METHODS AND ANNUAL SEQUENCE OF FORAGING BY THE SAPSUCKER

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No fewer than 13 species of woodpeckers have been recorded feeding at the phloem sap of trees as it flows from wounds, and at least 7 of them are known to produce the wounds in the phloem that let the sap flow. Members of the nearctic genus *Sphyrapicus* differ markedly from other woodpeckers by their modifications for sap feeding. The role this plays in the daily activities of the Yellow-bellied Sapsucker (*Sphyrapicus varius*) has not been emphasized.

The biology of the Yellow-bellied Sapsucker is best known from studies of *S. v. varius*, which breeds throughout the coniferous-deciduous ecotone of northeastern United States and Canada east of the Rocky Mountains. Some basic life history information was gathered by Baird (Baird et al. 1874), Bendire (1888), and Forbush (1921). Howell's (1952) lucid discussion of differentiation in four races of the Yellow-bellied Sapsucker includes some natural history and comparative behavioral information. Kilham (1962) presented a sketchy account of the breeding biology of the northeastern race. The most complete account of the breeding behavior of *S. v. varius* was done by Lawrence (1967). In this paper the term sapsucker means *S. v. varius* unless otherwise stated.

A controversy over the major food source of the sapsucker arose in the early 1900s. The species was condemned as injurious to trees, and its sap-drilling habits were attributed to the production of an attractive concentration site for edible insects (see Townsend 1932). Reports on various forms of damage caused by Yellow-bellied Sapsuckers continue to appear (Shigo 1963, Ohman and Kessler 1964, Shigo and Kilham 1968).

Bolles (1891) was one of the first to discuss the attraction that phloem sap has for other organisms at the sapsucker tree. Many authors, including McGuire (1932), Batts (1953), Kilham (1953a, 1953b, 1958, 1964), and Nickell (1956, 1965), have added to the list of animals seen at sapsucker trees. The interactions of other organisms using sapsucker trees were analyzed by Foster and Tate (1966). McAtee (1911) summarized the early literature listing the species of plants sapsuckers feed upon.

SOLID FOODS

Beal (1911) analyzed the stomachs of 313 *S. v. varius* and *S. v. nuchalis* and reported on the kinds and proportions of hard foods present

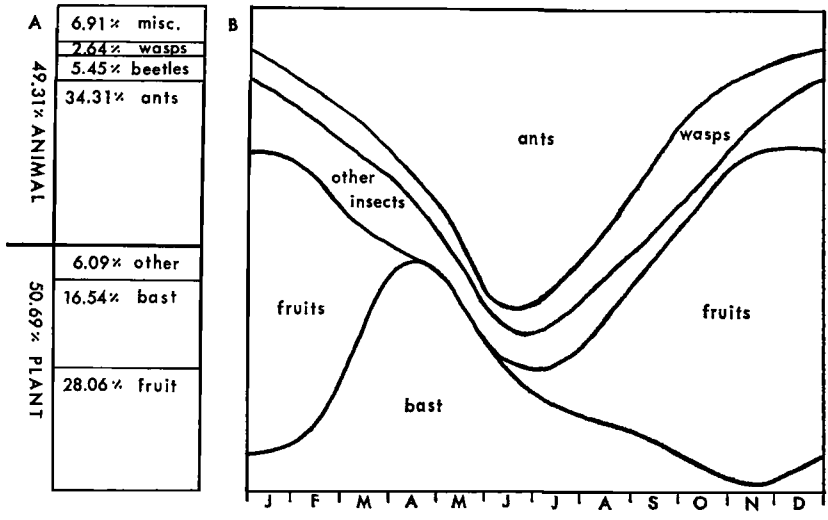

Figure 1. A, the stomach contents of 313 *Sphyrapicus varius varius* and *S. v. nuchalis* as analyzed by Beal (1911). B, the foods of *S. v. varius* based on Beal's stomach analysis data, literature review, and my own data.

throughout the year. Figure 1A presents the overall yearly percentages of different types of food he found in the stomachs. Figure 1B is based in part on Beal's data and in part on my own observations. These data include only the solid matter that would be available in such a stomach analysis.

Beal noted that stomachs contained no fruit in May, but 71.26% of them did in November. Lawrence (1967: 148) reported a greater dependence by sapsuckers than usual upon fruits during cold summers. Northward-wintering sapsuckers sometimes feed on apples still hanging on the tree (Nye 1918, pers. obs.) when little other food is available. In Beal's study the stomach contents taken from May to August averaged 68% ants. After the fledging of three young in 1964, a sapsucker nest I opened yielded nearly a pound of dried litter containing the heads of thousands of ants that had passed through the young and into the nest. The adult male had carried hundreds of others away with fecal material during nest sanitation. I have seen sapsuckers catching ants most often on their feeding trees near the sap holes and on the trunks of other trees. The sapsuckers catch the large carpenter ants (*Camponotus*) on the ground during June much after the manner of flickers (also see Lawrence 1967: 142).

Beal (1911) noted 5.45% beetles, 2.64% hymenoptera other than ants, and nearly 7% other insects. Sapsuckers nesting near open water will

take great numbers of swarming mayflies and stoneflies (Foster and Tate 1966: 89, Lawrence 1967: 147).

Large wasps and hornets (especially *Vespula maculata*) that are attracted to the sap wells in late summer are frequent sapsucker food items. Beal found that hymenoptera other than ants comprise 15.07% of the stomach contents in October. Wasps and large nonstinging insects (especially cicadas) are taken to a favorite knot or sap hole and beaten to a pulp. Lawrence (ibid.) noted sapsuckers pounding beetles before eating them.

Moths, often readily available in the moist forest, are regular items in the summer diet. In 1966 spruce budworm moths (*Choristoneura fumiferana*) were common sapsucker food in Michigan. In the early 1950s Lawrence (ibid.) noted them taking large numbers of forest tent caterpillar moths (*Malacosoma disstria*) in Ontario. Scale insects, psyllids, and other bark and tree insects are important foods for sapsuckers wintering in the north.

In addition to these hard foods, the more fibrous portions of cambium and bast may be recovered from stomach analyses. The literature often refers to "cambium" and "bast" as sapsucker foods, but actually all of the soft inner bark—cork cambium, phloem (fibers, rays, sieve tubes, and parenchyma), and cambium—is eaten as well as the sap associated with it. These cells contain considerable food value at some seasons, and are collectively referred to hereafter as bast. Beal (1911: 30) found bast in sapsucker stomachs in all months, but mostly in winter and spring. The greatest amount was in April, 48.95% of the total contents, and the least in November, 1.53%. It constituted the entire contents of 12 stomachs he examined, and in overall yearly average (16.54%) was exceeded only by fruits and ants. Because his study could not include data for sap, the proportions of foods could never total 100% of the bird's actual energy sources.

SOFT FOODS

Bolles (1892) showed that sugar could be an important energy source over a considerable period of time and demonstrated the role that sap-feeding played in the sapsucker's summer diet. Kilham (1962) states the young are fed a mixture of sap and insects. Foster and Tate (1966) describe how the parents form a bolus of insects soaked and worked in fresh sap to feed the young.

Markedly absent from the literature has been an understanding of the soft foods (sap, cambium, and phloem) eaten by sapsuckers. Kilham (1964) noted some of the variation in the types and distribution of sapsucker food tap holes, and speculated on this subject. In the present

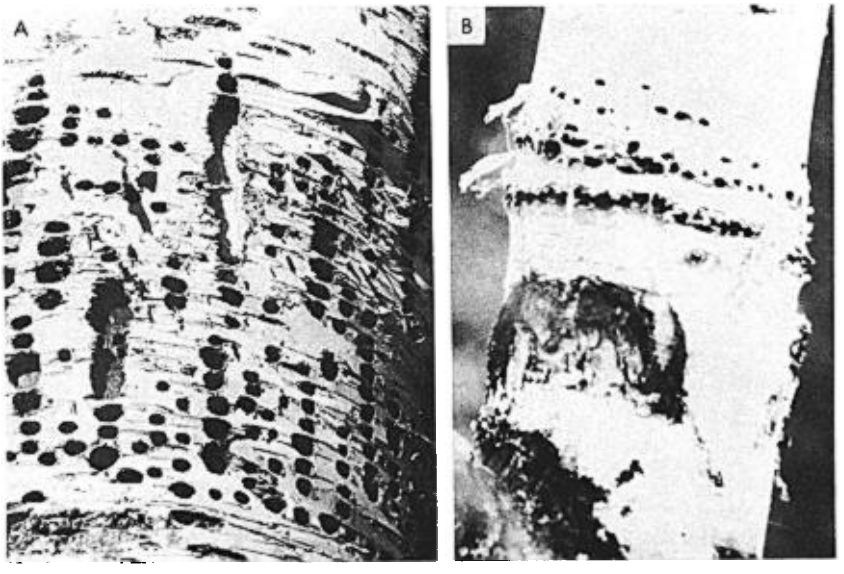

Figure 2. A, progressive columns of squarish holes drilled by the Yellow-bellied Sapsucker when feeding on sap. B, primary bands of holes drilled on a paper birch by Yellow-bellied Sapsuckers during exploratory tapping.

study I investigated the soft foods and foraging behavior of the sapsucker including the daily and seasonal variation in foods taken and the factors that affect them.

The plants sapsuckers commonly feed upon fall into a variety of taxonomic groups and botanical categories, but all are perennial woody plants. The phloem sieve tubes, just outside the cambium, are formed in early spring and are filled with phloem sap under a positive turgor pressure. This new layer, often less than 1 mm thick, may then be the plant's sole phloem sap-conducting system for that growing season. Additional phloem cells that are derived from the cambium as the season progresses are often nonconducting cells that function primarily as storage units in the bark. With approaching fall conditions, the sugar content of the phloem sap decreases and the positive turgor pressure of the sieve tubes is slowly reduced until the cells collapse.

The phloem sieve tubes of conifers are of a simpler construction and do not collapse, but rather the phloem sap freezes within them. No freezing damage occurs, largely because of their more porous end plates.

In winter the phloem storage cells of temperate latitude angiosperms contain a dilute sugar solution (about 1% to 5% weight/volume) with a small amount of nitrogen present mostly as water-soluble amino acids. Similarly, the winter phloem sap of conifers in temperate latitudes is

TABLE 1

TYPES OF FOOD TAP HOLES DRILLED BY THE YELLOW-BELLIED SAPSUCKER AND THEIR CHARACTERISTICS

	Primary bands			Columns	
Type	Sap bands	Bast bands	Spiral bands	Sap	Bast
Season					
Summer	Rare	Rare	None	Abundant	As drilled
Fall	Common	Abundant	None	Rare	Rare
Winter	Rare-common	Rare-common	None	Rare-common	Common
Spring	Common	Common	Common	As available	Abundant
Preferred plants	Pines Hemlocks Maples Many others	Maples Beeches Elms Few others	Aspens Others?	Birches Aspens Beeches Many others; nonsummer	
Location on plant	Most of bole Angiosperms: major limbs	Bole	Uppermost branches	Bole Angiosperms: limbs	
Group configuration	Line	Line	Spiral	Band below columns	
Shape of hole	Round	Ragged	Rectangular	Round	
Cross section	"V"-shaped	Inverted "V"	Squared	Inverted "V"	

composed for the most part of a dilute sugar solution. During the summer when photosynthate levels are high, the concentration of phloem sap in deciduous trees rises to 20 or 25% sugar (Huber 1958). This summer sap varies in its sugar and nitrogen content diurnally and through the season (Zimmerman 1960). It provides a variable but predictable food source for dozens of species of mammals, birds, and insects (see Foster and Tate 1966, Radwan 1969).

METHODS

The data used herein are from field studies of wild sapsuckers. William L. Foster and I (Foster and Tate 1966) conducted our joint studies in northern Michigan for three summers. Since that time I spent two spring seasons (1967 and 1968) and shorter periods in the fall studying sapsuckers in northern Lower Michigan (Figure 1 in Foster and Tate 1966). I also studied migrant and wintering sapsuckers near Lincoln, Nebraska and Fayetteville, Arkansas (November 1967). My field notes include information gathered from short (1 day or less) observations of sapsuckers and their work in dozens of localities in eastern Canada and northeastern United States.

Concentrations of dissolved materials in phloem sap were measured with a temperature-compensated hand refractometer. Because of the very small quantities of materials other than raffinose sugars (mostly sucrose), I considered all of the

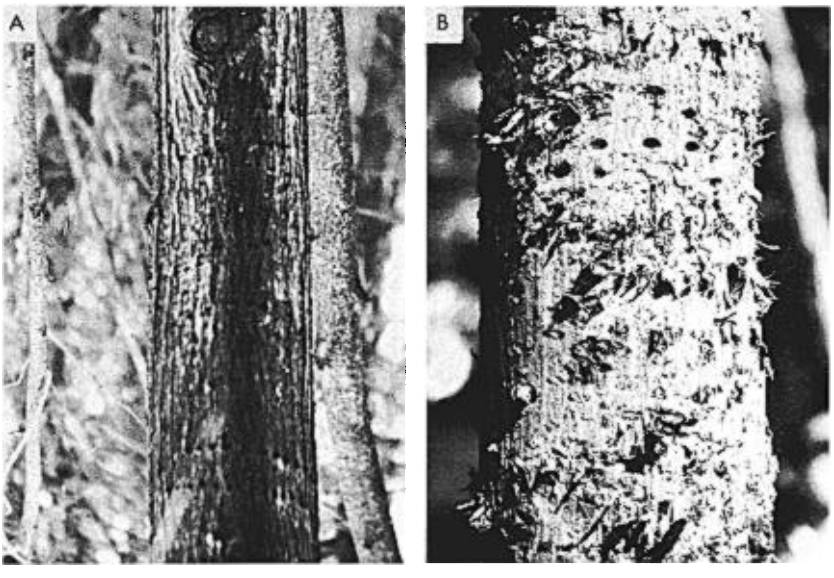

Figure 3. A, sap bands drilled by migrant Yellow-bellied Sapsuckers at Point Pelee, Ontario. B, bast bands drilled by a Yellow-bellied Sapsucker in a red maple in late August in northern Michigan. Note in the upper center the five sap holes that were drilled the previous spring. (Photograph by W. L. Foster.)

dissolved material measured by the hand refractometer to be sugar (see Zimmerman 1958). Temperatures at the feeding holes were measured with a rapid adjusting mercury thermometer.

Weather data for the study areas in Michigan were obtained from Federal Aviation Administration forms WBAN 10, which are gathered hourly at the United States Weather Bureau Station at the Pellston, Michigan airport, 2 to 6 miles from the major summer sapsucker feeding areas I studied.

Types of Food Tap Holes

The most commonly recognized sap-feeding areas of the sapsucker are columns of squarish holes (Figure 2A). These are often extensive, discolor the tree bark, attract many animal visitors, and are otherwise quite noticeable. The sapsucker also makes other kinds of food tap holes.

The following classification is based largely on arrangement and use of the food tap holes. It divides them into primary bands (horizontal rows) and progressive columns (vertical patterns). These two major types can be further classified on the basis of location on the tree, size and shape of the hole, and food obtained (sap or bast). Table 1 presents a survey of the types of holes and their characteristics.

Primary bands.—When engaged in exploratory food tapping, the sap-

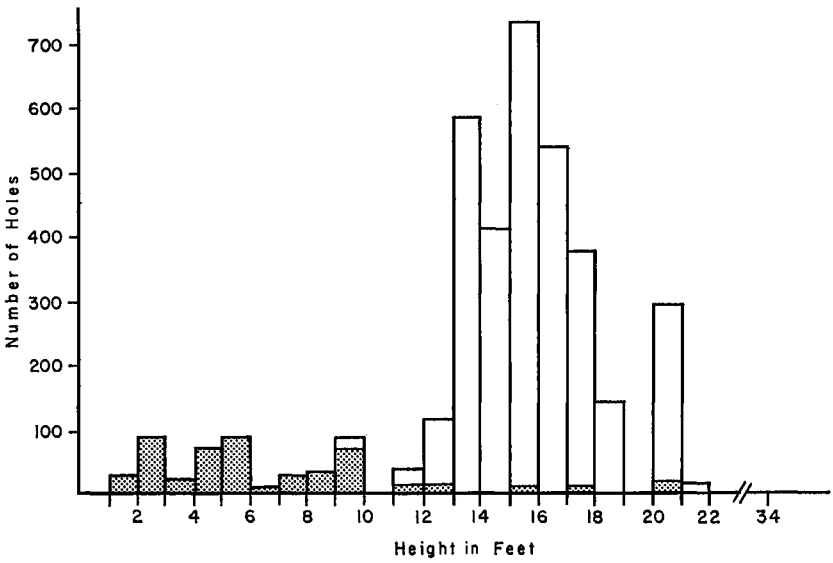

Figure 4. The distribution of primary bands (shaded area) and progressive columns (white) of food tap holes in a 34-foot Scotch pine in northern Michigan.

sucker lands on a live trunk or branch and drills holes side-by-side in a horizontal row (Figures 2B and 7). Primary bands, which are always laid down first, are exploratory. If these holes are productive, especially for sap, the birds may progress to drilling columns.

Kilham (1964) mentioned and figured horizontal rows of holes made in the spring on eastern hophornbeams (*Ostrya virginiana*) in New Hampshire. He called these satellite bands. Foster and Tate (1966: 91) found horizontal rows of holes on several species of trees, and attributed them to spring food taps. There are functional differences among the varieties of horizontal rows, and not all of them are made in the spring, nor are they all drilled to obtain sap. Three types of primary bands can be distinguished: sap bands, bast bands, and spiral sap bands.

Sap bands.—Primary bands that produce sap quickly are often shallow, cone-shaped depressions (Figure 3A). Little removal of material is necessary. A single band may be revisited several times the same day, but in spring is seldom revisited on subsequent days. Sap bands that are not enlarged heal quickly, but not without leaving inner scarring on the tree that may show up many years later as grade defects that the lumber industry terms ring shake and bird peck defects (McAtee 1911: 56–91, Shigo 1963). Sap bands remain visible for years on the bark, but only the newly drilled holes are functional.

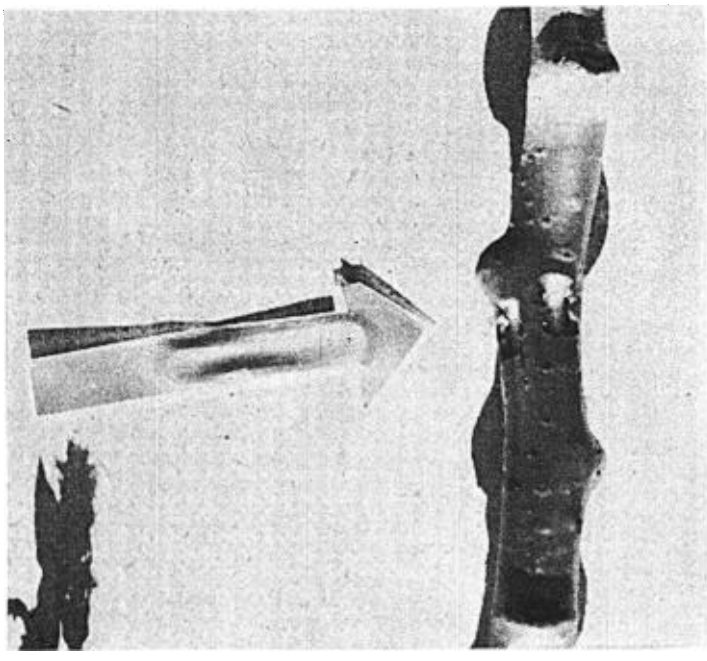

Figure 5. Spiral bands drilled by a Yellow-bellied Sapsucker in April on one of the uppermost tip branches of a quaking aspen in northern Michigan.

Because of their exploratory nature, sap bands can be found on nearly all species of plants the sapsucker visits. Figure 4 shows the distribution of holes along the first 22 feet of trunk in a 34-foot Scotch pine (*Pinus sylvestris*). Above 22 feet there were no holes. The holes that appeared in the first 9 feet were all sap bands. The next 13 feet of trunk were drilled with sap bands plus additional numbers of progressive column holes indicated in Figure 4.

Bast bands.—In the fall primary bands of holes are drilled rapidly, the edges are not cleaned, and little or no sap flows from them (Figure 3B). These are bast bands. The bird that drills these ragged holes obtains and eats bast from just beneath the outer bark and drills them most commonly on the trunks and major branches of angiosperms. I have seen them in profusion in the fall on sugar maples (*Acer saccharum*) in Michigan and striped maples (*Acer pennsylvanicum*) in Maine, near major summer feeding stands of birch that have just ceased to produce sap.

Spiral bands.—In the early spring sapsuckers sometimes move to the outermost tips of quaking (*Populus tremuloides*) and bigtooth (*P.*

grandidentata) aspen trees where they drill one to three holes in pencil thin branches (Figure 5). The holes are not arranged side-by-side as in a typical primary band, but rather spiral up the stem. The lowermost hole is drilled first. These food tap holes produce moderately sweet sap (mean of four samples—4.91% sugar). They are of limited occurrence (early spring only), and restricted distribution (probably aspen tips exclusively).

Progressive columns.—At trees where photosynthesis is occurring more or less continuously, sapsuckers return repeatedly to a primary sap band to feed. Often they drill other primary bands next to the first band until the stem is nearly girdled by one or two rings of holes (Figure 2B). If a sapsucker remains in the area, and if photosynthesis continues in the tree, the next holes are drilled directly above individual holes in the primary bands, soon forming the typical progressive columns of sapsucker holes (Figure 2A). The birds drill these columns not as successive rows of holes above the primary bands, but rather as individual holes above individual holes.

The uppermost holes of each column yield sap directly from the phloem transport system of the plant. The sapsuckers eat the bast from the edges of the hole, shaping it into an inverted cone. Mammals (rarely the sapsuckers) enlarge some active holes until they merge to form open vertical scars (top of Figure 2A).

During winter and spring these columns appear most often on conifers. Bast seems to be the most important food obtained. Above 13 feet on the Scotch pine in Figure 4, most of the holes formed progressive columns drilled for bast. Sap flows from the uppermost of such holes, and under some conditions the sapsucker stops drilling and feeds on fairly dilute resinous sap. Late in the spring similar holes almost exclusively on the trunks of the same conifers will produce sap of a higher sugar concentration.

Progressive columns drilled on angiosperms that are actively photosynthesizing serve as major summer sap sources. For nonsummer feeding they are drilled so long as the tree is actively transporting phloem sap, and the birds thus drill columns in an astounding variety of sizes and species of trees and shrubs.

SEQUENCE OF FEEDING TREES

Throughout the year a sapsucker's habitat contains trees of many species of various ages, sizes, and physiological states. Not only does the migrating sapsucker encounter different kinds of trees in different conditions, but temperate-latitude trees go into dormancy for the winter. Thus no single food source remains constantly available to the sap-

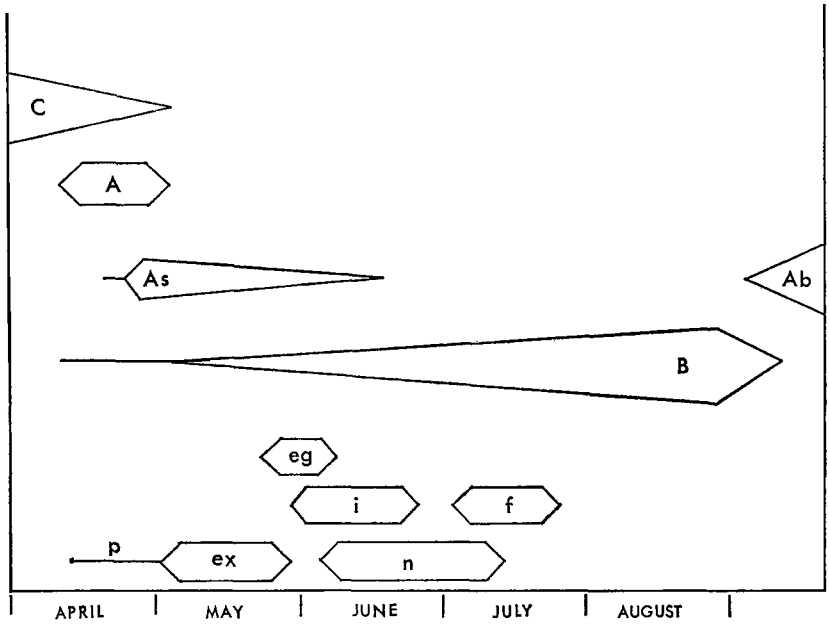

Figure 6. The sequence of feeding trees, and the nesting cycle of the Yellow-bellied Sapsucker in northern Michigan. Legend: C, conifer sap and bast feeding; A, aspen budding and tip feeding; As, angiosperm dilute sap feeding; Ab, angiosperm bast feeding; B, major summer feeding on birches; p, pair formation; ex, excavation; eg, egg laying; i, incubation; n, nestlings; f, feeding fledged young. Nesting cycle after Lawrence (1967: 29) modified for northern Michigan.

sucker, and the species must use a sequence of plant foods through the seasons (Figure 6).

Obtaining sap and bast from conifers in spring.—In northern Michigan in early April the sapsuckers encounter few insects, and many trees are still dormant. They feed mainly on sap from the native conifers, which retain their leaves and are capable of photosynthesis and phloem transport when the temperature of the outer bark and phloem is above freezing. They visit other tree species and lay down primary bands, but as no sweet sap is forthcoming, they abandon these almost at once (see Figure 7). They drill aspens and birches in this manner, but do not visit them again until later in the spring.

In addition to sap, the sapsuckers obtain much of their nourishment from the bast they remove from the holes. Dozens of holes must be drilled to sustain one bird, and extensive tree damage occurs at this time. A single male sapsucker feeding on the bole of a Scotch pine for 335 minutes the morning of 18 April 1968 drilled 129 holes. A female

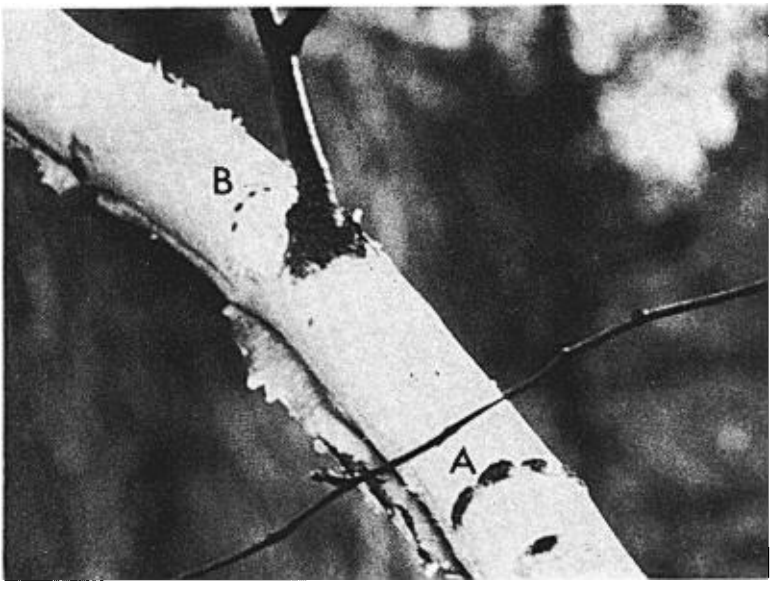

Figure 7. Two single rows of exploratory primary bands drilled in a paper birch limb by Yellow-bellied Sapsuckers before the phloem exudate sweetened in April in northern Michigan. The lower set (A) is 1 year old and shows healing. The farther set (B) is freshly drilled.

working for 567 minutes on 26 April produced 286 holes. The birds ate the excavated material, and defected dry splintery feces much like those of a Ruffed Grouse (*Bonasa umbellus*) that has been budding.

Bud eating and drilling of aspen tips.—Buds on the tips of aspens are swelling in northern Michigan by the end of the first week in April. During warm sunny periods the sapsuckers move to the outermost branches and feed on the buds, bast, and sap of the trees. The birds hang on the branch tips much like chickadees, reaching from bud to bud, plucking them off, and eating the soft inner portions.

The sapsuckers usually drill two or three food tap holes in a group along the branch (Figure 5) and eat the bast as they drill it away. They remain to eat the sap, which begins to flow almost at once (Table 2).

Dilute sap feeding.—By late April in northern Michigan most of the deciduous trees have begun the process of spring reawakening. Buds are swelling on elms, maples, and oaks. The xylem has already restored most of the water to upper tissues, and the phloem sap is being reconstituted from winter stores.

On warm, cloudy days sapsuckers drill one or two shallow bands

TABLE 2

SUGAR CONCENTRATIONS (%) OF SAP SAMPLES FROM SAPSUCKER WOUNDS ON ASPEN TIP BRANCHES AND FROM WOUNDED BIRCHES ON 15 APRIL 1968

	Populus tremuloides	*Betula papyrifera*
From spiral band food tap holes	5.14	—
	4.81	—
Drip from spiral band food tap holes	5.48	—
	5.14	—
Freshly cut limb	—	0.28
	—	0.28
Wound from climbing iron	—	2.08
	—	1.39

of food tap holes just a few feet off the ground between ridges of the rough outer bark of certain deciduous trees (sap bands). They often choose maples, but also drill American elms (*Ulmus americana*), red oaks (*Quercus rubra*), and hackberries (*Celtis occidentalis*). Old bands from previous years look much like the newly drilled bands. These sap bands produce surprisingly large amounts of liquid which, if unattended by a sapsucker, runs down the trunk and wets the ground. The sap is very dilute; 12 such drillings averaged 3.13% sugar (Table 3).

The sapsuckers stay at these holes for extended periods. In northern Michigan, a male began feeding at a band of five holes at 08:37 on

TABLE 3

TEMPERATURE (°C), SKY COVER, AND SUGAR CONCENTRATION FOR 14 CASES OF DILUTE SAP FEEDING BY YELLOW-BELLIED SAPSUCKERS

	Sex	Sky cover	Temperature		Sugar conc.
			air	sap	
16 April					
American elm	M	>0.9	38	44.2	3.86
Sugar maple	M	>0.9	38	45.8	3.04
American elm	F	>0.9	38	45.4	2.62
Sugar maple	F	>0.9	41	41.6	3.20
Sugar maple	F	>0.9	41	44.2	3.04
Sugar maple	M	>0.9	41	48.2	2.01
Northern red oak	F	0.6–0.9	41	40.8	3.81
Sugar maple	M	0.6–0.9	44	44.0	3.26
Northern red oak	M	0.6–0.9	46	46.6	—
17 April					
American elm	M	>0.9	39	41.2	3.44
Sugar maple	M	>0.9	40	44.4	3.22
Sugar maple	F	>0.9	40	43.4	3.90
Sugar maple	M	>0.9	47	49.4	2.13
Northern red oak	F	0.6–0.9	47	49.0	—

TABLE 4

SAP AND CLOACAL DISCHARGE CONCENTRATIONS AT A DILUTE SAP FEEDING SITE OF THE YELLOW-BELLIED SAPSUCKER IN NORTHERN MICHIGAN ON 16 APRIL 1968

	% sugar[1]
11:50	
sap	3.86
13:13	
sap	3.04
discharge	0.28

[1] % suger if all of dissolved material were sugar.

16 April 1968. He dipped his beak into one hole after another, removing the drop of sap that formed, at an average of 8.7 times per minute for 8 hours and 32 minutes. He remained on the one tree all day, except when I disturbed him from his feeding post twice, once at 11:50 to take a sap sample and to rig a plastic sheet to catch his excreta, and again at 13:13 to collect a sample from the plastic trap. The bird emptied its cloaca at the average rate of 1.13 times per minute, voiding a clear, faintly brown liquid. The sap from the holes measured 3.86 and 3.04% sugar, and the cloacal discharge 0.28% (Table 4). The 0.28% refractive reading was identical to the readings of xylem sap from the birches (see Table 2).

Establishment of the summer feeding area.—By the first week of May in northern Michigan the sapsuckers are no longer at conifers and seldom at the large butts of rough-barked deciduous trees. They continue to feed at tap holes they established in hackberries, maples, or elms until late May, but they are simultaneously establishing major summer feeding areas at birches and starting to pair and excavate nest sites. In 1965, a dry spring in northern Michigan, the birches were slow to leaf out, and some sapsucker pairs continued to feed on maples into June.

Birches—paper, yellow (*Betula alleghaniensis*), sweet (*B. lenta*), or gray (*B. populifolia*), depending on the area—are by far the most commonly used summer trees. The sap obtained from these trees after their leaves have come out has a much higher sugar content than that from any of the other sap sources mentioned so far. This sap is commonly 20% sugar, which evaporation concentrates to 30% on some midsummer afternoons.

At first the drilling pace is slow. A pair of birds on territory has only slight food requirements compared to their later needs when the young have hatched, and the food source is relatively rich. From mid-May to mid-June a pair drills relatively few holes in birches per week.

TABLE 5

RATES OF USAGE AND DEATH OF PAPER BIRCHES IN A SINGLE FEEDING ORCHARD OF THE YELLOW-BELLIED SAPSUCKER IN NORTHERN MICHIGAN

	Yearly loss	Live	In use	Up dead	Down dead	Total loss
1965		27	6	2	0	2
1966	5	22	5	5	2	7
1967	5	17	5	8	4	12
1968	3	14	3	8	7	15

$\bar{x}$ loss/yr = 3.75

Lawrence (1967: 149) estimated that one pair of nesting sapsuckers probably accounted for the death of one or perhaps two trees a year. At one major feeding ground in northern Michigan for which I have data from 1965 through 1968, at least 12,240 holes were drilled, giving a yearly summer average of 3,060 holes. When first discovered the summer feeding orchard contained 27 living paper birches, two of which were the major feeding trees that year. This one sapsucker orchard lost two to five trees per year ($\bar{x}$ = 3.75) from 1964 to 1968. Table 5 summarizes the data.

As the number of food trees available in a summer orchard decreases as pecked trees die, the sapsuckers are exposed to an increasingly open habitat. As Lawrence (1967: 148) noted, an area used extensively will be abandoned when the occupants of a territory change. After sapsuckers abandon it, the visible remains of a major orchard persist for years. Natural succession takes over and the section of the woods regrows slowly. In Reese's Bog (about 52 acres), I knew of nine active sapsucker territories and six abandoned summer birch orchards in the spring of 1968. Three orchards were used at least 5, 3, and 3 years each.

Fall feeding.—As the summer draws to a close, the sapsuckers feed more and more often on the sap and bast of rough-barked trees once again. Bast bands often appear in abundance on maples and some other species near the now useless birch orchard (Figure 3B). Native fruits become an important item in the diet of most pairs.

On southward migration sapsuckers may drill many species of trees and shrubs. They have to make extensive drillings to obtain bast and a little sap. They drill mostly in single horizontal bast bands, and lay many of these down. At Point Pelee, Ontario, for example, where many migrant birds pause, nearly every hophornbeam, maple, and elm is covered with short horizontal bands of holes.

Winter feeding.—The Yellow-bellied Sapsucker winters from southern

Canada and the northern tier of states southward to beyond the southern continental boundaries. A sexual difference is apparent in extent of migration (Howell 1953), and a few males winter in the far north (Maine, Ontario, Michigan) where winter temperatures sometimes reach far below zero Fahrenheit. Most of the population winters from the central tier of states to the Gulf of Mexico. The few southernmost wintering birds reach Central America and the West Indies, where females predominate over males 3.5 to 1 (Howell 1953).

Northern wintering birds subsist on a diet of arthropods (mostly insects) obtained from the bark of trees, frozen fruit, and very little sap. Their insect foraging at this time closely resembles that of the three-toed (*Picoides*) woodpeckers. Both pry for insects under bark scales (e.g. Nye 1918), and like *Picoides,* northern wintering sapsuckers sometimes scale large sections of bark, leaving bare patches on the trunk.

At the northern latitudes where sapsuckers sometimes winter, the birds have to feed intensively to get enough food in the short day. Beginning with the first light, a sapsucker in Maine foraged uninterruptedly for 9 hours on 2 January, spending most of its time searching for insects and a lesser amount of time at apples (Nye 1918).

During warm winter days, sapsuckers in the middle latitudes feed on local sap flow from many tree species. Usually the sapsucker drills only one or two rows of holes (sap bands), which it attends for hours. Sapsuckers wintering in middle latitudes act like sapsuckers at dilute sap feeding sites during spring in Michigan. Kilham (1956) describes such a situation in Maryland during January.

ACKNOWLEDGMENTS

This investigation began as an outgrowth of a study of the animal visitors at sapsucker feeding trees conducted by William L. Foster and myself. The many discussions we held and the great amount of observation time that he contributed were very important to the completeness of this study.

I wish to thank O. S. Pettingill, Jr., Paul A. Johnsgard, D. Jean Tate, Patricia Rand, and Douglas and Frances James, all of whom contributed to this study in some way.

The Frank M. Chapman Memorial Fund of the American Museum of Natural History provided a grant for equipment, and a National Science Foundation summer fellowship supported my studies at the University of Michigan Biological Station. The Woodrow Wilson Foundation provided a travel grant for the spring of 1967.

SUMMARY

Unlike most woodpeckers, the eastern Yellow-bellied Sapsucker (*Sphyrapicus varius varius*) feeds on sap, adult insects, and fruit. The ex-

tent and manner in which it utilizes the phloem sap and living phloem tissue of woody plants for food has been widely disputed despite evident morphological adaptations to sap-feeding. Field studies conducted to determine the foods and foraging behavior of this sapsucker showed it used five types of food tap holes to extract sap and phloem tissue from living trees: vertical columns of holes for sap (1) or bast (2), horizontal bands of holes for sap (3) or bast (4), and spiral groups of holes (5). They use bands of holes in early spring to obtain bast and some sap from conifers. As spring progresses, sapsuckers drill bands of holes in angiosperms on warm, cloudy days to obtain the copious and dilute sap. On sunny days, they drill spiral groups of holes in tips of aspen branches for the sap. During midsummer, they create extensive vertical columns of holes in birches for sap. In the fall they drill many horizontal rows of holes in maples to obtain bast.

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