Rings and Wings: Observations from a Nest of the Western Yellowjacket, *Vespula pensylvanica* (Hymenoptera: Vespidae)

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Abstract: During the summer of 2015 a large and active colony of *Vespula pensylvanica* occupied and grew in a hollow log in the author's backyard in Calgary, Alberta, Canada. This paper details the observations made over the summer of 2015 and finally in March, 2016 when the nest and its contents were investigated. Investigation of the nest and its occupants included examination of the envelope, combs and numerous specimens of dead *V. pensylvanica* within. The specimens were examined to determine species, wing length, facial pattern and continuity of the yellow loop around each eye to determine the range of variation among individuals within a single colony.

Introduction

Vespula pensylvanica (de Saussure, 1857), the western yellowjacket, is a common species found from Manitoba to British Columbia in Canada (Buck et al. 2008). The wasps have the typical yellow and black coloration associated with the name yellowjacket. The diagnostic characteristic of this species is reported as a complete yellow ring or loop around the top of each eye (Buck et al. 2008). Subterranean nesting sites such as rodent burrows are common (MacDonald et al. 1974), but other nesting sites with dark spaces may be selected, including attics and inter wall spaces in houses (Buckell and Spencer 1950) and hollow logs. This species of yellowjacket is both a predator of other arthropods (Akre et al. 1981) and a general scavenger (Kimsey and Carpenter 2012). As such, its foraging can bring it into conflict with humans, resulting in its designation as a pest species (Akre et al. 1981).

During the spring of 2015, a queen of *V. pensylvanica* took up residence in a large hollow log (1.5 m long) in the author's back yard in Calgary, Alberta, and founded a colony (Figure 1). The log provided an ideal location for an urban colony as it provided protection from the elements and it minimized the chance of unwanted disturbance. The log has a hole from an old branch 35 cm from its base that would later provide an ideal entrance/exit to the developing nest.

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Figure 1. Hollow log on south side of author's backyard on a typically sunny summer day. Note the opening, which would eventually become the entrance to the wasp nest.

The author is a rapt observer of yellowjackets and as such the non-typical location (i.e., in a hollow log) of this colony

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provided an exceptional opportunity for observation and later investigation. Of specific interest were: 1) The rate the colony grew at and what precautions it took to prevent unwanted intrusions. Having previously observed guarding behavior in *Dolichovespula arenaria* (Calgary, Alberta) during the summer of 2008, the author wondered how it would manifest in *V. pensylvanica*. 2) How big was the nest - how many combs would there be and how many cells in each comb? 3) What variation existed among the individuals in a single colony? How often was the eye loop interrupted? (Buck et al. [2008] state that the eye loop in females is rarely interrupted) Was there a wide range of clypeal marking or only a few variations? What was the range of wing length - did this colony fall within the norms? A review of numerous published papers did not reveal any specific analysis of individual variation within a colony that answered these questions.

Summer 2015 Colony Observations

Wasps were first observed on 12 July 2015 when a few wasps were noticed coming and going from the entrance hole in the log. The maximum number of wasps seen in the entrance at any given time was three and no guard wasps were seen at the entrance. A small amount of finely chewed wood debris lined the base of the hole, although the nest had not grown large enough to extend past the hole (Figure 2). After 5 weeks, the activity at the colony had increased markedly. Forty-six wasps were seen entering the nest and 26 leaving it over a 41-second period observed in a video captured at 6:12 PM on 19 August. There also appeared to be at least one dedicated guard at the entrance for the majority of the video. Additional photographs taken on 25 August showed a continued high activity level with up to six guard wasps (Akre et al. 1976) on duty (Figure 3). By this time, much of the original large hole had been filled in with small bits of wood debris. The first male *V. pensylvanica* was noted and photographed on a nearby (opposite side of the yard) sunflower leaf on 13 October 2015 (Figure 4). No male wasps were observed entering or exiting the nest, so it is not known if this male was produced by this colony. Colony activity subsequently declined as the ambient temperature slowly dropped below freezing over a period of 3 weeks and food sources became scarce.

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Figure 2. Entrance to nest with a small amount of wood debris lining the base of the entrance area, 12 July 2015.

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Figure 3. Level of activity around the entrance to the nest on 25 August 2015. By this time, the diameter of the entrance had been restricted by a thick layer of wood mulch (small, loose particles of decayed wood), and at least six guards were facing outward and monitoring the traffic into the nest.

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Figure 4. A typical male *V. pensylvanica* photographed near the nest. Note the 13 antennal segments and 7 segments in the abdomen.

Observations from Dissection of the Nest

The nest was investigated further after overwintering, to provide information on its contents and morphology. The log was frozen to the ground and covered in snow during the winter, but enough thawing had occurred by 5 March 2016 (after 2 weeks of warm weather) to examine the nest inside the log. The envelope of the nest extended to within 40 cm (Figure 5) of the base of the log and was later found to terminate 13 cm from the apex of the hollow area in the log. The length of the nest from the exterior edges of both envelopes was 70 cm. The inside dimensions (at the outside edge of the envelopes) were 19 cm wide by 14 cm high on the opening end of the log, tapering to 12 cm in diameter near the apex. Assuming an average diameter of 14.25 cm this would make the volume of the nest, including the envelope, approximately 11.2 litres. Removing the envelope allowed for examination of the nest morphology. The nest was made up of eight combs. Four combs were located just under the envelope (three large ones with numerous cells and a smaller one at the base; Figure 6), and four more combs were found further into the log. Cells within each comb varied in size, depending on whether they housed worker or reproductive wasps (Figure 7). The number of cells per comb ranged from 61 in the smallest comb to over 1060 in the largest comb, with an average of about 620 cells per comb (Table 1). Each comb (except the smallest) was 11.1-16.3 cm by 19.0-35.5 cm in size (Table 1).

Observations of wasps from the overwintered nest

Ninety-four dead yellowjackets were found in the nest, including 3 queens and 91 workers. Antennal segments were counted for each specimen to determine sex, and based on the counts, none of the specimens were males. Upon removal from the nest, the specimens were stored frozen until further analysis was completed – at which point they were pinned and dried for storage in insect drawers. Of the three queens, one had damage to her wings and, assuming the damage is related to age, this might indicate that this one was the foundress. All specimens were *V. penslyvanica* and no other *Vespula* species were present.

Figure 5. Appearance of the nest on 5 March 2016. The outer envelope of the nest extends to within 40 cm of the base of the log. The dimensions of the envelope are 19 cm wide by 14 cm high. The base of the envelope is buried under woody debris.

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Figure 6. Three of the four combs revealed upon removal of the envelope. Note the tapering pillars connecting the lower combs to the ones above. Interestingly, some of the dead *V. pensylvanica* were found in lifelike poses (see inset).

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Figure 7. Sample comb showing variation in cell size within the comb. This shows comb #6 which had 663 cells. The smaller cells (441) on the right are worker cells while the larger cells (222) on the left were constructed later in the season for reproductives.

Table 1. Comb dimensions and number of cells

Comb #	Length (cm)	Width (cm)	# cells
1	35.5	13.3	857
2	25.1	12.2	1066
3	20.0	11.1	474
4	4.6	4.1	61
5	19.0	11.9	354
6	23.5	14.2	663
7	28.4	16.3	506
8	27.8	12.7	980
Average	23.0	12.0	620
Total			4961

Wing Lengths

The forewing lengths of 30 randomly selected workers and the 2 queens with undamaged wings were measured with digital calipers under a stereoscopic microscope at 10X magnification to determine the range of wing sizes for the wasps that died in the nest. Each wing length was measured from the base of the costal vein to the tip of the wing (Figure 8). The length of both wings on each specimen was measured twice and the average value of all four measurements was plotted in a frequency histogram (Figure 9). If a

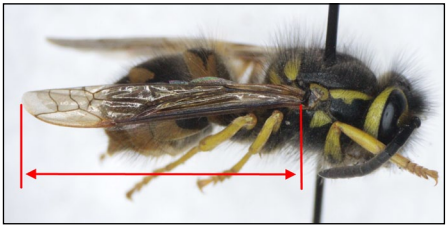

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Figure 8. Lateral view of a *V. pensylvanica* specimen showing the measurement points used in forewing length determination: base of the costal vein (just in front of the tegula) to the tip of the wing.

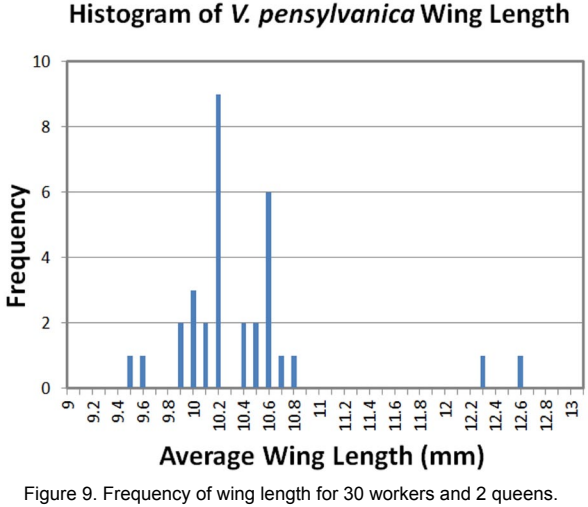

Figure 9. Frequency of wing length for 30 workers and 2 queens.

wing on a specimen was damaged or broken, the two measurements from the damaged wing were excluded from the average for that specimen. Worker wing lengths ranged from 9.5 to 10.8 mm with an average length of 10.26 mm. The most common length was 10.2 mm (found in 30% of the workers). The undamaged wings from the two queens were larger than those of the workers, with their forewings averaging 12.45 mm. These wing length ranges are similar to those published by Buck et al. (2008) for workers (8.5 – 10.5 mm) and on the low end of the range published by Jacobson et al. (1978) for queens (12.5 – 14.5 mm).

Facial Patterns and Eye Loops

Variations in head markings were noted during examination of wasps from the nest, so these were examined more closely to determine the variation of markings within the colony. The front of the head of the 91 worker specimens was photographed at 12.5X magnification to determine the variation of markings on the clypeus. The spectrum of markings varied from a single "dot" to "anchor" shaped to a vertical "stripe" (Figure 10 and Table 2). The most common markings were dots (34%) and pendulums (32%), and the least common clypeus marking was the presence of two dots. It is also worth noting that the black marking between the antennal bases varied from a solid band to a star-shape that was abruptly narrowed on each side close to the antennal base.

One of the diagnostic characteristics of this species is a complete yellow ring or loop around the top of each eye (Buck et al. 2008). So, it was interesting to note that 15 out of the 91 specimens (16.5%) had broken loops with thin bands of black breaking the yellow loop (Figure 11). Of these 15, 7

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Figure 10. Clypeal and frontal markings of six *V. pensylvanica* workers. These fell into the six basic categories shown here: Column 1 top to bottom: Dot, Vertical Dash, 2 Dots; Column 2 top to bottom: Anchor, Pendulum and Stripe. The top two images show the star-shape (left) and solid band (right) between the antennal bases. (12.5X magnification)

Table 2. Variation in clypeus markings (workers only)

Marking	#	%
Dot	31	34.1%
Dash	13	14.3%
2 Dots	1	1.1%
Anchor	8	8.8%
Pendulum	29	31.9%
Stripe	9	9.9%
Total	91	

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Figure 11. Variation in the structure of the characteristic yellow eye-loop in *V. pensylvanica* workers observed in this study. The top image shows an incomplete or broken loop above the eye (side view), and the bottom image shows a complete loop.

(7.7%) had both loops broken and 8 (8.8%) had one loop broken. It was also noted that specimens with broken eye loops predominantly have larger black markings, with none of the specimens having a dot or two dots. The two most common clypeal markings for workers with broken eye loops are pendulum (40%) and anchor (26.7%). Also 14 (93%) of the workers with broken eye loops showed no significant narrowing of the black band between their antennal bases.

Discussion

The observation and subsequent investigation of this *V. pensylvanica* colony have provided insight into the individual variation seen within a single colony in Calgary, Alberta. The wasps located the hollow log in just over a year after it was positioned, and the colony grew rapidly through the summer of 2015, producing eight combs. The presence of two additional queens in the nest is curious. Typically, new queens would have left the nest in search of mates and of overwintering sites (Akre et al. 1980). It is likely that these queens emerged too late in the season and did not have time to mature and leave the nest before the onset of unfavorable temperatures. Although this species of wasp is considered a pest, the author wasn't subjected to aggressive behaviour from individual wasps during nest and colony observations.

Some variation was noted in facial markings and wing lengths for colony members. The taxonomically diagnostic character of a yellow loop above each eye showed the lowest variation, but 16.5% of the specimens examined did not possess this character. Even in such specimens the yellow extends much farther dorsally on the inside of each eye than in related species such as *V. germanica* (Buck et al. 2008) enabling them to be correctly identified. In contrast, facial markings on the clypeus and frons showed a wider range of variation, though two markings, a pendulum and dot shape made up 66% of the markings for the population. Specimens with broken eye loops tended to have larger black clypeal and frontal markings. Forewing lengths of workers also showed some spread, though the values generally fell within published values for wing lengths (Buck et al. 2008). One queen had damaged wings, likely due to age, and may have been the foundress of the colony. The two additional queens found in the colony in the spring had smaller forewing lengths than reported by Jacobsen et al. (1978), and may not have reflected the size of queens that were produced earlier in the season. Since the damaged wings of the

probable foundress queen could not be measured, it isn't possible to state whether the relatively low wing lengths of the other two queens were related to the time of year (and potentially low food resources) or whether they were typical of the colony.

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