# CONTROL OF YELLOWJACKETS (HYMENOPTERA:VESPIDAE) IN BRITISH COLUMBIA

by

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**Control of yellowjackets (Hymenoptera: vespidae) in British Columbia**

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ABSTRACT

Yellowjackets may cause serious illness and death by stinging. They can cause economic losses to resort operators, disrupt agricultural operations and reduce the public's enjoyment of outdoor activities. Not all yellowjackets are pests, however, and some are highly beneficial because they prey on other insects.

At least 12 species of yellowjackets occur in British Columbia, but only two are serious pests; these scavenge for human food, which brings them into close contact with man, build very large nests that they defend vigorously and may sting without provocation in the fall. Two species are obligatory social parasites and the remaining eight species pose a problem only if their nests are disturbed. A brief review of the biology of yellowjackets, a discussion of outbreaks of wasps, a distribution map, a key for all yellowjackets, a pictorial key for workers and a key for nests of the common species in British Columbia, are included here.

The most common method of control is destruction of colonies. This technique is often indiscriminately applied and may not lower the numbers of scavenging yellowjackets in a large outdoor area significantly. Other methods of control are discussed, even though many are ineffective, impractical, unavailable in British Columbia or may make the problem worse. Insecticidal baiting and the use of synthetic lures are the most promising methods of control for populations of yellowjackets but more information and some experimentation is needed before they

can be recommended. A discussion of possible reasons for the attractiveness of synthetic lures and a description of the development of a municipal control program are included, along with recommendations for personal protection against yellowjackets and the treatment of stings.

## ACKNOWLEDGEMENTS

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## 1) Introduction

"Yellowjackets" is the North American vernacular name for a very successful group of social wasps, Hymenoptera that are nearly ubiquitous in much of the Holarctic (Greene 1979). They are primarily pests of north-temperate regions (Akre *et al.* 1980) and their presence in B.C. has been dated to the middle Eocene, approximately 50 million years ago (Wilson 1977). Most people recognize these relatively large, strikingly marked insects but few realize their seriousness as potentially dangerous arthropods (Fluno 1961) and even fewer appreciate their beneficial aspects.

Yellowjackets probably cause more illness and death in the Pacific Northwest than more well-known and better-controlled pests of public health importance such as mosquitoes and rats. Depending on a person's general health and susceptibility to the venom of a particular yellowjacket, a single sting from any yellowjacket can cause an allergic response ranging from slight discomfort to general malaise to death. This creates a problem for people who control yellowjackets because the damage threshold, a basic concept of pest management, is zero for highly sensitive individuals. Since the eradication of all yellowjackets is not practical nor desirable, only those controls that reduce the chances of being stung appreciably should be applied. For example, the *Dolichovespula* species and members of the *Vespula rufa* species group seldom bother man and are not a stinging hazard unless their colonies are disturbed or individuals are provoked. The only control that should be applied against these yellowjackets is the destruction of those colonies that are located in areas where they probably will be disturbed. On the other hand, members of the *V. vulgaris* group, *V. vulgaris* and *V. pensylvanica*, are stinging hazards near their nests and away because they are attracted to human foods and are more aggressive than other yellowjackets. All control measures, including the destruction of colonies, could be applied against these pests in an attempt to reduce the number of foragers. Unfortunately, however, most of the controls that have been developed to control yellowjackets, other than the destruction of colonies, are ineffective, insufficiently tested, or not available for use in British Columbia.

This paper discusses simply the biology of yellowjackets, the species present in B.C., and provides keys for their identification in an attempt to reduce the indiscriminate destruction of the *Dolichovespula* species and members of the *V. rufa* species group. Much more research on the biology of yellowjackets and their control must be done before an effective pest management program can be recommended for the members of the *V. vulgaris* species group.

2) Yellowjackets as pests

At least 15 to 20 people per year are killed in the United States by yellowjacket stings (Akre *et al.* 1980) but this estimate may be low because allergic people who die may be misdiagnosed as having died of a heart attack since the symptoms are similar (Blatherwick 1983).

In a 1965 report of the American Medical Association's Insect Allergy Committee (IAC), 2,606 victims of insect stings responded to a questionnaire and provided the following information on their allergic reactions:

Local reaction, 13% (347 of the respondents); local pain and swelling only.

Slight general reaction, 16% (421 of the respondents); mild disturbance, such as hives, in a "distant part" of the body.

Moderate general reaction, 44% (1,135 of the respondents); symptoms intermediate between slight and severe reactions.

Severe general reaction, 24% (630 of the respondents); severe breathing difficulties, shock and throat swelling; 292 became unconscious.

Delayed reaction, 3% (73 of the respondents); symptoms, including fever, joint pain and gastrointestinal disturbances, occurred at least one hour after being stung.

Barr (1975) reported the following symptoms from 249 patients he treated for insect sting allergy: generalized itching, angioedema, weakness, lowered blood pressure, unconsciousness, rapid heart beat, rashes, lymph node swelling, epigastric pain, vomiting, diarrhoea, incontinence and general paralysis.

It is apparent that the proportion of serious reactions increases after the age of 30 (IAC 1965). In addition, the severity of reaction to a future insect sting cannot be accurately predicted from previous reactions. Of the 630 people who reported a severe general reaction in the 1965 IAC survey, 83 could not remember a previous sting and 303 were previously stung with no reaction or, at most, a local reaction.

Allergic reactions to insect stings are not confined to atopic individuals: about 40% of the respondents to the IAC survey had not personal or family history of allergies.

Vespinae, especially yellowjackets, appear to be implicated in many stinging incidents. Of Barr's (1974) patients who identified the stinging insects, 67% named vespinae as the offenders: 47% of these were yellowjackets, 14% were "wasps" (possibly *Polistes* spp.) and 6% were "hornets" (probably the yellowjacket *Dolichovespula maculata*). Beard (1963) stated: "Allergists seem to agree that the yellowjacket (of all stinging insects) is the most potent in sensitizing individuals...".

Although Fluno (1961) claimed that yellowjackets do not transmit any disease, Edwards (1980) stated that yellowjackets, like house flies, are potentially able to transmit pathogenic bacteria onto human foods. Yellowjackets may acquire the bacteria while foraging at animal dung, garbage bins or other unsanitary areas.

People tend to avoid areas where yellowjackets are overabundant: park attendance in San Mateo County, California, was reduced by 90% at the peak of yellowjacket activity in 1962

(Grant *et al.* 1968). Not only are tourists and residents inconvenienced, but businesses catering to these people may experience losses: some California resorts reported losses up to $5,000 annually in the 1960's (Poinar and Ennik 1972).

Yellowjackets may cause problems for agricultural operations, especially in the orchard industry, through time lost from work, loss of fruit not picked, hospitalization of workers and, sometimes, primary damage to fruit (Spradbery 1973). Poinar and Ennik (1972) cited an unpublished report by Hawthorn (1969) claiming that yellowjackets cost California agriculture $200,000 a year.

Abandoned yellowjacket nests may be a source of infestation for stored product pests: the dried fruit moth *Vitula serratilineela*, dermestid beetle larvae and spider beetles have been reported from nests of yellowjackets in B.C. (Spencer 1960).

Other problems that yellowjackets may cause include the possible loss of goodwill and business in food handling establishments, contamination of manufactured foodstuffs (Edwards 1980), automobile accidents caused by reacting to their presence or sting (Fluno 1961), minor damage to tubular flowers (Edwards 1980) and interference with bee-keepers, including predation on honeybee colonies (MacDonald *et al.* 1974; Line 1965). And finally, as Akre *et al.* (1980) have said: "...most people are terrified of Hymenoptera and yellowjackets in particular. There is no way to determine the economic value of this stress upon people, but its importance must be recognized."

3) <u>Yellowjackets as beneficial insects</u>

Little is known about the role of yellowjackets in the biological control of pest insects but "it must be considerable" (MacDonald *et al.* 1974). Evans (1975) stated: "...yellowjackets consume great quantities of pest insects such as flies and caterpillars." *Dolichovespula arenaria* and *D. maculata* have been reported as effective predators of the fall webworm, *Hyphantria cunea* (Morris, 1972). Schmidtmann (1976) stated that *Vespula germanica* may be an effective predator of muscid flies. Payne and Mason (1971) stated that *D. maculata* fed on eggs, larvae and adults of Diptera. In B.C., Chapman (1963) noted that *V. pensylvanica* preyed on the reproductives of the ants *Leptothorax muscorum* and *Formica subnuda*.

*D. arenaria* and *Vespula consobrina* are important pollinators of the native orchid *Epipactis helleborine* (Judd 1971). Edwards (1980) stated that wasps, in search of nectar, must be as effective as bees in pollinating plants; this assertion, however, is doubted by Winston (1983).

Wasps may play a role in the distribution of naturally occurring diseases that affect some arthropod pests; Smirnoff (1959) reported that *Vespula vulgaris* and *V. consobrina* were efficient vectors of a virus affecting *Neodiprion swainei*, the Swaine jack-pine sawfly.

Some yellowjackets are important in the biological recycling of nutrients: scavenging yellowjackets are among the first insects to begin decomposing the protein of dead animals (Payne and Mason 1971).

4) Classification of yellowjackets occuring in B.C.

Richards (1971) stated that the word "wasp" could include almost any Hymenopteran that was not an ant, bee or sawfly. In his review of the biology of social wasps, Richards narrowed the field to contain members of the superfamily Vespoidea which are most easily recognized by their longitudinally folded wings and kidney-shaped eyes.

The Vespoidea contains three families: the Masaridae and Eumenidae, members of which are all solitary and the Vespidae, whose members are social. The Masaridae are characterized by clubbed antennae, members of the other families have filamentous antennae. The Eumenidae have one apical spur on their middle tibia whereas the Vespidae have two.

The Vespoidea contains three sub-families, two being found in British Columbia: the Polistinae and the Vespinae.

The Polistinae are a large sub-family, composed of three tribes. Two of the tribes are represented in B.C. (Buckell and Spenser 1950): the Polistini by *Polistes fuscatus*, characterized by a conical first abdominal segment and the Polybiini by *Mischocyttarus flavitarsis*, characterized by a slender and stalk-like first abdominal segment (Ebeling, 1978).

The Vespinae can be taxonomically separated from the other Vespidae by the presence of a broad first abdominal segment. According to Richards (1971) the Vespinae is composed of three principal genera, only one of which, *Vespula*, is found in B.C. Rohwer (1916) had divided the genus *Vespula* into two sub-genera: the *Vespula* and *Dolichovespula* but Duncan (1939) elevated them to full generic rank. Many North American yellowjacket authorities, including Akre and Masner, have since accepted Duncan's classification. Edwards (1980) provides a good summary of the history of Vespinae taxonomy.

Three major publications are directly concerned with the classification of British Columbia's social wasps. The first, by Buckell and Spencer (1950), listed and discussed 11 species of yellowjackets. Miller (1961) described a twelfth species, renamed one species, raised two sub-species and three varieties to species rank and omitted one species. Akre *et al.* (1980) discussed *Vespula* and *Dolichovespula* as full genera, followed Bequart's (1931) classification scheme of dividing the genus *Vespula* into two species groups and added one species, *V. germanica*, to the list of yellowjackets found in North America. Although *V. germanica* is not known to be present in B.C. as of 1983, it probably will be soon and has been included in this paper. The papers quoted above are compared in table 1.

Wagner in 1978 added *D. saxonica* to the list of yellowjackets found in B.C., but Akre *et al.* (1980) questioned its occurrence and I have not included it in this paper.

Table 1. Comparison of three papers on the taxonomic status and records of occurrence of yellowjackets in British Columbia, from 1950-1980

| Buckell and Spencer (1950) | Miller (1961) | Akre *et al*. (1980) |
|---|---|---|
| Genus: *Vespula* | Genus: *Vespula* | Genus: *Vespula* |
| Sub-genus: *Vespula* | Sub-genus: *Vespula* | |
| | | *V. vulgaris* species group |
| *V. vulgaris* | *V. vulgaris* | *V. vulgaris* |
| *V. pensylvanica* | *V. pensylvanica* | *V. pensylvanica* |
| | | *V. germanica** |
| | | *V. rufa* species group |
| *V. rufa atripilosa* | *V. atripilosa* | *V. atripilosa* |
| *V. rufa sladeni* | *V. acadica* | *V. acadica* |
| *V. rufa consobrina* | *V. consobrina* | *V. consobrina* |
| *V. austriaca* | *V. austriaca* | *V. austriaca* |
| | *V. intermedia* | *V. intermedia* |
| | | Genus: *Dolichovespula* |
| Sub-genus: *Dolichovespula* | Sub-genus: *Dolichovespula* | |
| *V. maculata* | *V. maculata* | *D. maculata* |
| *V. arenaria* | *V. arenaria* | *D. arenaria* |
| *V. norwegica* var. *norvegicoides* | *V. norvegicoides* | *D. norvegicoides* |
| *V. norwegica* var. *albida* | *V. albida* | *D. albida* |
| *V. adulterina* var. *arctica* | *V. arctica* | *D. arctica* |
| *V. adulterina* | | |

* not known to occur in B.C. as of 1983.

## 5) Biology

### 5.1) General

The following generalized account of yellowjacket biology is taken from Akre *et al.* (1980), except where noted. More detailed accounts can be found in Duncan (1939), Edwards (1980), MacDonald *et al.* (1974), Spradbery (1973) and Akre *et al.* (1976).

With the exception of the obligatory social parasites, *D. arctica* and *V. austriaca*, all normal non-parasitic yellowjacket colonies "develop in the same general way, exhibit the same general characteristics and undergo the same sequence of developmental changes" (Duncan 1939). This statement is correct for the purposes of this paper but the reader is directed to Archer's (1981) paper for a discussion of abnormal colony development.

Overwintered, impregnated young queens emerge from their protected hibernating sites during the first warm days of spring. They feed on flowers and other sources of nectar and catch and maxalate arthropod prey. The queen selects a suitable nesting site and gathers plant fibers to construct the queen nest.

The queen's nest ultimately consists of 20 to 45 cells covered with a paper envelope; a single egg is laid in each cell. The queen forages for nectar and arthropod prey to feed to the larvae. In about 30 days, from five to seven workers emerge and assume all the nest activities except egg laying. The queen, after a short period of additional foraging, does not leave the nest again.

The colony grows exponentially until late in the season when workers build large reproductive cells to raise queens and males. The colony begins to decline and the workers exhibit erratic behavior, sometimes pulling healthy larvae from cells and becoming more aggressive and unpredictable.

The new queens and males leave the nest and mate. The males, the original founding queen and the remaining workers soon die. The new queens find suitable hibernaculae to begin the cycle again.

The obligatory social parasites do not have a worker caste. A parasite queen enters a young colony of its host and, after a period of little activity, becomes aggressive and kills the host queen. The parasite queen and her brood are then tended by the host's workers.

5.2) Perennial colonies

Colonies of yellowjackets usually are annual in duration but there have been reports of perennial, or overwintered, colonies of wasps of the *V. vulgaris* species group. Richards (1978) stated that in areas with warm climates and mild winters, newly-fertilized queens may return to the colony and begin egg-laying. Spradbery (1973) calculated that one overwintered nest of *V. germanica* in New Zealand weighed about 450 kg. Duncan (1939) described a perennial colony of *V. vulgaris* in California. In the southeastern U.S.A., Ross and Matthews (1982) discovered two overwintered colonies of *V. squamosa*. In Washington State, Akre and Reed (1981b) discovered a large colony of *V. pensylvanica* with three functional queens and stated that it had the potential of becoming perennial. Perennial colonies of yellowjackets possibly may occur in the Lower Mainland of B.C.: Spencer (1960) described a large colony of *V. pensylvanica* found in a Vancouver house that the home-owner claimed was active for two years and I destroyed a colony of *V. vulgaris* in Coquitlam that the home-owner also stated was active for two years: three large plastic garbage bags were needed to remove the nest.

5.3) *Dolichovespula* spp.

The *Dolichovespula* spp. commonly build their nests in aerial, exposed locations. They feed primarily on live arthropod prey but may occasionally scavenge for protein foods. Like all yellowjackets, they may sometimes be attracted to sweets. Most nests are inactive by the middle of September ,figure 1 .

*D. arenaria*, the aerial yellowjacket, is the most common yellowjacket in B.C. (Buckell and Spencer 1950). This large, black and yellow species is also known as the yellow hornet (Caron 1974) and the Sandhills hornet (Milne and Milne 1980). *D. arenaria* builds relatively large nests with upwards of 2,000 cells (Greene *et al.* 1976) which are commonly found under eaves, in low bushes or trees, on telephone poles and in almost any other similar locations. *D. arenaria* is seldom a problem to humans if undisturbed but it will vigorously defend its nest and is capable of forcibly ejecting its venom (Greene *et al.* 1976).

*D. maculata*, the baldfaced hornet, is the largest yellowjacket in North America. It is found throughout B.C. and is particularly common in fruit growing areas (Buckell and Spencer 1950). This black and white wasp, also known as the spotted wood wasp (Couper 1870) and the black hornet (Sladen

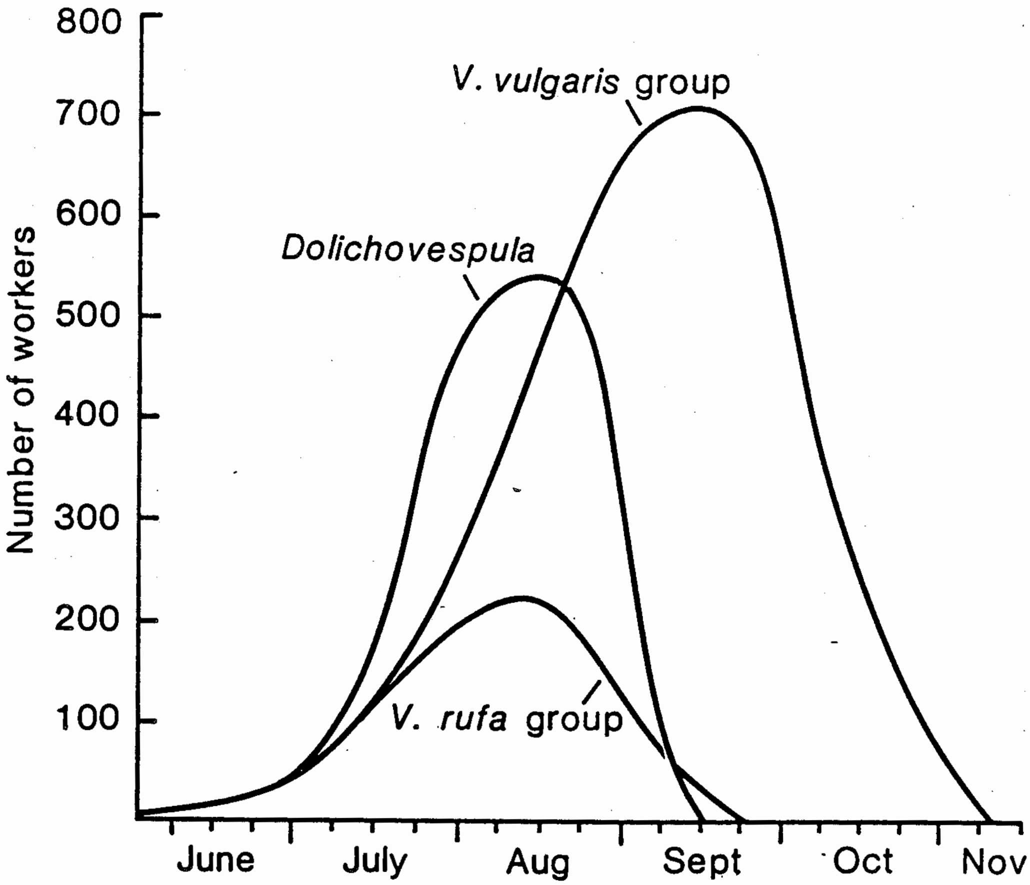


Figure 1. Comparison of the seasonal development of the Dolichovespula, the V. rufa group, and the V. vulgaris group (from Akre et al., 1980).

1918) is one of the less aggressive yellowjackets (Akre *et al.* 1980). *D. maculata* usually nests in vegetation, often many meters above the ground, under rock overhangs or on man-made structures; the nests can be very large, up to 35 cm in diameter with lengths of 60 cm (Akre *et al.* 1980).

*D. norvegicoides* is uncommon and little is known of its biology; it is presumed to be distributed throughout B.C. (Akre *et al.* 1980).

*D. albida* is found only in northern B.C., figure 2, and is uncommon; practically nothing is known of the biology or behavior of this species (Akre *et al.* 1980).

*D. arctica* is an obligatory social parasite of *D. arenaria* and, perhaps, of *D. norvegicoides*; it is found throughout B.C. (Akre *et al.* 1980).

### 5.4) *Vespula* spp.

#### 5.4.1) *V. rufa* species group

Members of this species group are seldom encountered because usually they nest in protected underground locations , have small colonies, often with less than 200 workers at any one time and fewer than 1,000 cells,and usually prey on live arthropods only (Akre *et al* 1980). They have a short colony duration and colonies often are inactive by mid- to late-September , figure 1 .

*V. atripilosa*, the prairie yellowjacket, is common in prairie and open forest habitats in the southern half of B.C., figure 2 . This species occasionally builds large nests,

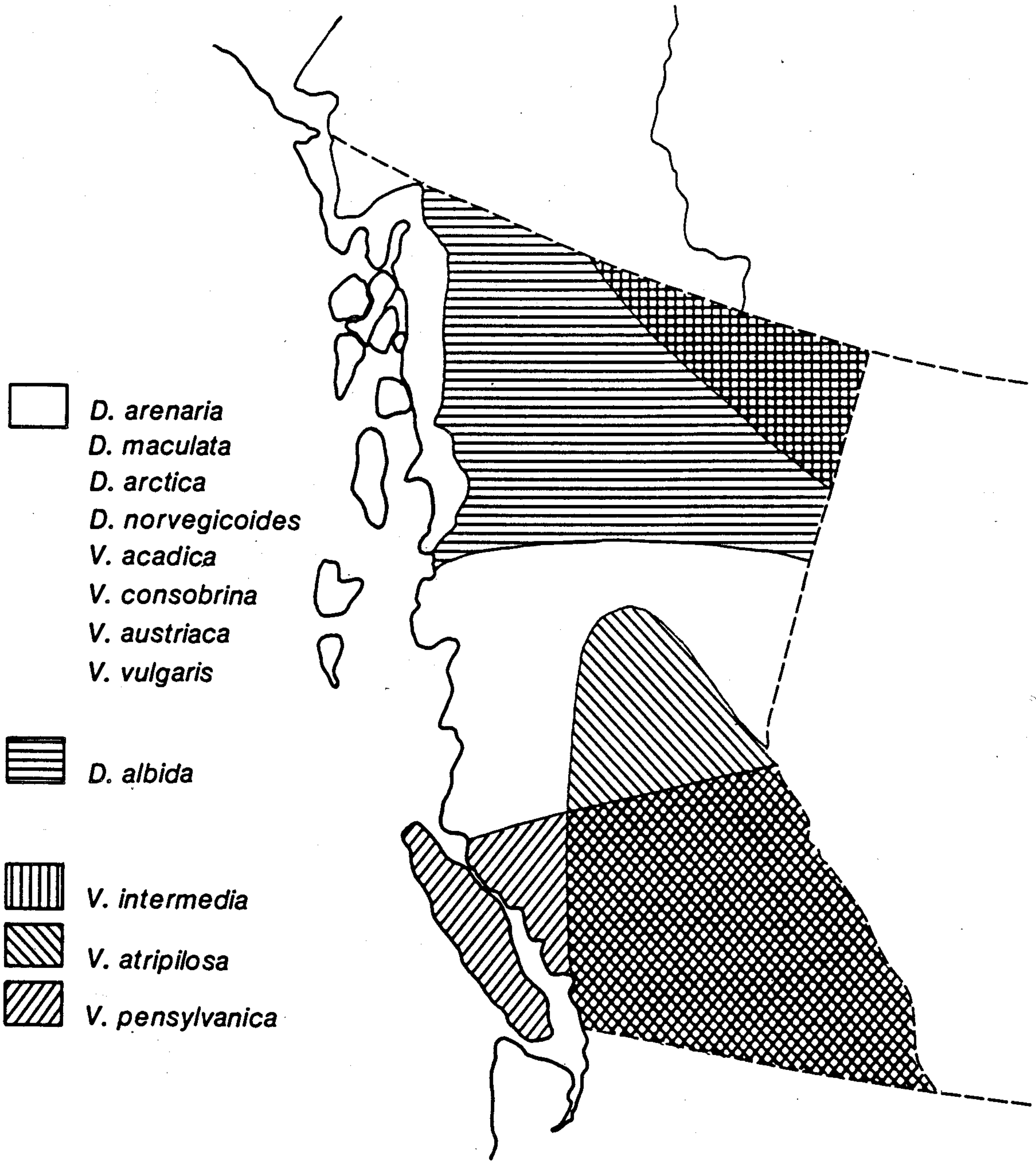


Figure 2. Distribution of yellowjackets in British Columbia (after Akre et al., 1980).

compared to those other *V. rufa* group members, with more than 2,500 cells (Akre *et al.* 1980). This yellowjacket is generally considered to be strictly predaceous (MacDonald *et al.* 1974).

*V. acadica*, the forest yellowjacket, is common in heavily forested areas in B.C., especially along the humid coast (Buckell and Spencer 1950).

*V. consobrina*, the blackjacket, is a black-and-white wasp which, along with *V. acadica*, forms the dominant *V. rufa* group species in forested areas in B.C.

*V. intermedia* is an uncommon black-white-and-red wasp found in the north-east corner of B.C. , figure 2 .

*V. austriaca* is a rarely collected obligatory social parasite, probably of *V. acadica*.

5.4.2) *V. vulgaris* species group

The *V. vulgaris* species group is often referred to as the genus *Paravespula* by many European authorities, for example Spradbery (1973) and Edwards (1980), and most recently by Akre (1983) of Washington State. It contains the most problematic yellowjackets. Members of this species group sometimes construct very large colonies often in wall-voids of houses. They persistently scavenge for human foods and have an extended colony duration often lasting into November, figure 1 . They can be extremely aggressive in defense of their nests and may sting with no apparent provocation.

*V. pensylvanica*, the western yellowjacket, is commonly found in open, dry habitats in southern B.C. , figure 2 . This species is a notorious picnic pest and is considered to be the primary yellowjacket pest from Washington to California (Akre *et al.* 1980).

*V. vulgaris*, the common yellowjacket, if found throughout B.C., especially in wet, forested habitats. The nests are found commonly in partially rotted stumps, buried logs or soil rich in organic matter (Ebeling 1978). It is the most common of its group in the Lower Mainland and scavenges for almost all types of sweets and proteins.

*V. germanica*, the German yellowjacket, has not been reported in B.C. at the time of this writing. This rather formidable wasp, which tends to nest more in wall-voids of houses than in the ground (MacDonald *et al.* 1980) and is more successful in urban centers than in rural areas (Parrish and Roberts 1982),is a recent importation from Europe. *V. germanica* was reported in Montreal in 1976 (Morse *et al.* 1976), in Winnipeg in 1979 (MacDonald *et al.* 1980) and in Puyallup, Washington in 1982 (Belton 1983). *V. germanica* often produces large colonies: Ishay and Brown (1975) reported that some annual colonies in Israel had 15 combs. This wasp scavenges for almost all types of protein and is especially attracted to sweets.

6) Outbreaks of yellowjackets

Populations of yellowjackets undergo enormous variations from year to year (Edwards 1979) and seasons of exceptional abundance are often called "wasp years".

The scavenging yellowjackets are responsible for outbreaks but other yellowjackets may also experience fluctuations in numbers. *D. maculata* has been reported to be common every three years in northern Ontario (Couper 1870) and *D. arenaria* was common in the Lower Mainland in 1977. Non-scavenging yellowjackets, however, seldom bother anyone and so their abundance may go unnoticed.

"Wasp years" are obvious when they occur and receive attention from the media, figure 3, but they have not been adequately defined. Basically, they are characterized by more and larger colonies of scavenging yellowjackets and large numbers of foragers: Akre and Reed (1981a) stated that the density of workers of three or more per square meter agreed with what they considered to be a "wasp year".

Most of the theories that attempt to explain the causes of "wasp years" are based on the number of inquiries received or on the number of nests destroyed by an authority. This can be misleading, however, because many inquiries concern the highly visible but generally non-pestiferous *Dolichovespula* species. The Simon Fraser Health Unit received 86 inquiries in 1979, a "wasp year", and 85 complaints in 1977. Most complaints in 1977 were about the early maturing yellowjackets, the *Dolichovespula* species,and the year was characterized by a large number of complaints in June, table 2. The data can be affected by other

Figure 3. 1979 Newspaper headline.

The **Columbian**

SATURDAY, AUGUST 11, 1979—58 PAGES

**Late Final**

15 cents

**SUBURBAN VANCOUVER'S DAILY NEWSPAPER** serving Burnaby, New Westminster, Coquitlam, Pt. Coquitlam, Pt. Moody, Surrey, N. Delta, Pitt Meadows, Maple Ridge, White Rock, Langley

# Stung again? Try a head to toe body-stocking

**What is black and yellow, one-inch long and stings all over?**

**If you guessed wasps, you're right.**

**By DARLENE BEATTIE**
**Columbian Staff Reporter**

And if you haven't been stung yet, you're lucky.

Swarms of them have struck the Lower Mainland and they're more brazen than ever. They'll eat pizza out of your mouth, buzz dive in your glass of coke, land smack in the middle of your ice cream cone and sting you if you take a swat at them.

Some experts say the influx is due to the dry weather. Others say it is a cycle.

But whatever the reason, they'll be here until the first frost.

At the teen day Surrey Centennial celebrations in Bear Creek Park this week, 50 kids were stung. Hospital Emergency wards are busy and pest control companies are buzzing with calls to remove nests.

Alladin Pest Control Ltd. owner Val Helgason says it is the worst summer for wasps in several years due to the dry weather and lack of moisture.

"We've been getting dozens of calls from people who say they can't go out on their patio and enjoy a barbecue because of them," he says.

Helgason says wasps are starving for moisture and will fly miles for water. He says people who have a swimming pool or put their sprinklers on, will attract even more wasps.

Helgason estimates he has removed 400 to 500 nests this season.

Art Grover of A-1 Professional Pest Services Ltd. says 90 per cent of their calls are to remove wasp nests.

He says most nests are found hanging from trees or eaves of houses but are also found in attics and behind walls.

Entomologist Bob Costello of the B.C. Ministry of Agriculture says wasps are bothering people more this season because they can't find enough natural prey and are looking for food.

He said he has had a 10-fold increase in the number of complaints of wasps this season, but can't pinpoint why there is an increase in the wasp population.

"The factors aren't well understood. They seem to be cyclical in numbers. But I don't know if it can be pinned to any one factor."

Costello discourages people from destroying the nests unless they are allergic to the wasp sting or because of their children.

"Wasps are beneficial insects. They feed primarily on caterpillars and other pests," he says.

All three men advise people to remove nests with caution and at night, after the wasps have bedded down.

There are three methods which can be utilized.

The easiest is to spray insecticide into the nest. There are some strong ones on the market. Raid isn't considered strong enough.

The other methods are to knock the nests down into a plastic bag and either burn them or drown them.

Putting the hose on them will only anger them and won't kill them.

Amateurs are advised to wear head gear and a net over the face, gloves tied to the wrist and coveralls tied around the ankle, so there is no opening to the clothing.

Table 2. The number of inquiries about yellowjackets during nine years, 1975 - 1983, by month, at the Simon Fraser Health Unit, Coquitlam, B.C.

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | | | | | | 4 | 12 | 24 | 10 | | | | 50 |
| 1976 | | | | | | 3 | 10 | 4 | 8 | | 2 | | 27 |
| 1977 | | | 1 | | 3 | 24 | 21 | 21 | 14 | | 1 | | 85 |
| 1978 | | | | | 3 | 6 | 5 | 6 | | 1 | | | 21 |
| 1979* | 1 | | | 1 | 1 | 7 | 39 | 32 | 5 | | | | 86 |
| 1980 | | | | | 1 | 2 | | 3 | 2 | | | | 8 |
| 1981 | | | 2 | | 2 | 2 | 5 | 6 | 1 | | | | 18 |
| 1982 | | | 2 | | 1 | 15 | 5 | 8 | 2 | 2 | 1 | | 36 |
| 1983 | | 2 | | | 1 | 3 | 7 | 9 | 3 | | | | 25 |
| TOTAL | 1 | 2 | 5 | 1 | 12 | 66 | 104 | 113 | 45 | 3 | 4 | 0 | 356 |

* 'wasp year': large numbers of _V. vulgaris_ foragers

factors. For example, an increase in the cost of destroying a colony reduced the number of complaints received by local boards of health in England (Edwards, 1979). Data may have been collected over too short a period to allow accurate interpretations. Edwards (1974) tallied the number of colonies destroyed by authorities in England over a period of 10 years and stated that 1970 and 1971 were years of "exceptional wasp abundance". Using data collected over 15 years, however, Edwards (1979) stated that the wasps in 1970 and 1971 were of "medium abundance" and 1974 and 1976 were "the wasp years".

No other area of the biology of yellowjackets has produced such strong and divergent opinions and include weather during the spring (Beirne 1944; Fox-Wilson 1946; Akre *et al.* 1980), weather at times of the year other than the spring (Scott 1945; Walsh 1945), competition between queens for nesting sites (Lord and Roth 1978; Matthews and Matthews 1979), availability of nesting sites (Spradbery 1973), pathogenic nematodes and bacteria (Poinar *et al.* 1976), genetic self-regulation of queens (Archer 1973), the availability of carbohydrate food (Rau 1929) and the availability of protein food, specifically, arthropod prey (Madden 1981). Four authors have reviewed these theories and have come to three conclusions:

1) Spradbery (1973) stated that the availability of many nesting sites was the most important factor. This seems unlikely, however, because of the great numbers of potential nesting sites that are available to scavenging yellowjackets.

2) Archer (1980) and Edwards (1974) supported Archer's 1973

theory of genetic self-regulation of queens. This theory is based on data that showed an alternating abundance of yellowjackets every two years. The data collected at the Simon Fraser Health Unit also shows that the yellowjackets are more abundant every other year, table 3 .

3) Akre and Reed (1981a) stated that a warm, dry spring is the primary cause of an outbreak of yellowjackets and is probably the most accepted reason. A mild spring allows young queens to forage more effectively for food to feed to her developing brood, lessens heat loss from the poorly-insulated queen-nest (Gibo *et al*. 1977) and reduces the risk of flooding underground nests. Occasionally, however, a warm, dry spring will not precede a season of exceptional numbers of wasps (Fox-Wilson 1946) and this hypothesis does not appear to explain such exceptions. Madden (1981) produced good correlations between the number of workers later in the spring and autumn- and spring-rainfall and the availability of prey while the queen is establishing its nest. Using casual records collected at the Simon Fraser Health Unit, table 3 , absolutely no correlation in ranking was found between the numbers of inquiries about yellowjackets and flies ($r_s$=0.00, Spearman's test), the prey in Madden's study and a slight but not significant correlation was found between the number of inquiries about yellowjackets and those of flies plus garden insects ($r_s$=.217), table 3. It seems probable that two or more factors need to coincide if an outbreak of yellowjackets is to occur. Spring-weather may be the most important but a variety of other factors may also be needed, figure 4.

An understanding of the causes of outbreaks would be useful for the control of yellowjackets. Populations might be manipulated or time and money could be budgeted for their control, but as Edwards (1979) stated: "... it is still a matter of waiting for the season to arrive".

Table 3. The number of inquiries about insects during nine years, 1975 - 1983, by year, at the Simon Fraser Health Unit, Coquitlam, B.C.

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL | AVERAGE | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ants | 7 | 44 | 32 | 18 | 16 | 13 | 19 | 11 | 19 | 179 | 20 | 12.6 |
| Carpet beetles | 12 | 15 | 12 | 6 | 3 | 8 | 7 | 14 | 16 | 93 | 10 | 6.6 |
| Cockroaches | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 33 | 4 | 2.3 |
| Fleas | 10 | 46 | 26 | 14 | 19 | 21 | 35 | 40 | 37 | 248 | 28 | 17.5 |
| Flies | 5 | 5 | 9 | 5 | 1 | 2 | 10 | 13 | 5 | 55 | 6 | 3.9 |
| 'Garden insects' | 16 | 31 | 26 | 4 | 4 | 5 | 6 | 32 | 26 | 150 | 17 | 10.6 |
| Mosquitoes | 42 | 44 | 16 | 9 | 63 | 4 | 8 | 46 | 13 | 245 | 27 | 17.3 |
| Silverfish | 8 | 10 | 5 | 5 | 7 | 3 | 9 | 9 | 2 | 58 | 6 | 4.1 |
| Yellowjackets | 50 | 27 | 85 | 21 | 86 | 8 | 18 | 36 | 25 | 356 | 40 | 25.1 |
| TOTAL | 152 | 225 | 214 | 85 | 203 | 68 | 116 | 206 | 148 | 1417 | | |

The number of complaints were significantly greater in odd years than even years (t=2.06; 95% conf.)

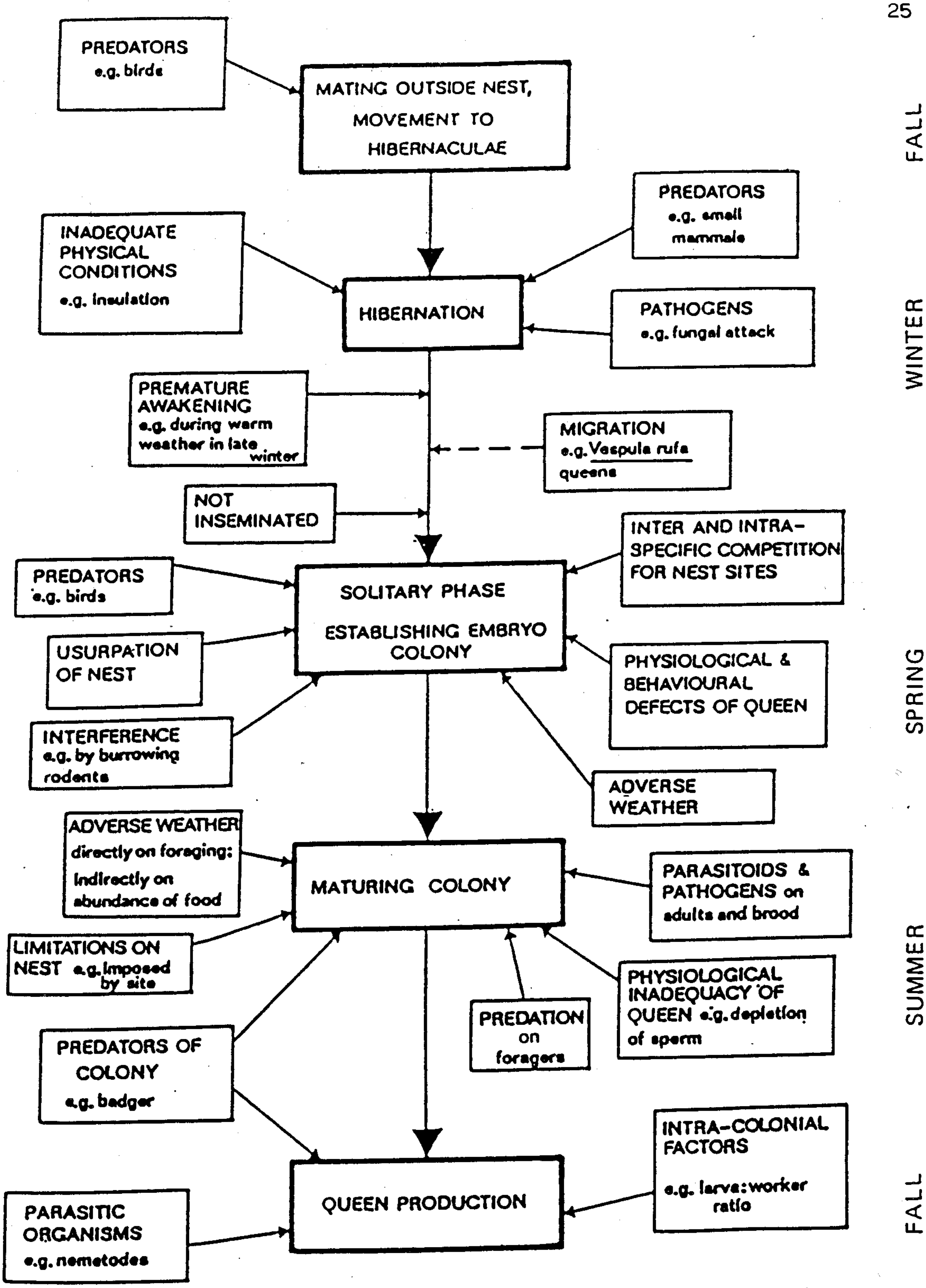


Figure 4. Factors that might affect populations of yellowjackets (after Spradbery, 1973).

7) <u>Why yellowjackets sting</u>

Yellowjackets sting in defense of their colony. Away from the colony, yellowjackets are usually peaceful and will not sting unless severely disturbed, as by being swatted or stepped on (Spradbery 1973). Any disturbance of the nest, however, may result in extremely aggressive behavior because the colony is highly vulnerable to predation. As Jeanne (1975) stated: "...(1) eggs, larvae, and pupae occur in large concentrations, making them attractive sources of food for a wide ranges of predators; (2) eggs and larvae are exposed in open cells, leaving them readily accessible to detection and predation; (3) nests are fixed in space, and the brood cannot escape predation by fleeing; (4) colonies of social wasps are of long duration (several months to several years), making the chance of discovery by predators relatively high".

The level of response exhibited by the defending yellowjackets is dependent on at least five factors:

1) The extent of the disturbance. A large disturbance, such as hitting the nest with rocks, usually will produce a strong response (Gaul 1948);

2) The size of the colony. Small colonies are less aggressive than larger ones (Akre *et al.* 1980);

3) The stage of colony development. At the time of emergence of the reproductives in the fall, adult yellowjackets can be extremely aggressive (Akre 1983a);

4) Previous exposure to disturbances. Colonies that have been repeatedly disturbed respond much more aggressively than undisturbed ones; and

5) Weather.

Defensive flights last longer, up to five minutes, in warm weather (Gaul 1953). Rau (1929) noted that *D. maculata* seemed to be more aggressive immediately preceding storms.

There are times, however, when yellowjackets are overtly aggressive in defense of their nests. As Akre (1983a) stated: "I have been stung too many times immediately upon leaving the car and slamming the car door. Workers from a large, disturbed colony have come up to 100 meters or more to sting me".

## 8) Control of yellowjackets

### 8.1) General

Controls should be directed only at the scavenging yellowjackets *V. vulgaris, V. pensylvanica* and, when it arrives, *V. germanica*. *Dolichovespula* spp. and members of the *V. rufa* group should not be controlled because they are beneficial insects and are not pestiferous unless their colonies are disturbed.

### 8.2) Identification

Any rational control program is dependent on correctly identifying the suspected pests. Yellowjackets can often be identified by the patterns on their gasters: a pictorial key for workers found in B.C. is presented in figure 5. Gastral patterns are fairly consistent but variations do occur. The key (8.2.1) is more accurate than figure 5 and includes the obligatory social parasites, *D. arctica* and *V. austriaca*, and is applicable, to a degree, for the three sexual castes: males are characterized by their long, strongly-curved antennae and the queens usually by their larger size compared with the workers.

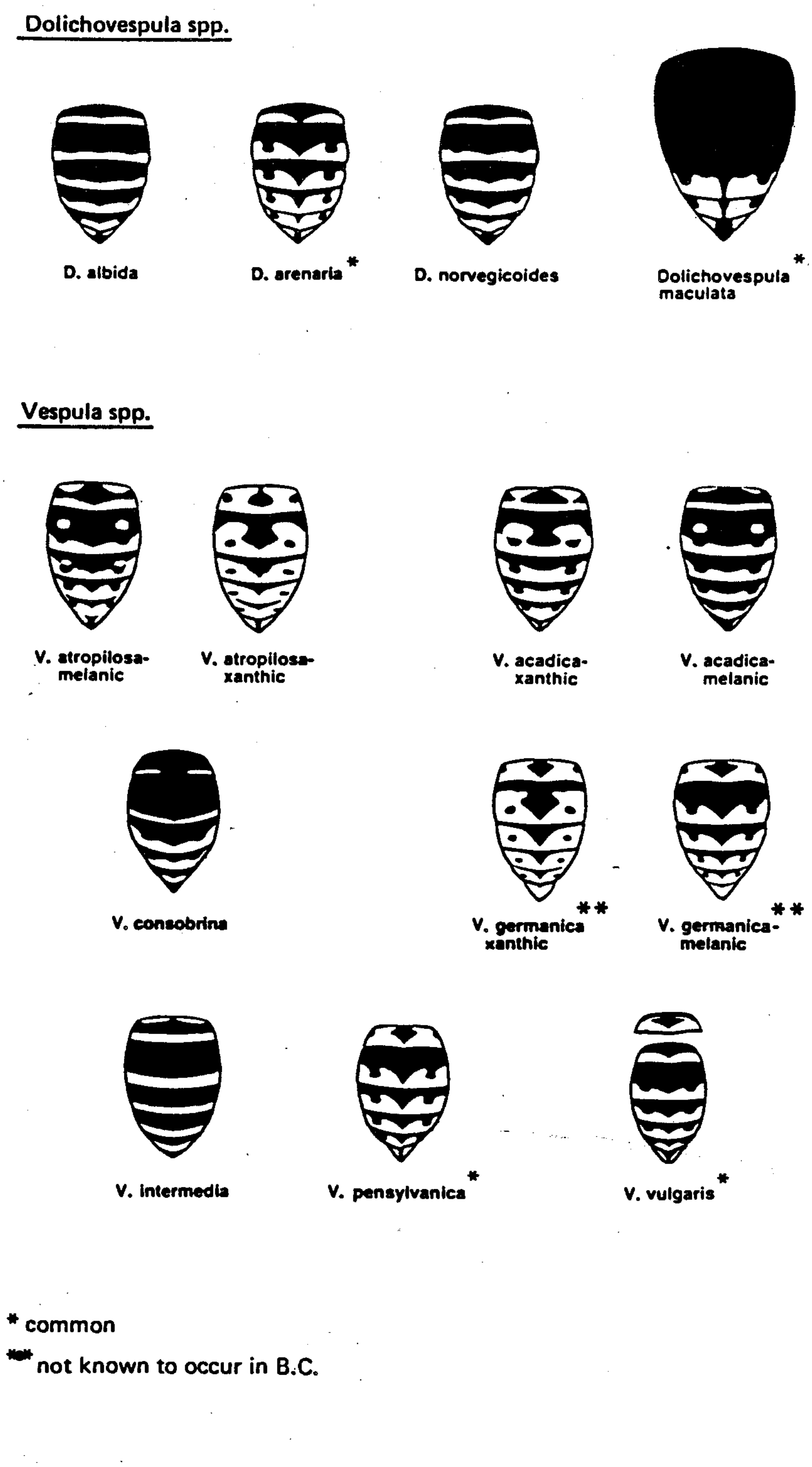


Figure 5. Key to gaster patterns of worker yellowjackets found in British Columbia (after Akre <u>et al</u>., 1980).

8.2.1) Key to yellowjackets of British Columbia

The following key is from Akre *et al.* (1980), Wagner and Reierson (1978) and Miller (1961).

1) Compound eyes touching or nearly touching upper edge of mandibles, figure 6 (genus *Vespula* Thomson)............2

Compound eyes well separated from upper edge of mandibles, figure 6 (genus *Dolichovespula* Rohwer)......9

2) Occipital carina never reaching base of mandibles, figure 7 (*V. rufa* species group)........................3

Occipital carina always reaching base of mandibles, figure 7 (*V. vulgaris* species group)....................7

3) Pale markings white.....................................4

Pale markings yellow....................................5

4) Reddish markings on terga I and II.................................................*V. intermedia* (Buysson)

Gaster with no reddish markings.*V. consobrina* (Saussure)

5) Entire length of extensor surface of hind tibia with long, erect hairs.................*V. austriaca* (Panzer)

Only proximal portion of extensor surface of hind tibia with long, erect hairs...................................6

6) Yellow genal band continuous......*V. atripilosa* (Sladen)

Yellow genal band interrupted with black.......................................................*V. acadica* (Sladen)

7) Compound eyes encircled with yellow.......................................................*V. pensylvanica* (Saussure)

Compound eyes with some black contacting them at top...8

8) Yellow genal band continous..........*V. germanica* (Fab.)

Yellow genal band interrupted with black.......................................................*V. vulgaris* (L.)

9) Pale markings white....................................10

Pale markings yellow...................................12

10) Dorsal surface of first three terga entirely black...........................................*D. maculata* (L.)

Dorsal surface of first three terga with some white markings.......................................11

11) Reddish spot on sides of tergum II....*D. albida* (Sladen)

No reddish spot on sides of tergum II........................................................*D. arctica* (Rohwer)

12) Yellow genal band continuous..........*D. arenaria* (Fab.)

Yellow genal band broadly interrupted with black.........................................*D. norvegicoides* (Sladen)

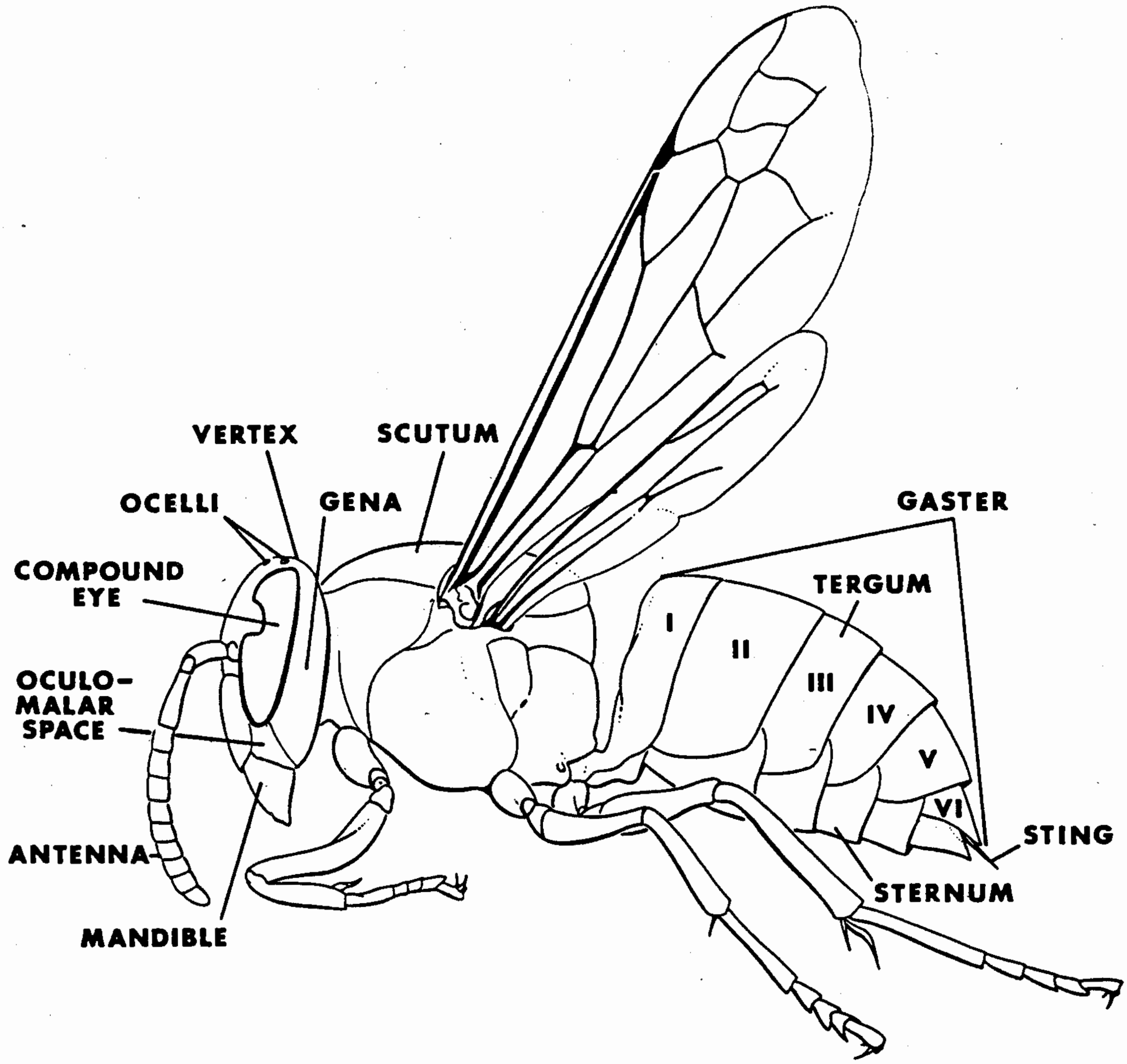


Figure 6. Structure of a worker yellowjacket (from Akre et al., 1980).

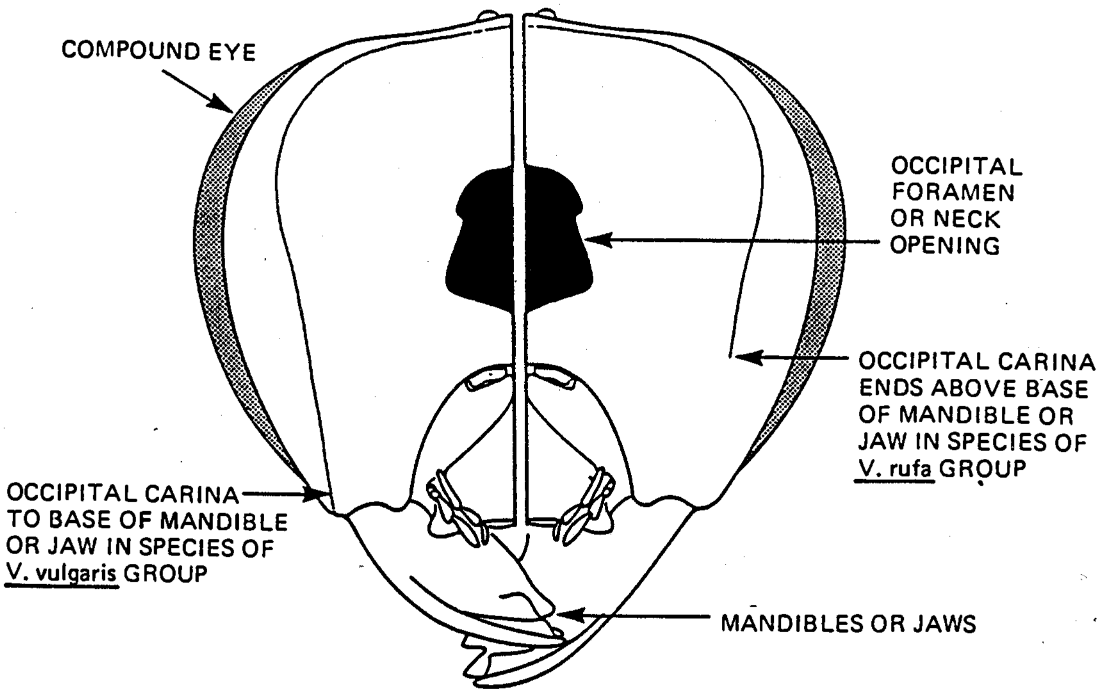


Figure 7. Rear view of the head capsule of a yellowjacket (after Akre et al., 1980).

8.2.2) Key to nests of yellowjackets common in B.C.

Nests of yellowjackets occasionally may be identified by their nest architecture. The key (8.2.2) is presented for interest and is applicable to the most common species of yellowjackets only.

1) Nest underground, in wall-voids, attics, or other enclosed areas........................(genus *Vespula*) 2

Nest usually above ground and in exposed locations ................................(genus *Dolichovespula*) 4

2) Scalloped, fragile envelope; pillar-like supports between all combs (figure 8 ); usually large (3,500-15,000 cells)..............(*V. vulgaris* group) 3

Laminar, pliable envelope; ribbon-like supports (figure 8 ); usually quite small (500-2,500 cells)...... ..........................................*V. rufa* group

3) Tan envelope................................*V. vulgaris*

Grey envelope...........................*V. pensylvanica*

4) Large nests; envelope often partially scalloped and cupolas present (figure 9 ); usually located high in bushes...................................*D. maculata*

Small to large nests; envelope always laminar; very common, often under eaves of houses.........*D. arenaria*

From Akre *et al.* (1980), Edward (1980) and Spradbery (1973).

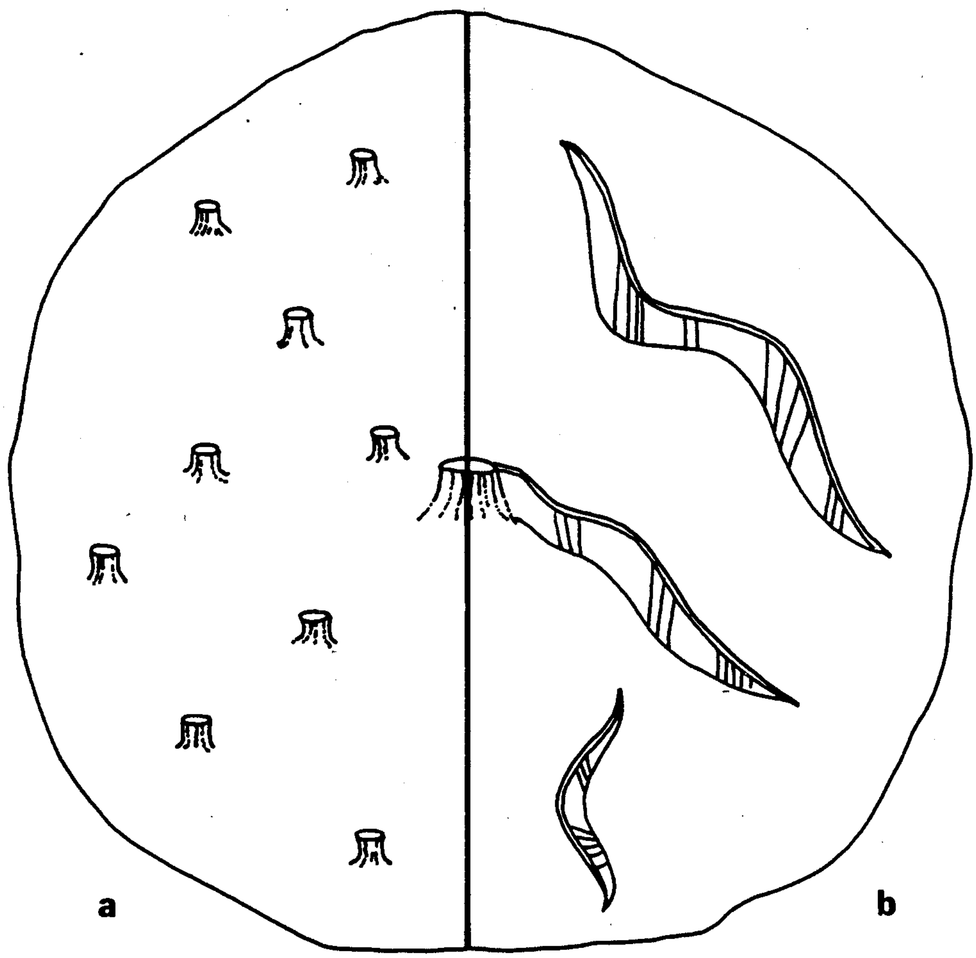


Figure 8. Supports between combs of a nest: a) pillar-like supports of V. vulgaris group; b) ribbon-like supports of V. rufa group (redrawn from Spradbery, 1973).

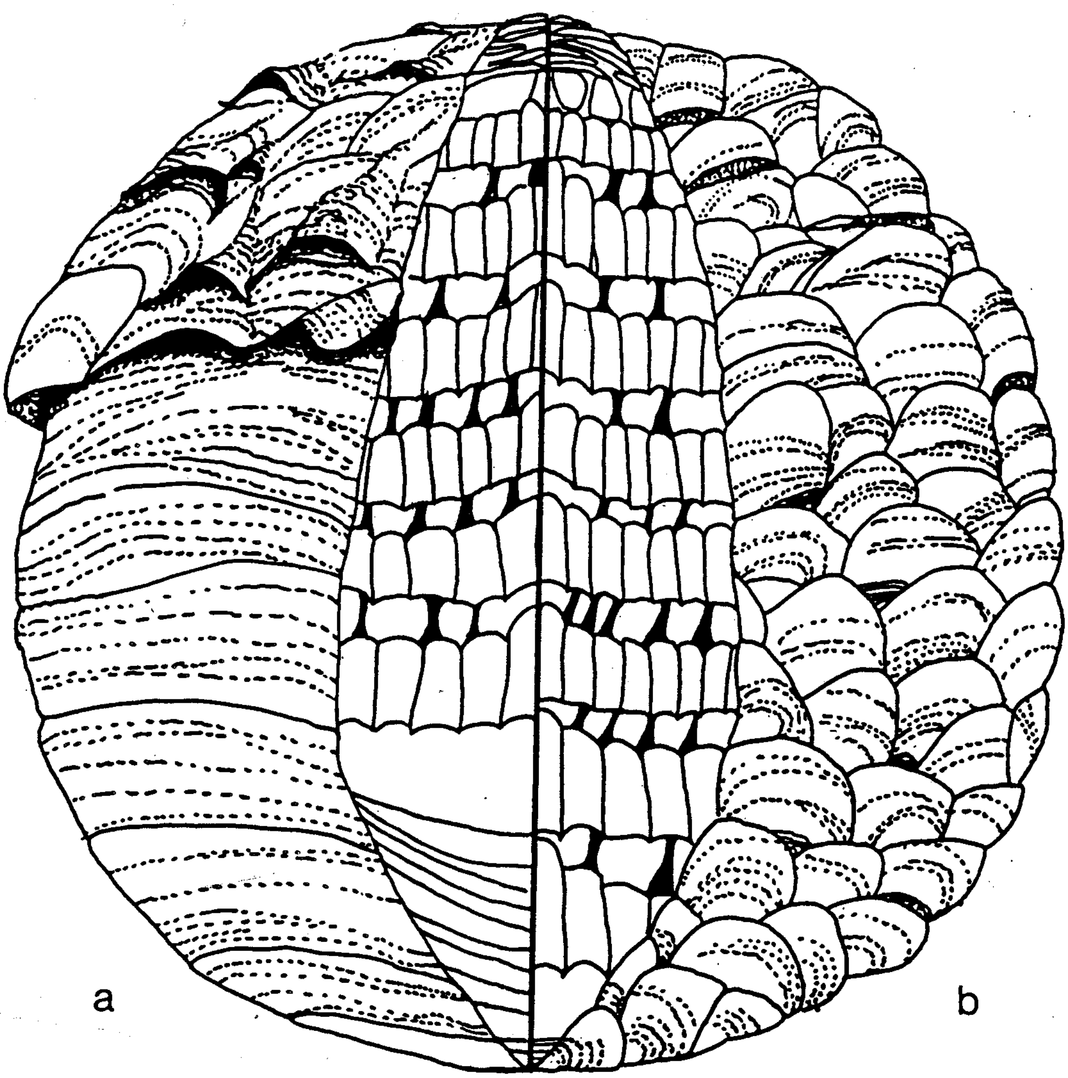


Figure 9. Nests of yellowjackets: a) D. maculata; b) V. vulgaris ( b redrawn from Spradbery, 1973).

8.3) Destruction of colonies

Destruction of colonies is the most common form of wasp control because the problem is controlled at the source, the results are quick and it is relatively inexpensive and straightforward. Often it is not effective for controlling scavenging yellowjackets over large areas because of the great difficulty in finding their colonies: yellowjackets forage in all directions from their colonies and, while most forage within 50 to 400 meters of the nest (Edwards 1980; Akre *et al.* 1975), some may travel up to 1.6 km in search of food (Mampe 1979).

A variety of techniques have been used to locate colonies: some private businesses that produce highly attractive commodities such as sweets and candies have offered bounties for information regarding locations of nests close to their property (Madden 1981); tying brightly colored yarn or string to a yellowjacket in hopes of making them more visible and slowing their flight is usually quite dangerous and ineffective (Spradbery 1973; Rogers 1972). MacDonald *et al.* (1974) stated that yellowjackets could be more easily followed back to their nests in the early morning when low-angled sunlight is reflected off their wings.

8.3.1) Procedures

Colonies of yellowjackets are best destroyed in the late evening or at night when it is cool and most of the wasps are inside the nest. Their activity is low and there is a reduced chance of agitated wasps stinging bystanders. If the colony is to be controlled in the daytime onlookers should remain still because yellowjackets are attracted to moving objects (Edwards 1980) and they should be out of the defensive flight range of about seven meters (Spradbery 1973). If illumination is needed, a flashlight supported on a structure away from the operator should be used because the wasps are attracted to light. The operator should wear protective clothing whenever the nest is closely approached. Standard bee-keeping equipment, including a suit, veil, helmet and gloves, should be used. The bee-suit should be loose fitting because most wasps can sting through tight clothing (Edwards 1980). Wagner and Reierson (1975) developed a cool, lightweight bee-suit made from rip-stop nylon, as used for sails, and reported good success: the yellowjackets could not cling to the slick surface or obtain a firm purchase in preparation for stinging.

8.3.2) Non-chemical controls

Considering the potential danger that a colony of yellow jackets represents to the contoller, the limited area of pesticide application and the relative safety of many of the chemicals available, non-chemical controls are not generally recommended.

Edwards (1980) stated that small aerial nests can be easily removed by securing a plastic bag over the nest, cutting the nest free with a knife, then filling the bag with water. An inexperienced operator may lack the calmness to remove the nest successfully and safely.

A common technique is to hold under an aerial nest a burning, kerosene-soaked rag, attached to the end of a long pole.

This technique is highly dangerous in combustible areas.

Knocking down an aerial nest greatly irritates the yellowjackets and the agitated wasps often remain in the area for a few days attempting to repair the nest, stinging with no apparent provocation.

Pouring gasoline or kerosene into the nest entrance of subterranean colonies, as recommended by Spradbery (1973), usually is successful and kills the adult yellowjackets but, occasionally, the brood is not killed (Haviland 1962). This technique is recommended only for those locations where there is minimal risk of damage to vegetation or of fire and explosion.

Pouring "lots of boiling hot water into the nest entrance" of ground-nesting yellowjackets, as recommended by Anon. (1982), usually is safe for the operator and surrounding area but often will not kill the colony if the nest is above or far away from the entrance hole.

Milne and Milne (1980) recommended placing a transparent bowl firmly over the entrance hole to a subterranean nest: "Adults will be confused by their inability to escape and seek food in the daylight; they will not dig a new entrance hole and will soon starve to death". Entrance holes to subterranean nests seldom are situated in smooth, flat areas that are amenable to this technique. The method may be of interest to those who want more excitement but I certainly do not recommend it.

Setting a small fire over a subterranean colony's entrance hole sometimes damages the nest but usualy the soil is a good heat barrier and prevents much damage.

To control colonies that are located in wall-voids and attics of houses, West and Smallman (1983) recommended placing the suction nozzle of a vacuum cleaner to the entrance hole and rapping the wall. The wasps will tumble out and be drawn into the machine to which moth-balls previously have been added. This technique has some merit for colonies whose entrance hole is small and well defined and could be used in the day because only yellowjackets present in the nest will defend the colony; returning foragers do not usually defend the colony (Spradbery 1973).

The common technique of sealing the entrance hole to colonies located in wall-voids and attics of houses in hopes of starving the yellowjackets to death often meets with poor success because the wasps usually create another exit hole, sometimes into the house itself.

8.3.3) Chemical controls

The best method of destroying aerial colonies of yellowjackets is to use so-called wasp bombs which are pressurized containers that eject a solid stream of insecticide up to three or four meters. They are relatively inexpensive and quite safe to use for the operator who need not come in contact with the insecticide or get close to the colony. The liquid, which usually contains propoxur as the active ingredient, may stain woodwork and will damage vegetation. To eliminate the need for ladders in controlling nests that are outside the range of the long-throw applicators, an aluminum extension pole is available: the Pro-Pole™, distributed by Northshore Distributing Co., is capable of holding and spraying pressurized cans of insecticide and can be extended to six meters.

Dust formulations of insecticides are useful for controlling aerial colonies but protective clothing is a necessity. Benefits include reduced costs for pest control companies because the chemicals can be bought in bulk and there is no danger of damaging surrounding materials. Anon. (1982) recommended dust formulations of 1% rotenone or 5% carbaryl or 5% methoxychlor while McCarthy (1983) recommended diatomaceous earth.

Hand-pumped compression sprayers fitted with pin-stream nozzles are good for accurately dispensing liquid formulations of propoxur and dichlorvos, two insecticides that are registered for destruction of colonies in Canada.

Akre *et al.* (1980) stated that subterranean colonies could be killed by applying a liquid formulation of propoxur or a dust formulation of carbaryl into the entrance hole. They also recommended saturating the immediate area with insecticide to kill returning foragers. Green (1982) recommended dust formulations of bendiocarb, carbaryl, diazinon and resmethrin to destroy subterranean colonies whereas Anon. (1982) recommended dust formulations of carbaryl, or methoxychlor, or rotenone.

Dust formulations usually are effective in controlling ground-nesting yellowjackets because the position of the nest need not be known exactly. The insecticide should be blown into the entrance hole with a puffer gun but can be applied with a spoon tied to the end of a long stick. A thick layer of insecticide should be applied around the entrance hole and the hole should be left open (Edwards 1980). A board or some other cover should be propped over the entrance hole if rain is expected.

Fumigants usually are very effective in killing subterranean colonies but they are dangerous to store and use and will kill surrounding vegetation. Most are not registered for destruction of colonies and none is available to the general public. Akre (1981) strongly recommended the use of carbon bisulphide as a fumigant for colonies but this chemical has been associated with a variety of human reproductive effects including decreased libido, impotence and miscarriages (Chenier 1982). Other fumigants that have been used include carbon tetrachloride (Spencer 1960), ether (Parrish and Roberts 1983) and phosphine gas, which may not penetrate the nest (Edwards 1980).

To kill colonies in wall-voids and attics of houses, MacDonald *et al.* (1980) recommended the following sequence of measures: 1) forcibly blow 5% carbaryl dust deep into the nest's entrance hole in all possible directions. The agitated workers will track the dust into the nest, contacting the queen and brood; 2) apply 1% resmethrin aerosol for 30 to 45 seconds to kill the adults quickly; 3) plug the access hole with steel wool sprinkled with 5% carbaryl dust to kill the returning foragers.

Resmethrin is a relatively stable contact synthetic pyrethroid with an oral $LD_{50}$ (rat) of 4,240 mg/kg (Spencer 1982) but is not registered for colony destruction in B.C. Dichlorvos often is substituted for resmethrin and is labelled for yellowjacket control. Dichlorvos has excellent penetrant and fumigant action but it is much more toxic to mammals with its $LD_{50}$ (rat) of 80 mg/kg (Spencer 1982). It is corrosive to application equipment (Storey 1983), repellent to yellowjackets

(Akre 1983) and should not be used in locations that would allow the vapors to escape into a living area.

If possible, nests should be removed and destroyed soon after chemical treatment to prevent resurgence: pupae and mature larvae are sometimes not affected by the insecticides.

Nests in wall-voids and attics of houses decompose and possibly may cause some structural damage and offensive odor (MacDonald *et al.* 1980). The dead colony is an attractive source of food for many scavenging household pests and may act as a source of infestation.

To reduce the danger of unnecessary exposure to toxic chemicals, the common practice of displaying aerial nests should be discouraged if a residual insecticide was used for killing the colony.

Green (1982) stated: "If the nest can be found, control of its residents is simple". This may be true for most aerial and some subterranean nests, but often it is untrue for colonies located in wall-voids and attics.

Control may fail for any of the following reasons: 1) an insufficient quantity of the chemical was used; 2) the insecticide may not have reached the colony because it was applied far from the actual nest. One *V. germanica* nest was 30 meters from its entrance hole (MacDonald *et al.* 1980). A technique to overcome this problem is to locate the colony inside the wall-void by using a stethoscope and drilling a hole for the application of an insecticide. Usually, however, agitated wasps tumble from the hole as soon as the drill bit is removed; 3) resurgence may occur if an insecticide with insufficient residual activity was used; 4) surviving yellowjackets may have made or found another exit (MacDonald *et al.* 1980), by-passing the insecticide; and 5) insecticidal dusts may have settled out or become damp and ineffective in the high humidity of the nest.

8.4) <u>Trapping</u>

Trapping is one of the oldest methods of yellowjacket control, having been recorded in 1493 (Edwards 1980). It is environmentally safe, often inexpensive and, occasionally, effective in protecting relatively small areas from scavenging yellowjackets.

Traps consist of an attractant and a killing or holding container. Either naturally occurring or synthetically-produced attractants are commonly used.

8.4.1) <u>Natural lures</u>

Natural lures based on animal proteins, such as meat and fish, are useful because they attract scavenging yellowjackets only. Non-target insects, such as blow flies and house flies, may be attracted to these lures but often they are pests themselves. Since yellowjackets do not forage for spoiled or decaying flesh, traps baited with protein lures require frequent servicing because most attractants quickly dry-up, putrefy or go moldy (Edwards 1980).

Carbohydrate-based attractants do not deteriorate so quickly as protein-based lures (Edward 1980) and, in some cases, are much more attractive to yellowjackets (Akre *et al.* 1980; Free 1970). Unfortunately, they are also highly attractive to many beneficial insects; for example, in one trapping trial, Edwards (1980) caught 17,300 yellowjackets but also 37,000 honeybees in traps containing a sweet lure.

8.4.2) Synthetic lures

In the early 1960s, USDA researchers accidentally discovered that some chemicals, including 2,4-hexadienyl butyrate (2,4-HdB), attracted yellowjackets (Davis *et al.* 1967). This began an intensive search for more effective lures (Davis *et al.* 1968; McGovern *et al.* 1970). In 1969, Davis *et al.* reported that heptyl butyrate (HB) was a superior attractant compared to 2,4-HdB. Serious research into attractants for yellowjackets apparently ended with the 1972 report of Davis *et al.* concerning octyl butyrate (OB), a lure that was as attractive as heptyl butyrate but was significantly less expensive to synthesize and required less trap servicing because of its lower volatility.

Synthetic attractants have many advantages over natural ones: small carnivores are not attracted, therefore special protection of the trap is not needed (Wagner and Reierson 1969); they are effective in the presence of sources of food (Davis *et al.* 1973); they are easy to use, do not putrefy and many beneficial insects, such as honeybees and aerial nesting yellowjackets, are not attracted (Davis *et al.* 1972; Fluno 1973).

Synthetic lures, however, are not problem-free. They attract only a single species of scavenging yellowjacket, *V. pensylvanica*. *V. vulgaris* and *V. germanica* are not significantly attracted to synthetic lures (Macdonald *et al.* 1980). And, unfortunately, some members of the beneficial *V. rufa* species group, *V. atripilosa* and *V. acadica* for example, are greatly attracted (Reierson and Wagner 1975; MacDonald *et al.* 1974).

8.4.3) <u>Trap design</u>

A good trap for yellowjackets should be inexpensive, efficient, non-repellent, durable, easy to clean and bait and be small for transportation and storage (Rogers and Lauret 1968).

Dry traps have been used for collecting yellowjackets (Rogers and Lauret 1968; Davis *et al.* 1973) but there is a danger of being stung when servicing the trap. Most commercial traps use a killing agent such as a mixture of water and detergent. Other fairly cheap killing agents that have been used include propylene glycol and vegetable oil (Reierson and Wagner 1975), acetone (Davis *et al.* 1972) and ethanol (Wagner and Reierson 1969).

The color of traps, or the lack of it, may have some effect on yellowjackets. R.C. Goulding (pers. comm. in Reierson and Wagner 1975) stated that significantly more yellowjackets were attracted to red and yellow traps than to green ones. MacDonald *et al.* (1973) found that catches of yellowjackets increased with the use of transparent traps: the wasps were attracted to the presence of other yellowjackets.

8.4.4) <u>Application</u>

Trapping is most effective for small areas such as around buildings and back-yards. Edwards (1980) stated that a glass jar trap, containing a mixture of jam, beer, water and detergent and covered with paper pierced at the center, was very effective for controlling yellowjackets scavenging around the home. Commercial traps are available and serve the same purpose as the jam-jar. Akre *et al*. (1980) stated that one of the more effective methods of trapping scavenging yellowjackets is to hang an excoriated fish over a pan of water to which a wetting agent has been added. To reduce the problem of bait removal by cats and dogs, Akre *et al*. suggested placing a wire cage around the trap.

"Pestarester" is the only trap using a synthetic lure, pentyl valerate, commercially available in B.C. Traps using synthetic lures should be used only after *V. rufa* populations decline and before the scavenging yellowjackets become a problem (MacDonald *et al*. 1976). This is most easily determined by setting a few traps beginning in the first weeks of August to establish the species' present. Sweep-netting is often ineffective because of the different foraging habits of yellowjackets. Traps with synthetic lures should not be used in the spring because some queens of the *V. rufa* group, *V. atripilosa* for example, are highly attracted and a reduction in their numbers may result in less competition for nesting sites and food with queens of the *V. vulgaris* group: the problem with scavenging yellowjackets in the fall may actually be made worse if these traps are used in the spring (MacDonald *et al*. 1973; Macdonald *et al*. 1974).

MaDonald *et al*. (1974) recommended placing traps containing synthetic lures under a vegetative canopy that was exposed to direct morning sunlight. This provides good volatilization of the attractant early in the morning when the yellow jackets are foraging most actively.

8.4.5) Depletion trapping

Depletion trapping is the reduction of the numbers of yellowjackets to tolerable levels by trapping. Although it is a desirable method of control, it has been reported only once as an effective method to reduce a scavenging yellowjacket population (Davis *et al.* 1973): dry traps containing heptyl butyrate were placed every 20 m around the perimeter of a 10 ha peach orchard and quickly reduced the *V. pensylvanica* population to below damaging levels. Depletion trapping should be useful in an integrated control program for yellowjackets. Howell and Davis (1972) used HB traps to lower the numbers of yellowjackets which were disrupting a monitoring program by removing codling moths from traps. Akre *et al.* (1980) stated that fish-traps "...in combination with several other control procedures" reduced the number of yellowjackets to tolerable levels in two weeks. The "other control procedures" included trapping with heptyl butyrate, removing all garbage, putting an insecticide into garbage cans and destruction of colonies (Akre 1983a).

One major advantage of trapping is that the results are visible. Usually, however, even though large numbers of scavenging yellowjackets may be trapped, the numbers of foraging wasps are not noticeably reduced. For example, Reierson and Wagner (1975) collected almost 0.5 million *V. pensylvanica* foragers over a nine-week period in southern California in traps baited with HB but no significant reduction in foraging activity of scavenging wasps, as measured by the amount of food removed from protein-baited controls, was noted between trapped areas and control areas. Edwards (1980) noted similar results with *V. vulgaris* and *V. germanica* collected in traps baited with sweets in England.

8.4.6) Possible reasons why synthetic lures attract

Many factors can affect the performance of a trap: physiological and behavioral differences of the yellowjackets and correct trap design and use are only two areas that need a better understanding before trapping can become a successful method of control. The fundamental reason why synthetic lures attract some species of yellowjackets has not been investigated. An understanding of this phenomenon should enable more specific and attractive lures to be synthesized and would be of great value in controlling troublesome yellowjackets over a wide area. Depletion trapping might be more effective, timing would be less critical if *V. rufa* group species were not attracted and the lures possibly could be added to toxic baits to increase the uptake of bait.

Synthetic lures probably do not act as carbohydrate or "animal-flesh" protein stimuli because, other than *V. pensylvanica*, members of the *V. vulgaris* species group are not attracted significantly (Fluno 1973). In the same manner, these lures probably are not "insect-protein" stimuli because *Dolichovespula* spp. are not attracted.

Fluno (1973) made the "weak conjecture" that synthetic lures may mimic a soilborne odor because, in addition to attracting ground-nesting yellowjackets, other groups of soil inhabitating insects such as Chloropid flies are also attracted (Fluno *et al.*

1972; Rogoff *et al.* 1973). This conjecture, while being possible, is questioned because not all ground-nesting yellowjackets are attracted and *V. pensylvanica* often nests in wall-voids and other non-subterranean areas. And finally, it could be presumed that a particular soilborne odor would be most beneficial to young queens searching for nesting sites, a favorable nesting site may be associated with a particular odor. This presumption is supported by attraction of many *V. atripilosa* queens to lures in the spring but, on the other hand, queens to *V. pensylvanica*, which have similar nesting habits, are only weakly attracted (MacDonald *et al.* 1973).

Synthetic lures may mimic a particular attractive pheromone or other chemical that is produced by some or all members of the colony or, possibly, by the material of the nest. This is another weak conjecture but does have some support. Yellowjackets possess many exocrine glands (Landolt and Akre 1979) and conduct much pheromonal communication. Alarm-, thermoregulatory-, footprint- and mating-pheromones have been shown, at least circumstantially, to be possessed by many yellowjackets (Maschwitz 1964; Ishay 1972; Butler *et al.* 1969; Sandemann 1938). Ishay (1975) speculated that queens may release a pheromone to initiate the construction of queen-cells. Jeanne (1977) stated that *D. arctica* queens may produce an allomone that inhibits attacks by *D. arenaria* workers and queens and speculated about the possibility of a marking pheromone to keep other *D. arctica* queens away. Lord *et al.* (1972) noted that there was a 1 to 2% rate of exchange of *D. maculifrons* workers with overlapping foraging ranges and suggested that a colony-specific pheromone might be one of the possible reasons responsible. Ishay *et al.* (1965) provided evidence that the Oriental hornet, *Vespa orientalis*, possessed a queen-pheromone which Ikan *et al* (1969) identified as δ-n-hexadecalactone. Batra (1980) discussed four possible pheromones of the European hornet, *Vespa crabro germana*, which is closely related to the yellowjackets (Richard 1971). Wright (1969) discovered that yellowjackets were attracted to n-butyl benzoate. The wasps were not identified but from the description, he probably was attracting *D. arenaria* or, possibly, *D. maculata*. This would be the only recorded instance of *Dolichovespula* being attracted to a synthetic lure and may support the possibility of a species- or genus-specific pheromone. The molecular structure of synthetic attractants, most of which are esters of 10 to 11 carbon atoms, could mimic an airborne pheromone, a common method of communication in some social insects (Wilson 1971).

Obviously, less conjecture and more information is needed on the causes of attraction to synthetic lures. One method of investigating this problem would be to record the electrical activity from mounted antennae of different species of yellowjackets with extracts of exocrine glands and synthetic lures.

### 8.5) Insecticidal baiting

A non-repellent insecticide mixed with an attractive bait is potentially the most efficient method of controlling yellowjackets because the colonies do not have to be found, minimal environmental contamination occurs and, if a protein-bait is used, only scavenging yellowjackets are attracted. Foraging yellowjackets take the poisoned bait to the colony and it is distributed to the larvae who, while being fed, return some of the insecticide to the adults. Death of the colony usually occurs in two weeks or less (Akre 1983).

8.5.1) Choice of bait

A good bait should be inexpensive, easily available, stable, easily formulated and compatible with the toxicant (Wagner and Reierson 1969). The bait must be attractive to yellowjackets, obviously, but should be unattractive to non-target animals.

Most baits used in North America are based on animal proteins. Wagner and Reierson (1969) stated that canned pet-foods made from fish and grains retained their attractancy longer than pet-foods made from fish alone, which is the type of bait recommended by Penwalt, the makers of the insecticide Knox-out 2-FM®. Grant *et al.* (1968) stated that cooked horsemeat provided more consistent performance than canned tuna-fish. To prevent spoilage and to extend the period of attractiveness, salts and glycerin can be added to the meat (Akre 1983).

Toxic baits made from carbohydrates have been used only experimentally in North America (Parrish and Roberts 1983) but in England, Rentokil markets "Waspex", a toxic bait based on fondant sugar with ginger syrup as the attractant (Edwards 1980).

8.5.2) Choice of insecticide

A good insecticide for toxic baiting should be effective, non-repellent and fairly slow in action (Edwards 1980). It should also be relatively harmless to non-target animals if accidentally eaten. Wagner and Reierson (1969) tested 12 commonly available insecticides and discovered that all were repellent except mirex. Dieldrin, which is probably the insecticide used in "Waspex" (Spradbery 1973), and mirex, are Schedule 1 insecticides in B.C. (Anon. 1978) and so are effectively banned for most uses.

Microencapsulation of an insecticide masks its odor. Knox-out 2-FM, a microencapsulated formulation of diazinon, is currently registered in the United States for insecticidal baiting of yellowjackets but Basudin, the Canadian equivalent, is not. Akre (1983) stated that this insecticide was somewhat repellent to all species of yellowjackets. There are no products for insecticidal baiting of yellowjackets available in B.C. as of 1983.

8.5.3) Bait protection

A major problem with insecticidal baiting is the possibility of accidentally poisoning non-target animals. Penwalt recommend that the toxic bait should be contained in dispenser cages constructed from 1/2 inch hardware cloth; these cages should be hung from tree limbs or set on posts. While this method of locating and protecting bait should exclude most vertebrates, it would be attractive to vandals and should be used only in restricted, supervised areas. The publicity arising from having poisoned cat-food distributed in a family park would be unpleasant.

Grant *et al.* (1968) described three types of bait stations:

a permanent pole dispenser embedded in concrete, a semi-permanent stand to be attached to trees and a suspended wire cage, similar to Penwalt's dispenser. The permanent pole dispenser is probably the most acceptable bait container for public areas. Its relatively high initial cost would be off-set by reduced maintenance expenses. A cheaper but still secure alternative would be to attach permanent bait-stations to existing structures such as light standards.

Protecting baits made with protein from other non-target insects is seldom necessary or practical. Most flying insects that are attracted to these baits are pests themselves. Crawling insects such as ants, however, may deplete a source of bait but can be kept from baits dispensed from permanent pole stations by spreading a band of "Tanglefoot" or other sticky material around the pole (Grant *et al*. 1968).

Toxic baits made with sweets must be protected from beneficial flying insects, especially honey-bees. Considering the honey-bee's ability to communicate sources of food to its nest-mates, the results could be devastating to a colony if an attractive insecticidal bait became available. The primary method of keeping these baits away from honey-bees is through formulation: the fondant sugar used in "Waspex" is too hard for honey-bees to eat but is sufficiently soft for yellowjackets (Edwards 1980). "Waspex" may liquefy in the presence of free water or high humidity (Spradbery 1973), however, so that the insecticide may become available to honey-bees.

8.5.4) <u>General considerations</u>

To ensure maximal consumption of bait, Edwards (1980) recommended that as many bait containers as possible should be placed in and around the area to be protected. This would seem plausible because of the large, omnidirectional foraging range of yellowjackets (Akre *et al.* 1976) and their inability to communicate sources of food to their nest-mates (Kalmus 1954) although Maschwitz *et al.* (1974) (ref. not seen, cited in Jeanne 1980) showed experimentally that yellowjackets could inform their nest-mates of a rich source of food. Grant *et al.* (1968) stated, however, that good results were obtained in controlling *V. pensylvanica* and *V. vulgaris* by placing horsemeat impregnated with chlordane at the rate of one container for every two acres. Using microencapsulated tetrachlorvinphos and diazinon, Ennik (1973) placed from 0.6 to 10 bait stations per hectare to successfully control these species. The number of bait stations was determined by terrain, availability of bait-sites and the actual yellowjacket problem. Akre (1983b) stated that, when using Knox-out 2-FM, one bait station per hectare is the minimum and four per hectare is preferable. In parks, Akre suggested placing the bait stations around the perimeter and one or two in the center.

Unlike trapping the synthetic lures, toxic protein baits can be set out while members of the *V. rufa* species group are still active and before the scavenging yellowjacket problem becomes intolerable (MacDonald *et al.* 1976). The area to be protected should be prebaited with non-toxic baits for at least three days before toxic baiting because yellowjackets return to good foraging areas (Grant *et al*. 1968). Competing food sources should be removed or made unavailable to the wasps. Ennik (1973) splashed heptyl butyrate on trees surrounding the bait-stations to attract more *V. pensylvanica*. Penwalt recommend that the toxic bait should be placed out for two to three days or as long as yellowjackets are present, then rebaiting about 10 days later for long-term control. This second application is to kill those yellowjackets, recently emerged from their pupal cells, that did not receive a lethal dose from the first baiting.

Insecticidal protein baiting has been used successfully to control *V. vulgaris* and *V. pensylvanica* in California but no information is available on its effects against *V. germanica*. It is not known if this method of control would be effective against B.C.'s scavenging yellowjackets. Probably because of differences in foraging behavior between species, 0.5% chlordane (WP) in a protein-bait successfully controlled *V. pensylvanica* in Washington State but failed to control *V. vulgaris* (Akre 1983b). The foraging behavior of different populations of the same species of yellowjacket may also vary. For example, California's yellowjackets are more heavily committed to scavenging than those farther north (Akre *et al*. 1980) and Reierson and Wagner (1978) observed *V. atripilosa*, a yellowjacket that is considered to be strictly predaceous, feeding on carrion in California.

8.6) Area spraying with insecticides

Large, outdoor spraying operations to control foraging yellowjackets would be difficult and unpopular because of the large areas of land involved (Grothaus *et al*. 1973). In addition, the insecticides would have to be applied during the day when yellowjackets as well as many beneficial insects are active. To control yellowjackets in orchards, an area pesticide treatment may cause injury to the fruit pickers and there is a possibility of pesticide residues remaining on the fruit (Davis *et al.* 1973). Despite these drawbacks, methoxychlor has a Canadian registration for this use.

8.7) <u>Use of residual insecticides</u>

Residual contact insecticides often are not effective against yellowjackets because the wasps seldom alight and remain on any substrate long enough to obtain a lethal dose (Edwards 1980) and their diverse foraging habits do not lend themselves to this form of control (Spradbery 1973). Nevertheless, propoxur and diazinon are registered for this use.

Areas where wasps congregate can be sprayed with residual insecticides. Inside a building, Edwards (1980) recommended that windows be sprayed with an oil-based or emulsifiable concentrate insecticide. Outside, Mampe (1979) recommended that paved areas, the outsides of garbage bins and walls of buildings adjacent to the affected area could be sprayed. Edwards (1980) recommended a wettable powder formulation of insecticide.

Mampe (1979) suggested that sugar could be added to the residual insecticide sprayed outdoors to attract the wasps to the treated surface; he cautioned that the sugar would support mold growth and wall discoloration might occur. Another problem with this technique is the possibility of beneficial insects, such as honey-bees, being attracted.

Plants with exposed nectaries often are attractive to many species of wasps (Edwards 1980). In the fall, ivy is frequently visited by foragers in search of nectar, but they seldom bother anyone but homeowners, who often complain. The most permanent control is the removal of the plant but if this is impractical, methoxychlor is registered for controlling yellowjackets in this situation.

8.8) Destruction of queens

Since all colonies of yellowjackets are initiated by a single queen, Philbrick and Philbrick (1974) suggested that the destruction of hibernating or spring queens would reduce the following season's population of yellowjackets. This action may provide some psychological relief but it is of doubtful value because a healthy mature colony may produce thousands of new queens. As Spradbery (1973) stated: "the potential queens and incipient colonies can experience a mortality of 99.9% and still maintain the average number of annual colonies". The destruction of queens in the spring may actually increase the following season's population of wasps by reducing competition for suitable nesting sites in the spring.

8.9) Biological control

There are no known biological control agents that can be manipulated to control yellowjackets at present.

Spradbery listed more than 135 species of insects that were reported mostly from European colonies of yellowjackets. Most of the insects were scavengers of dead brood, detritus and nest carton and few affected the vigor of the colony. MacDonald *et al.* (1975) stated that the beetles *Dendrophaonia querceti* and *Cryptophagus pilosus* and flies of *Fannia* spp. found in North American colonies of *V. atripilosa* and *V. pensylvanica*, were scavengers and had no apparent affect on the colonies.

The Ichneumonid pupal parasite, *Sphecophagum vesparum burra*, has been reported from nests of *V. atripilosa* (Macdonald *et al.* 1975), *D. arenaria* (Spencer 1960) and *V. vulgaris* (Akre *et al.* 1980), but has been notably absent from nests of *V. pensylvanica* (MacDonald *et al.* 1975; Greene *et al.* 1976). MacDonald *et al.* (1975) stated that *S. v. burra* can adversely affect incipient colonies of the beneficial yellowjacket *V. atripilosa* but its effect on other species is not known. Spencer (1960) noted that the largest and most vigorous of five *D. arenaria* colonies contained the greatest number of these parasites.

Other natural controls that also affect beneficial yellowjackets include a chalcid wasp that may regulate the size and number of *D. maculata* colonies (Akre *et al.* 1980) and the obligatory social parasites, *D. arctica* and *V. austriaca*, which parasitize *D. arenaria* and *V. acadica*, respectively (Greene *et al.* 1978; Reed *et al.* 1979). The productivity of the hosts' colonies is zero because only the parasites rear reproductives (Taylor 1939). Switching the host preference of the parasites from beneficial yellowjackets to scavenging species would be useful but has not been attempted because so little is known of their biology.

Only one insect has been shown to affect the vigor of colonies of scavenging yellowjackets. The phorid fly, *Triphleba* *lugubris*, may lower the productivity of colonies of *V. pensylvanica* significantly by destroying developing queen larvae (MacDonald *et al.* 1975). It is unknown, however, what effects this would have on the following year's population of yellowjackets (see section 8.8).

Intra- and inter-specific competition is common and may regulate the numbers of yellowjacket colonies. Akre *et al.* (1977) stated that *V. pensylvanica* may restrict *V. vulgaris* to more mesic areas through interspecific competition. But exchanging one scavenging species of yellowjacket for another is probably not a good idea.

Poinar and Ennik (1976) speculated that the nematode *Pheromermis pachysoma* may be an important regulator of populations of yellowjackets. This is an interesting hypothesis but probably has little value for biological control because of the nematode's complicated life cycle. A more promising nematode for biological control is *Neoaplectana carpocapsae*. In limited laboratory experiments with only 100 yellowjackets, Poinar and Ennik (1972) found a 95% rate of mortality of adult yellowjackets within seven days as compared with a 32% rate of mortality in the controls; the effects on the larvae were not examined. The deaths were caused by *Achromobacter nematophilus*, a bacterium carried in the nematode, which produced general septicaemia in the wasps. It may be possible to use *N. carpocapsae* with sugar-based lures because it might not affect honey-bees: the temperature in beehives is too high for this nematode to survive (Rutherford 1983) but more information is needed.

Small rodents and weasels may disrupt or destroy incipient colonies located in burrows (MacDonald and Matthews 1981) and bears and skunks prey on mature terrestial colonies of yellowjackets (Spradbery 1973). *Ursus americanus*, the black bear, also preys on aerial nests (Bigelow 1922). It is doubtful that mammals, especially the larger ones, could be used as successful biological control agents but as Ratcliff (1983) has stated: "If you can get a bear to walk through the cut area (the area to be logged) before you, he'll have all the nests cleared right out".

A variety of other controls may affect yellowjackets but most are relatively inconsequential. Birds, dragonflies, robber flies and spiders may capture the occasional foraging yellowjacket (Edwards 1980). Disease does not appear to adversely affect yellowjackets, although Spradbery (1973) stated that wasps probably succumb to micro-organisms on occasion.

8.10) Barriers

For some businesses, such as sweet shops, candy and preserve factories and fish processing plants, whose activities are highly attractive to yellowjackets, wasp-proofing may be an acceptable method of control. All openings greater than six mm should be sealed and window-screens and self-closing screen-doors should be tightly fitted (Edwards 1980). For large doorways, properly installed air curtains with an air movement of at least 500 meters per minute are effective but are noisy, expensive to buy, install and maintain and often prove unpopular with staff who frequently turn them off. An alternative that is possibly more acceptable is a heavy plastic strip curtain that is most commonly used in large, cold-storage facilities but was originally developed to keep wasps out of a candy shop (Edwards 1980).

Reisman (1975) suggested that outdoor cooking and eating should be avoided during the yellowjacket season. It is doubtful that many people would accept this suggestion as a viable management practice.

If more accepted methods of control, such as physical barriers, are impractical or ineffective in candy factories or other highly attractive structures, it might be possible to alter production techniques or schedules to eliminate attractive materials or to produce them only after the annual cycle of the wasps is completed (MacDonald *et al.* 1980).

### 8.11) Management of garbage

Akre *et al.* (1980) stated that the reduction of garbage would force scavenging yellowjackets to increase the energy spent in foraging for live prey and this would probably result in smaller colonies. Trash, garbage, fallen fruit and other potential sources of food should be kept in insect-proof containers and should be removed frequently. In public areas, an adequate number of trash-cans should be placed out to encourage people to dispose of their garbage properly. Tight-fitting lids for public trash-cans are impractical. "Moth crystals" (paradichlorobenzene) thrown into trash-cans has been recommended as a repellent for yellowjackets (Anon. 1981). A more effective approach is to spray the interior of trash-cans with dichlorvos, a residual insecticide with good fumigating and repelling properties. Resin strips containing dichlorvos usually have a registration that permit their use in garbage-cans to control flies and they are effective against yellowjackets (Akre *et al.* 1980).

8.12) Miscellaneous controls

Repellents, such as diethyl toluamide and dimethyl phthalate, that commonly are used against mosquitoes and other biting flies, will not stop an irritated yellowjacket from stinging (Akre *et al.* 1980).

Because yellowjackets are attracted to ultraviolet (UV) light (Edwards 1980), UV light traps may be of some value for controlling foraging wasps in buildings. Belton (1983) stated that Nabob Foods collected "dozens" of yellowjackets during the jam-season in UV traps for flies. To reduce the chance of a stunned wasp falling into foodstuffs and to maximize their effectiveness, the units should be suspended over an open floor in the darkest part of the structure to be protected.

Most yellowjackets seldom harm a healthy, well-managed colony of bees (Winston 1983) but, if a control is needed to reduce robbing, Line (1965) recommended reducing the hive opening and placing a sloping sheet of glass over the landing area.

The adhesives used in most sticky insect-traps usually do not have enough tenacity to hold yellowjackets (Howell and Davis 1972).

Fly swatters are effective for dispatching the occasional yellowjacket but the activity may agitate other wasps that are present. A novel technique used by one candy store was simply to suck up foraging yellowjackets with a vacuum cleaner. This was aesthetically acceptable to customers, eliminated the chance of a swatted yellowjacket falling into the candy and did not appear to irritate the wasps.

9) Prevention of stings

Frazier (1976) suggested the following preventive measures to reduce the chance of being stung by Hymenopterans in general: do not go barefoot or wear sandals outdoors from April to October; do not wear bright, flowery clothing; do not wear floppy clothing to entangle and anger the Hymenoptera; wear long pants, long-sleeved shirts and gloves if working among flowers or fruits; avoid wearing anything reflective such as jewelry or buckles; do not use scented lotions, soaps, shampoos or perfumes; wear light colors such as white, light green, tan or khaki. While these recommendations are a little extreme and many are not substantiated, they do show most of the possible procedures that a highly allergic or a paranoid person could take to reduce the chance of being stung.

People should remain calm in the presence of yellowjackets. Slow and deliberate movements will seldom provoke a sting and wasps should be gently brushed off the body, not swatted (Akre *et al*. 1980). If a person disturbs a nest, he should slowly and deliberately retreat from the area because yellowjackets are attracted to quick movements (Spradbery 1973). If retreat is impossible, Frazier (1976) stated that the person should lie down and cover his head until the wasps leave.

## 10) Treatment of stings

### 10.1) Short-term management

Most people do not react strongly to wasp stings. The application of a soothing agent such as calamine lotion or a paste of baking soda,or "Right Guard" deodorant (Belton 1983) or meat tenderizer (Akre *et al.* 1980) is often sufficient to reduce the pain and discomfort. To prevent secondary infection, the sting site should be washed with soap and water and an antiseptic should be applied. Generalized itching and malaise can often be reduced by the oral administration of antihistamines (Spradbery 1973).

For serious systemic reactions, Frazier (1976) recommended immediate subcutaneous injection of epinephrine (adrenalin). Insect kits, containing a syringe pre-loaded with epinephrine, antihistamine tablets and a tourniquet, are available in B.C. without a prescription. Akre *et al.* (1980) recommended that these kits should be a standard item in first aid supplies at public facilities such as campgrounds and parks. For highly sensitive individuals, the epinephrine should be injected immediately after being stung because the venom causes vasodilation which may reduce the uptake of the drug and death may occur quickly, often within one hour (Blatherwick 1983). The Simon Fraser Health Unit's protocol for the treatment of bee/wasp stings is given in appendix I and the instructions for the administration of adrenalin is given in appendix II.

### 10.2) Long-term management

Anyone who experiences a severe reaction to an insect sting should consult with a physician because a subsequent sting may cause death (Frankland 1976). Some authors recommend desensitization treatments (Fluno 1961; Frazier 1976; Akre *et al.* 1980) but they are expensive, time consuming, painful and their protection is often variable and short-lasting (Baldwin 1983).

11) Municipal yellowjacket control

The Simon Fraser Health District initiated a program to control yellowjackets in the District of Coquitlam, the City of Port Coquitlam and the City of Port Moody in 1981 partially because yellowjackets represent the greatest number of inquiries about insects received at the health department , table 2 ; a good representation of the types of inquiries received by local authorities is found in appendix III. The basic goals of the program are to control yellowjackets that are pests on public land and to provide information to residents (appendix IV).

Other than minimal costs for protective gear, application equipment and insecticides, the yellowjacket control program does not require any additional funding because the work is conducted by seasonal, summer, mosquito control personnel. This is made possible by the separation of the local mosquito and yellowjacket seasons: mosquito control is done mostly in June and July and scavenging wasps become most pestiferous in August. The summer staff usually find the control of yellowjackets to be an interesting and welcome break to their standard activities.

Destruction of colonies using naturally-derived insecticidal dusts such as 1% rotenone, 1% pyrethrum and diatomaceous earths is the primary method of control. These insecticides are generally considered to be safe to the environment and are exempt from many B.C. Provincial Government regulations, including those that regulate the use of pesticides on public land. To locate colonies of yellowjackets, we rely on complaints from the general public and information from parks board-, school board- and public works-employees as well as our own summer staff. Colonies of *Dolichovespula* spp. and members of the *V. rufa* species group are not destroyed unless they are likely to be disturbed. All colonies of members of the *V. vulgaris* species group are destroyed. This method has worked well but we have not experienced an outbreak of wasps since the program was initiated.

One major difficulty with relying on the destruction of colonies as the primary method of control, other than finding the nests, is that often a colony is located on private land. We do not destroy colonies of yellowjackets on private land and we lack the legal ability to have the colonies destroyed quickly. It has been our experience, however, that once a home-owner has been made aware of the colony, it is destroyed.

Area-wide abatement of yellowjackets in B.C. is limited. No insecticides are legally available for use in a toxic baiting program except through special use permits. We have used pentyl valerate, the synthetic attractant for yellowjackets, in a variety of different traps with poor success. Future plans for control include investigating the use of "pathogenic" nematodes in an insecticidal baiting program and the synthesis and use of economical lures for a more comprehensive trapping program.

## 12) Summary and conclusions

Yellowjackets are feared by most people and their stings may cause serious illness and even death in some highly allergic individuals. Unfortunately, the only effective method of control is the destruction of colonies. All colonies of *V. vulgaris* species group but only those colonies of *Dolichovespula* species and members of the *V. rufa* species group that probably will be disturbed should be destroyed:

-aerial nests: use a "wasp-bomb" containing propoxur.

-subterranean nests: apply a liquid formulation of propoxur into the entrance hole and saturate the immediate area with the insecticide.

-colonies in wall-voids: apply carbaryl dust then dichlorvos liquid into the entrance hole and plug the hole with steelwool sprinkled with carbaryl dust.

To reduce the numbers of *V. vulgaris* and *V. pensylvanica*, the following have some use:

-traps containing natural lures, such as fish or sweets.

-traps containing a synthetic lure.

-residual sprays in small areas where yellowjackets congregate.

-"wasp-proofing" businesses that produce attractive commodities.

-the removal of all garbage.

Techniques that have little or no value include:

-area spraying with insecticides.

-destruction of queens.

-biological control.

Washing a sting-site with soap and water and the application of an antiseptic and soothing agent is usually sufficient to reduce the effects of a sting. Anyone who exhibits a systemic reaction should consult a physician.

A vector control district can develop a program to control yellowjackets but it is effectively limited to the destruction of colonies. More work is needed on the use of synthetic lures and insecticidal baiting before a comprehensive management program can be developed.

# Appendix I

Protocol for bee/wasp stings, Simon Fraser Health Unit.

Province of British Columbia

# MEMORANDUM

To: Public Health Nurses
Simon Fraser Health Unit

Date: October 15th 1982

Re: Protocol for Bee/Wasp Stings

All children designated allergic who are stung should go to hospital as emergency patients. Depending on the distance from hospital there are 3 alternatives.

Transport the child to Royal Columbian Hospital if within 15 minutes.

or Call ambulance if more than 15 minutes from hospital.

or Take child to a local pre-arranged physicians office.

BEFORE TRANSPORTING

* If Epinephrine (adrenalin) is available give injection immediately. It is acceptable to give a dose of 0.3 ml to all school aged children. Give injection in the arm.
* Notify parents.
* Give antihistamine if ordered for this child (contained in anakit). Amount varies with age. (age 6-12 - 2 tablets).
* Apply ice to site.
* Leave stinger for hospital to remove.
* Application of a tourniquet is not recommended.
* If transporting have someone besides driver accompany.
* Advise emergency personnel what treatment has been given.

F.J. Blatherwick, M.D., F.R.C.P.(C).
Director.
Simon Fraser Health Unit.

FJB/mbd

# Appendix II

Instructions for the administration of adrenalin for use with ampoule and syringe,and with Anakit.

Province of
British Columbia

Ministry of
Health

Simon Fraser Health Unit
Office of the Director
644 Poirier Street
Coquitlam
British Columbia
V3J 6B1
Telephone: 939-9261

OFFICES

Speech and Hearing Clinic
80A Sixth Street
New Westminster, B.C.
V3L 5B3
Telephone: 525-2437

537 Carnarvon Street
New Westminster, B.C.
V3L 1C2
Telephone: 525-3661

2266 Wilson Avenue
Port Coquitlam, B.C.
V3C 1Z5
Telephone: 941-3451

2336 Clarke Street
Port Moody, B.C.
V3H 1Y8
Telephone: 931-4521

TO BE USED WITH AMPOULE AND SYRINGE

**Instructions for use of Adrenalin**

1) use arm as injection site

2) prepare syringe for injection:

   a) snapp of tip of ampoule by holding it between thumb and index finger and force it backwards

   b) remove needle cover - do not touch needle

   c) insert needle into ampoule and draw up content of ampoule

   d) to expel air and surplus Adrenalin hold syringe with needle pointing up and slowly push plunger until prescribed amount of 0.3 cc is left in syringe

3) inject Adrenalin:

   a) form a sizable roll of skin and insert the needle in a dart-like fashion until needle is inserted completely

   b) pull back on plunger slightly - if blood enters syringe remove and re-insert in another site testing in the same manner for blood

   c) push plunger until it stops

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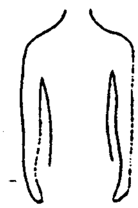
Telephone: 941-3451

2338 Clarke Street
Port Moody, B.C.
V3H 1Y8
Telephone: 931-4521

TO BE USED WITH ANAKIT



**Instructions for use of Adrenalin**

1) use arm as injection site

2) prepare Anakit syringe for injection:

   a) remove needle cover - do not touch needle

   b) to expel air and surplus Adrenalin hold syringe with needle pointing up and slowly push plunger until it stops

   c) turn rectangular plunger ¼ turn to right to line up with slot in syringe

3) inject Adrenalin

   a) form a sizable roll of skin and insert the needle in a dart-like fashion until needle is inserted completely

   b) pull back on plunger slightly - if blood enters syringe remove and re-insert in another site testing in the same manner for blood

   c) push plunger until it stops

# Appendix III

The types of inquiries about wasps during 19 years, 1961-1976, 1981-1983, by months, at Agriculture Canada's Vancouver Research Station, U.B.C.

| DATE | INQUIRY | POSSIBLE GENUS |
|---|---|---|
| 61/8/14 | yellowjackets at garbage at bakery. | either |
| 62/6/11 | yellowjackets in ground near patio. | Vespula |
| 62/8/1 | hornet's nest 30' up in tree. | Dolichovespula |
| 62/8/1 | yellowjackets' nest under eave. | Dolichovespula |
| 62/8/24 | yellowjackets' nest under eave. | Dolichovespula |
| 62/9/12 | yellowjackets' nest in wall-void. | Vespula |
| 62/9/21 | yellowjackets' nest in ground at root of tree. | Vespula |
| 63/8/2 | yellowjackets' nest in lawn. | Vespula |
| 63/8/5 | hornets' nest in ground. | Vespula |
| 64/7/16 | yellowjackets in wall of garage. | Vespula |
| 64/8/24 | hornets' nest in stone wall. | Vespula |
| 64/8/25 | yellowjackets' nest in wall of house. | Vespula |
| 65/6/15 | yellowjackets' nest in laurel hedge. | Dolichovespula |
| 65/7/23 | yellowjackets coming from tangled morning glory. | either |
| 65/8/27 | yellowjackets disturbed by bulldozer. | Vespula |
| 66/4/4 | yellowjackets common on warm side of house. | either |
| 66/7/18 | yellowjackets in wall of house. | Vespula |
| 67/8/23 | yellowjackets' nest under steps. | either |
| 67/8/24 | hornets' nest in shrubs. | Dolichovespula |
| 67/8/24 | yellowjackets' nest | either |
| 67/8/31 | yellowjackets' nest under eave. | Dolichovespula |
| 67/9/5 | yellowjackets' nest in attic. | Vespula |
| 68/3/4 | yellowjackets' nest in attic, very large. | Vespula |
| 68/6/24 | yellowjackets' nest under eave. | Dolichovespula |
| 68/7/18 | yellowjackets' nest under eave. | Dolichovespula |
| 68/7/27 | yellowjackets' nest under eave. | Dolichovespula |
| 68/8/5 | yellowjackets' nest under shingle roof. | Vespula |
| 68/8/7 | yellowjackets' nest, not found. | either |
| 68/8/7 | yellowjackets' nest under concrete steps. | Vespula |
| 68/8/9 | yellowjackets swarming in cherry tree. | either |
| 68/8/23 | yellowjackets' nest under shake roof. | Vespula |
| 68/8/29 | yellowjackets around willow tree with aphids. | either |
| 68/8/29 | yellowjackets. | either |
| 68/9/10 | yellowjackets' nest in barrel in garden. | either |
| 69/7/8 | yellowjackets' nest under eave. | Dolichovespula |
| 69/8/6 | yellowjackets' nest in wall. | Vespula |
| 69/9/3 | yellowjackets' nest under house. | Vespula |

continued

| | | |
|---|---|---|
| 70/8/11 | yellowjackets' nest in ceiling of outdoor pool. | Vespula |
| 70/8/17 | yellowjackets' nest under roof. | either |
| 70/8/18 | yellowjackets' nest inside wall of house. | Vespula |
| 70/?/? | white-faced hornets' nest. | Dolichovespula |
| 70/9/16 | yellowjackets' nest on shelf in house. | either |
| | | |
| 71/7/9 | yellowjackets' nest hanging in tree. | Dolichovespula |
| 71/7/30 | yellowjackets' nest in attic. | Vespula |
| 71/8/12 | yellowjackets on patio and in garden, numerous. | either |
| 71/8/12 | yellowjackets extremely numerous. | either |
| 71/8/16 | yellowjackets' nest under timber on ground. | Vespula |
| 71/9/14 | yellowjackets' nest under gable of house. | Dolichovespula |
| 71/9/15 | yellowjackets in garbage cans. | Vespula |
| | | |
| 72/4/10 | yellowjackets' nest in shake roof. | Vespula |
| 72/5/5 | yellowjackets' nest in carport. | Dolichovespula |
| 72/7/6 | yellowjackets' nest under eave. | Dolichovespula |
| 72/8/3 | yellowjackets' nest in hollow tree. | either |
| 72/8/8 | yellowjackets, how to kill. | either |
| 72/8/14 | yellowjackets' nest in carport. | Dolichovespula |
| 72/8/14 | yellowjackets' nest on fence. | Dolichovespula |
| 72/8/18 | yellowjackets' nest under eave. | Dolichovespula |
| 72/9/14 | yellowjackets' nest in roots of tree. | Vespula |
| 72/9/22 | yellowjackets' nest under shingle roof. | Vespula |
| | | |
| 73/6/22 | yellowjackets' nest in wall. | Vespula |
| 73/6/27 | yellowjackets' nest under steps. | either |
| 73/8/8 | yellowjackets' nest in apple tree. | Dolichovespula |
| 73/8/13 | yellowjackets' nest under shingles. | Vespula |
| 73/8/20 | yellowjackets' nest in wall-void. | Vespula |
| 73/9/6 | yellowjackets' nest on church. | Dolichovespula |
| | | |
| 74/2/15 | interest in chemical in Pestarester traps. | other |
| | | |
| 75/8/7 | yellowjackets' nest in ground. | Vespula |
| 75/9/2 | yellowjackets' nest hanging in tree. | Dolichovespula |
| 75/9/5 | yellowjackets' nest, location unknown. | either |

no records from 1976 to 1980.

| | | |
|---|---|---|
| 81/7/6 | yellowjackets. | either |
| 81/7/10 | yellowjackets' nest. | either |
| 81/9/2 | yellowjackets on trees. | either |
| 81/9/2 | white-faced hornet on trees. | Dolichovespula |
| 81/9/9 | yellowjackets' nest under shingles. | Vespula |

continued

| | | |
|---|---|---|
| 82/5/31 | yellowjackets' nest, small. | either |
| 82/7/9 | yellowjackets in attic. | Vespula |
| 82/7/14 | yellowjackets (hornets) - broke up nest. | Dolichovespula |
| 82/8/9 | yellowjackets in attic. | Vespula |
| 82/8/18 | yellowjackets in house. | either |
| 82/8/19 | yellowjackets in gutter (eave?). | either |
| 82/9/16 | yellowjackets' nest. | either |
| 82/9/17 | yellowjackets in house while canning. | Vespula |
| 82/10/8 | yellowjackets. | Vespula |
| 83/1/5 | yellowjackets' nest in attic. | Vespula |
| 83/4/29 | yellowjackets' starting nest in attic. | Vespula |
| 83/5/31 | yellowjackets starting nest in ceiling. | Vespula |
| 83/6/20 | yellowjackets' nest, size of a football. | Dolichovespula |
| 83/7/4 | yellowjackets' nest. | either |
| 83/7/21 | yellowjackets' nest. | either |
| 83/7/22 | yellowjackets' nest. | either |

Summary of the types of inquiries about wasps during 19 years, 1961 - 1976, 1981 - 1983, at Agriculture Canada's Vancouver Research Station, U.B.C., by year.

| Inquiry | Year | | | | | | | | | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 81 | 82 | 83 | |
| nest of <u>Dolichovespula</u> spp. | | 3 | | | 1 | | 2 | 3 | 1 | 1 | 2 | 5 | 2 | | 1 | 1 | 1 | 1 | 24 |
| nest of <u>Vespula</u> spp. | | 3 | 2 | 3 | 1 | 1 | 2 | 4 | 2 | 2 | 2 | 3 | 3 | | 1 | 1 | 2 | 3 | 35 |
| nest of either genus | 1 | | | | 1 | 1 | 1 | 5 | | 2 | 3 | 2 | 1 | | 1 | 3 | 6 | 3 | 30 |
| other | | | | | | | | | | | | | | 1 | | | | | 1 |
| TOTAL | 1 | 6 | 2 | 3 | 3 | 2 | 5 | 12 | 3 | 5 | 7 | 10 | 6 | 1 | 3 | 5 | 9 | 7 | 90 |

# Appendix IV

Control of yellowjackets: Simon Fraser Health Unit.

SIMON FRASER HEALTH UNIT

## CONTROL OF YELLOWJACKETS

Yellowjackets are common and potentially dangerous stinging insects. At least 10 species are found in the Lower Mainland but only two are serious pests. The others are highly beneficial insects because they eat flies, bugs and caterpilars. Unfortunately, however, most yellowjackets look alike and can be difficult to identify.

The aerial-nesting yellowjackets are represented by four species; two, including the bald-faced hornet, are common. These wasps build their large, grey, soccerball-shaped nests under the eaves of houses, in trees and shrubs and other exposed locations. They are not a problem unless their nests are disturbed.

The ground-nesting yellowjackets are represented by six species. Four species are uncommon, build small nests in the soil and eat insects only and are seldom a problem. The last two species, the common yellowjacket and the western yellowjacket, are often serious pests because they are attracted to our food and are very aggressive; they build large nests in ditch-banks, rockeries, compost heaps, rotted logs and, occasionally, in wall-voids and attics of houses.

Destruction of Colonies: "Wasp Bombs" containing propoxur are available at most garden centers. Follow the directions on the label. These units eject the insecticide from three to four m so protective clothing may not be necessary. Spray at night when most of the wasps are inside the nest. They are attracted to light, so position a flashlight well away from where you are spraying. Colonies in wall-voids and attics of houses are often difficult to control and it may be advisable to hire a pest control company to kill them. Inactive colonies in wall-voids and attics should be removed because they are attractive to many house-hold pests.

Don't:

-destroy colonies of aerial-nesting yellowjackets unless they will be disturbed.

-attempt to control colonies if you are allergic to their stings.

-knock aerial nests down because the wasps will often stay in the area and are a stinging hazard.

-plug the entrance hole of colonies in wall-voids and attics without first applying an insecticide because the wasps will often make an exit hole into the house.

Trapping

A pop-bottle half-filled with water, some beer and jam, and a few drops of liquid detergent, all mixed together, is a good trap for scavenging yellowjackets. The traps should be placed around the perimeter of your property.

A fish hung over a pan of water to which some detergent has been added is often effective. Chicken-wire can be placed over the trap to keep dogs and cats away.

<u>Miscellaneous Control</u>

-remove all attractive sources of food, such as fallen fruit and garbage.

-a Vapona strip can be bolted to the inside of garbage cans to kill yellowjackets and flies.

-for colonies of yellowjackets on public land, phone the health department.

<u>Treatment of Stings</u>

Wash the sting-site with soap and water and apply an antiseptic. A soothing agent, such as calamine lotion or a past of baking soda, or "Right Guard" deodorant or meat tenderizer often reduceds the pain. Inform your family doctor of any discomfort other than localized pain and discomfort.

More information about the biology and control of yellowjackets can be obtained from S.F.H.U. at 939-9261.

14) References

Akre, R.D. 1981. Personal communication.

Akre, R.D. 1983a. Personal communication.

Akre, R.D. 1983b. Yellowjackets. A major pest problem at time. Pest Cont. 51(7): 42, 44, 46, 64.

Akre, R.D., W.B. Garnett, J.F. MacDonald, A. Greene and P. Landolt. 1976. Behavior and colony development of *Vespula pensylvanica* and *V. atripilosa* (Hymenoptera:Vespidae). J. Kans. Ent. Soc. 49: 63-84.

Akre, R.D., A. Greene, J.F. MacDonald, P.J. Landolt and H.G. Davis. 1980. Yellowjackets of America north of Mexico. USDA Ag. Handbook No. 552: 1-102.

Akre, R.D., W.B. Hill and J.F. MacDonald. 1973. Magnetic recovery of ferrous labels in a capture-recapture system for yellowjackets. J. Econ. Ent. 66: 903-905.

Akre, R.D., W.B. Hill, J.F. MacDonald and W.B. Garnett. 1975. Foraging distances of *Vespula pensylvanica* workers (Hymenoptera:Vespidae). J. Kans. Ent. Soc. 48: 12-16.

Akre, R.D. and H.C. Reed. 1981a. Population cycles of yellowjackets (Hymenoptera:Vespinae) in the pacific northwest. Env. Ent. 10: 267-274.

Akre, R.D. and H.C. Reed. 1981b. A polygynous colony of *Vespula pensylvanica* (Saussure) (Hymenoptera:Vespidae). Ent. News 92: 27-31.

Akre, R.D., C.F. Roush and P.J. Landolt. 1977. A *Vespula pensylvanica/Vespula vulgaris* nest (Hymenoptera:Vespidae). Env. Ent. 6: 525-526.

Anon. 1981. Control of wasps and bees. Ag. Can. Pub. No. 1212, 2pp.

Anon. 1982. Pest control for the home and garden. B.C. Min. Agriculture and Food, Victoria, B.C. 118pp.

Archer, M.E. 1973. The population ecology of *Vespula vulgaris* (L.) Vespidae:Hymenoptera, and the computer simulation of colonial seasonal development. IUSSI Proc. VII Int. Congr.: 2-10.

Archer, M.E. 1980. In Social Wasps: their biology-control (R. Edwards, auth.). Rentokil Ltd., Sussex. pp. 172-207.

Archer, M.E. 1981. Successful and unsuccessful development of colonies of *Vespula vulgaris* (Linn.) (Hymenoptera:Vespidae). Ecol. Ent. 6: 1-10.

Baldwin, K. 1983. Immunotherapy. Am. Bee J. 123: 101-104.

Barr, S.E. 1974. Allergy to Hymenoptera stings. JAMA 228: 718-720.

Batra, S.W.T. 1980. Sexual behavior and pheromones of the European hornet *Vespa crabro germana* (Hymenoptera:Vespidae). J. Kans. Ent. Soc. 53: 461-469.

Beard, R.L. 1963. Insect toxins and venoms. Ann. Rev. Ent. 8: 1-18.

Beirne, B.P. 1944. The causes of the occasional abundance or scarcity of wasps (*Vespula* spp.) (Hymenoptera:Vespidae). Ent. Mon. Mag. 80: 121-124.

Belton, P. 1983. Associate Professor, Simon Fraser University, Burnaby. Personal communication.

Bequaert, J. 1931. A tentative synopsis of the hornets and yellowjackets (Vespinae:Hymenoptera) of America. Ent. Am. 12: 71-138.

Bigelow, N.K. 1922. Insect food of the black bear (*Ursus americanus*). Can. Ent. 54: 49-50.

Blatherwick, F.J. 1983. Medical Health Officer, Simon Fraser Health Unit, Coquitlam. Personal communication.

Buckell, E.R. and G.J. Spencer. 1950. The social wasps (Vespidae) of British Columbia. Proc. Ent. Soc. B.C. 46: 33-40.

Butler, C.G., D.J.C. Fletcher and D. Watler. 1969. Nest-entrance marking with pheromones by the honeybee *Apis mellifera* L. and by a wasp, *Vespula vulgaris* L. Anim. Behav. 17: 142-147.

Caron, D.M. 1974. Evaluation of chlorphyrifos for hornet and wasp control. Down to Earth 30: 10-12.

Chapman, J.A. 1963. Predation by *Vespula* wasps on hilltop swarms of winged ants. Ecol. 44: 766-767.

Chenier, N.M. 1982. Reproductive hazards at work. Canadian Advisory Council on the Status of Women. Ottawa. 105pp.

Couper, W. 1870. Remarks on the history and architecture of the wood paper-making wasps. Can. Ent. 2: 49-53.

Davis, H.G., G.W. Eddy, T.P. McGovern and M. Beroza. 1967. 2,4-hexadienyl butyrate and related compounds highly attractive to yellow jackets (*Vespula* spp.). J. Med. Ent. 4: 275-280.

Davis, H.G., G.W. Eddy, T.P. McGovern and M. Beroza. 1969. Heptyl butyrate, a new synthetic attractant for yellow jackets. J. Econ. Ent. 62: 1245.

Davis, H.G., T.P. McGovern, G.W. Eddy, T.E. Nelson, K.M.R. Bertun, M. Beroza and J.C. Ingangi. 1968. New chemical attractants for yellow jackets (*Vespula* spp.). J. Econ. Ent. 61: 459-462.

Davis, H.G., R.J. Peterson, W.M. Rogoff, T.P. McGovern and M. Beroza. 1972. Octyl butyrate, an effective attractant for the yellowjacket. Env. Ent. 1: 673-674.

Davis, H.G., R.W. Zwick, W.M. Rogoff, T.P. McGovern and M. Beroza. 1973. Perimeter traps baited with synthetic lures for suppression of yellowjackets in fruit orchards. Env. Ent. 2: 569-571.

Duncan, C.D. 1939. A contribution to the biology of North American vespine wasps. Stanford U. Pub. U. Serv. Biol. Sci. 8: 1-272.

Ebeling, W. 1978. Urban entomology. U. of Cal., Berkeley. 695pp.

Edwards, R. 1974. The seasonal abundance of wasps - can it be forecast. Env. Health. 82: 11-113.

Edwards, R. 1979. The number of wasps's nests destroyed by local authorities. Env. Health 87: 100, 105.

Edwards, R. 1980. Social wasps: their biology and control. Rentokil Ltd. Sussex. 398pp.

Ennik, F. 1973. Abatement of yellowjackets using encapsulated formulations of diazinon and rabon. J. Econ. Ent. 66: 1097-1098.

Evans, H.E. 1975. Social parasitism of a common yellowjacket. Ins. World Dig. 2: 6-13.

Fluno, J.A. 1961. Wasps as enemies of man. Bull. Ent. Soc. Am. 7: 117-119.

Fluno, J.A. 1973. Chemical proof of validity of the taxonomic separation of *Vespula* subgenus Vespula from *Vespula* subgenus *Dolichovespula*. Proc. Ent. Soc. Wash. 75: 80-83.

Fluno, J.A., H.G. Davis and W.M. Rogoff. 1972. Chloropid flies attracted to synthetic chemical lures. Proc. Ent. Soc. Wash. 74: 443-446.

Frankland, A.W. 1976. Bee sting allergy. Bee World 57: 145-150.

Frazier, C.A. 1976. Insect stings - a medical emergency. JAMA 235: 2410-2411.

Fox-Wilson, G. 1946. Factors affecting populations of social wasps, *Vespula* species, in England (Hymenoptera). Proc. R. Ent. Soc. Lond. (A) 21: 17-27.

Free, J.B. 1970. The behaviour of wasps (*Vespula germanica* L. and *V. vulgaris* L.) when foraging. Ins. Soc. 17: 11-20.

Gaul, A.T. 1953. Additions to vespine biology. XI. Defense flight. Brook. Ent. Soc. Bull. 48: 35-37.

Gibo, D.L., A. Temporale, T.P. Lamarre, B.M. Soutar and H.E. Dew. 1977. Thermoregulation in colonies of *Vespula arenaria* and *Vespula maculata* (Hymenoptera:Vespidae). Can. Ent. 109: 615-620.

Grant, C.D., C.J. Rogers and T.H. Lauret. 1968. Control of ground-nesting yellow jackets with toxic baits - a five year testing programme. J. Econ. Ent. 61: 1653-1656.

Green, S.G. 1982. Bees and Wasps. In Handbook of Pest Control (A. Mallis, ed.). Franzak and Foster Co., Cleveland. pp.489-505.

Greene, A. 1979. Behavioral characters as indicators of yellowjacket phylogeny (Hymenoptera:Vespidae). Ann. Ent. Soc. Am. 72: 614-619.

Greene, A., R.D. Akre and P. Landolt. 1976. The aerial yellowjacket, *Dolichovespula arenaria* (Fab.): Nesting biology, reproductive production, and behavior (Hymenoptera:Vespidae). Melanderia 26: 1-34.

Greene, A., R.D. Akre and P.J. Landolt. 1978. Behavior of the yellowjacket social parasite, *Dolichovespula arctica* (Rohwer) (Hymenoptera:Vespidae). Melanderia 29: 1-28.

Grothaus, R.H., H.G. Davis, W.M. Rogoff, J.A. Fluno and J.M. Hirst. 1973. Baits and attractants for east coast yellowjackets, *Vespula* spp. Env. Ent. 2: 717-718.

Haviland, E.E. 1962. Observations on the structure and contents of yellow jackets' nests (Hymenoptera). Proc. Ent. Soc. Wash. 64: 181-183.

Hawthorne, R.M. 1969. Estimated damage and crop loss caused by insect/mite pests - 1968. CA. Dept. Ag. Bur. Ent. Unpublished Rept. 11pp. (Cited by Poinar and Ennik, 1972).

Howell, J.F. and H.G. Davis. 1972. Protecting codling moths captured in sex-attractant traps from predaceous yellow jackets. Env. Ent. 1: 122-123.

Ikan, R., R. Gottlieb, E.D. Bermann and J. Ishay. 1969. The pheromone of the queen of the oriental hornet, *Vespa orientalis* J. Ins. Phy. 15: 1709-1712.

Insect Allergy Committee. 1965. Insect sting allergy. Questionnaire study of 2,606 cases. JAMA 193: 115-120.

Ishay, J. 1972. Thermoregulatory pheromones in wasps. Experimentia 28: 1185-1187.

Ishay, J. 1975. Caste determination by social wasps: cell size and building behavior. Anim. Behav. 23: 425-431.

Ishay, J. and M.B. Brown. 1975. Patterns in the sound produced by *Paravespula germanica* wasps. J. Acout. Soc. Am. 57: 1521-1525.

Ishay, J., R. Ikan and E.D. Bergmann. 1965. The presence of pheromones in the oriental hornet, *Vespa orientalis* F. J. Ins. Phy. 11: 1307-1309.

Jacobson, R.S., R.W. Matthews and J.F. MacDonald. 1978. A systematic study of *Vespula vulgaris* group with a description of a new yellowjacket species in eastern North America (Hymenoptera:Vespidae). Ann. Ent. Soc. Am. 71: 299-312.

Jeanne, R.L. 1975. The adaptiveness of social wasp nest architecture. Quart. Rev. Biol. 50: 267-287.

Jeanne, R.L. 1977. Behavior of the obligate social parasite *Vespula arctica* (Hymenoptera:Vespidae). J. Kans. Ent. Soc. 50: 541-557.

Jeanne, R.L. 1980. Evolution of social behavior in the Vespidae. Ann. Rev. Ent. 25: 771-796.

Judd, W.W. 1971. Wasps (Vespidae) pollinating helleborine, *Epipactia helleborine* (L.) Crantz, at Owen Sound, Ontario. Proc. Ent. Soc. Ont. 102: 115-118.

Kalmus, H. 1954. Finding and exploitation of dishes of syrup by bees and wasps. Brit. J. Anim. Behav. 2: 136-139.

Landolt, P.J. and R.D. Akre. 1979. Occurrence and location of exocrine glands in some social vespidae (Hymenoptera). Ann. Ent. Soc. Am. 72: 141-148.

Line, S. 1965. Preventing wasp raids on beehives. N.Z. J. Ag. 110: 161.

Lord, W.D., D.A. Nicholson and R.R. Roth. 1977. Foraging behavior and colony drift in *Vespula maculifrons* (Buysson) (Hymenoptera:Vespidae). J. N.Y. Ent. Soc. 85: 186.

Lord, W.D. and R.R. Roth. 1978. Is there intraspecific competition in *Vespula maculifrons* (Hymenoptera:Vespidae)? J. N.Y. Ent. Soc. 86: 304-305.

MacDonald, J.F., R.D. Akre and W.B. Hill. 1973. Attraction of yellowjackets (*Vespula* spp.) to heptyl butyrate in Washington State (Hymenoptera:Vespidae). Env. Ent. 2: 375-379.

MacDonald, J.F., R.D. Akre and W.B. Hill. 1974. Comparative biology and behavior of *Vespula atripilosa* and *V. pensylvanica* (Hymenoptera:Vespidae). Melanderia 18: 1-66.

MacDonald, J.F., R.D. Akre and W.B. Hill. 1975a. Locations and structures of nests of *Vespula atripilosa* and *V. acadica* (Hymenoptera:Vespidae). J. Kans. Ent. Soc. 48: 114-121.

MacDonald, J.F., R.D. Akre and W.B. Hill. 1975b. Nest associates of *Vespula atripilosa* and *V. pensylvanica* in southeastern Washington State. J. Kans. Ent. Soc. 48: 53-63.

MacDonald, J.F., R.D. Akre and R.W. Matthews. 1976. Evaluation of yellowjacket abatement in the United States. Bull. Ent. Soc. Am. 22: 397-401.

MacDonald, J.F., R.D. Akre and R.E. Keyel. 1980. The German yellowjacket (*Vespula germanica*) problem in the United States (Hymenoptera:Vespidae). Bull. Ent. Soc. Am. 26: 436-442.

MacDonald, J.F. and R.W. Matthews. 1981. Nesting biology of the Eastern yellowjacket, *Vespula maculifrons* (Hymenoptera:Vespidae). J. Kans. Ent. Soc. 54: 433-457.

MacDonald, J.F., R.W. Matthews and R.S. Jacobson. 1980. Nesting biology of the yellowjacket, *Vespula flavopilosa* (Hymenoptera:Vespidae). J. Kans. Ent. Soc. 53: 448-458.

Madden, J.L. 1981. Factors influencing the abundance of the European wasp (*Paravespula germanica* (F.)). J. Aust. Ent. Soc. 20: 59-65.

Mampe, D. 1979. Answers. Pest Control 47(10): 57.

Maschwitz, U.W. 1964. Alarm substances and alarm behavior in social Hymenoptera. Nat. 204: 324-327.

Machwitz, U.W., W. Beier, I.Dietrich and W. Keidel. 1974. Futterverstandigungbei Wespen der gattung *Paravespula*. Naturwissenschaften 61: 506.

Matthews, R.W. and J.R. Matthews. 1979. War of the yellowjacket queens. Nat. Hist. 88: 56-67.

McCarthy, B. 1983. Service Manager, PCO-Pied Piper, Burnaby. Personal communication.

McGovern, T.P., H.G. Davis, M. Beroza, J.C. Ingangi and G.W. Eddy. 1970. Esters highly attractive to *Vespula* spp. J. Econ. Ent. 63: 1534-1536.

Miller, C.D.F. 1961. Taxonomy and distribution of nearctic *Vespula*. Can. Ent. Suppl. 22: 1-52.

Milne, L. and M. Milne. 1980. The Audobon Society Field Guide to North American Insects and Spiders. Knopf. N.Y. 989pp.

Morris, R.F. 1972. Predation by wasps, birds and mammals on *Hyphantria cunea*. Can. Ent. 104: 1581-1591.

Morse, R.A., G.C. Eickwort and R.S. Jacobson. 1976. The economic status of an immigrant yellowjacket, *Vespula germanica* (Hymenoptera:Vespidae), in northeastern United States. Env. Ent. 6: 109-110.

Parrish, M.D. and R.B. Roberts. 1982. Successful establishment of the German yellowjacket in urban New Jersey indicated by relative abundance of *Vespula germanica* and *V. maculifrons* (Hymenoptera:Vespidae). J. Kans. Ent. Soc. 55: 272-276.

Parrish, M.D. and R.B. Roberts. 1983. Insect growth regulators in baits: methoprene acceptability to foragers and effect on larval eastern yellowjackets (Hymenoptera:Vespidae). J. Econ. Ent. 76: 109-116.

Payne, J.A. and W.R.M. Mason. 1971. Hymenoptera associated with pig carrion. Proc. Ent. Soc. Wash. 73: 132-141.

Philbrick, H. and J. Philbrick. 1980. The Bug Book. Harmless insect controls. Garden Way Publ. Charlotte. 124pp.

Poinar, G.O. and F. Ennik. 1972. The use of *Neoaplectana carpocapsae* (Steinernematidae:Rhabditoidea) against adult yellowjackets (*Vespula* spp., Vespidae:Hymenoptera). J. Invert. Path. 19: 331-334.

Poinar, G.O., Jr., R.S. Lane and G.M. Thomas. 1976. Biology and redescription of *Pheromermis pachysoma* (V. Linstow) N. Gen., N. Comb. (Nematoda:Mermithidae), a parasite of yellowjackets (Hymenoptera:Vespidae). Nematologica 22: 360-370.

Ratcliff, C. 1983. In CZers cope with flesh-eating flies but bees, wasps are another matter. Crown Zellerbach News. July:4.

Rau, P. 1929. The nesting habits of the bald-faced hornet, *Vespa maculata*. Ann. Ent. Soc. Am. 22: 659-675.

Reed, H.C., R.D. Akre and W.B. Garnett. 1979. A North American host of the yellowjacket social parasite *Vespula austriaca* (Panzer) (Hymenoptera:Vespidae). Ent. News 90: 110-113.

Reierson, D.A. and R.E. Wagner. 1975. Trapping yellowjackets with a new standard plastic wet trap. J. Econ. Ent. 68: 395-398.

Reierson, D.A. and R.E. Wagner. 1978. Trapping to determine the sympatry and seasonal abundance of various yellowjackets. Env. Ent. 7: 418-422.

Reisman, R.E. 1975. Insect stings - danger season opens. U.S. News and World Rep. 78: 65.

Richards, O.W. 1971. The biology of the social wasps (Hymenoptera:Vespidae). Biol. Rev. 46: 483-528.

Richards, O.W. 1978. The Australian social wasps (Hymenoptera:Vespidae). Aust. J. Zool. Suppl. Ser. 61: 1-132.

Rogers, C.J. 1972. A method for marking ground nesting yellowjackets. J. Econ. Ent. 65: 1487-1488.

Rogers, C.J. and T.H. Lauret. 1968. A standard yellowjacket trap for population sampling and control evaluation. J. Econ. Ent. 61: 1793-1740.

Rogoff, W.M., H.G. Davis, T.P. McGovern, E.H. Ilcken and J.B. Kreasky. 1973. Synthetic attractants screened in the field as lures for Chloropidae. Ann. Ent. Soc. Am. 66: 262-265.

Rohwer, S.A. 1916. In Guide to the insects of Connecticut, Pt. III. the Hympenoptera, or wasp-like insects of Connecticut. Connecticut Geol. Nat. Hist. Survey, Bull. 22: 640-645.

Ross, K.G. and R.W. Matthews. 1982. Two polygynous overwintered *Vespula squamosa* colonies from the southeastern U.S. (Hymenoptera:Vespidae). Flor. Ent. 65: 176-184.

Rutherford, T. 1983. Post-doctoral Fellow, Simon Fraser University, Burnaby. Personal communication.

Sandeman, R.G.C.C. 1938. The swarming of the males of *Vespula sylvestris* (Scop.) around a queen. Proc. R. Ent. Soc. Lond. (A) 13: 87-88.

Schmidtmann, E.T. 1976. Muscid fly predation by *Vespula germanica* (Hymenoptera:Vespidae). Env. Ent. 6: 107-108.

Scott, H. 1945. Rainfall in relation to scarcity or abundance of wasps (Hymenoptera:Vespidae). Ent. Mon. Mag. 81: 97-98.

Sladen, F.W.L. 1918. The genus *Vespa* in Canada. Ott. Nat. 32: 71-72.

Smirnoff, W.A. 1959. Predators of *Neodiprion swainei* Midd. (Hymenoptera:Tenthredinidae). Larval vectors of virus diseases. Can. Ent. 91: 246-248.

Spencer, G.J. 1960. On the nests and populations of some vespid wasps. Proc. Ent. Soc. B.C. 57: 13-15.

Spencer, E.Y. 1982. Guide to the chemicals used in crop protection. Ag. Can. Publ. No. 1093. 595pp.

Spradbery, J.P. 1973. Wasps. An account of the biology and natural history of solitary and social wasps. U. Wash. Press. Seattle. 408pp.

Storey, E. 1983. Questions and Answers. Pest Cont. Tech. 10: 94-95.

Taylor, L.H. 1939. Observations on social parasitism in the genus *Vespula* (Thorison). Ann. Ent. Soc. Am. 32: 304-315.

Walsh, G.B. 1945. Causes of abundance or scarcity of wasps. Ent. Mon. Mag. 81: 89.

Wagner, R.E. 1978. The genus *Dolichovespula* and an addition to its known species of North America. Pan. Pac. Ent. 54: 131-142.

Wagner, R.E. and D.A. Reierson. 1969. Yellow jacket control by baiting. 1. influ ence of toxicants and attractants on bait acceptance. J. Econ. Ent. 62: 1192-1197.

Wagner, R.E. and D.A. Reierson. 1975. clothing for protection against venemous Hymenoptera. J. Econ. Ent. 68: 126-128.

Wagner, R.E. and D.A. Reierson. 1978. In Urban Entomology (W. Ebeling, auth.). U. of Cal. Press, Berkley, pp 356.

West, A. and B. Smallman. 1983. Goodbye Bugs. A practical guide to coping with insects in the great outdoors. Grovenor House Press. Toronto. 144pp.

Wilson, E.O. 1971. The Insect Societies. Belkap Press. Cambridge. 548pp.

Wilson, M.V.H. 1977. New records of insect families from the freshwater Middle Eocene of British Columbia. Can. J. Earth Sci. 14: 1151-1155.

Winston, M. 1983. Assistant Professor, Simon Fraser University, Burnaby. Personal communication.

Wright, R.H. 1969. Insect attraction (wasps). Israel J. Ent. 4: 83-87.

Addendum

Anon. 1978. Pesticide control act regulation. The British Columbia Gazette (II). 13 pp.