

Observations on the Ecology and Breeding Biology of the Speckled Warbler *Chthonicola sagittata* near Bendigo, Victoria

by CHRIS L. TZAROS, 20 Guys Hill Road, Strathfieldsaye, Victoria 3551

Summary

Observations on the Speckled Warbler *Chthonicola sagittata* were made between June 1992 and January 1993 in box-ironbark open forest near Bendigo in central Victoria. Foraging behaviour, movements and vocalisations of a pair of birds were studied from June to September, but these birds were not located during the breeding period. Speckled Warblers were found to forage predominantly on the ground, often among mixed-species feeding flocks, but they were observed to hawk insects in summer, feeding more on the ground in winter. They were found to be competent mimics of other birds, as well as having nine recognised calls of their own.

Breeding of a single pair of Speckled Warblers was studied in spring 1992. Both sexes built the nests, which were placed on the ground under small, leafy branches (both living and dead). Eggs were laid on alternate days from c. 13 to 17 September and hatched on c. 29 September to 3 October (c. 16 days incubation). A total of three eggs was laid, and all three of the young survived and left the nest on 18 or 19 October (c. 15-20 days nestling period). Only the female was observed to incubate but both parents shared equally in feeding the nestlings. Once fledged, the young stayed within 250 m of the nest and were fed by both parents for 43-67 days. During the first few days after fledging, the young perched quietly together on small, low branches and roosted in a similar situation. On approximately the third or fourth day after fledging, the young became noticeably more active and began flying more.

Two subsequent attempts at breeding failed. A second nest was commenced but the birds abandoned this. The female laid a second clutch in a third nest, which was destroyed during the incubation period by an unknown predator.

Introduction

There are few published studies of the ecology of the Speckled Warbler *Chthonicola sagittata*. Bell (1984), like others (e.g. Schodde & Tidemann 1986), found that Speckled Warblers were often in small groups (mainly in pairs) and frequently associated with other species in foraging flocks. Bell found that young Warblers stayed with their parents until just before the following breeding season, when they dispersed. Annual mortality was also high.

The species is a ground-forager and ground-nester, has two usual vocalisations as well as occasional mimicry, feeds mainly on invertebrates and occasionally seeds and fruits, and often occurs in mixed-species foraging flocks (Serventy & McGill 1982, Blakers et al. 1984, Schodde & Tidemann 1986, Emison et al. 1987).

Lepschi (1987) recorded a late brood of the Speckled Warbler in the Canberra district (35°15'S, 149°08'E), where a pair successfully bred in April. Emison et al. (1987) recorded October as being the only breeding month in Victoria, and Schodde & Tidemann (1986) recorded the Speckled Warbler breeding from August to January.

This paper describes observations on the behaviour and breeding of the Speckled Warbler near Bendigo in central Victoria.

Study area and methods

The study area was located within the boundaries of the One Tree Hill Regional Park 6 km south-east of Bendigo (36°40'S, 144°15'E), Victoria. An average annual rainfall of 541 mm is recorded for the area, and the average daily maximum temperature in summer is 29.2°C and in winter 12°C (Morcom 1988).

The area was intensively clear-felled during the gold-mining period (mid-late 1800s) and the present forest is regrowth and relatively immature Red Stringybark *Eucalyptus macrorhyncha*/Red Box *E. polyanthemos* open forest, with small amounts of Long-leaved Box *E. goniocalyx* and Red Ironbark

E. tricarpa in the eastern section. Red Stringybarks are more abundant on the shallow soils of the ridges and hilltops, and this species has suffered badly from cupmoth larvae infestations (Morcom 1988).

Most eucalypts were between 8 and 15 m tall. Vegetation was sparse in the gullies, and shrubs were more abundant on the lower hill slopes. The understorey was mainly grassy with species such as the introduced Quaking Grass *Briza maxima*, Common Raspwort *Gonocarpus tetragynus*, Kangaroo Grass *Themeda triandra* and Wallaby Grass *Danthonia* spp. Common shrubs included Daphne Heath *Brachyloma daphnoides*, Grey Everlasting *Ozothamnus obcordatus*, Golden Wattle *Acacia pycnantha*, Cat's Claws *Grevillea alpina* and Drooping Cassinia *Cassinia arcuata*. These were well spaced with frequent patches of grass and leaf litter.

The western section was burnt in late February 1989 and now consisted of dead and living Red Stringybark, Red Box and Long-leaved Box. There was also much fallen timber, particularly on the hilltops. Outcropping rock was also plentiful. Epicormic and lignotuberous shoots from the eucalypts now dominated the understorey vegetation, and widespread regrowth of grasses and herbs dominated the ground coverage.

All prey items observed were grouped together as macrofauna (between 10 and 100 mm), except for lerps (mesofauna, 2-10 mm) (Hurditch 1986).

Nesting and breeding data were obtained by observing nests located at the study site and from an analysis of Royal Australasian Ornithologists Union Nest Record Scheme (NRS) cards. Breeding behaviour (nesting to post-fledging) was observed between 7 September and 5 December 1992 for a total of 35 hours, and adults were studied during the non-breeding period for a total of 36 hours (48 observation sessions). Sex was determined from the birds' plumage, males having a black streak above the eyebrow and females having a brown streak. Photographs were taken to confirm plumage details. Individual recognition was determined by observing different colour-band combinations, the two breeding adults of the study pair having been mist-netted near the nest and banded.

Results

Movements and social organisation

Usually, single pairs were observed ($n=53$) but occasionally (usually during the breeding season) the Warblers formed small parties. The largest party observed contained nine birds (two adult pairs together with young). On 13 occasions, a group of five birds (an adult pair with three young) was observed, but this family party decreased to only the two adults when young either dispersed or died. Single birds ($n=20$), groups of three ($n=13$) and groups of four birds ($n=3$) were also observed.

Home-range size varied. One pair covered 4.3 hectares whereas another pair covered an area of 8 hectares. When the birds had a nest with eggs or nestlings, their home range decreased markedly to 0.3 ha as they were observed only within c. 60 m of their nest. Three pairs were located along one ridge-line, the average distance between each pair being c. 230 m.

The pairs did not have any regular daily movements and never covered all of the home range in a day. Each pair remained in a small (1-2 ha) section of the home range for c. 2 to 3 days, then moved to a different section and remained there for a similar length of time.

After roosting for the night, the Speckled Warblers usually called frequently early in the morning. Once enough light penetrated through to ground level, they commenced foraging and continued this for the remainder of the morning, only flying up to perches to preen or sing, or when flushed. During the early afternoon they preened on low perches, and resumed foraging later in the afternoon.

At the study site, all three young birds from one nest disappeared within 49 days of fledging. It is possible that they did not disperse but were taken by predators. A Collared Sparrowhawk *Accipiter cirrhocephalus* was seen in the home range of this pair on three separate occasions. During one instance, the adult female Warbler perched just 50 cm from the Sparrowhawk and began a scolding chatter, raising her head feathers and flicking her tail up and down whilst hopping from branch to branch. Amongst

the harsh chattering, the Warbler also uttered a soft musical whistle. Once the Sparrowhawk flew from the area, the distressed Warbler immediately concluded this display.

Effect of fire

The Speckled Warblers at the study site were perhaps more affected by the changed structure of the forest after burning than by the alterations in the level of insect abundance. Short grasses (10-20 cm tall) and small herbaceous plants formed a consistent sparse ground cover in the burnt section of the forest. Patches of Common Raspwort, regenerating Daphne Heath and fallen limbs and small trunks of the Red Stringybark and Long-leaved Box provided suitable nest sites. Small areas of ash beds, rock outcrop and fallen timber provided Speckled Warblers with increased preferred foraging substrates, as sections once containing dense grass and shrub cover were eliminated.

The number of Warblers may have decreased initially after the fire (Tzaros pers. obs.; also see Recher et al. 1985) but as the vegetation re-grew, the birds re-inhabited the area, preferring the new sparse growth to the nearby unburnt sections of thicker vegetation.

Bark gathered from Red Stringybark trunks and branches, fallen as a result of the fire, was used by a pair of Speckled Warblers during nest construction.

Mixed-species feeding flocks

The Speckled Warbler is a regular attendant in mixed-species feeding flocks at all times of the year, but more frequently during the non-breeding period (86.2%, n=82) than in the breeding months (68.1%). When in mixed-species feeding flocks, the birds were not observed to alter their foraging method. The main advantage for Speckled Warblers participating in these flocks appeared to be the detection of predators by other birds. Arboreal species such as the Striated Thornbill *Acanthiza lineata* and occasionally the Buff-rumped Thornbill *A. reguloides* and Brown-headed Honeyeater *Meliphreptus brevirostris* usually detected predators before the ground- or understorey-foragers and their alarm calls alerted all other species in the vicinity. The major nuclear species were Buff-rumped and Striated Thornbills. Other participants of mixed-species feeding flocks are listed in Table 1.

Several bird species frequently foraged near the Warblers' nest, but this was accepted by the Warblers. Only when birds came within 50 cm of the nest did the male show concern and, on two occasions, he was observed to chase individual Buff-rumped Thornbills away from the nest.

Flight and perch sites

The Speckled Warbler was found to have a rather weak, undulating flight, usually slow and direct and close to the ground. Juveniles flew more slowly over shorter distances and with fewer undulations than adults. Adult flight lengths were estimated 98 times, with most being 20 m (20.4%). The longest flight distance recorded was 90 m. Juvenile flights were also mainly 20 m in length (35.7%) with the longest flights measuring 50 m. Adults generally took about 5 to 6 seconds to fly a distance of 20 m (12-14.4 k.p.h.).

Speckled Warblers were often seen perched on the ground (24.6%, n=207), but when flushed or when preening or singing, they perched on branches with either sparse or no foliage (eucalypts 45.4%, acacias 8.7%). Rocks (4.3%) and low fallen branches or twigs (1.0%) were rarely used. Dense shrubs were also rarely used (6.8%). On

Table 1: Bird species associated with the Speckled Warbler in mixed-species feeding flocks at the study site, Bendigo, Victoria.

<i>Common name</i>	<i>Scientific name</i>	<i>No. of days associated with Speckled Warbler</i>
Buff-rumped Thornbill	<i>Acanthiza reguloides</i>	52
Scarlet Robin	<i>Petroica multicolor</i>	33
Striated Thornbill	<i>Acanthiza lineata</i>	30
Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>	28
Spotted Pardalote	<i>Pardalotus punctatus</i>	24
Silvereye	<i>Zosterops lateralis</i>	20
Golden Whistler	<i>Pachycephala pectoralis</i>	15
Yellow Thornbill	<i>Acanthiza nana</i>	13
Brown Thornbill	<i>Acanthiza pusilla</i>	12
Varied Sittella	<i>Daphoenositta chrysoptera</i>	12
White-throated Treecreeper	<i>Cormobates leucophaeus</i>	11
Weebill	<i>Smicronis brevirostris</i>	11
Brown-headed Honeyeater	<i>Meliphreptus brevirostris</i>	11
Grey Fantail	<i>Rhipidura fuliginosa</i>	11
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	10
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>	7
Striated Pardalote	<i>Pardalotus striatus</i>	5
Horsfield's Bronze-Cuckoo	<i>Chrysococcyx basalis</i>	1

the occasions when the birds were seen in dense shrubs, they perched on distal branches which were usually relatively bare or defoliated. When the Warblers preened during the day, they usually sat on exposed branches. The birds were observed on 15 occasions (7.2%) to fly and perch in Box Mistletoes *Amyema miquelii* where they preened amongst the relatively dense foliage. A male bird, during nest construction, perched sideways on a vertical trunk of a Red Stringybark to gather bark fibres. Juveniles also perched in open circumstances, even while roosting at night. Juvenile roosts were between 40 cm and 3 m above ground in low sapling eucalypts where the foliage was sparse, usually on proximal branches. The young birds huddled close together for the night. Adults roosted at a height of between 2 and 5 m, again where the foliage was not dense.

Different substrates were used by the birds for different purposes. The highest perch recorded in adults was 8 m (3.0%, n=200) and the lowest was at ground level (29.0%). Eucalypt branches between 2 and 5 m were the most popular perch heights for adults (47.5%). The highest perch for juveniles was also 8 m (2.3%, n=87), the lowest was at ground level (17.2%) and the most popular perch height for juveniles was between 2 and 4 m (35.6%).

Foraging methods and substrates

The Speckled Warblers foraged predominantly in small open patches on the ground (94.3%, n=70) and among layers of relatively thin leaf/stick litter, rather than among thick grass or stems of shrubs (Ford et al. 1986, Tzaros pers. obs.). On the ground, they jumped with both feet together. They foraged mainly by gleaning prey off the ground, and occasionally probing among the forest litter. Most of their foraging was undertaken during the morning and late afternoon.

Most small prey items were swallowed whole but items such as moths or caterpillars were first dismembered, usually by tapping the prey on a branch or other substrate, or by very rapidly and repeatedly releasing the prey from the beak and hurriedly snapping at it again.

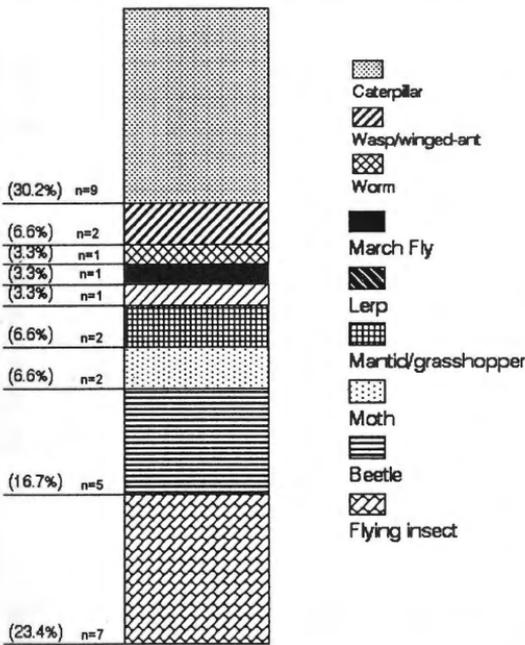


Figure 1. Percentage of different invertebrates eaten by Speckled Warblers, identified from feeding observations at the study site (June-December 1992).

Warblers among clumps of fruiting mistletoe but I have not recorded them feeding on the fruits.

Vocalisations

Nine different Speckled Warbler calls were identified, as well as mimicking of several other bird species:

- A soft, musical whistle heard all year round, but more frequently during the breeding months. Both males and females used this call but the male called louder, more frequently and for longer periods than the female. The whistle usually lasted for between 4 and 8 seconds. This call was easily distinguished from other birds' calls and was usually used to locate the Warblers in the field.
 - Juvenile birds also whistled musically but this was softer and higher pitched than the adults. This was first heard from a juvenile 42-43 days old (22 days after fledging), and was not heard before this stage.
- Harsh chatter. This scolding, aggressive churr was uttered only by adults (both sexes) when flushed from the ground, even during the non-breeding period. The female also used this when disturbed from the nest and it was used by the male when confronting other male Warblers in his territory. The pitch and tone of this call seemed different in different pairs of birds, sometimes being more rattly and soft rather than scolding.
- Harsh single note. If an intruder approached while the birds were foraging on the ground, this alarm call was given, then the birds flew to a nearby perch. Adults and juveniles of both sexes gave this call.
- Flight call. During pauses between wing-beats in their undulating flight, the birds gave a short *pip* call, repeating this until they alighted on a perch. This was useful

The average distance jumped by Speckled Warblers was 2.5 m per minute, with an average number of jumps being 80.3 per minute (recorded at 1 min. intervals over a 5-min. period). They had an average feeding strike rate of 4.2 captures per minute over 30 minutes.

Diet

The diet consisted of various invertebrates, mainly small unidentified insects which the birds captured while hopping along the ground and briefly probing among leaf/stick litter. Usually, only brief sightings of prey items were obtained, but some invertebrates were identified to order or family (Figure 1). The largest observed prey item was a caterpillar measuring c. 30 to 35 mm. Most insects consumed were between 2 and 4 mm in length.

I regularly saw Speckled

Table 2

Species mimicked by male and female Speckled Warblers at the Bendigo, Vic., study site, and numbers of times each species was mimicked (June 1992-January 1993).

Common name	Scientific name	No. of times mimicked	Sex of bird mimicking
Horsfield's Bronze-Cuckoo	<i>Chrysococcyx basalis</i>	4	male
Varied Sittella	<i>Daphoenositta chrysoptera</i>	4	male
Shining Bronze-Cuckoo	<i>Chrysococcyx lucidus</i>	2	male
Weebill	<i>Smicrornis brevirostris</i>	2	male
Brown Treecreeper ^a	<i>Climacteris picumnus</i>	1	male
Buff-rumped Thornbill	<i>Acanthiza reguloides</i>	1	female
Striated Thornbill	<i>Acanthiza lineata</i>	1	male
Scarlet Robin	<i>Petroica multicolor</i>	1	male
Restless Flycatcher ^a	<i>Myiagra inquieta</i>	1	male
White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>	1	male
Grey Currawong	<i>Strepera versicolor</i>	1	male

^afrom a cassette recording by Bill Flentje

in the field as I could determine when the birds departed from a perch.

5. A *pip-pip* note, similar to the flight call, was given while the birds perched. This was usually accompanied by the tail flicking up and down and frequent hopping from perch to perch.
6. Soft, rattly chatter. Only the adult male used this call when he accompanied the female to the nest. On a perch near the nest, the male watched the female enter, uttered the call, then departed.
7. A single, plain whistle lasting for about one second given by the adult female when accepting food from the male.
8. Juvenile begging calls. Begging calls (typical of small passerines) made by nestlings only when adults arrived with food.
9. Fledgling begging calls. A *pip-pip-pip-pip* (repeated in quick succession) call was given by the fledglings. This was used to maintain contact with other young Warblers and the adults. When the adults fed the fledglings, the latter gave the same call but louder and more frequently.
10. Mimicry. Speckled Warblers mimicked a total of nine different species (Table 2). Mimicry was interwoven into their usual song. The greatest number of species mimicked in one singing session was three. Males were responsible for the majority of the mimicry (16 of 17 records). Young birds were never recorded to mimic other species.

In summer, Speckled Warbler singing began about 40 minutes before sunrise (0520 h Eastern Summer Time) and reached a peak 30 to 40 minutes after sunrise (0630-0640 h). They continued to call irregularly throughout the remainder of the day. Towards dusk, calling decreased and the last call was recorded 5 minutes before sunset at 2000 h (method in Keast 1985) (Figure 2). In winter, calling began about 5 minutes after sunrise and the birds repeatedly called for 1 to 1½ hours thereafter. A peak was reached 10 minutes after sunrise where the birds called 21 times during a 10-minute period.

Mating strategy

During the non-breeding period, I observed four pairs of Speckled Warblers, all of which remained as pairs. On one occasion, two pairs foraged quietly together for

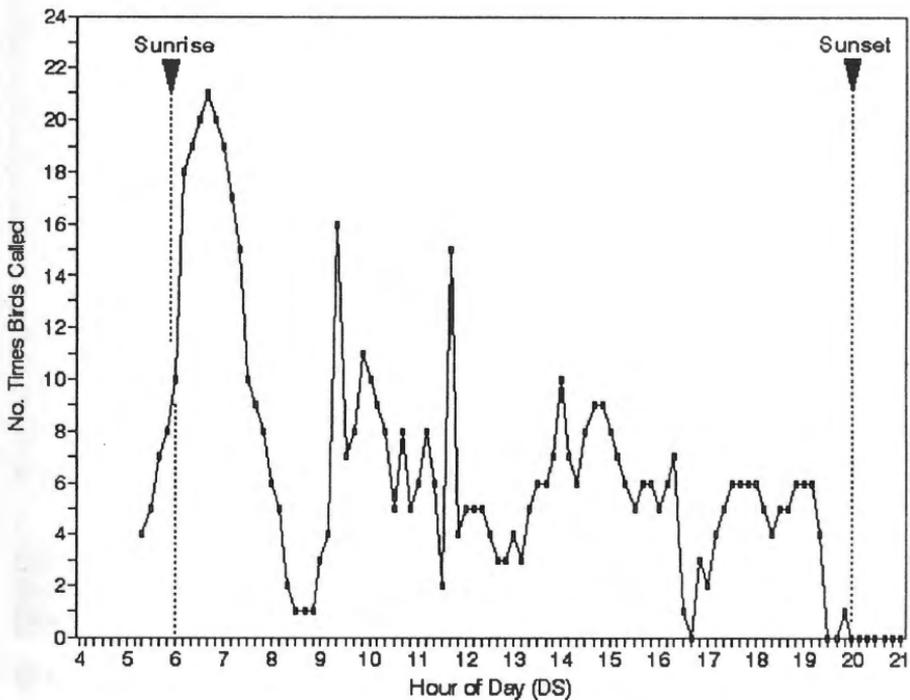


Figure 2. Song periodicity for the Speckled Warbler at the study site recorded at 10-minute intervals (26-27 December 1992) (DS = daylight saving) (method adapted from Keast 1985).

about 1 to 2 hours before separating back into their original pairs, one of which was the colour-banded pair. In another instance, a pair was intruded upon by a single male, which was vigorously chased away by the male.

Males belonging to pairs fed the females, even throughout the winter. Mutual preening was not observed in either breeding or non-breeding months. Two pairs nested and raised young. The pair under observation raised three young, began building a second nest, abandoned this second nest soon after completion, and then constructed a third nest and laid three eggs. This third nest was destroyed during incubation, but the male continued to feed the female and they foraged and roosted together. However, 13 days after the nest destruction, the female was observed with another adult male in the same territory she had occupied with the original male. The original male was not seen again. The female was observed to be fed by the new male five days later. The female and the new male were observed again on 14 July 1993 at the same site, where the male fed the female with an insect while both were foraging on the ground.

No behaviour which could be interpreted as advertisement, courtship or mating displays was witnessed. The male frequently offered prey items to the female and she accepted them. This occurred throughout the year and was therefore not considered a courtship act, but was probably directed at maintaining the pair-bond.

Breeding season, nest-site selection and construction

In this study the first observation of a nesting Speckled Warbler was made on

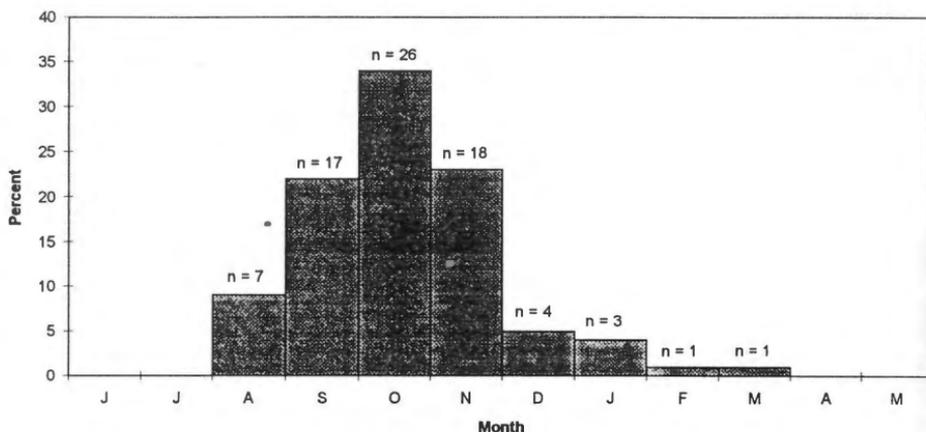


Figure 3. Breeding season of the Speckled Warbler (from an analysis of NRS data) (n = number of breeding occasions).

7 September (nest construction probably began c. 2-3 days earlier) and the last observation was at a nest containing eggs (which was destroyed) on 9 December. Recently fledged juveniles raised by a different pair of birds at the study site were observed on 28 October.

From analysing NRS cards, it was determined that October was the period of greatest breeding activity [33.8%, n=26 (13 eggs, 13 young)]. Breeding began in August and continued through to March, with a distinct peak in September, October and November (79.4%, n=61) (Figure 3).

I observed a male Speckled Warbler beginning to construct a nest depression in the absence of the female, which suggests in this instance that the male selected the nest site. However, this nest was abandoned soon after building commenced.

The first nest constructed by a pair of birds at the study site was in the burnt section of the forest (Plates 44 & 45), and was placed under a small, dried, fallen branch of a Long-leaved Box. The branch had c. 40 leaves, of which 28 directly sheltered the nest. Common Raspwort grew in small dense clumps (210-260 mm high) on either side of the nest but was more sparse in front of the nest. A small (50 mm wide) path led to the nest entrance from a rock 270 mm away. The birds used the rock as a landing point and hopped to the nest from that position.

The second nest, which was abandoned, was commenced under a horizontal branch growing from a low (310 mm high) sapling of a Red Stringybark. About 10 leaves directly covered the top of the nest, and Common Raspwort grew in small clumps in the general vicinity, giving the nest some camouflage. Quaking Grass was common throughout the entire site and this also obscured the nest.

The third nest, sited only 50 cm away from a regularly used wallaby trail, was under a small, fallen branch of a Red Stringybark, which again held dried leaves which covered the nest. Quaking Grass grew in profusion around the nest vicinity. Of the three nests, this was built in the most open site.

All three nests were located along a north-south ridgeline and all were on the eastern side of the ridge. The entrances to the first and second nests faced east-north-east, whereas the third faced south-south-east. Two nests were totally unprotected by canopy foliage and one nest was partly sheltered.



Speckled Warbler nest under dried, leafy branch, amongst a clump of Common Raspwort, One Tree Hill Regional Park, Victoria, 13 September 1992.

Plate 44

Photo: C.L. Tzaros



Speckled Warbler nest, One Tree Hill Regional Park, Victoria, 13 September 1992.

Plate 45

Photo: C.L. Tzaros

Table 3

Causes for nest failures in Speckled Warblers (from an analysis of NRS data where cause of failure known).

	<i>Predator</i>	<i>Possible predator</i>	<i>Desertion</i>	<i>Parasitism</i>	<i>Bad weather</i>
n	14	11	5	4	2
%	39.6	31.4	13.2	10.4	5.4

Analysis of NRS cards revealed that 61 nests were situated on the ground: thirty-two were under or amongst clumps or tussocks of grass; seven were at the base of trees; and the remaining nests were built under shrub foliage (5), amongst fallen branches and shrubs (3), beside fallen logs or branches (3), at the base of saplings (3), between rocks (1), under leafy branches (1), amongst leaf litter (1) or inside a rotted-out stump (1).

At the study site, both the male and female participated in nest construction (male 39.7%, female 60.3%, n=68). A juvenile bird raised by the adult pair earlier in the season was seen to visit the new nest, but it did not assist in construction. The time taken to complete a nest was three days. The birds commenced nest-building by scraping a small depression in the ground in which to place the nest. This was achieved by pecking with their beaks at first, then later scratching with their feet. Excess soil was pushed to the circumference of the hole. The birds then gathered materials and began building, starting from the rear, then the sides and roof. After the general exterior was completed, finer grasses and feathers were taken inside as lining.

The greatest number of visits per hour with nest material was 41 (male n=19, female n= 22) and the least was 2 (both by female), with an average of 17 visits per hour (recorded over a total of 4 hours). Nest materials were usually gathered from within 15 m of the nest. The presence of roots on the grasses used suggested that the birds pulled the stems from the ground rather than snapped them off. The stems from Quaking Grass lacked seed-heads, indicating that the birds either selected stems without heads or they pecked off the seed-head. Most grasses were obtained 2 to 3 m from the nest, the birds gathering a beakful then hopping to the nest. Other grasses used in the nest included Spear Grass *Stipa* sp. and the introduced Silvery Hairgrass *Aira capaniana*. Bark fibres were collected from fallen Red Stringybark trunks which lined a nearby fire-access trail, and also from a vertical trunk of a living Stringybark. The birds jerked backwards, often fluttering as they pulled bark fibres from the trunk. The male perched horizontally on the vertical trunk while gathering fibres, often having up to three or four attempts at pulling bark. Thin strands of moss were placed in the depression first and were later covered with fine grasses and feathers. Identifiable feathers included those of Australian Raven *Corvus coronoides*, Little Eagle *Hieraaetus morphnoides*, Domestic Chicken *Gallus gallus* and duck sp.; Rabbit *Oryctolagus cuniculus* and Eastern Grey Kangaroo *Macropus giganteus* fur was also found. Feathers and fur were the last materials to be added to the nest.

Quaking Grass stems up to 135 mm in length comprised about 60% (visual estimate) of the exterior nest contents, while stringybark fibres up to 126 mm long made up c. 25%; the remaining 15% consisted of Quaking Grass and moss. The nest interior contained an estimated 95% of Silvery Hairgrass stems up to 100 mm in length, and also feathers up to 60 mm and moss.

Nest measurements were as follows: total vertical nest height 72 mm, total width 105 mm, total length (from exterior back wall to entrance) 90 mm, interior nest

Table 4

Breeding success of the Speckled Warbler (from an analysis of NRS data).

Clutches (n)	Eggs laid (n)	Eggs hatched (n)	Hatching success (%)	Young fledged (n)	Young fledged per nest	Breeding success rate (%)	Nest success rate (%)
57	145	84	57.9	38	0.6	26.2	65.5

chamber height 62 mm, internal egg-cup depth (from floor to entrance) 32 mm, entrance to exterior bottom of nest 38 mm, entrance-hole diameter 37 mm, thickness of nest walls 15-20 mm. The depression dug in the ground measured 21 mm in depth in the centre, 81 mm wide and 83 mm in length. The birds were inhibited from digging any deeper by rocks at the base of the depressions.

Laying, clutch size, incubation and hatching

Three eggs were laid in each of two nests at the study site. The first egg was laid the day after each nest was completed. Eggs were laid on alternate nights (c. 41-55 hour intervals). The first egg of the first clutch was laid on 13 September, with the remaining eggs following on 15 and 17 September. The laying of the second clutch began on 4 December; a second egg followed on 6 December and a third on 8 December.

Incubation started with the laying of the first egg, with only the female incubating. The male was not observed to incubate or feed the female on the nest, but the male often alighted near the nest and called to the female. The female then emerged from the nest and fluttered to a nearby branch, where the male occasionally fed her. The female left the nest at intervals of approximately 50 to 55 minutes, usually leaving the nest unattended for an average of 22 minutes while she foraged with the male (n=25). The male fed the female regularly while foraging.

When the birds returned to the nest from foraging, they always perched on an exposed dead branch of a Red Box 2 m above the ground and 3 m from the nest. Both birds, when flying from the nest, usually flew to this branch first, before flying further to continue foraging.

The first egg of the first clutch hatched on 29 September. Second and third eggs hatched on 1 October and 3 October (16 days incubation period). The nest containing the second clutch was damaged on 9 December and abandoned.

From NRS data clutch size usually is three (97.5%, n=41), with a single record of a clutch of four, and the number of young hatched is usually three (56.5%, n=23), but occasionally two (6), one (3) or four (1). From the 51 records, 22 nests failed to produce young, 10 were successful and 19 had an unknown outcome; predation was the cause for most failures (84.2%, n=26) (Table 3). Table 4 summarises breeding success of the Speckled Warbler.

Eggs (one measured 17.5 mm x 13 mm) were brownish terracotta in colour and had a darker brown inconspicuous ring around the broader end which was about 3 to 4 mm in width. Eggs were an elongated oval shape.

Nestlings and fledging

Nestlings were frequently fed by both parents (male 56.5%, female 43.5%, n=48). The greatest number of feeding visits per hour observed was 14, and the least was 3 (average 6.5 visits/hour, n=20). Nestlings begged for food only when parents were

on the ground close to the nest and could be seen. After the parents had departed, the young immediately ceased calling.

Apart from during nest construction, the first observed occasion of the male at the nest was on 1 October when he fed the 2-day-old nestling. The male was noticeably more nervous at the nest than the female, and he often spent up to 8 minutes hopping through the grass, cautiously making his way to the nest. In contrast, the female landed on a rock near the nest and hopped directly to the nest, fed the young and departed. The male was also observed to raise his head feathers only while on the ground in the vicinity of the nest, and he occasionally uttered a few harsh chattering notes.

Egg-shells and faeces from the nestlings were removed by the parents, after they had fed the nestlings; these wastes were picked up in the beak and discarded when the parent flew to one of several perches.

When the nestlings were 2 to 3 days old, they were covered in a thin layer of soft, pale grey down, which turned darker with age, and they had small cream-white markings on both sides of the beak. When 7 to 11 days old, the down on the young birds' heads was almost black and their eyes appeared to be closed. When 14 to 18 days old, their eyes were open and feathers were well developed. Only one of the three nestlings was noticed to have a distinct brown line above its eyebrows. Pale streaks on the crown and upper back, and darker streaks on the chest and abdomen were also prominent. Once the young fledged, they did not return to the nest.

Young fledged on either 18 or 19 October, at c. 15-20 days of age. Plate 46 shows a c. 30-day-old fledgling.

Of the two nests completed, only one produced young: three young hatched, and subsequently all fledged, from the three eggs laid. (The three eggs laid in the other completed nest were destroyed by a predator). Hence 1.5 young fledged per nest.

Both male and female parents fed the fledglings. In one 40-minute observation period the male supplied food four times and the female seven times.

Discussion

Speckled Warblers seem to require specific habitat. In the Bendigo district, the species is associated with Red Stringybark, Red Box and Long-leaved Box rather than Red Ironbark or Yellow Gum *Eucalyptus leucoxylon*. Owing to various stresses, such as defoliation from cupmoth caterpillars, rocky and relatively infertile soils and insufficient rainfall, the stringybarks and boxes on the ridges and slopes are not large, the canopy is broken and there is often a good sparse herbaceous plant coverage; the Speckled Warbler requires such vegetation for both nesting and foraging. In this district, they require an environment with fairly sparse vegetation in order for them to have good access to the ground.

Speckled Warblers also appear to inhabit drier forest belts and show a preference towards undulating country. Loyn (1985) found that birds feeding from bare open ground are far more numerous on the drier ridges than in moist gullies. Although the species occurs in the mountainous higher rainfall districts, it is more numerous along the northern and western slopes of the Great Dividing Range (Blakers et al. 1984, Emison et al. 1987, Atlas of Victorian Wildlife unpubl. data 1993).

Contrary to Emison et al. (1987), the Warblers at the study site did not appear to be associated with thicker clumps of vegetation, such as Cat's Claws or Grey Everlasting, even though these were plentiful near their home range.

Serventy & McGill (1982), Schodde & Tidemann (1986) and Emison et al. (1987) all recorded that Speckled Warblers often associate with Buff-rumped and Yellow-



**A recently fledged Speckled Warbler, One Tree Hill Regional Park, Victoria,
19 October 1992.**

Plate 46

Photo: C.L. Tzaros

rumped Thornbills *Acanthiza chrysorrhoa*. At the study site, the Warblers were most often seen in groups with Buff-rumped Thornbills and were rarely with Yellow-rumped Thornbills, the latter preferring more open areas than Speckled Warblers.

Buff-rumped Thornbills and Yellow-rumped Thornbills are potential competitors of the Speckled Warbler for food and they often associate together, and with other species, to forage, but often use different substrates and possibly different foods. Other ground-feeders, such as the White-browed Scrubwren *Sericornis frontalis*, Superb Fairy-wren *Malurus cyaneus* and Chestnut-rumped Heathwren *Hylacola pyrrhopygia*, frequent the moister gullies and lower slopes where there is thicker vegetation.

Primarily, Speckled Warblers are ground-feeders throughout the year, although some observations suggest that Speckled Warblers feed on the ground more in winter than in summer, and they were recorded hawking aerial insects and leaf-pecking in summer. Hawking seems unusual as the species is typically an insectivorous ground-forager (Ford et al. 1986). The inclusion of arboreal foraging could possibly be related to an increase in aerial insects. Although the Warblers were not observed to feed on mistletoe fruits, they were often seen to fly deliberately, without being flushed, to clumps of fruiting mistletoes up to 8 m above the ground. H.A. Ford (pers. comm.), who recorded seeds from a similar fleshy fruit (Berry Saltbush *Rhagodia* sp.) in a Speckled Warbler's stomach-flush sample, suspected that these birds cannot digest the seeds and hence disperse them. Speckled Warblers are also suspected to feed on the fruit of Fishweed Goosefoot *Chenopodium trigonum* (Ford et al. 1986). Speckled Warblers were not observed on any occasion to defend a food resource in their territory.

Four species of cuckoo — Fan-tailed *Cacomantis flabelliformis*, Black-eared *Chrysococcyx osculans*, and Horsfield's *C. basalis* and Shining Bronze-Cuckoos *C. lucidus* — were present in the study area during the observation period. Although no parasitism was recorded here, all have previously been recorded parasitising nests of the Speckled Warbler (Campbell 1900, Chisholm 1934, Serventy & McGill 1982, Flentje 1982, Bell 1986, Brooker & Brooker 1989; Slater et al. 1989, L. Millar/NRS).

Although polygamy by the Speckled Warbler has been observed (Bell 1984), this behaviour was not recorded at the study site. The species is possibly a co-operative breeder. At the study site, an adult pair of Warblers together with three young (two being young of the year and one being older, possibly last season's) were observed. The adult male and female regularly fed the two younger birds and on one occasion the male fed the older bird. It is possible that this older bird was an auxiliary. R. Noske (NRS) reported co-operative breeding where four Warblers (two males, two females) attempted to nest together at a single nest. H. Recher (NRS) also suspected co-operative breeding as three adult Warblers were seen together at a nest.

The good rainfall and subsequent grass growth may have encouraged the Speckled Warblers at the study site to have three breeding attempts. Beruldsen (1980) recorded the usual breeding frequency as once a year, but possibly twice. R. Noske (pers. comm.) recorded a group of four birds nesting four times in a season (23 August-25 November 1977) without any success, with nests being ruined by predators and deserted.

Egg size varies considerably. Beruldsen (1980), Schodde & Tidemann (1986) and Slater et al. (1989) recorded a measurement of 19.0 x 15.0 mm, B. Wykes (NRS) recorded 20.5 x 15.0 mm, Campbell (1900) reported eggs measuring 18.2 x 14.9 mm, 18 x 14.4 mm and 17.7 x 14.4 mm, and I recorded an egg measuring 17.5 x 13.0 mm.

Although the male seemed very slow and nervous at the nest whilst under observation, neither he or the female was observed to pause for prolonged periods (cf. Chisholm 1967).

Further quantitative study is clearly required on most aspects of the Speckled Warbler's ecology, especially habitat preferences and factors limiting their distribution (e.g. grazing and predation). Diet (level of frugivory if at all) and the extent of co-operative breeding also need to be examined in detail. Further information on movements of the species is also required.

Acknowledgements

I am grateful to John Robinson who commented on many aspects of Speckled Warbler behaviour, habitat and predation, and for identifying plant and feather materials contained in nests. Don Franklin, Hugh Ford, Stephen Debus, Bill Holsworth and an anonymous referee made helpful comments on a draft. I also thank John Ipsen for commenting on habitat and nests, and Hugh Ford and Richard Noske for details concerning the diet, habitat, nest sites, predators and breeding success of the Speckled Warbler. Bill Flentje donated audio-cassette copies of vocalisations, Rob Jarvis (Dept Conservation & Natural Resources, Victoria) arranged the use of measuring equipment and Jon Starks provided information from the RAOU Nest Record Scheme. Doug Robinson gave habitat details and reasons for a possible decline and Rory O'Brien (Museum of Victoria), Stephen Debus and Hugh Ford brought relevant references to my notice. Trifona Tzaros assisted in the preparation of figures for this paper.

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