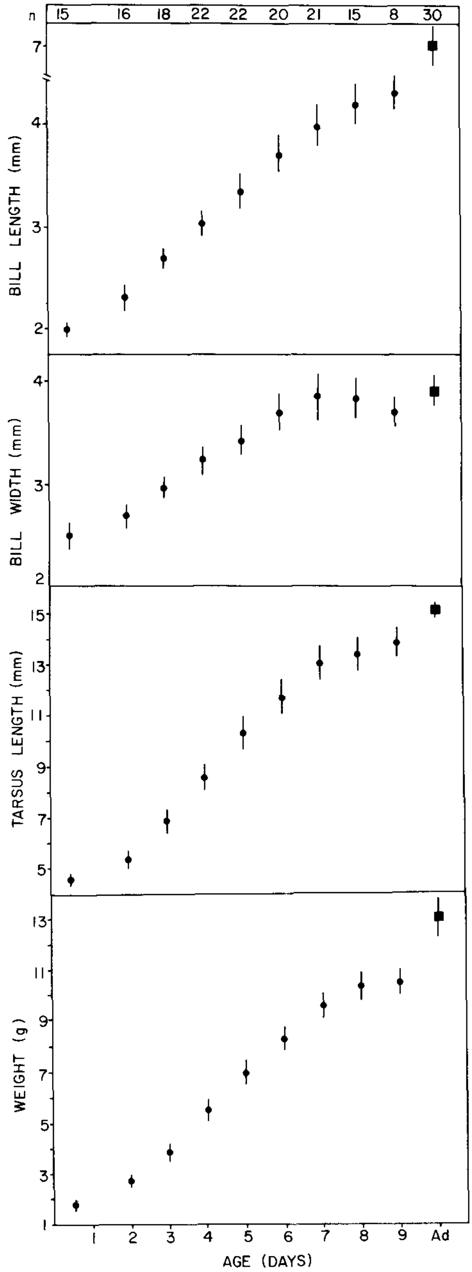

FIG. 1. Growth of nestling Chipping Sparrows. Means are given ±1 SD; sample sizes are given across the top of the figure. Measurements of 30 adults (Ad) are included for comparison.

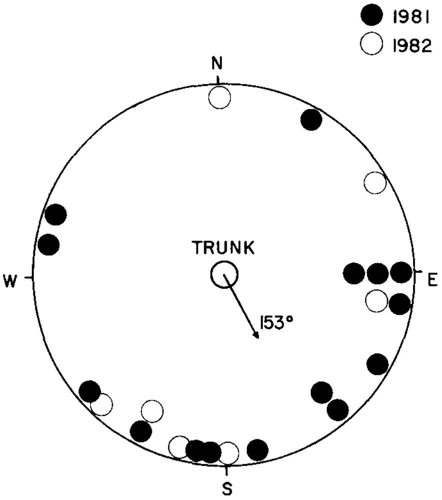

FIG. 2. Orientations of Chipping Sparrow nests around the nest trees. The central vector shows the mean orientation.

Clay-colored Sparrow [*S. pallida*]; Walkinshaw, Jack-Pine Warbler 22:120–131, 1944b). The extent of the male Chipping Sparrow's contribution to nest-building requires further clarification.

The outer cups of nests were composed of stems of grasses and other plants, and small roots. Nests were generally lined with fine roots and small amounts of animal hair. Four nests were lined almost exclusively with bright, golden-colored sporophyte stalks of moss (*Polytrichum* sp.).

Clutches.—The first egg was laid the day after nest construction was finished, and one egg was laid daily until the clutch was completed (see also Walkinshaw 1944a, 1952). The mean clutch-size was 4.0 ± 0.6. Clutch-sizes in 1981 and 1982 were not significantly different (Mann-Whitney *U*; Table 2).

The incubation period, defined as the interval from laying the last egg to hatching of the last young, was 11–12 days, a value consistent with the findings of Dawson and Evans (Physiol. Zool. 30:315–327, 1957), and Walkinshaw (1944a). In some nests, all eggs hatched within a few hours of each other; in others, hatching was spread over 24 h. Asynchronous hatching also was noted by Walkinshaw (1944a).

Nestling growth.—At hatch nestlings weighed 1.2–1.4 g. Nestling weight, tarsus length, and bill length and width grew in sigmoid fashion (Fig. 1), a pattern typical of most avian species (Ricklefs, Ibis 110:419–451, 1968).

The value of the growth curve index, k (Ricklefs 1967), for weight gain was 0.542. This value closely resembles the rate constants calculated by Ricklefs (1968), who reported k = 0.536 for Weaver's (Auk 54:103–104, 1937) New York study, 0.552 for Walkinshaw's (1944a) Michigan study, and 0.544 for Dawson and Evans' (1957) Michigan study. Relative to other avian species (c.f. Ricklefs 1968), there appears to be little geographic variation in the growth rate of Chipping Sparrows in northeastern North America.

Most young fledged at 9 days (±1 day) of age. Weight, tarsus length, and bill width of fledglings can be compared with adult measurements in Fig. 1. Human disturbance of the nestlings may lead to premature fledging (Walkinshaw 1944a, Dawson and Evans 1957, Stull 1968). However, the various body dimensions reported were all asymptotic by day 8 or 9, so although the natural fledging age may be a day or two later, these measurements still represent true fledgling size.

Nest orientation and nest success.—In Algonquin Park, 77% (17 of 22) of nests were situated on the south or east sides of the trees (Fig. 2). The average orientation was 153.3° with an angular deviation of $s = 63.7°$ (Batschelet, Circular Statistics in Biology, Academic Press, New York, New York, 1981). This degree of concentration was statistically significant ($r = 0.382$, Rayleigh test), and there was no significant difference in mean orientation between years (Mardia-Watson-Wheeler test, Batschelet 1981). There were no directional biases with respect to distances from nests to nearest trees (mean distance = 1.9 ± 1.6 m, N = 22, Mann-Whitney *U*).

Nest success for 1981 and 1982 is summarized in Table 2. In general, there was a trend toward lower success rates in 1981 than 1982. In 1982 all nestlings fledged (N = 24), whereas in 1981, 72% (26 of 36) fledged ($P < 0.005$, df = 1, *G*-test). In 1981 there was a relationship between nest height and success. Successful nests averaged 1.51 ± 0.64 m in height (range = 0.64–2.46, N = 8). Unsuccessful nests averaged 0.69 ± 0.29 m (range = 0.38–1.30, N = 7). The difference was significant ($P = 0.01$, Mann-Whitney *U*-test), and suggests a relationship between nest height and success in 1981 which, however, did not exist in 1982.

Successful nests averaged 158.1 ± 48.6° (N = 14), which is only 4.8° from the overall mean. Unsuccessful nests averaged 28.7 ± 76.3° (N = 8), or 124.6° from the overall mean. The difference was statistically significant ($P < 0.05$, Rank-sum test, Batschelet 1981).

Biases in nest orientation have generally been interpreted in terms of amelioration of the microenvironment (e.g., Cactus Wrens [*Campylorhynchus brunneicapillus*], Austin, Condor 76:216–217, 1974; Abert's Towhees [*Pipilo aberti*], Finch, Condor 85:111–113, 1983). However, all nest failures in the present study were attributable to predation (inferred from disappearances of clutches of eggs or nestlings). No instances of nest parasitism by Brown-headed Cowbirds (*Moluthrus ater*) were recorded, in contrast to Buech (1982). Nests on the southeast sides of trees were not better concealed from us, but because we lack information on the kinds of predators and their hunting methods, extrapolations would be hazardous.

Ultimately, thermoregulation of nestlings may be facilitated by southeastern orientation. Most nests were situated such that they were largely exposed to the early morning sun. Also, because the prevailing winds in the Algonquin Park area are from the northwest (Environment Canada, Canadian Normals, Vol. 3, Wind, 1975), the birds may gain some degree of protection from wind and rain by placing their nests on the opposite side of trees. The relative importance of predator avoidance and climatic moderation in nest-site selection requires further study.

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