Wider aspects of a career in entomology. 13. Graduate studies in England, continued

Hugh V. Danks

This series of articles outlines some ancillary aspects of my entomological career, for the potential amusement of readers. It reports the sometimes unexpected challenges of working in new places and in the real world, an approach that serves also to expose some conclusions about research activities and some information about insects and their environments. This article treats the rest of my time as a graduate student in entomology.

My research on solitary wasps and bees nesting in bramble stems (see ESC *Bulletin* **52**: 196) continued at the Silwood Park Field Station of Imperial College, near Ascot, Berkshire.

Nests outside the field station were sampled too. In addition, hundreds of trap-nest bundles were placed in various locations in southeast England (e.g., Figures 1, 2). However, those sites were accessible to the public and nearly all of the bundles were vandalized, suggesting that such time-consuming projects are not worthwhile except in protected locations[1].

The outside work was made feasible by replacing my motorcycle with a secondhand Mini van. That

Figure 1. Chobham Common (the largest national nature reserve in southeast England: 656 hectares), where trap nests were placed.

Figure 2. View from the North Downs near Albury (at Newlands Corner, a nature reserve of more than 100 hectares), where trap nests were placed.

[1]Therefore, the key discovery from these travels was not about insects. It was that the best places to eat were cafes frequented by lorry drivers [truck drivers], because businesses on common transport routes would fail unless they provided wholesome and inexpensive meals. This expectation was met less often in North America!

Hugh Danks (hughdanks@yahoo.ca) retired in 2007 after many years as head of the Biological Survey of Canada. In that role, he helped to coordinate work on the composition and characteristics of the arthropod fauna of the country, and to summarize the results. In addition, his research studied cold-hardiness, diapause, and other adaptations to seasonality in northern regions.

vehicle (Figure 3) was indeed "mini": it had small wheels and a small engine, and would have been unsuitable for most North American conditions—but it was ideal for English country roads, and there was space in the cargo area for armloads of brambles.

The van was used only once in an appreciable amount of snow (insufficient practice for later winters in Canada). The snowfall was followed by a warm spell, which softened the snow and made it more slippery. Assuming incorrectly that the warmth had made driving easier, one English student crashed into the field-station gate … but nevertheless reacted calmly.

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Figure 3. Vehicle used in the 1960s for the fieldwork noted here (Morris Mini Minor van), parked on a suburban street.

Some other residents at Silwood were less serene, given the range of personalities and cultural norms: people came from several regions of the United Kingdom, and from many different countries. Despite this diversity—and even because of it—they contributed to entomology in various ways, and subsequently promoted the study of insects across the world. Nevertheless, their differences led to occasional disagreements, and a few especially volatile individuals were involved in loud and spectacular incidents in the student lounge.

A student from Australia had a robust physique and a robust vocabulary. In the evenings, he and I would often play snooker at the field station, when his performance was reflected by how frequently he employed certain forthright expressions unsuitable for use in the *Bulletin*. It is said that proficiency in indoor games is the sign of a misspent youth, but those games taught me a valuable lesson: confidence is as necessary as technical ability. When confident, I expected to make every shot, and usually did; when I was unsettled, even easy shots would fail. Such a lesson applies to almost every activity. Confidence, like execution, is enhanced by study, preparation, effort, concentration, and practice.

One set of English students adopted an exaggerated simple or rustic demeanour, as if to contrast with the affected manner common at the Ascot races. A couple of them gained employment in Australia. A few years later, they already carried themselves in an even more relaxed manner, and spoke with pronounced Australian accents.

At the opposite extreme was an English student from the undergraduate cohort after mine. He was strikingly pompous, a trait maintained after he secured a university appointment overseas. The position led eventually to a professorship, and at a conference soon afterwards, talking with a group of past students from Silwood, he proclaimed: "I have a Chair!" A former classmate, familiar with his posturing, deflated it with the response: "...but *I* have a settee!" [sofa]

My research at the field station continued with an attempt to measure aculeate populations. One wasp species (Figure 4) and one bee species (Figure 5) were studied in most detail.

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Figure 4. The crabronid wasp *Pemphredon lethifer* (or a similar species). Female length about 0.65 cm.

Walwyn (CC BY-NC-SA 2.0)

Figure 5. The colletid bee *Hylaeus brevicornis*. Female length about 0.5 cm.

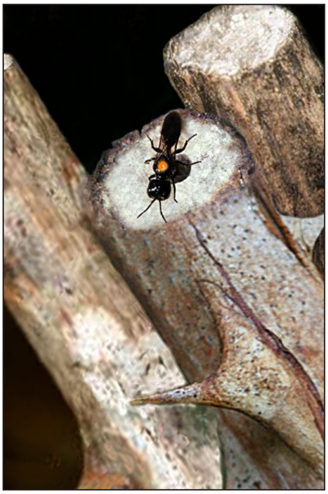

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Figure 6. Marked female of *Pemphredon lethifer* at the entrance to a nest. Wasps released in different areas of the field station were given different colours of mark.

Females emerging from nests collected locally were marked and released, and considered "recaptured" if any of them constructed nests in trap-nest bundles. Each day throughout the season, a long hike around the field station checked all of my 500 bundles. New nests were observed in suitable weather until the female was seen (cf. Figure 6). A population estimate could be derived from the ratio of marked to unmarked females.

My daily route took me past a small farm patrolled by a collie dog. It was not a threat. Many rabbits infected with myxomatosis virus were so sick that they might stop even when the dog was chasing them ... but then the dog would always stop too and wait for them to restart.

A second independent method of assessing aculeate populations focussed on bramble, by far the dominant habitat for nests. Bramble grew well on about 60 hectares of the field station, where there were more than 6 200 cubic metres of bushes.

The periphery of every bush had been searched for broken ends (which make the pith accessible) and nests, but to quantify their occurrence within entire stands I had to attack the virtually impenetrable bushes (Figure 7). Dozens of large samples were harvested with secateurs by cutting swathes 1.5 m wide through representative stands. Leather gauntlets held the thorns at bay … most of the time! In about half the samples, both living and dead stems were cut into 30-cm lengths to measure the diameter of the pith. The laboratory benches were soon overloaded, but at least there was plenty of material for additional trap-nest bundles.

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Figure 7. Stand of brambles, and (inset) close-up of the thorns.

The numbers of broken ends, nests, and successful cells could be related to the volume of bramble, giving population estimates, albeit with a high standard deviation. However, the less variable estimates from mark-recapture were in the same range, which lent credence to both estimates. Across the whole area, there were no more than a few hundred females of each of the two target species, despite the abundance of bramble and the fact that they were the most frequent and widely distributed species there. The populations of other species were limited too (as indicated by the bramble sampling only), although some were more aggregated or favoured shadier sites.

The bushes contained few broken, dead stems of large diameter, which are favoured by these species. Therefore—in view of the very low developmental mortality (see ESC *Bulletin* **52**: 200)—populations appear to be constrained chiefly by the availability of suitable nesting sites. Indeed, species that nest in existing cavities commonly occupied channels excavated by other species, and some were even seen to usurp active nests while the owner was away.

Assessing such low populations took much work but yielded relatively few publishable results. However, because work on nest contents was sure to yield data, this relatively risky attempt to advance knowledge seemed a useful way to develop the project. I sometimes questioned the wisdom of that decision whilst fighting more than 170 cubic metres of thorny bushes, measuring the pith diameters of more than 6 kilometres of stems, or completing the daily inspections of my trap-nest bundles when it was particularly hot or rainy!

Computer analysis of data is now taken for granted. One of the earliest computers had been installed at Silwood, but was much less powerful and efficient than modern computers despite its great size. A course for students taught simple programming with the now obsolete language FORTRAN, but a burdensome stack of punch cards had to be fed into the computer to run even the most elementary program.

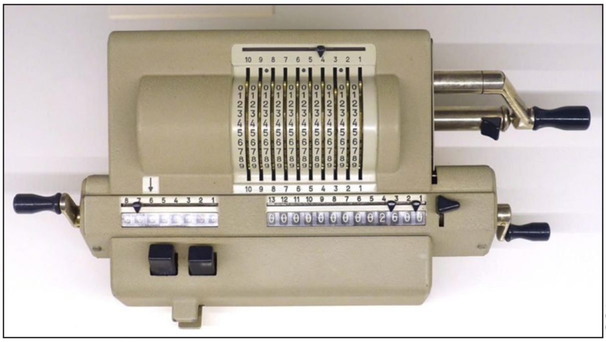

Figure 8. Example of a mechanical calculator.

Consequently, most of my data were analysed instead with a mechanical calculator (Figure 8). Its most conspicuous feature was the noise produced during division: the handle had to be cranked noisily multiple times until a bell rang, followed by a crank in the other direction[2]. Electronic pocket calculators became cheaper and more widely available towards the end of my degree, and I saved up to buy a sophisticated model designed for scientific calculations. It cost about £150 (worth several thousand in today's Canadian dollars), but was no more capable than the mass-produced scientific calculators now sold online and elsewhere for less than $20.

My graduate work exposed me to a number of professional entomologists with distinctive personalities. For example, a symposium of the Royal Entomological Society of London (subsequently published) was organized in 1967 by an Imperial College professor. He asked me to write down the questions and answers that followed each paper, to help him edit the proceedings. A senior professor from the hallowed halls of the University of Oxford approached me after his presentation, and told me to change his reply to one of the questions. I noted that my charge was merely to report accurately what was said, and he would have to address his request to the symposium organizer—a response that, given his unquestioned domain over students in his own department, was not received with equanimity!

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[2] Numbers were set in the register of the calculating machine by moving levers directly or through a keyboard. Forward rotation of the crank added the set number to an accumulator; backward rotation subtracted it. For division, the dividend was entered into the accumulator—if necessary by adding it from the setting field—and then the divisor was set. Division is equivalent to repeated subtraction: the answer (quotient) is how many times the divisor can be subtracted from the dividend. Therefore, backward rotations were made until a bell rang, showing that the number in the accumulator had become negative; a single forward rotation restored any remainder, while a rotation counter showed the answer. The number of rotations required was reduced because subtractions could be done separately, in decreasing sequence, for higher places in the quotient: each rotation would then subtract 100 or 10 times the divisor, for example, or add it back after the bell-ring prompt. [For multiplication, the set figure (the multiplicand) was added repeatedly to the accumulator. This was done the number of times specified by the multiplier, and verified by the rotation counter. Higher places in the multiplier could be accumulated separately too.]

One faculty member at the field station was a creative theoretician, but somewhat impractical. For example, he reached carelessly into a tree hole in the tropics and was injured by its occupant; and he limited the supply of oil to his old car in the hope it would use less. When he explained his theoretical conclusion that one should drive across intersections as fast as possible to be at the place of maximum danger for the minimum possible time, students suspected that he was not joking.

Another faculty member had designed a machine to monitor the activity of ants in a network of tubes. Whenever an ant passed a photoelectric sensor, it caused a pen to strike a paper chart. An audible alert could be added as each ant passed, and there was also a multiplier that served to visualize low levels of activity by creating 10 records for every passing ant. I was once nearby when ant activity increased. The audible signal and the multiplier were both engaged, and my first instinct was to take cover at the sound of machine-gun fire.

The faculty member requested resources to expand this network, and gave a long and detailed demonstration to O.W. Richards, who was head of the department (and my supervisor). O.W. listened silently until the end. "That's all very well," he said, "but I hope you remember you've got an ant in there somewhere." He did approve the request.

The fact that all of my reared specimens were mounted (e.g., Figure 9) allowed me to receive significant support from O.W. towards the end of my work. An unexpected taxonomic problem arose for *Spilomena* (Figure 10), a genus of tiny wasps that stock their nests with thrips. Only one species had been reported from the British Isles, but a key to the European species (in German) seemed to show that much of my reared material was a different species. I asked O.W. for confirmation, and he identified a few specimens to the previously unrecorded species. "Bring me all of your material," he said. Although he was leaving soon for an extended trip overseas, he examined every one of my 200 specimens, finding those two species as well as a third species from a single nest. He also looked at material in the British Museum (Natural History) and discovered a fourth species from Britain. That effort prevented misinformation in my thesis.

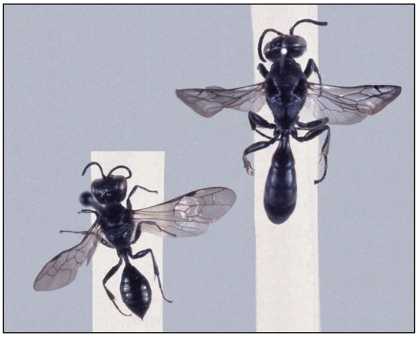


Figure 9. Stem-nesting aculeates from the research collection made during these studies: the crabronids *Pemphredon shuckardi* (L, length about 0.7 cm), which like *P. lethifer* stocks aphids in pith-partitioned tunnels; and *Trypoxylon figulus* (R, length about 1.2 cm), which stocks spiders in mud-partitioned cells in existing cavities.

Figure 10. Crabronid of the genus *Spilomena*, which stocks larval thrips in pith-partitioned nests. Length about 3.5 mm. Image from Bees, Wasps & Ants Recording Society 2020; bwars.com/wasp/crabronidae/inae/spilomena-troglodytes.

My general findings about the bramble-stem fauna were consolidated in a key to aculeate nests and the nearly 50 species that developed there. Diverse and overlapping characters gave the key an unusual structure: galleries might be linear or branched; cells varied in size and shape, and might be separated by pith, mud, sand, resin, leaf fragments, or salivary secretions; there were many different kinds of prey (aphids, spiders, flies, psocids, psyllids, thrips, or caterpillars); each nest might contain cells with one or some combination of prey, developmental stages of aculeates, and their natural enemies (e.g., Figures 11,12); more than one species of cell-maker might be present when a partly completed nest had been usurped or superseded; some of the parasitoids were associated with

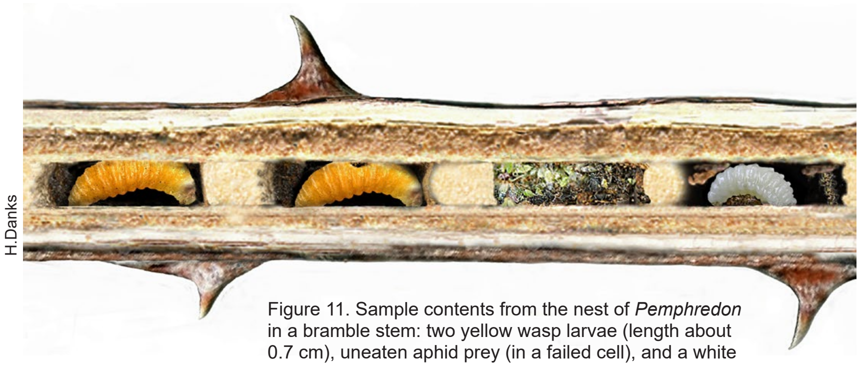


Figure 11. Sample contents from the nest of *Pemphredon* in a bramble stem: two yellow wasp larvae (length about 0.7 cm), uneaten aphid prey (in a failed cell), and a white chrysidid larva.

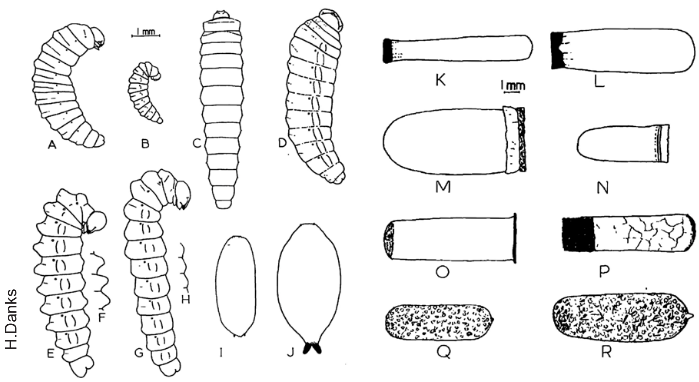


Figure 12. Sketches of some larvae and puparia (L), and cocoons (R) of crabronid wasps, megachilid bees, ichneumonids, chrysidids, and tachinids found in bramble stems.

several different hosts; and other insects were sometimes found, such as the puparia of a tachinid parasitoid that had come from earwigs sheltering in the nest channel.

My final request to O.W. was to review the draft of my thesis. The required format was more detailed than many modern theses, which contain papers suitable for publication (a valuable option that was not permitted at the time). Comments on the thesis did not relate to standards for publication, but only to the validity of the content.

Therefore, considerable additional work was required for subsequent publication. Only four papers were developed from my PhD, although the longest was 73 published pages. In contrast, one student from Silwood described many tiny aspects of his work in separate papers, a procedure that has become more frequent. Delivering results in “least publishable units” (LPUs) maximizes the number of publications, a statistic likely to impress administrators.

Another calculating approach, intended to favour promotions and grant applications, has developed more recently. A paper is submitted to the journal with the highest “impact factor” (provided the work might possibly be accepted there), whether or not it would be the most appropriate outlet; if rejected the paper is submitted to the journal with the next highest rank; and so on.

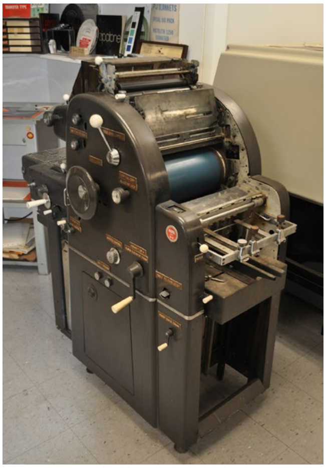
Such strategies might be acceptable if they have equivalent value for science, but not if they cause results to be published in too fragmentary a form or in the wrong place. My later attempt to synthesize the literature on insect dormancy was hindered by the need to integrate results published in multiple LPU papers by an author who should have done this himself in a much smaller number of publications.

Most of my contemporaries at the field station worked hard, having entered graduate school only by clearing the many hurdles of the British educational system. However, one PhD student had a limited focus on his studies of spiders. He often took a guitar into the field, whereupon his sampling might become erratic. When one laboratory trial was neglected for too long, he simply relabelled it as a "starvation experiment".

The student, hoping to obtain useful content for his thesis, requested a detailed analysis of his seasonal sampling records from a staff member whose particular expertise was interpreting the effects of weather in biological data. As soon as the assessment was complete, the student rushed over to find out the results.

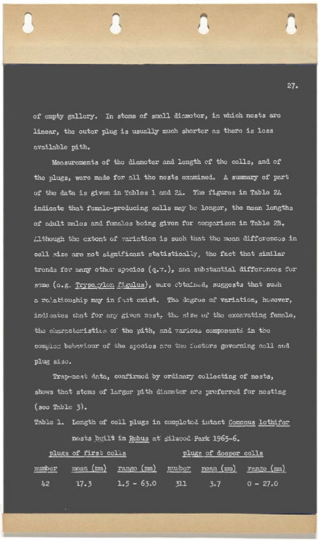
The analyst was a Scot, a man not known for elaborate commentaries, and he provided a complete summary of the results in a single sentence. "Your data show," he said, "that it got warmer in the summer, and then cooled back down again." The student eventually completed his thesis, but did not pursue an academic career.

When my own thesis was complete, multiple copies were made with a mimeograph (Figure 13)[3]. Duplicating the pages one by one was a time-consuming chore. Moreover, preparing the mimeograph stencils (cf. Figure 14), including many detailed tables, was a challenging task—and the thesis acknowledged not only my supervisor and the taxonomists who had helped me with identification of prey species, but also the expert typist who transcribed the manuscript on to more than 350 stencils![4]



Printhusiast (CC BY 4.0)

Figure 13. Example of a mimeograph (stencil duplicator). The model shown here is more sophisticated than the one used by the author.



27.

of empty gallery. In stems of small diameter, in which nests are linear, the outer plug is usually much shorter as there is less available pith.

Measurements of the diameter and length of the cells, and of the plugs, were made for all the nests examined. A summary of part of the data is given in Tables 1 and 2A. The figures in Table 2A indicate that female-producing cells may be longer, the mean lengths of adult males and females being given for comparison in Table 2B. Although the extent of variation is such that the mean differences in cell size are not significant statistically, the fact that similar trends for many other species (q.v.), and substantial differences for some (e.g. Trypoxylon figulus), were obtained, suggests that such a relationship may in fact exist. The degree of variation, however, indicates that for any given nest, the size of the excavating female, the characteristics of the pith, and various components in the complex behaviour of the species are the factors governing cell and plug size.

Trap-nest data, confirmed by ordinary collecting of nests, shows that stems of larger pith diameter are preferred for nesting (see Table 3).

Table 1. Length of cell plugs in completed intact Ceratina [illegible] nests built in Rubus at Silwood Park 1965-6.

plugs of first cells			plugs of deeper cells		
number	mean (mm)	range (mm)	number	mean (mm)	range (mm)
42	17.3	1.5 - 63.0	311	3.7	0 - 27.0

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Figure 14. Example of a mimeograph stencil. The holes near the top fit over pins on the drum, precisely positioning the stencil, which is then clamped at both ends.

[3]The mimeograph used a special wax-covered stencil, in which impressions were made by a typewriter with its ink ribbon disengaged. The ink-filled drum of the mimeograph had an absorbent ink pad on its surface, and the typed stencil was fastened around it. Each rotation of the drum against a pressure roller carried a sheet of paper through the machine and squeezed ink on to it through the impressions in the stencil. Running the machine (and pouring in the ink) required care to reduce the amount of extraneous ink transferred to the paper or the operator. Mimeographs became obsolete as soon as photocopiers were widely available.

[4]Most figures (including line drawings) were added to the thesis after the text had been duplicated, by interpolating pages with photographic copies. Captions were duplicated separately and affixed to those copies.

The thesis cited 263 references, the search for which had begun with titles provided by O.W. Richards. More than half were in languages other than English, consistent with my belief that effective scientific research requires thorough knowledge of the global literature[5].

Employment opportunities for entomologists were limited nationally, but there were more options overseas. My preference for Canada developed from many elements, including the size and natural diversity of the country. When O.W. heard of my interest, he suggested that I write to a former student of Imperial College then in Canada, Antony Downes. That contact elicited a later meeting in London, which led to my postdoctoral fellowship in Ottawa.

The formal oral examination remained. Unexpectedly, only my supervisor and the external examiner were there, sitting casually backwards on a pair of dining chairs. Nevertheless, I had prepared diligently, and braced myself for a penetrating question as the external examiner began his interrogation. "I hear you are leaving for Canada next week," he said. Fortunately, the doctorate was granted, allowing me to travel to Ottawa for the studies of insect cold hardiness outlined at the start of this series (ESC *Bulletin* **50**: 25).

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[5]Knowledge of the scientific literature outside the language of the author often is incomplete in current publications, even though computer-assisted searches are now available.