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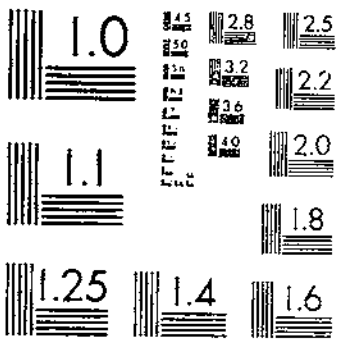

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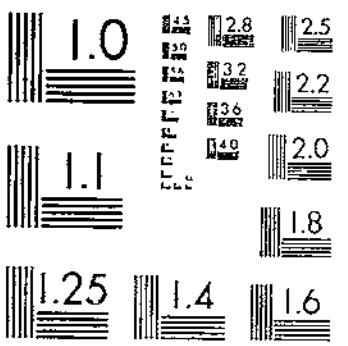

MICROCOPY RESOLUTION TEST CHART
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NOSEMA DISEASE

ITS CONTROL IN HONEY BEE COLONIES

IN COOPERATION WITH
WISCONSIN AGRICULTURAL EXPERIMENT STATION

UNITED STATES DEPARTMENT OF AGRICULTURE

TECHNICAL BULLETIN NUMBER 1569

PREPARED BY SCIENCE AND EDUCATION ADMINISTRATION

On January 24, 1978, four USDA agencies—Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), Extension Service (ES), and the National Agricultural Library (NAL)—merged to become a new organization, the Science and Education Administration (SEA), U.S. Department of Agriculture.

This publication was prepared by the Science and Education Administration's Federal Research staff, which was formerly the Agricultural Research Service.

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ABSTRACT

Moeller, F. E.1978. Nosema Disease -Its Control in Honey Bee Colonies. U.S. Department of Agriculture Technical Bulletin No. 1569.

A serious disease of adult honey bees, nosema, caused by *Nosema apis* Zander, retards colony development, thus affecting pollination, honey production, and package bee production. It is a major cause of queen supersedure in package bee colonies. Control consists of encouraging brood emergence, winter flight, and such chemotherapy as Fumidil B (fumagillin).

Package colonies treated with Fumidil B produced 45 percent more honey than untreated colonies. Thirteen years of nosema disease study on 200 colonies show the seasonal fluctuations in infection levels and the advantage of chemotherapy when conditions warrant.

This technical bulletin summarizes the studies and present knowledge on nosema controls stimulated by the Joint United States-Canada Nosema Disease Committee.

Key Words: *Nosema apis*, nosema disease, fumagillin, honey bees, queen supersedure, package bees, parasite, microsporidia.

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Washington, D.C. April 1978

NOSEMA DISEASE

Its Control in Honey Bee Colonies

FLOYD E. MOELLER[1]

INTRODUCTION

Throughout the world, nosema disease probably occurs wherever bees live. In 1911, E. Zander (*34*)[2] identified *Nosema apis* Zander, a spore-forming protozoan (class Sporozoa of the microsporidia), as responsible for nosema disease in the honey bee, *Apis mellifera* L. The parasite infects only adult bees. It attacks the lining or epithelium of the midgut (fig. 1) and occasionally the malpighian tubules (*33*). The disease is initiated by ingestion of the highly refractile, 2 μ by 5 μ oval spores (fig. 2). In 3 to 7 days, sporonts appear in the lumen of the gut, and millions of adult spores are then shed into the digestive tract and eliminated in the feces (fig. 3). Fecal contamination of water, food, or combs of a colony may also be the source of infection.

Severity of infection varies greatly in individual colonies (*7, 13, 19, 20, 24,*

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[2]Italic numbers in parentheses refer to Literature Cited, p.15.

PN-5781

Figure 1. Section through tissue of midgut showing spore-laden epithelium.

PN-5782

Figure 2.— *Nosema apis* spores: *a*. Young; *b*. Old. (Magnified 1000:1.)

25). The *Nosema* parasite does not kill the bees outright, nor does it cause them to manifest specific symptoms. However, the disease causes severe losses to the beekeeping industry by queen supersedure within 2 to 6 weeks after they become infected (*8*) and by retarding the development of package bees and overwintered colonies. Nosema shortens the life of worker bees about 50 percent and affects the quantity of brood reared; thus it impairs the production of honey (*3, 9, 19*). More a disease of the colony than of individual bees, nosema affects colony strength; it must be controlled.

A. S. Michael (*17*) thoroughly discussed the status of the Joint United States-Canada Nosema Disease Committee, which was established in response to a request of the Canadian Beekeepers Council and the Apiary Inspectors of America and by scientists from Canada and the United States, at Madison, Wis., in February 1962. Michael also lists research literature stimulated directly or indirectly by the Committee. This technical bulletin on nosema disease and its control was prepared at the request of the Committee.

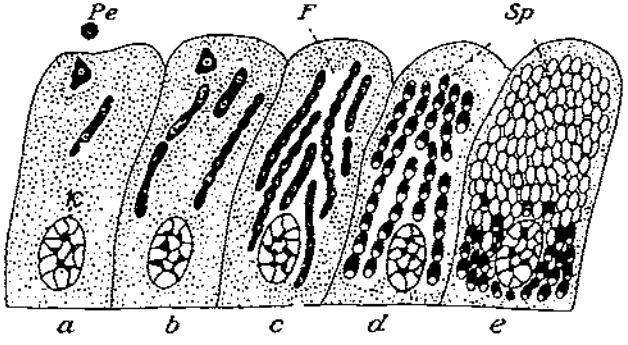

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Figure 3. Stages of the developing nosema parasite in epithelial cells of the ventriculus. In cell *a*: *K* = cell nucleus. *Pe* = planont before entering the cell. Two meronts within cell cytoplasm. Cells *b* and *c* show increase of the parasite. *F* = rows of meronts. Cells *d* and *e* show production of young and older spores. *Sp*.

DETECTION (DIAGNOSIS)

Nosema could aptly be called "no-see-um" disease because infected colonies show few characteristic symptoms other than retarded colony development and disappearance of infected queens. Crawling bees are the only characteristic of the disease during the first few days of a heavy honey flow—apparently they are too weak to handle heavy loads of nectar.

If the gut is carefully removed from crawling bees by pulling the last abdominal segment and gently drawing out the gut, the brown, feces-laden hindgut is seen first and then the midgut. In a healthy bee, the midgut is amber and translucent; in nosema-infected bees, the midgut is often swollen and milky. It later becomes chalky white and returns to normal size (fig. 4). When chalky or milky guts are macerated with a tweezer in a droplet of water on a microscope slide and viewed at about 440X, almost a pure culture of nosema spores (as many as 10^8 spores per bee) can be seen. *Nosema apis* spores can be readily seen without staining by means of a compound microscope at 440X.

Spotting or dysentery, not a symptom, may or may not characterize a nosema-infected colony. Bees of weak colonies that are dying from whatever cause—nosema, starvation, or queenlessness—may defecate. Conversely, grossly infected nosema bees may not void noticeable amounts of feces.

Queens can become infected while in mating nuclei, in transit with package bees, or after package bees are installed. Most beekeepers would not take time to look for a dead queen, but if they found one they probably would not be equipped to examine her for nosema. The loss would be called "supersedure."

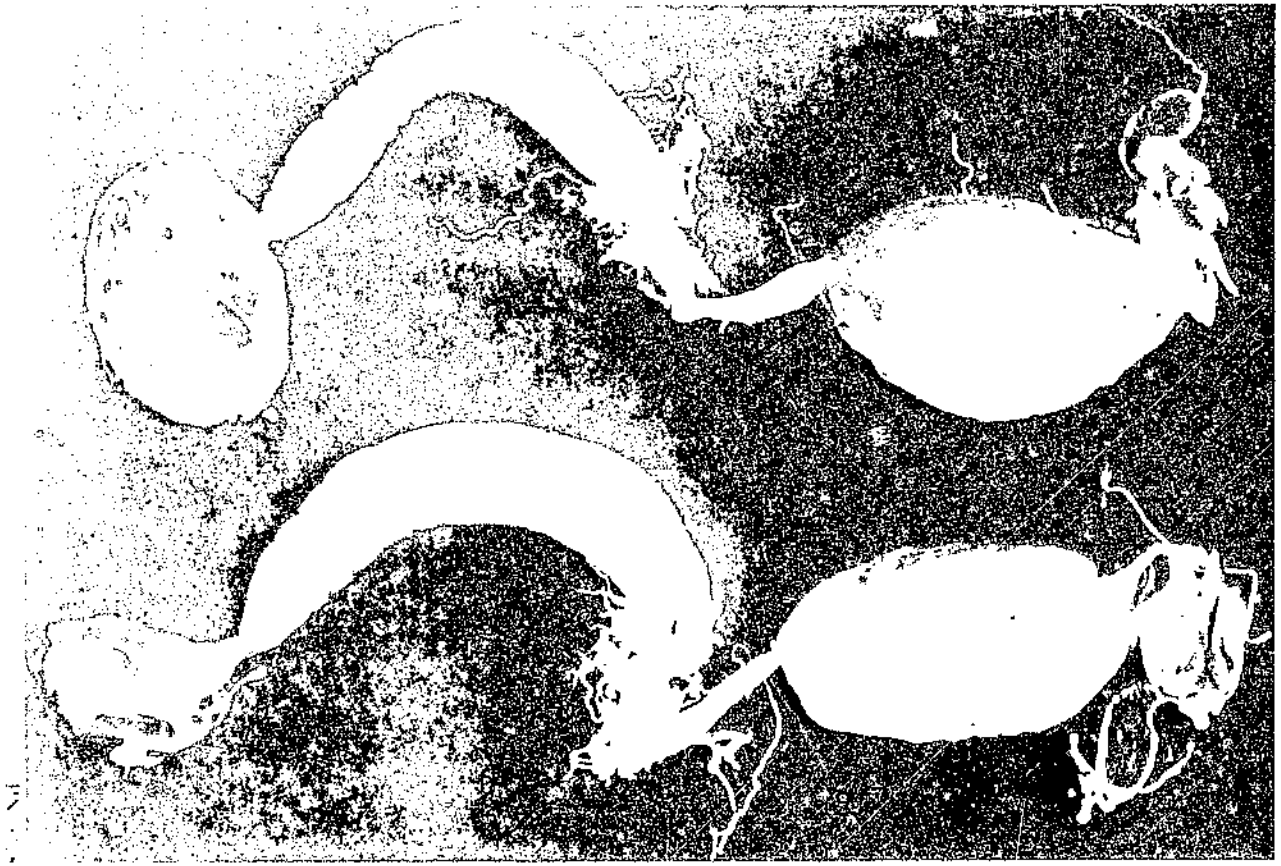
Roberts (*27*) described a method of detection of nosema spores in living queens by inducing them to defecate, thus enabling coprological examination without injury to the queen.

In northern latitudes, the annual cycle of natural nosema infections in honey bee colonies has been shown to reach the highest levels in March (*20*), or sometimes later in April, May, or June (*23, 25*).

Mussen *et al.* (*24*) sampled apiaries instead of individual colonies to get a survey of nosema incidence across the country. They also used an alternative sampling method based on hemocytometer counts giving an average number of spores per bee. This method was also used by Cantwell (*4*).

When the disease is acute, colonies may become depleted in population and eventually will dwindle to a handful of bees and a queen. They defecate in the hive and look dirty and sluggish. "Oldtimers" called this stage "spring dwindling." Eventually some colonies can outgrow the disease, as foraging becomes possible, but they are usually nonproductive and develop queen problems.

In colonies not so severely affected, brood emergence eventually allows the colony to recover and produce a normal honey crop. How much honey is annually lost because of such subacute or endemic nosema infection is impossible to estimate, but the loss must be substantial.



FACTORS FAVORING NOSEMA DISEASE BUILDUP

Contaminated Equipment

Equipment is often laden with nosema-contaminated feces from weakened colonies that died over winter. Such equipment, when used to hive new packages or divisions, will be a source of nosema inoculum. Also, contaminated equipment can inoculate normal colonies later in the summer when used as honey supers or additional brood comb. Bailey (*1, 2*) stated that the primary means of transmission of *Nosema* spores was by workers cleaning combs soiled by excreta during the winter. He reasoned that new bees in the colony also became infected as the brood nest expanded downward in the spring over soiled combs, which increased the incidence of infected bees.

Colony Disturbance

Oertel (*26*) showed that colonies of honey bees that are opened and manipulated at regular intervals showed more infection with *Nosema apis* than did others that were not opened. Thus, he concluded that queen-rearing colonies, which must be manipulated frequently, are likely to show more infection than colonies worked normally for honey production.

Confinement

Compared to colonies confined during the winter, shorter confinements during inclement or rainy weather also encourage disease buildup. In early spring, cold, rainy weather may occur for several weeks, even in the Deep South, causing a potential nosema problem in package-bee and queen-rearing operations.

In overwintering colonies in the North, winter flights are desirable. Such flights enable bees to defecate outside and reduce involuntary defecation within the cluster, however slight. Nosema-sick bees fly from the hive at marginal flight temperatures probably because they are under stress. They are also weak, drop to the snow, become chilled, and are unable to return to the colony (*21*). Sick bees, thereby, are eliminated from the colony. The benefits of winter flight are denied when bees are confined by cold weather or indoor wintering.

Disruption of Brood Emergence

Because a primary natural defense against nosema is the emergence of brood—allowing replacement of infected bees with healthy young bees—any disruption or break in brood rearing and emergence of bees will make the colony a candidate for nosema disease (*21*).

In routine winter sampling of colonies for nosema at the Madison laboratory, unusually high nosema levels in some colonies almost invariably pointed to colonies that were queenless and, of course, broodless. Usually these colonies had been queenless since late fall, and by February or March they showed high levels of nosema. Sometimes as many as 90 or 100 percent of the bees showed infection. At any time of year, colonies with an interruption of normal brood rearing caused by queenlessness can get into serious difficulty if nosema is already present, even at low levels. Such difficulty exists in "baby nucs" used for queen mating. If extra brood is not provided, chances are the nucs cannot rear much brood because the queens are promptly removed for sale as soon as they start to lay.

A lack of pollen can result in reduced brood rearing and eventual reduction in normal emergence of young bees. Such pollen shortages frequently curtail brood rearing in March and April in northern areas. In midsummer drought in such areas as California or the Southern United States causes pollen shortages. When such curtailment of brood occurs, colonies become more vulnerable to nosema.

The newly hived package colony is one of the most likely candidates for nosema problems. During the first 3 weeks following installation, the colony has no emerging young bees and must depend entirely on the original package bees, which commonly carry nosema infection.

Pesticide damage to a colony may cause a reduced brood level, either by direct poisoning of brood or loss of supporting population or, more likely, by both. A late summer application of pesticide that does not actually kill a colony outright may weaken it by fall and cause a subnormal population with proportionately fewer young bees. This weakened population will become weaker as winter progresses, thereby reducing normal winter brood rearing and allowing the colony to become more susceptible to nosema. From late August 1964 until early spring 1965, 50 percent of the colonies in an apiary were lost. All were nosema infected (50 to 100 percent of the bees in samples showing positive nosema).

NOSEMA DISEASE IN PACKAGE BEES AND QUEEN SUPERSEDURE

Nosema has long been recognized as important in package bee colony development and queen supersedure (*8, 10*). Nosema infection in package bees from the same or different shippers during the same year may vary. The Madison laboratory routinely sampled most queen attendants and package bees received over the years. One of the larger samplings was taken in the spring of 1953 during fumagillin tests. Table 1 shows the percentage of samples from 1,961 packages, received on one date in April 1953, that showed nosema infection. Presumably, each shipment received in Wisconsin was shaken from a different apiary. This evidence explains why different shipments from the same source may vary in their ability to develop productive colonies. Jay (*12*) found similar trends in packages received at

Table 1.—Nosema infection (percentage) in samples from package shipments on arrival at Madison, Wis.

Source	Lot[1]							
	1	2	3	4	5	6	7	8
1	6	15	17	28	29	40	52	55
2	8	9	27	30	41	49	60	83
3	2	7	13	16	17	22	38	---
4	12	18	27	---	---	---	---	---
5	18	35	---	---	---	---	---	---
6	22	27	37	43	62	89	---	---

[1] Each lot presumably came from a different apiary on the same date in April.

Manitoba, Canada. Cantwell and Shimanuki (*6*) reviewed the work of independent surveys by well-qualified investigators and show how widespread and severe nosema disease is in honey bees. These surveys were at the source and not with beekeepers in any particular region or area.

Such wide disparity of infection stems from colony and weather conditions and methods of operation. When package bees are shaken over a queen excluder in fair weather, the older bees, most heavily infected with nosema, fly off whereas the younger bees stay clustered beneath the excluder. When packages are shaken without an excluder, especially on dark, cool days, all the older bees will go into the shaker box, causing a higher incidence of nosema. In the spring, the first bees shaken from colonies may also have a higher percentage of older bees, thus more nosema. As the season progresses, a higher percentage of young bees is typical. Moist, low-lying, cool, or shaded yards may have a higher percentage of nosema than dry locations (*6*). Strong colonies, because of a greater brood-rearing level, may give healthier bees.

Queen bees and worker attendants also vary in nosema incidence depending on colony conditions before shipment. When held in "bank" colonies, queens can become infected; when older bees are used as queen attendants, nosema incidence may rise. All too often, when baby nucs are used for queen mating, a queen is seldom allowed to rear much brood in the nuc, and because older bees predominate in the nuc, a potential nosema problem arises. Bees from the nuc are usually used as queen cage attendants that may carry the disease.

Studies were made at Beltsville of the transmission of nosema disease from infected honey bee workers to queens in queen mailing cages (*16*) and in mating nuclei (*30*). Because the newly hived package colony is without emerging young bees for 3 weeks, the colony is especially vulnerable to nosema. Heavily infected package colonies may appear to stand still—slow

to build populations—because of bees' shorter lifespan, reduction in brood-rearing efficiency, and inability to make brood food (*32*).

Queen supersedure, or loss, in package bees is a serious problem closely related to nosema disease (*8, 10*). Probably 90 percent of all queens lost in package colonies during the first 6 or 8 weeks after installation results from nosema infection. Queens may appear normal and begin a normal brood nest, then suddenly disappear for no apparent reason. If the bottom board or the 3- or 4-foot area immediately in front of the hive is thoroughly searched, the dead queen may be found. Microscopic examination of the gut usually reveals many nosema spores.

NOSEMA DISEASE IN OVERWINTERED COLONIES

An 8-year study of nosema infection in 200 overwintered colonies was made at the Madison laboratory before the use of Fumidil B.[3] The survey represents normal buildup of bees infected during the winter (*20*). Samples were taken from the top center of the winter clusters because nosema-infected bees congregate in and above warm brood areas (*18*).

Table 2 summarizes eight winter samplings. During December the samplings showed infections building up from a low of 1 to 11 percent; at the end of winter confinement, late March or April, infections rose from 19 to 70 percent. Note also that the percentage of nosema-infected bees in these colonies increased from 10 to 19 percent in December to highest levels of 30 to 68 percent in March. The intensity of infection usually subsides in April as field flights begin and brood emergence accelerates. When winter flights are few, or even nonexistent, infection spreads acutely within the overwintering colonies in late winter and early spring.

CONTROL

Reduced honey production from nosema disease is difficult or impossible to measure in commercial apiaries, but loss may be greater from nosema than from any other disease. An approved beekeeping practice consists of rebuilding inferior colonies by adding brood and bees from stronger colonies. In the 1953 fumagillin test, cooperators indicated honey production of approximately 30 pounds more than produced in treated package colonies. In tests with Fumidil B in 1962 (*19*), about 45 percent increased poundage was produced when package colonies were treated.

White (*33*) described experiments that set some limits for the resistance of *Nosema apis* spores to environment. Note the following limits when considering possible controls:

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[3]Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture nor an endorsement over other products not mentioned.

Table 2.—Nosema infection in untreated, overwintered colonies (natural infections)

Sampling date	Colonies sampled	Colonies infected[1] per sampling	Bees infected[2] in colonies with nosema
	Number	*Percent*	*Percent*
Dec. 8, 1954	194	11	12
Jan. 14, 1955	230	11	20
Feb. 9, 1955	230	13	37
Mar. 3, 1955	228	17	38
Apr. 18, 1955 ...	182	35	20
June 20, 1955 ...	59	2	10
Dec. 6, 1955	186	8	19
Jan. 11, 1956	186	5	15
Feb. 6, 1956	186	10	30
Mar. 13, 1956 ...	184	24	36
Apr. 10, 1956 ...	148	12	24
Dec. 14, 1956 ...	197	3	13
Jan. 21, 1957	197	5	26
Feb. 12, 1957 ...	197	10	27
Mar. 13, 1957....	196	33	30
Apr. 12, 1957 ...	194	58	31
Dec. 3, 1957	191	8	14
Jan. 8, 1958	191	14	26
Feb. 19, 1958 ...	191	9	38
Mar. 13, 1958 ...	191	19	24
Apr. 7, 1958	191	15	17
Dec. 4, 1958	195	7	13
Jan. 6, 1959	194	15	34
Feb. 4, 1959	194	41	63
Mar. 12, 1959 ...	188	57	68
Apr. 8, 1959	138	70	44
Dec. 2, 1959	102	2	10
Jan. 4, 1960	102	5	10
Feb. 4, 1960	102	4	27
Mar. 4, 1960	101	8	46
Apr. 4, 1960	98	30	44
Dec. 7, 1960	196	1	10
Jan. 7, 1961	196	2	10
Feb. 7, 1961	196	8	15
Mar. 1, 1961	196	6	29
Apr. 11, 1961 ...	97	69	28
Dec. 19, 1961 ...	204	7	10
Jan. 16, 1962	204	10	23
Feb. 15, 1962 ...	204	18	47
Mar. 7, 1962	196	23	51

[1] Diseased colonies detected via 20-bee mass samples.
[2] Obtained by examination of 10 individual bees after the mass sample disclosed infection.

1. **Heat**

In water suspension, spores are destroyed in 10 minutes between 135° F (57° C) and 138° (59°).

In honey, spores are destroyed in 10 minutes between 136° F (58° C) and 140° (60°).

2. **Drying**

At incubator temperature, spores are killed between 15 and 21 days.

At room temperature, spores remain virulent for 2 months.

At outdoor temperature (summer), spores are virulent after 2 months.

At refrigerator temperature, spores remain virulent for 7 months but lose virulence after 7-1/2 months.

3. **Fermentation**

At incubator temperature in 3 days and at outdoor temperature in 9 days, spores are destroyed by fermentation in 20-percent honey solution.

At room temperature, spores are destroyed by fermentation in 10-percent sugar solution in 7 to 11 days.

At refrigerator temperature, spores resist fermentation for more than 7 but less than 9 days.

4. **Putrefaction**

Spores are destroyed by putrefaction at incubator temperature in 5 days, at room temperature in 2 weeks, at outdoor temperature after 22 days; and spores resist putrefaction for more than 3 months in refrigeration.

5. **Sunlight**

Spores in crushed gut tissue are destroyed in 15 to 32 hours when exposed to direct sunlight.

In water suspension, spores are killed by sunlight in 37 to 51 hours.

6. **Honey**

At room temperature and in darkness, *Nosema apis* spores suspended in honey remain virulent for 2 to 4 months.

7. **Dead bees**

At incubator temperature, spores cease to be virulent after 1 week.

At room temperature, spores are virulent for 3 to 4 weeks but not after 1 month.

At refrigeration, spores remain virulent for 2-1/2 to 4 months.

On the soil during the summer, spores are virulent for 44 days but nonvirulent after 71 days.

8. **Combs**

Infection was not transmitted in any experiments where brood combs from nosema-infected colonies were given to healthy ones.

9. **Cold**

At Madison, heavily infected nosema guts were frozen April 1970; 6

years later in January 1976, the spores were completely viable and produced active infection when fed to laboratory bees.

Moffett and Wilson (*22*) conducted similar tests in Laramie, Wyo., and found the spores viable for well over 2 years.

Chemotherapy has been explored in some depth for the control of nosema disease. Two materials, Nosemack, an effective mercury salt (*28*), and Fumidil B (fumagillin), were explored extensively. Only fumagillin (*11, 14*) has given consistently good results against nosema. In 1953, extensive tests, which used 2,340 package colonies owned by beekeepers in Wisconsin, Iowa, and Minnesota, were conducted (*9*), to evaluate fumagillin. These tests conclusively showed the effectiveness of fumagillin. Further cooperative work with Abbott Laboratories in North Chicago, Ill., resulted in the development of Fumidil B, now available to beekeepers. Recently, enteroseptolum-5-chloro-7-iodine-8-hydroxy quinoline was described by Smirnova and Peregud (*31*) as more effective than fumagillin against nosema.

Management of Colonies

Nosema disease is probably present in all bee localities throughout the world. Any disruption of the normal emergence of young healthy bees into the population by lack of sufficient pollen, queenlessness, brood disease, or insecticides must be considered with prolonged confinement as conditions that increase nosema disease in colonies. Beekeepers also must recognize the danger of using combs or equipment soiled with feces.

Colonies should be kept strong at all times of the year—keeping vigorous young queens, feeding pollen supplement when needed, using a two-queen system or some modification of it, and using a good swarm control system. Even during winter, brood rearing should be encouraged at all times. In the fall, weak colonies should be united or disposed of so that only first-class colonies are overwintered. Colony losses should be taken in the fall so the almost certain soiling of equipment by colonies that expire in the late winter or spring can be reduced as much as possible.

The best defense against nosema is to winter strong colonies with plenty of honey in the proper position, feed pollen supplement in the spring, and then divide the bees early to make colony increase. A two-queen colony that is properly overwintered is seldom lost or weakened enough to become a candidate for severe nosema disease.

Winter flights should be encouraged as much as possible. Generally, colonies should be overwintered outdoors with good wind protection and provided upper flight entrances. Avoid heavy winter packing. In a heavily insulated hive, bees might fail to sense a temporary outside warming when defecation flights might be possible.

Fumigation of hives, combs, and package cages contaminated with spore-laden fecal material has been used in some operations but, except for package-cage treatment, it generally involves too much time, labor, and expense. Contaminated hives and combs can be used to hive package

bees safely when Fumidil B protects the bees during cleanup. Acetic acid fumes (*1*), ethylene oxide (*29*), and heat (*5*) also have been described for treating nosema-contaminated equipment and combs. Because nosema spores readily are destroyed by moist heat (135° F for 10 min), live steam can be used to clean contaminated package cages or hive parts. Live steam is usually available in the honey processing plant.

A colony can be cleansed of nosema disease without using fumagillin. The colony must be reasonably strong, have good brood emergence, and be moved periodically to a new spot in the apiary to lose all the old, potentially infective bees. This care would insure clean attendant bees for queen shipment.

Use of Fumidil B (Fumagillin)

By far the best adjunct to good colony management is the consistently effective antibiotic fumagillin, available as Fumidil B. It is an excellent management tool for nosema control in overwintered colonies and newly established package colonies.

For optimal nosema control in overwintered colonies, initial infection levels should be reduced in early winter. In late fall, when brood rearing normally declines, colonies should be fed about 1 gallon of heavy sugar sirup (2 parts sugar, 1 part water) containing Fumidil B. This sirup should be stored where the last brood emerges and used as the first winter feed by the colony. In this way, the initial buildup of any infection from winter confinement and reduced brood emergence is delayed enough to make sure the disease never reaches such high levels as seen in unprotected colonies.

Experiments indicate that Fumidil B can be mixed with pollen supplements or substitutes and still maintain its effectiveness; however, colonies must be actively rearing brood to eat the pollen supplement. When infection is high and brood rearing is seriously reduced, the colony will not eat sufficient supplement for control. A combination of fall sirup and spring pollen supplement; which both contain fumagillin, gave excellent control. Figure 5 shows the effect of such experimental treatments over 5 years (1963-67) on some 200 colonies previously without treatment. Shown is the percentage of colonies infected once or more during each December through April period.

No blanket recommendations can be given for the use of Fumidil B. When an apiary or outfit has a known past history of spring colony loss and slow spring buildup, the feeding of Fumidil B in sirup in the fall for 2 or 3 years is warranted until nosema is less of a problem. Microscopic examination of bees is helpful during this period. When bee populations go into winter with good levels of brood rearing in late fall and plenty of pollen, such feeding can be suspended for 1 or 2 years.

Fumagillin in sugar sirup should measure 100 mg fumagillin per gallon of sirup, 5 grams or 1-1 2 level teaspoons of Fumidil B.

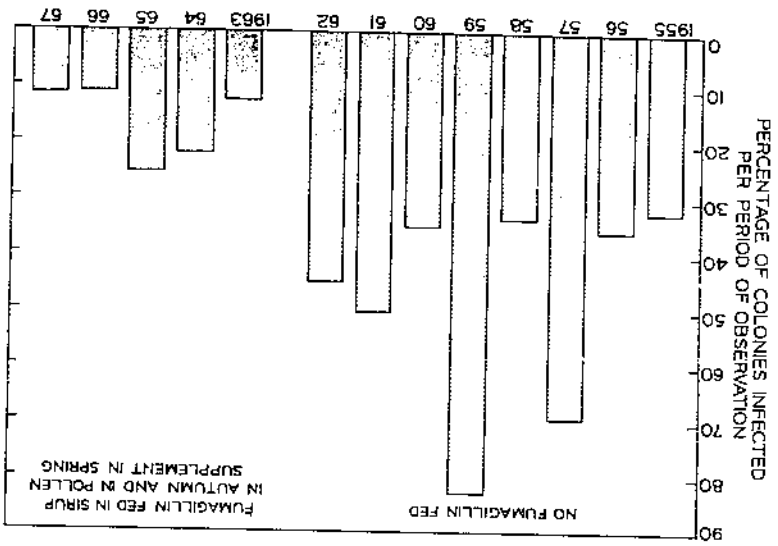

Figure 5.—Effect of Fumidil B (fumagillin) feeding on nosema disease in Wisconsin.

An effective place for Fumidil B is in newly established package colonies. Here, nosema must be controlled during the first 3 weeks before brood emergence. At least 1 gallon of medicated sirup should be fed to each newly established package colony to provide fumagillin protection during the first 3 weeks. In package-bee colony tests, 57 colonies were fed sugar sirup containing 2 parts sugar and 1 part water plus 5-1/2 grams of Fumidil B per gallon (110 mg fumagillin activity per gallon). Twenty-four colonies were fed untreated sirup. Each colony received approximately 1-1/3 gallons of sirup, which was consumed during the first 3 weeks following installation of the packages on feces-contaminated equipment (table 3).

Not only does Fumidil B allow the colony to overcome nosema in the developing population, but it also guards against inevitable queen supersedure or loss because of infection. (In the Madison test, four queens were lost in the untreated colony group; two subsequently were recovered, examined, and found infected by nosema.)

Fumidil B sirup should be fed to queen-bank colonies, to provision bees used in queen-mating nuclei, and to guard against disease buildup in mating nuclei.

In queen-bank colonies, fumagillin sirup should be fed continuously to the bees. Fumidil B stores can be prepared by massive feeding of Fumidil B sirup to a colony that stores the sirup in empty combs as "honey." Sealed combs of medicated stores will retain fumagillin activity for 8 months or longer. Such combs can be given to queen-bank colonies at intervals throughout the winter and should be positioned immediately adjacent to the caged queens.

The use of Fumidil B and comb fumigation has been discussed by Lehnert and Shimanuki (*15*) as a means of production of nosema-free bees in the South.

Table 3.—Effect of feeding Fumidil B on nosema disease in two stocks of package-bee colonies

Stock	Treated colonies			Untreated colonies		
	Number	Infected initially	Infected after 3 weeks	Number	Infected initially	Infected after 3 weeks
		Percent	*Percent*		*Percent*	*Percent*
A	27	44	15	11	64	100
B	30	13	10	13	[1]ND	100

[1] ND = not detected.

CAUTION: No medication should be fed to colonies when there is danger of contaminating the honey crop. Be sure to stop all drug feeding at least 4 weeks before the onset of the main surplus honey flow.

A summary of feeding of Fumidil B for prevention and control of nosema disease follows:

1. Fall feeding (September-November) wintering colonies:
   a. 1-1/2 level teaspoons Fumidil B/gal 2:1 sirup, 1 gal sirup/colony.
   b. 9.5 gm bottle Fumidil B/100-120 gal 2:1 sirup, 1 gal sirup/colony.
   c. 57 gm—six-pack Fumidil B/600-720 gal 2:1 sirup, 1 gal sirup/colony.
2. Winter feeding (January-March) wintering colonies:
   a. Repeat above treatment for colonies that are normally fed sugar sirup.
3. Spring feeding when packages are installed:
   a. 1-1/2 level teaspoons Fumidil B/gal 2:1 sirup, 1 gal sirup at installation.
   b. 9.5 gm bottle Fumidil B/100-120 gal 2:1 sirup, 1 gal sirup at installation.
   c. 57 gm—six-pack Fumidil B/600-720 gal 2:1 sirup, 1 gal sirup at installation.

If package bees are confined by unfavorable weather conditions, repeat treatment 10 to 15 days after installation.

Fumidil B, sulfa, and terramycin are compatible and can be fed together in the same sirup.

Most effective feeding of Fumidil B is as bulk feed in sugar sirup. When Fumidil B is fed in powdered sugar, extender patties, or supplemental diets, it is not so effective.

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