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HABITATS AND SPIDER PREY OF *DIPOGON SAYI SAYI* (HYMENOPTERA: POMPILIDAE) IN WASHINGTON COUNTY, MAINE[1]

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ABSTRACT

Spider wasps were reared from three types of trap-nests deployed in strip-clearcut areas of a spruce-fir-mixed hardwood forest of Maine. Collections of *Dipogon sayi sayi* from Moosehorn National Wildlife Refuge, Washington County, represent the easternmost records for the United States. Spider prey included females of *Misumena vatia, Xysticus emertoni* (new prey record), and *X. punctatus,* and juveniles and penultimate males of *Xysticus* sp. We found no evidence of nest-site competition between spider wasps and eumenid wasps (Hymenoptera: Eumenidae) that prey on spruce budworm, *Choristoneura fumiferana*, when available nesting sites ranged from 320 to 4400.

The spider wasp *Dipogon sayi sayi* Banks is frequently encountered in forested regions of the northeastern United States and Canada. Its biology has been studied by Medler and Koerber (1957) in Wisconsin, Evans and Yoshimoto (1962) in New York, Krombein (1967) in New York and in Washington, D.C., and Godfrey and Hilton (1983) in Quebec. Virtually nothing is known about the biology of this spider predator in Maine forests.

During our investigations of eumenid wasps (Hymenoptera: Eumenidae) that prey on the spruce budworm, *Choristoneura fumiferana* (Clemens), we gathered information on the habitats, spider prey, and nest structure of *D. sayi sayi* in Maine. This paper describes new locality records, coniferous habitats, spider prey, and nesting substrate for the pompilid wasp, *D. sayi sayi.*

MATERIALS AND METHODS

Study Sites. Spider wasps were reared from trap-nests deployed in a spruce-fir-mixed hardwood forest located in the Moosehorn National Wildlife Refuge, Washington County, Maine. Individual study sites were about 6.2 km (Calais Minor Civil Division [MCD]) and 13.6 km (Baring Plantation MCD) south of Calais, Maine. The forest at both study sites had been strip clearcut, which resulted in alternating clearcut and uncut residual strips. The open areas of strip clearcuts had an abundance of ferns (*Pteridium aquilinum* (L.)), shrubs (*Spiraea* sp., *Vaccinium* sp., *Kalmia angustifolia* L.), and young, sapling

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trees (*Populus tremuloides* Michx., *Alnus rugosa* (Du Roi) Spreng., *Salix* sp.). The uncut residual strips, were composed mainly of mature and pole-size conifers, including balsam fir (*Abies balsamea* (L.) Mill.), red spruce (*Picea rubens* Sargent), white spruce (*P. glauca* (Moench) Voss), northern white cedar (*Thuja occidentalis* L.), and eastern white pine (*Pinus strobus* L.). Common hardwood species in uncut residual strips were gray birch (*Betula populifolia* Marsh.), red maple (*Acer rubrum* L.), ash (*Fraxinus* sp.), and speckled alder (*Alnus rugosa*).

Trap Nests. Three types of trap-nests were used to attract nesting wasps.

Type A traps. Small blocks (1.9 × 1.9 × 17.8 cm) cut from straight-grained eastern white pine, with an 8-mm diam hole drilled 15.2 cm deep in each block. In 1981, bundles of nine blocks each, spaced 10 m apart, were hung 1.5 m above ground from trees (Collins and Jennings 1984) along north and south edges of five replicated east-west strip clearcuts (Calais MCD). Type A traps totaled 450 (9 blks/bundle × 5 bundles/forest edge × 2 edges (N,S)/clearcut strip × 5 replicated strip clearcuts).

Type B traps. Small blocks (3.8 × 8.8 × 17.8 cm) cut from eastern white pine two-by-four stock, with eight 8-mm holes drilled 15.2 cm deep. In 1982, four line-transects were established in a strip-clearcut area (Baring Plantation MCD), with one line transect per clearcut strip. Five type A traps and five type B traps were randomly assigned to 10 trapping stations, spaced 3 m apart, along each line transect. Total available nesting sites was 320 (8 holes/trap × 10 traps/line transect × 4 line transects).

Type C traps. Condominium-style trap (11.5 × 11.5 × 15.2 cm) cut from northern white-cedar, with 36 evenly spaced holes drilled completely though the long dimension of each block. Blocks were dipped in polyurethane and one end covered with aluminum foil tape (Scotchbrand®). All seams were sealed with all-purpose hot melt adhesive (Thermogrip®). Paper soda straws (8 mm outside diam, ca. 7 mm inside diam., 152 mm long) were inserted into 35 holes; one centrally located hole was used to spike (20.3 cm) mount the condominium trap to a stake, stump, or shelter. In 1983, 10 type C blocks were randomly mounted on stumps (ca. 30 cm high) in each strip-clearcut; 10 blocks were also mounted in a plywood shelter (0.3 × 0.6 × 1.2 m) ca. 1.2 m above ground and centrally located among the 10 stump-mounted blocks. In 1984, 1985, and 1986, all type C blocks were mounted on stakes 60 cm above ground. Stakes and blocks were placed in a grid pattern, i.e., four rows with five blocks in each row. Spacing of traps within and between rows was 4 m. Five strip clearcuts (Calais MCD) were studied in 1983 and 1984; six strip clearcuts were studied in 1985 and 1986 (5—Calais MCD; 1—Baring Plantation MCD). For study years 1983 and 1984, available nesting sites totaled 3500 (35 holes/block × 20 blocks/rep × 5 reps); in 1985 and 1986, available sites total 4400 (6 reps).

Wasp Rearings. For most study years, traps were examined weekly in June and July. Provisioned blocks or straws were removed and replaced with new, unused blocks or straws. Provisioned nests were opened in the laboratory and wasps (summer generation) reared individually in 4-dram vials at room temperature (ca. 22°C). Measurements (mm) were taken of nest cell length, cell partition thickness, and plug thickness.

After the midsummer examinations, traps were left undisturbed in the field until October when all traps were retrieved (except 1985–86) and placed in an unheated building over winter. The following spring (April, May), diapausing wasp larvae (overwintering generation) were either (1) reared in situ at room temperature, or (2) removed from blocks or straws, placed in gelatin capsules (size 00), and reared in environmental chambers (30°C) to maturity.

Wasp-Spider Identifications. Spider wasps were sent to a specialist for species identification. After identification, wasps were sexed by the presence (female) or absence (male) of a maxillary beard (Townes 1957). Spider prey were identified by the senior author, following the keys and species descriptions of Dondale and Redner (1978). Representative specimens of spider wasps collected and reared during this study are deposited in the entomological collection of the U.S. National Museum, Washington, D.C.

RESULTS AND DISCUSSION

Reared Wasps. Spider wasps (*Dipogon sayi sayi* Banks) were reared from all three trap types; most (56%) from Type C traps (Table 1), the most abundantly available trap. Our collections of *D. sayi sayi* from Washington County, Maine, represent the easternmost records of this species in the United States.

Thirty-five females and ten males were reared, which indicates a 3.5:1 sex ratio. Krombein (1967) found a 2:1 sex ratio in favor of *D. sayi sayi* females. Most (56%) of our reared wasps came from the summer generation when traps were most frequently examined.

There is only one previous record of *D. sayi sayi* from Maine; Jennings et al. (1984) reared *D. sayi* from a trap-nesting block placed in a dense spruce-fir forest, Piscataquis County, Maine. Procter (1946) noted a related species, *D. calipterus* (Say), carrying an unidentified spider on dead spruce, Mt. Desert Island, Hancock County, Maine. Dearborn et al. (1983) reported that six genera and seven species of pompilid wasps were housed in the entomological collections at Augusta, Maine; however, species of *Dipogon* were not included.

Our collections of *D. sayi sayi* from soda-straw nests represent new records of nesting substrate used by these wasps. Previous nest-substrate records include sumac (*Rhus* sp.) and bamboo stems (Medler and Koerber 1957); *Carya* and *Celtis* wood (Townes 1957); an elm (*Ulmus* sp.) log (Evans and Yoshimoto 1962); elderberry (*Sambucus* spp.) tubes and root of an overturned balsam fir (*Abies balsamea*) stump (Fye 1965); and eastern white pine (*Pinus strobus*) trap-nests (Jennings et al. 1984).

Wasp Habitats. All of our collections of *D. sayi sayi* came from open habitats of spruce-fir-mixed hardwood forests. These habitats differ from the open deciduous woodlands previously recorded for this spider wasp (Medler and Koerber 1957, Evans and Yoshimoto 1962). Krombein (1967:161) reared *D. sayi sayi* from trap nests "placed along edges of woods or in wooded areas" of New York and Washington, D.C. In northwestern Ontario, Fye (1965) trapped *D. sayi sayi* in open woodland habitats; in eastern Quebec, Godfrey and Hilton (1983) recovered *D. sayi sayi* from two trap nests placed near a red pine (*Pinus resinosa* Ait.) stand.

From recorded observations and our own data, we conclude that *D sayi sayi* probably prefers open habitats of wooded areas—deciduous, coniferous, or mixed. In Maine, strip-clearcut areas of mixed coniferous-deciduous forest provide suitable habitat for *D. sayi sayi*. The open, cleared strips have abundant flowering shrubs and forbs which may provide nectar sources; however, Evans and Yoshimoto (1962) noted that *sayi* rarely visits flowers for nectar. The open, cleared strips also have abundant logging debris which provides natural nesting sites for spider wasps. After logging, numerous species of

Table 1. Spider wasps (*Dipogon sayi sayi*) reared from three trap-nest types, Moosehorn National Wildlife Refuge, Calais and Baring Plantation MCD's, Washington County, Maine.

Year	Locality	Trap type	Wasp generation[a]	Wasp number and sex
1981	Calais	A	S	3 ♂♂, 8 ♀♀
1982	Baring Plt.	A	OW	2 ♀♀
		B	OW	2 ♂♂, 3 ♀♀
1983	Baring Plt.	B	OW	2 ♀♀
1985	Calais	C	OW	2 ♂♂, 9 ♀♀
1985	Calais	C	S	2 ♂♂, 3 ♀♀
1986	Calais	C	S	1 ♂ , 8 ♀♀

[a]S = summer; OW = overwintering.

wood-boring insects (Cerambycidae, Buprestidae) create tunnels and cavities in stumps, logs, and slash. Evans and Yoshimoto (1962) noted that *D. sayi* nests in preexisting galleries in wood, which the wasps clean out before searching for prey.

Spider Prey. Spider prey were recovered from four trap nests, all Type C traps placed in strip clearcuts. Detailed records were obtained from only three nests (Tables 2 and 3). Additional prey from an overwintering type C nest were *Xysticus* sp., one penultimate male, two immature females, one juvenile, all possibly *X. emertoni* Keyserling, though the absence of fully developed genitalia precluded positive species determination.

Our spider prey records for *D. sayi sayi* in Maine are in general agreement with previous observations; however, *X. emertoni* is a new prey record for this spider wasp. Krombein (1967) listed spiders of 5 families, 10 genera, and 23 species as prey of *D. sayi sayi*. Crab spiders (Family Thomisidae), and particularly species of *Xysticus*, are by far the most common prey of this spider wasp. Medler and Koerber (1957) recorded nine species of crab-spider prey; Evans and Yoshimoto (1962) recorded five species of crab-spider prey. These authors indicated that the female wasp hunts for spiders on low vegetation near the ground and in litter on the forest floor. Our most common prey species, *X. emertoni*, is frequently collected by sweeping old-field herbaceous vegetation (pers. observ.) and by pitfall traps in fields, meadows, and bogs (Dondale and Redner 1978). Provisioning of nests with *X. punctatus* Keyserling crab spiders indicates that *D. sayi sayi* also searches arboreal habitats for prey. *X. punctatus* is usually found on coniferous-tree foliage (Jennings and Collins, in press). Fye (1965) also recovered *X. punctatus* from nests of *D. sayi sayi* near Black Sturgeon Lake, Ontario.

Eight of the identified prey spiders (n = 15 observ.) showed evidence of *possible* leg amputation by wasps; no data were taken on 10 spider prey consumed by reared wasps. Evans and Yoshimoto (1962) observed a female *D. sayi* bite off one leg of an immature *X. ferox* (Hentz). Krombein (1967) concluded that *D. sayi sayi* does not normally amputate legs of spider prey; however, he observed two legs of an immature *Xysticus* sp. that were amputated beyond the coxae. All but one of our leg-amputated spiders had the severed joint between the spider's coxa and trochanter, the exception being between the trochanter and femur. Because appendotomy, and particularly autospasy at the coxa-trochanter joint, is an escape mechanism employed by many spiders against predators (Roth and Roth 1984), recognition of leg amputation by wasps after the fact may be

Table 2. Prey records of *Dipogon sayi sayi*, Moosehorn National Wildlife Refuge, Calais MCD, Washington County, Maine, 1985.

Rep-block no.	Cell length (mm)	Species of spider	Prey life stage	Sex of reared wasp
III-125	12	*Xysticus* sp.	1 penult. ♂	—[a]
	11	*X. emertoni*	1 ♀	1 ♀
	11	*X. emertoni*	1 ♀	—[a]
	11	*X. emertoni*	1 ♀	1 ♀
	12	*X. punctatus*	1 ♀	—[b]
	13	*Misumena vatia* (Clerck)	1 ♀	1 ♀
	13	*X. emertoni*	1 ♀	1 ♂
III-135	15	*X. emertoni*	1 ♀	—[a]
	14	*Xysticus* sp.	1 undet.[c]	—[b]
	14	*X. emertoni*	1 ♀	1 ♂
	15	*Xysticus* sp.	1 juv.	—[a]
	16	*X. emertoni*	1 ♀	—[a]

[a]Died in rearing, sex undetermined.
[b]Dipterous parasite emerged from spider prey, but died in rearing.
[c]Spider genitalia absent in wasp nest cell.

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Table 3. Prey records of *Dipogon sayi sayi*, Moosehorn National Wildlife Refuge, Calais MCD, Washington County, Maine, 1986.

Rep-block no.	Cell length (mm)	Species of spider	Prey life stage	Sex of reared wasp
III-125	16	*Xysticus* sp.	1 undet.[a]	—[b]
	8	*X. emertoni*	1 ♀	1 ♂
	11	*Xysticus* sp.	1 undet.[a]	1 ♀
	11	*X. emertoni*	1 ♀	1 ♀
	11	*Xysticus* sp.	1 undet.[a]	1 ♀
	12	*Xysticus* sp.	1 undet.[a]	—[c]
	11	*X. emertoni*	1 ♀	—[d]
	11	*X. emertoni*	1 ♀	—[c]
	15	*X. emertoni*	1 ♀	—[c]

[a]Spider genitalia absent in wasp nest cell.
[b]Wasp lost in field.
[c]Died in rearing, sex undetermined.
[d]Larva in diapause?

difficult. However, crab spiders (Thomisidae), the most common prey of *D. sayi sayi*, show less tendency to lose legs than some other families of spiders (Roth and Roth 1984).

Wasp Nests. Our limited observations on provisioned nest-cell length (n = 30, $\bar{x}$ = 12.2 ± 0.4 mm); mud partition-wall thickness (n = 23, $\bar{x}$ = 3.3 ± 0.2 mm); vestibule length (n = 4, $\bar{x}$ = 29.0 ± 4.1 mm); and mud-plug thickness (n = 2, $\bar{x}$ = 5.5 ± 0.5 mm) are in general agreement with previously reported data for *D. sayi sayi* (Medler and Koerber 1957, Evans and Yoshimoto 1962). The Maine-collected plugs and partition walls were composed of a great variety of materials, including mud; exuviae of insect larva, insect pupa, eumenid wasp, jumping spider (Salticidae), and gnaphosid spider (Gnaphosidae); beetle elytra; curled deciduous leaves; grass; seeds and seed pod; lichens; and miscellaneous plant parts.

Wasp Competition. Medler and Koerber (1957) noted some competition between *D. sayi*, eumenid wasps, and megachilid bees for nesting holes. However, we found no apparent evidence of competition for nesting sites between spider wasps and eumenid wasps (Eumenidae) that prey on larvae of the spruce budworm. Although species of *Ancistrocerus* and *Euodynerus* also provisioned some trap blocks and straws, the large number of available nesting sites (range 320 to 4400) apparently was not a limiting factor. Competition for nesting sites may occur under more natural conditions when preexisting galleries and cavities are limited. We conclude that provisioning by spider wasps during this study did not interfere with eumenid-wasp predation on spruce budworm larvae.

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