MINUTES OF THE MEETING
AGRICULTURE, LIVESTOCK & IRRIGATION COMMITTEE
50TH LEGISLATIVE SESSION
HOUSE OF REPRESENTATIVES

January 30, 1987

Representative Duane W. Compton, Chairman of the Agriculture, Livestock & Irrigation Committee, called the meeting to order at 1:00 p.m. in room 317 of the Capitol, Helena. All members were present, as was Tom Gomez, researcher.

Bills to be discussed were HB 446 and HB 461.

HOUSE BILL 446

Rep. Dean Switzer, District 28, sponsor of HB 446 mentioned that he had carried a bill into the statutes for beef cattle promotion, and this bill intends to take that 25 cent fee back out of the statutes, depending on whether the $1.00 National Beef Council checkoff either passes or fails in the referendum. HB 446 would suspend the beef research and marketing assessment of 25 cents presently being collected by the county treasurer of each county, provides for an immediate effective date, and has a retroactive application.

The 25 cents per head checkoff would be suspended for 1987, and if the $1.00 referendum passes, the Department of Livestock would certify to the Governor that the 25 cent fee is to be suspended for 1988 also. If the referendum passes, it would nullify collection of the 25 cents, and HB 446 provides for an automatic refund for any collections made for 1987 and 1988.

PROPONENTS

Kim Enkerud, representing Montana Association of State Grazing Districts, Montana Cattlewomen, and Montana Stockgrowers, said they are in support of HB 446. They support the National Beef Council program, but think when producers are paying $1.00 per head checkoff for beef promotion, they should not have to pay the 25 cents also. See exhibit #1.

Claribel Bonine, WIFE, is in favor of HB 446.

Stuart Doggett, Montana Chamber of Commerce, supports HB 446.

Les Graham, Director of the Department of Livestock, supports HB 446. See exhibit #2.

Mons Teigen, Montana Beef Council supports HB 446.

OPPONENTS - None

QUESTIONS FROM THE COMMITTEE

Rep. Cody asked Mr. Graham if we are getting any feedback to Montana from this $1.00 checkoff the Beef Council is collecting. How does that $1.00 work? Mr. Graham stated it is a federal act that 50 cents of that $1.00 must go to the National. The Montana Beef Council had to be certified so that the $1.00 could be collected. The Montana council has traditionally sent 80% of their portion on to the national program. They have been keeping 10 cents in Montana, and that is at their discretion, but they could change. They will be sending about 80 cents.

Rep. Campbell asked Mr. Graham about the states that apply for a refund. Mr. Graham explained section six says that it is a voluntary program, but they must apply within 30 days of sale of the cattle for a refund. Since this will no longer be a state law, there will be no proof of sale required.

Rep. Switzer closed, recommending HB 446 get a DO PASS.

HOUSE BILL 461

Rep. Dick Corne', District 77, Bozeman, said HB 461 would generally revise the laws pertaining to apiary activities by increasing registration fees; providing for inspection fees; and providing for the detection, quarantine, and destruction of diseased or pest honeybees; amends several sections; and provides an effective date.

HB 461 will basically do three things: broaden the scope of the present law so that africanized honeybees will be detected and destroyed; registration fees will be increased; the word "pest" is inserted into the statute.

Africanized honeybees are spreading northward at the rate of 400 miles per year, and they are expected to spread into the southern part of the U.S. by 1988-89. Many American honeybees are wintered in the south and may become africanized if a queen african bee mates with an American honeybee. Africanized bees are defined as being a pest so HB 461 inserts the word pest into the law. The proposed 58% increase in registration and inspection fees will bring an additional $5,000 into the general fund. (See attached Bill Summary)

PROPONENTS

Ron Barnett, Board of Directors of the Montana State Beekeepers Association, supports HB 461. Montana is a major honey producing state. See his testimony, exhibit #1.

Bob Burnes, Montana State Beekeepers, Dillon, MT supports HB 461.

Ray Dawes, Fort Shaw, MT, supports HB 461.

Roy Bjornson, Montana Department of Agriculture, supports HB 461.

There were no opponents.

QUESTIONS FROM THE COMMITTEE

Rep. Bachini asked how africanized bees are going to be controlled when they get here. Mr. Barnett explained how cyanide gas is used to kill the whole hive when there is a positive test that they are africanized bees. They spread so fast because they are a very aggressive bee. When a hive is full of honey, they move to another one. An africanized hive is discovered through their aggressive behavior, and also because they produce an overabundance of honey. Africanized bees are very mean and will attack a human.

Rep. DeMars asked if the honeybees are checked when they are taken to California and again before they are returned to Montana. They are inspected when they are taken into California before they get certification to enter, and they are again inspected before they can be returned to Montana.

The Department of Agriculture is trying to keep the africanized bees from coming into the U.S. They are putting up a neutral barrier using a tremendous number of bee colonies in the hope that the african queen bees will mate with an American honeybee thereby neutralizing their meanness and unacceptable behavior. The beekeepers in the south who raise queen bees are very worried about getting any crosses with african bees. They are setting up standards and are trying to eliminate the african bees before this problem gets very far.

Rep. Bachini asked if that is the reason for the increase in fees. Mr. Bjornson stated that the beekeepers asked for an increase in fees for registry of bee colonies and to provide laboratory services on a cost service basis. They already have a bee laboratory for leaf cutter bees and will use that.

Hobbist beekeepers are not aware of problems that are being encountered by beekeeping businesses such as diseases and africanized bee infiltration possibility.

Since africanized bees are so prolific and aggressive and mean, the beekeepers are afraid landowners will not allow them to put hives on their land if they are afraid the bees will be a hazard. See exhibit #2.

Rep. Corne' closed recommending a DO PASS.

Since both HB 446 and HB 461 require fiscal notes, no executive action was taken.

Duane W. Compton

REPRESENTATIVE DUANE W. COMPTON

DAILY ROLL CALL

AGRICULTURE, LIVESTOCK & IRRIGATION COMMITTEE

50th LEGISLATIVE SESSION -- 1987

Date January 30, 1987

NAME	PRESENT	ABSENT	EXCUSED
Rep. Duane Compton, Chairman	✓		
Rep. Loren Jenkins, Vice Chairman	✓		
Rep. Bob Bachini	✓		
Rep. Bud Campbell	✓		
Rep. Dorothy Cody	✓		
Rep. Richard Corne'	✓		
Rep. Gene DeMars	✓		
Rep. Orval Ellison	✓		
Rep. Leo Giacometto	✓		
Rep. Marian Hanson	✓		
Rep. Harriet Hayne	✓		
Rep. Gay Holliday	✓		
Rep. Vernon Keller	✓		
Rep. Francis Koehnke	✓		
Rep. John Patterson	✓		
Rep. Bing [illegible]	✓		
Rep. Paul [illegible]-Svrcek	✓		

EXHIBIT #1
DATE 1/30/87
HB 446 Rep
Switzer

MONTANA ASSOCIATION OF STATE GRAZING DISTRICTS

420 North California St.

Helena, Montana 59601

(406) 442-3420

HB 446

My name is Kim Enkerud and I am representing the Montana Association of State Grazing Districts, the Montana Cattlewomen, and the Montana Stockgrowers

WE are in favor of this bill due to the National Beef Promotion and Research Act of 1985 being implemented and this money being designated for support and maintenance of research into beef production. When producers are already paying $1.00 per head sold, they should not be required to pay a state fee of another 25¢ on these same cattle.

We urge the committee to vote do pass on HB 446.

Thank you.

EXHIBIT #2
DATE 1/30/87
HB 446 Rep D. Switzer

DEPARTMENT OF LIVESTOCK

TED SCHWINDEN, GOVERNOR

CAPITOL STATION

STATE OF MONTANA

(406) 444-2023

HELENA, MONTANA 59620

Testimony
House Bill 446

The Department of Livestock favors this proposed legislation and are prepared to inact it's provisions.

50th Legislature LC 1452

STATEMENT OF INTENT

H Bill No. 461

A statement of intent is required for this bill because it provides the department of agriculture authority to adopt rules for administration of this act.

It is the intent of the legislature that the department establish rules for the detection of pest honeybees by using the most efficient, scientifically acceptable method of identifying pests.

It is further the intent of the legislature that the department establish by rule a fee structure for laboratory services. The department should set fees to correspond with the costs of providing services. These costs include both direct and indirect costs, plus expenses associated with operation of the laboratory authorized under section 9.

In setting fees, the department may take into consideration the economic difficulties of the apiary industry and may reduce fees as may be necessary to promote increased use of services. The department may provide services at less than cost if alternative funding is available or if the economic conditions of the industry require the reduction of charges.

In addition, it is the intent of the legislature that the department establish by rule an effective method for conducting quarantines to prevent the entry and spread of harmful honeybee pests and diseases, such as Africanized honeybees and honeybee mites. It is contemplated that the department quarantine any apiary where pest honeybees or any contagious or infectious diseases are present and, during the quarantine, prevent the removal from the apiary of any bees or equipment.

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EXHIBIT #1
DATE Jan. 30, 1987
HB 461 - Rep. Corne'

MONTANA'S BEEKEEPING INDUSTRY - BACKGROUND INFORMATION

Montana is a major honey producing state. It generally ranks 10th in the nation for honey production and 1st or 2nd in production per hive. Approximately 10 million pounds of honey are produced annually in Montana with a wholesale value of 7 million dollars. Approximately 110,000 beehives are registered in 5,000 bee yards each year. There are 563 beekeepers registered.

Besides providing a living for 55 commercial beekeepers in Montana, honeybees also pollinate many agricultural crops from cherries around Flathead lake to alfalfa, sanfoin, sunflowers and beans. Even many wildland flowers are pollinated by honeybees.

PURPOSE OF HB 461

The bill primarily does three things:

(1) Broadens the scope of the present law so that Africanized honeybees (erroneously known as "Killer Bees") can be dealt with when they arrive in the U.S. and eventually Montana.

The Africanized honeybee is a much more aggressive subspecies of honeybee than the European strain of honeybees now in Montana and the U.S. Since first being introduced into Brazil in 1956, it has spread north at an average of 400 miles per year. On January 7, 1987, several swarms of Africanized bees were confirmed in southern Mexico. They are expected to spread into southern United States in 1988 or early 1989.

The present honeybee law only controls honeybee diseases. Africanized bees are proposed to be controlled by defining them as being pests and then inserting the word "pest" into the law wherever appropriate.

(2) Increases the honeybee registration and inspection fees.

Considering the present financial situation of state government, the honeybee industry recognizes that it must do more to support it's program. The proposed 58% increase in registration and inspection fees will bring an additional $5,000.00 into the general fund.

(3) Provides a means whereby the department can legally sample, analyze and charge fees for detecting Africanized bees and honeybee tracheal mites, both of which require extensive laboratory resources.

EXHIBIT #2
DATE Jan. 30, 1987
HB 461 - Rep. R. Corné

Posted: Wed Jan 7, 1987 12:11 PM EST Msg: NGIH-2379-6309
From: PPQ.HQ.SERS
To: PPQ.SPRO
Subj: AFRICANIZED HONEY BEE

On December 23, 1986, Government officials in Mexico announced that swarms of africanized honey bees have been confirmed in southern Mexico. The announcement indicated that two swarms of honey bees caught in traps located in Cuidad Hidalgo in Chiapas were confirmed as africanized. No other information is available at this time.

A:\>

Up until two years ago the beekeeping industry was primarily concerned with a bee disease called American Foulbrood. This disease can easily be identified by visually inspecting each hive in the field, without a need for laboratory analysis. The inspection program and fees in the present honeybee law are designed for this type of on the spot inspection.

Unfortunately two years ago a very small internal mite which infests honeybees, called the Honeybee Tracheal Mite, came into the United States via Mexico. This mite invades and blocks the breathing tubes of honeybees causing chronically sick honeybees and a resultant loss of honey production by the hive. The only way to inspect for these mites is to take a sample of bees and have them analyzed in a laboratory. Many states including Montana require a mite inspection before they will allow beehives from another state to move into their state. Since the present law does not provide for this type of laboratory analysis inspection it must be broadened to give the department the authority to provide such services, as well as a means of charging lab fees on a cost-retrieval basis.

It should also be noted that Africanized honeybees cannot be visually distinguished from normal honeybees. The only method of identifying Africanized honeybees is also by taking a sample and analyzing it in a laboratory.

RESOLUTION NO. [illegible]
(FOR NASDA USE ONLY)

SUBJECT OF RESOLUTION State Legislation to Control African Bees

ORIGIN OF RESOLUTION Apiary Inspectors of America

DATE OF ORIGIN January 30, 1986

The African honey bee, Apis mellifera scutellata is currently moving northward through Central America and is expected to make its way into the United States by approximately 1990. This bee is expected to have a negative impact on beekeepers and the public due to its negative attributes. The Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture currently has contingency plans for dealing with incipient infestations of African honey bees that have been used to deal with isolated cases of the bee's presence inthis country. However, it is assumed that once the African honey bee becomes widespread across the U.S. border with Mexico, APHIS will no longer deal with the problem.

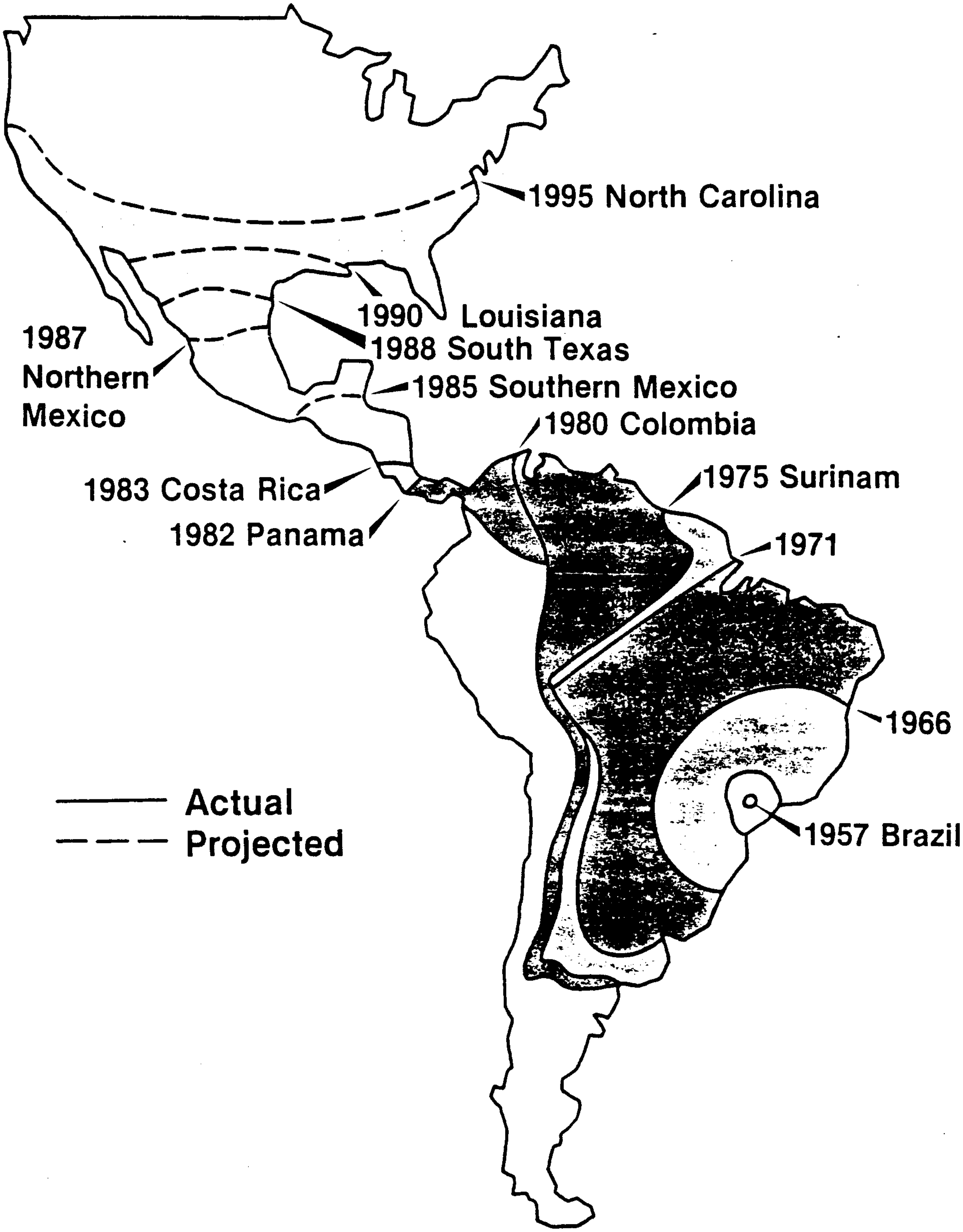
RESOLVED, that the National Association of State Departments of Agriculture, meeting in Chicago, Illinois, on September 17, 1986, urges all states to prepare legislation to enact effective quarantines against the introduction and movement of African honey bees.

ACTION TAKEN BY NASDA STANDING COMMITTEE Passed

ACTION TAKEN BY NASDA RESOLUTION COMMITTEE Passed

ACTION TAKEN BY NASDA Passed

Spread of the Africanized Honey Bee



African Bees: Potential Impact in the United States

There seem to be no guidelines for predicting the various impacts an invading species such as the African bee, *Apis mellifera scutellata*, might have on an indigenous fauna and flora, and on people and human endeavors. Although some consequences can be estimated in these cases, often, important variables such as weather and economics, that will determine the magnitude of the impact, remain unpredictable. Thus, precise statements are likely to be incorrect. Nevertheless, given specific premises, and some basic assumptions, it is possible to bracket the possible outcomes. In the discussion that follows I will emphasize the biological attributes of feral African bees and how these attributes might affect the honeybee industry, agriculture and the public in the United States.

Unless viewed through a microscope, the African and European bee appear similar. A European bee is in the center surrounded by African bees.

Premises

The interpretations given in this article are based on the following premises:

1) African bees will invade the southern United States. 2) African bees will be limited in the United States by climatic factors that are similar to those that limit their distributions in South Africa and Argentina. 3) Attributes of these bees such as stinging, swarming, absconding, low honey production, management problems, hybridization with European stocks and inability to overwinter in the northern states will cause this insect to be unwelcome by beekeepers and the public. 4) An impact model based on the effects of African bees on beekeeping, honey production, agriculture and human health in tropical regions does *not* apply to the United States. 5) African bees in the American tropics are similar to African bees from Africa and are *not* true hybrids. 6) The source of most African bee problems will be its feral population; suppression of this population will be required to protect the public and the beekeeping industry. 7) American beekeepers, at least initially, will maintain only European bees. Justification for many of these premises has appeared elsewhere (Michener 1975, Taylor 1977, Taylor and Spivak 1984) and will be incorporated in the appropriate sections of the discussion that follows. However, one point, (4) tropical America as a model for the impact of African bees, requires separate treatment.

An impact model based on events in tropical South and Central America will not apply to the United States for a number of biological, technological, and economic reasons. In the American tropics, African bees advance into new habitats at rates of 300–500 km per year (Taylor 1977). Feral populations build up rapidly (Otis 1980) and densities of 10–20 or more wild colonies per square mile can be found 2–3 years after the initial colonization (personal observation, Kerr 1971). Hybridization of European bees follows the invasion and apiaries usually become completely Africanized within 2 years unless requeening with European stock is practiced. However, requeening is usually abandoned by beekeepers because of the lack, or expense, of purely-mated European queens and because beekeepers soon come to realize that, in most circumstances, pure European bees are poor producers when in competition with African bees. Therefore, the tropical beekeeper is forced to adapt to African bees. This will not be the case in the United States. In this country, African bees will be approaching their climatic limits and the rate of movement will decrease, as it did in southern Brazil and northern Argentina

Orley R. Taylor, Jr.

(Taylor 1977). Furthermore, most of the subtropical and temperate areas occupied by these bees in the United States will be suboptimal for this tropical biotype: overwintering mortality will be substantial and densities of feral colonies will be lower than in the tropics (Taylor and Spivak 1984). Competition for nectar and pollen resources will be less intense and American beekeepers will find it easier to produce honey and minimize hybridization of their European bees than their tropical American counterparts. The North American beekeeper will also be aided by the availability of queens, technical assistance programs and by programs that are designed to suppress the feral African bee population.

Strong versus weak impact

In order to demonstrate the dimensions of the African bee problem I have chosen to establish strong (worst case) and weak (best case) impact scenarios. Each of these scenarios is based on a set of assumptions concerning the biology of African bees and possible responses by beekeepers, scientists, governments, and the public to an African bee invasion. For the sake of completeness I have included some of the premises mentioned above and in the sidebars in the list of assumptions (Table 1). I will admit at the outset that the strong or "worst case" scenario is a bit of a straw man, however, it is also apparent that the weak case contains an element of Panglossian philosophy. The real outcome will probably be somewhere in between these projections. However, my purpose is to show that the weak case is biologically more realistic and that there is a great deal that can be done to reduce the impact of African bees.

The major assumptions and my evaluation of whether they are most, least or equally likely to come true are listed in Table 1. Several minor predictions and assumptions will be mentioned as each of the major issues is discussed below.

Climatic limits. The conclusion that African bees will invade the southern United States is based on extrapolation from the climatic conditions tolerated by these bees at their southern limits in South Africa and Argentina (Taylor and Spivak 1984). Similar climates occur in the United States and since there appear to be no physical or biological barriers that will confine them to Central America or Mexico, it is possible that African bees will reach the vicinity of Brownsville, Tex. as early as late 1988 (Taylor 1977). The predicted limits of African bees in the United States are based on the premise that organisms will not be able to invade habitats with climates more extreme than those in which they evolved (Janzen 1967). This expectation holds for the majority of invading species and applies in this instance since the southern limit for these bees in Argentina is similar to their climatic limits in South Africa (Taylor 1977, Taylor and Spivak 1984). In the United States it is possible that African bees will become the dominant feral bee in areas with winters in which the mean high temperature for the coldest month exceeds 66°F (19°C) and will overwinter in areas with mean high temperatures for January of 60°F (16°C) or warmer (Taylor and Spivak 1984). This prediction is as good as the data it is based on; new information could indicate that these limits are too generous or too restrictive.

Evolution of greater cold tolerances. The possibility has been raised that African bees will evolve greater tolerances to cold temperatures and thus be able to expand beyond their apparent climatic limits (Anonomyous 1982). However, we have argued elsewhere (Taylor and Spivak 1984) that this may not happen or, at least, is not to be expected soon for the following reasons:

(1) Efficient overwintering in extreme cold for prolonged periods by European bees is a complex adaptation that is not due to one or even a few genes but involves large numbers of attributes such as metabolic rates, heat conservation efficiency, hoarding behavior, nest site selection, nest construction, longevity, etc. African bees differ from European bees in all these characteristics and many more (e.g. Núñez 1982, Rinderer et al. 1982, 1984, Seeley and Morse 1976, Seeley 1978, Winston 1980, Winston et al. 1979, 1981, 1983).

(2) The appearance of a more cold tolerant African phenotype is likely to be a slow process. To acquire a complex of European traits, hybridization must occur, yet, the African bees must mate predominantly with themselves. Even if selection strongly favors hybrids with European traits for overwintering, because these

Table 1. Assumptions for the scenarios of the impact of African bees in the United States.

Strong impact	Weak impact
1. Climatic limits have been underestimated (E)	Climatic limits have been overestimated
2. African bees will evolve greater cold tolerance (L)	African bees will be unable to spread beyond their predicted limits
3. Gene flow will extend African bee problems beyond their natural limits (L)	Gene flow will not result in acquisition of African traits by European bees
4. Population density of feral African bees will be high (L)	Populations will be low
5. African bee populations will build up rapidly in spring (L)	Build up will be delayed relative to European bees due to cold weather
6. Overwintering populations will have a high density and summer distribution will extend 450 km beyond overwintering limit (L)	Few colonies survive winter and summer distribution extends <225 km beyond natural limit
7. African bees will reach their climatic limits in <5 years after reaching the United States (L)	Attainment of climatic limits will take 10 years or longer
8. No effective suppression or delay (M)	Partial suppression and delayed spread
9. No effective program in Mexico (M)	Partial "Europeanization" of African bees in Mexico
10. Public and legislative reaction will be severe (M)	Public reaction will be low or moderate
11. Extensive Africanization of apiaries will occur (L)	Requeening will minimize Africanization of apiaries
12. Existing technology will not be effective in preventing incorporation of African characteristics into breeding stocks (E)	Use of instrumental insemination, closed breeding systems will eliminate infusion of African traits into breeding stocks
13. Regulation of interstate shipments will not be effective in controlling spread of African bees (E)	Effective regulation of interstate traffic will minimize spread of African bees
14. Funding for regulation and research will not be adequate (M)	Funding will be adequate to support regulation and a diverse array of research programs
15. Queen rearing and package industry will not adjust (L)	Increased production in non-African areas will offset losses
16. Research will not produce solutions to African bee problems (E)	Research will be important in developing ways of suppressing African bees

Expectations: M, most likely; L, least likely; E, equal.

African Bee Origin

There is some confusion concerning the origin and present status of the African bee of South America. Much of the literature refers to "Africanized bees" and makes reference to their origin from hybrids formed with European bees shortly after they became established in Brazil in 1957 (Kerr 1967).

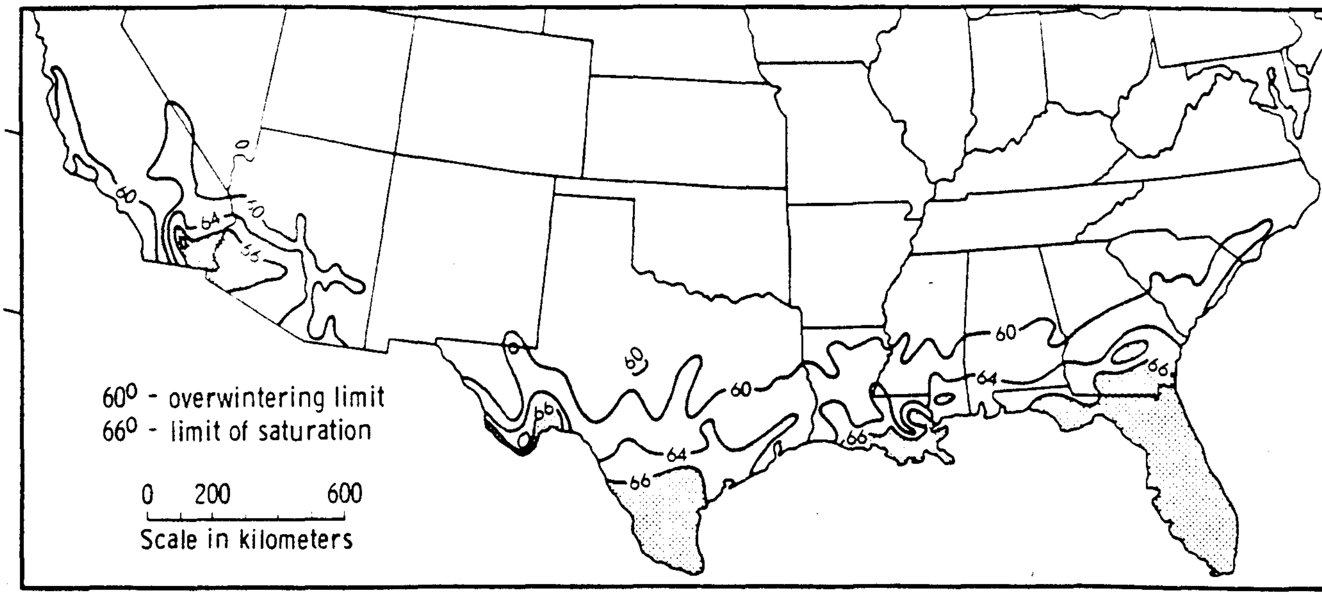
In my view, it is uncertain whether these bees had a true hybrid origin or arose from the establishment of a feral population that mated sufficiently with itself to retain the original African phenotype. In honeybees, multiple mating by queens is the rule, and a hybrid origin seems to require (a) that daughter queens from the original 26 escaped African swarms (Kerr 1967) mated extensively with European drones, (b) that African drones mated with some virgin European queens, and (c) that daughters of these queens subsequently mated predominantly (>50%) with African drones. An origin involving breeding among offspring of the original African queens requires that dispersal of the 26 escaped swarms was such that a large proportion established nests within 3 km of each other. At greater distances the chances that virgin African queens would mate with African drones would be greatly reduced due to dilution if European drones were also in the area (Taylor, Kingsolver and Otis, 1985). Both of these scenarios are unsatisfactory, the first because it's difficult to explain the predominance of African drones in backcrosses when European drones were presumably abundant (Nunamaker, Wilson, and Haley 1984) and the second because the dispersal tendencies of African swarms are so strong (Taylor 1977, Otis et al. 1981) that the probability of more than a few of 26 dispersing swarms nesting close (<3 km) to each other is remote. A third possibility, that of selection favoring the most African among the various hybrid crosses, also appears to be inadequate because of the small number of generations (2–4) per year and the rapid spread (an area 500 km in diam. from 1957–1963) of the African phenotype (Kerr 1967). For selection to have given rise to a feral African-like phenotype so rapidly, the differences in relative fitness of feral colonies with >50% of the African genotype would have to have been substantially greater than F_1 crosses and those with a predominance of European traits. Although there appear to be significant differences between F_1 colonies and European stocks in characters that influence fitness, such as swarming frequency, differences in fitness characters between "pure" African and F_1 crosses are not obvious.

Even though it is not clear whether African × African matings or hybridization led to the formation of the feral African population, it seems probable that African drones predominated in the crosses as early as the second generation. Nogueira-Neto (1964) appears to be the first to have recognized that African drones predominate in matings. How might this occur? In Venezuela comparisons of mating flights by queens and drones of both races indicate partial reproductive isolation (see also Kerr and Bueno 1970) by time of mating (Taylor et al. in press). This temporal separation of mating flights, combined with the patchy distribution of apiaries with European bees, assures that the majority of feral African queens mate predominantly with African drones. Although the flight times of F_1 queens have not been established, flight times similar to those of African queens would result in substantial backcrossing to African drones. Because of the separation in mating times, a portion of the feral population can mate and remain relatively pure in the presence of European bees (Taylor et al. in press). This appears to explain why low numbers of African colonies are able to maintain their phenotype while invading new areas containing large numbers of European bee colonies. These dynamics also appear to be a factor in the predominance of African drones in F_1 crosses. As the density of the feral African population increases, virgin European queens mate with increasing numbers of African drones—in spite of the presence of large numbers of European drones and the absence of African colonies within the apiaries. The explanation for this mating advantage appears to be that honey bee queens fly further on mating flights than drones from their own colonies. Under normal circumstances these flight differences result in outbreeding but for virgin European queens in an area with African bees it means that they will encounter increasing numbers of African drones (Taylor et al. in press).

Because the mating dynamics appear to favor continuous backcrossing to African drones, "African" rather than "Africanized" bees seems to be a more appropriate descriptor of the feral bees in Central America and northern South America. This terms also seems preferable because feral bees located in regions without European bees (e.g., French Guiana) have no identifiable European characteristics. Behaviorally, morphologically and biochemically these bees have not been shown to be different from African bees from Africa in ways that could be attributed to hybridization. In addition, a temporary increase of hybrid feral bees, which appear to originate primarily from swarms issuing from managed colonies, is only evident 6–18 months *after* the invasion (personal observation, Roubik, personal communication). During the following 2–3 years feral hybrids decline and European traits disappear as genetic dilution by the larger and more mobile feral population proceeds. The bees at the front of the invasion, up to 300 kilometers in advance of the hybridization, appear to remain relatively pure.

Although selection may play a role in eliminating that portion of the feral population which is less fit by virtue of having disadvantageous European traits, it appears that the predominant force that eliminates European characteristics is genetic dilution. In most South and Central American countries, managed European bees number in the tens of thousands and these numbers are easily overwhelmed by the larger, and more dynamic feral populations. As an example, in 1976, before Africanization began, Venezuela had 30–40,000 colonies of European bees; now, except for recent requeenings, these bees are Africanized, and there are probably 1–2 million feral colonies in the Venezuelan countryside. With such high densities of African bees, unless selection strongly favors certain European traits, which does not appear to be the case, the feral population will retain few, if any, hybrid characteristics.

It is apparent that we are not dealing merely with the spread of undesirable traits via gene flow from apiary to apiary, but with a large, mobile and rapidly reproducing feral population that has the effect of overwhelming all domestic beekeeping in areas with tropical climates. ■



Prospective limits of feral African honeybees in the United States. The 60°F (16°C) and 66°F (19°C) isotherms represent the mean high temperatures for January (from Taylor and Spivak 1984).

traits are likely to be polygenic or involve coadapted gene complexes, new adaptive peaks will be reached infrequently and will probably not persist because the mating system of honeybees is one of outbreeding and multiple paternity.

(3) There is no evidence as yet that African bees are increasing their ability to overwinter further south in Argentina.

(4) There are only a few cases where invading species have expanded beyond their original climatic limits and in each case expansions occurred many years after the initial limits had been reached (Powell, 1983).

Gene Flow. Once African bees reach their climatic limits there will be a broad northern zone dominated by European bees, relatively small southern areas where the majority of the feral bees are African and a broad (300–600 km) zone of overlap. Hybridization wherever both races occur, but particularly in the overlap zone, could lead to introgression of African traits into feral and managed European bee populations and of European traits into the feral African population. In the former case, the prospect is that African traits will be acquired by feral and managed European bees well beyond the zone of overlap. Although this might occur, such gene flow or introgression should not be a serious problem because: 1) At present, there is no evidence from Argentina that African traits are being acquired by European bee populations further to the south; and 2) among feral bees in regions north of, and perhaps within, the overlap zone, selection for ability to overwinter should favor pure European crosses. Hybrid colonies would be less fit. There could be two consequences of this: 1) depression of the feral European bee population in areas where hybridization is common, and 2) creation of a steep cline along which there are few hybrid colonies outside the overlap zone. Under these conditions gene flow of African traits into the feral European population would be slow and would be limited to characteristics that are independent of traits responsible for overwintering success. Our knowledge of the genetics of honeybees is too scant to predict which, if any, traits might introgress into feral European populations, particularly across a steep selection gradient.

If, on the other hand, introgression is extensive, we must consider the consequences of hybridization between feral European drones with some African traits and queens originating from managed bee populations. If introgression involved such African traits as extreme sensitivity to disturbance, absconding, and excessive swarming and these traits appeared in European stocks, they would be quickly recognized and strongly selected against by commercial beekeepers. Serious problems could develop, however, if pure European queens were unknowingly mated with drones carrying such characteristics and were subsequently used as breeders whose daughter queens were shipped to numerous amateur beekeepers. Maintenance of pure European stocks will be a complicated task and testing of breeder progeny would be essential if introgression of African traits into the feral European population becomes extensive.

Nevertheless, if pure stocks are maintained by instrumental insemination and closed breeding systems (Page and Laidlaw 1982b) then annual or biannual requeening of colonies with purely mated European queens should be effective in minimizing the impact of African traits into managed beekeeping operations.

Invasion routes, initial and ultimate densities. The two most important points of entry of African bees into the United States will be in the Brownsville–McAllen area of Texas (1988–1989) and about 2 years later in south central and western Arizona near Nogales and the Colorado River respectively. African bees will also enter New Mexico during the warmer months and California from Baja California. The initial invasion will be by a small number of swarms which may go unnoticed for several months. Undetected colonies will produce additional swarms which will move to new locations thus expanding the range. In Texas, because of the warmer climate along the coast, the distribution should expand more rapidly eastward than to the north and west. Central Arizona, as far north as Phoenix, and western Arizona will be colonized rapidly. Even though African bees may enter California from Baja, they will probably move into the Imperial Valley first and then into the coastal areas. Although the initial densities of African bees will be low, there are three regions, south central Texas, the vicinity of New Orleans, all of Florida, and part of southeastern Georgia, where the climatic conditions and the availability of pollen, nectar and nesting sites might allow them to reach high densities. These areas are bounded by mean high temperatures of 66°F in January, which appear to define the limits of high density feral populations in Argentina and Uruguay (Taylor and Spivak 1984). Between the 66°F and 60°F lines, Kerr et al. (1982) found lower densities of African bees in Argentina.

Swarm of African bees in French Guinea.

It is evident that African and European bees continue to co-exist in this region in spite of the fact that African bees have been present for at least 14 years. This is the only region invaded by African bees in the Americas where European bees have not been eliminated by hybridization and competition. There are several implications of this fact, the most important of which is that the densities of African bees will be relatively low in most of the area they will occupy in the United States. Low densities should translate into a reduced impact.

Seasonal dynamics and spring build-up. The population dynamics of the feral African population will be critical to their impact on beekeeping and particularly queen rearing in the southern states. In Argentina low densities between 60°F and 66°F isotherms may be due to a variety of factors such as low survival of overwintering colonies, absconding and migration of a large portion of the population to warmer areas prior to winter, slow recolonization and slow build up under relatively cool spring conditions (Taylor and Spivak 1984). Because feral colonies build small nests and store relatively little honey, starvation during the winter months or absconding followed by starvation of absconded swarms probably contributes significantly to overwintering mortality. If these conditions develop in the United States, densities of surviving feral colonies in the early spring could be quite low, especially in areas close to the climatic limit. How low the density becomes, coupled with the rate of spring build-up, will determine the densities of wild colonies at the time queen and package bees are produced. Low densities might not be significant if queen breeders learn to saturate breeding areas with much larger numbers of European colonies and therefore drones. Initial densities of two or more feral colonies per square mile could lead to significant levels of hybridization during the queen breeding season. Although I anticipate that overwintering African bee populations will be low (<0.5 colonies per square mile) in most areas between the 60°F and 66°F winter isotherms, and the rate of spring build-up to be slow, these dynamics could be upset if large numbers of swarms migrate into this zone from areas with warmer climates.

Summer distribution. During each spring and summer the distribution of the feral African population will expand beyond the overwintering limit through long distance movement by swarms. The range of this expansion and the number of African swarms involved will be determined by a number of factors, such as swarm to swarm intervals, number of swarms per swarming cycle (Otis 1980), density of the source population, density independent mortality (Otis 1982), and physical factors that might lead to strongly directional swarm movement. The movement of African bees in the Americas is consistent with a number of diffusion models (e.g. Okubo 1980) that have been used to describe movements of animal populations. The principal variables that define the rate of movement are reproductive rate and density. In South America, African bee populations generally spread rapidly in the favorable conditions of the dry season when reproduction and colony numbers are high and more slowly during the less favorable wet season. It follows that in the United States range expansion will be determined by the density of the overwintering population and the spring and early summer weather and floral conditions that determine swarming rates. Low overwintering numbers will result in a reduced summer spread.

The maximum range expansion can be estimated in two ways: by working with hypothetical reproductive rates and by extrapolating from movement rates in the tropics. My predictions are based on observations in the tropics that are consistent with historical trends. During the favorable dry season conditions several observers in South America have noted that the African population advanced approximately 45 km per month. If we assume that 45 km per month could be sustained from mid-March through mid-August in the United States, African bees would expand their overwintering population by only 225 km.

This interpretation assumes that there are no biological or physical factors that would give strong directionality to swarm movements. If such factors exist, African bees could advance much further than 225 km through some corridors.

The key to the outcome of this prediction is the density of the overwintering population. If it is low, it is unlikely that African bees will attain a substantial expansion in the summer or have a significant impact if they do so.

Rate of spread. The capacity of the honeybee industry to respond to changes necessitated by African bees, and indeed the reaction by the public, will be determined in part by the rate of spread of African bees in the United States. If African bees spread rapidly and reach their climatic limits within 5–6 years of reaching Brownsville, their impact will be far more significant than if their population advances more slowly. As I have mentioned, rate of spread is a function of climate, reproductive rate and density. The most favorable climates and conditions for reproduction should occur along the Gulf Coast and we might expect African bees to advance rapidly through this region. Although I cannot predict the exact rate, it seems probable that it will be <375 km per year. Rates of movement to the north of the immediate coast will be much slower. In South America the rate of spread of African bees declined to 225 km and then to <120 km per year as they approached their climatic limits (Taylor 1977). In the United States this means that it could take 1–5 years for African bees to expand northward to their overwintering limit from any point reached on the Gulf Coast.

If we assume a mean rate of spread of 375 km along the coast and an average of 3 years to expand to the overwintering limit, it would require a minimum of 8 years for African bees to colonize the area from Texas to North Carolina. This prediction assumes there will be favorable conditons each year and that man's activities will have no impact on reducing the density of the feral population. Because both of these are unrealistic assumptions, it will probably take much longer than 8 years for African bees to colonize the southeastern United States.

Control measures

Presence of feral African bees in the United States will stimulate efforts to eradicate, contain, suppress, and delay their spread (Gary 1971, Stibick 1985). As mentioned above, the impact of African bees will depend, in part, on the success of these efforts. Historically, the prospects for success are not promising. With the exception of Trinidad, no government in South or Central America has developed an effective program to suppress the feral African bee population. In Trinidad, the rate of invasion of African bees across the Golfo de Paria was low and a program was initiated to locate and destroy all feral swarms and colonies. It appears that this program was successful in delaying establishment of a large feral population and consequently the Africanization of the country's apiaries (Hallim, personal communication). The earliest known colonization occurred there in April 1979, but it wasn't until 4.5 years later (early 1984) that Africanization of apiaries was widespread (Barrow, personal communication). On the adjacent Venezuela mainland the interval from first colonization to substantial Africanization ranged from 1.5 to 2.5 years. Localized suppression of feral bees is practiced by fire department and agricultural personnel in a number of South and Central American cities. These programs, combined with attempts to educate people not to provoke African bees, have been successful in reducing the number of stinging incidents. Because the feral bee population competes with managed bees for pollen and nectar, some commercial beekeepers in Brazil used poison baits to attract and eliminate feral colonies before moving their own bees into an area (Michener, personal communication). This practice, however, is not common and its degree of success has not been evaluated. In spite of these limited achievements, there are several reasons to believe that programs to suppress African bees will be much more successful in the United States. Two advantageous factors will be, relatively low rates of invasion from Mexico and decreasing survivorship through the winter paralleling the decline in mean high temperatures toward the northern limit. As indicated earlier, there will be two primary points of entry of African bees into the United States, the vicinities of Brownsville, Tex. and west of Nogales, Ariz. Concentrated suppression efforts in these areas at the inception of the invasion, could slow the spread of African bees and could provide the time and experience needed to develop a number of alternative approaches.

Because feral honeybees usually nest in cavities and have low population densities relative to those of other pest species, and

Impact of African bees on Mexican beekeeping and the potential for "Europeanization"

The response of beekeepers and the government of Mexico to the African bee problem will partly determine the impact of these bees in the United States. A strong effort to reduce the impact of African bees on beekeeping in Mexico could result in a reduction of the rate of spread and considerable Europeanization of the feral African population. A weak program would lead to a sharp decline in Mexican beekeeping (Winston 1979) and the likelihood would increase that African bees will arrive in the United States unchanged.

Mexico is one of the leading honey producing countries (Patty 1978) and is second only to China on the world market. If no effective program is developed to minimize the impact of African bees on Mexican beekeeping, export revenues could decline by 20–30 million dollars per year. Because a large proportion of Mexico's 46,000 beekeepers earn >60% of their income from honey production (Zozaya, personal communication), the economic and social costs of African bees will be very high.

Nearly every government in the path of the African bee has adopted an African bee program to meet the threat posed by these bees. With the exception of Trinidad, these efforts have been totally ineffective in dealing with the feral bee population or in improving beekeeping. The prospects that Mexico will fund a meaningful African bee program are diminishing rapidly. African bees are likely to invade the Tapachula area in Chiapas by the end of 1985 or by mid 1986 and unless a program, including facilities and staff, is in place at this time, the chance of effectively dealing with the African bee will be lost.

Even if efforts are made to suppress the feral African bee population in Mexico, these are not as likely to be as successful as in the United States because of more suitable climates and the likely higher densities of feral bees there. More promising and useful approaches include the development of selected European strains, which when mating to African drones, produce high yielding and manageable F_1 hybrids. If such European stocks possess characteristics for later mating flights, the prospects for increasing genetic dilution and Europeanization of the feral population would be enhanced. Perhaps the most realistic long-term solution for Mexico is the selection and production of an improved African bee stock. Improved management of hybrid and African bees is also needed. Each of these options, and several others require long-term research efforts. Unfortunately, there is no research institution and no professional personnel specializing in honeybee research in Mexico. Therefore, the possibility that a significant program will develop is low.

The public, possibly because of newspaper accounts, seems to believe that the African bee has been modified by mating with European bees or that this will happen as African bees advance through Mexico. Even though there are 2.6 million managed bee colonies in Mexico (Zozaya, personal communication), hybridization with African bees will result in only a temporary increase in European characteristics among the feral bees. As with Venezuela, the feral population will soon exceed the managed population in size and, because there are large areas of Mexico that are suitable for African bees with few or no European bees, there will be reservoirs of undiluted feral bees that will continually move into the beekeeping areas. As the rate of requeening managed colonies with European queens declines, the source of European genes will decrease and the populations—both managed and feral—will return to the "pure" African phenotype. The only way of reversing or stalling this process would be with a program designed to sustain European stock in managed apiaries by requeening with European queens on a continuous basis. Without a major research program to produce stocks and breeder queens this is not likely to be attempted except by a few of the country's larger commercial beekeepers.

The probability that African bees will arrive in Brownsville, Texas unchanged seems high. ■

African bee colony just starting comb building in a swarm.

because managed honeybees would be affected, widespread aerial application of pesticides seems to be precluded. Rather, a combination of techniques specific for feral honeybees seem more appropriate. Poison baits, perhaps employing pheromones, other known honeybee attractants and compounds with low vertebrate toxicity, could be developed and deployed in invaded regions that contain no managed colonies. Swarm boxes or, more properly, bait hives, could be positioned in the areas where swarms are likely to invade (Gary 1971). Attractant odors (beeswax and resins) and pheromones might be used to increase the attractiveness of these boxes to swarms (Lesher and Morse 1983, Free et al. 1984) and toxins (Laidlaw 1984), perhaps released as the bees chew on a scented bait, could be used to kill the swarm. Less complex and more certain would be monthly inspections of all swarm boxes. Unwanted occupants, (e.g., wasps, birds) could be removed and all bee colonies could be killed. In agricultural regions, where most of the nesting cavities are likely to be found in hedgerows or in buildings, trash, culverts, bridges et t should be possible to search out and destroy a large proportion of the feral colonies. This type of program is proving to be quite effective in the Canal Zone (Boreham and Roubik, personal communication). Such systematic searches, combined with an education program designed to encourage the public to report all wild colonies, could be effective in increasing the proportion of feral colonies that are discovered and destroyed.

The most promising approach might be through genetic manipulation by increasing the probability that feral African queens mate with European drones, thus genetically diluting the feral population. At present, such dilution is not occurring, in part, because of the daily difference in flight times of African queens and European drones. In our laboratory we are attempting to develop a line of European drones that will fly later in the afternoon. Such late flying drones should increase the likelihood of mating with the later flying African queens. We have been encouraged to pursue this option because computer simulations of drone and queen flight distances indicate that by strategically positioning and managing European colonies, invasions of up to four African colonies per square mile would be swamped out because European drones would predominate in all matings (F_1, F_2 and backcrosses) (Taylor and Kingsolver, unpublished data). Such low density African populations would therefore become "Europeanized." Continuous conversion of the invading African bees to hybrids with increasing proportions of European genes could result in a substantial reduction in the rate of spread of the feral population and diminishing of objectionable African characteristics.

Simultaneously with these measures to suppress African bees, it will be necessary to requeen annually, or as needed, all managed colonies in the affected area with purely mated European queens. This practice will not only protect the interests of the beekeepers but will assure that managed colonies do not become a major source of hybrid swarms.

Public and legislative reaction to African bees

The perception that African bees are or could be a public health problem could lead to some severe reactions on the part of the public, and various law-making bodies. In contrast to Latin American countries, the United States is more a country of laws, restrictive legislation, lawyers and legal suits. A few chance stinging incidents by feral bees could create a blizzard of proposals to restrict beekeeping. Beekeepers could be faced with nuisance suits, increased liability insurance, legal fees, loss of apiary sites, and numerous restrictions on where and how bees can be kept. Some of these problems have plagued beekeepers in South America (Michener 1975). In the United States an overreaction by the public and lawmakers could be avoided with some forethought and aggressive propaganda by the beekeeping industry.

In parts of South America the public has been educated to avoid African bees and to accept them. As each new area is invaded, encounters between people and African bees seems to fit a pattern which has a relatively short time course. Initially the invasion involves few swarms and bees may go undetected for as much as a year. Toward the end of the first, and especially during the second year, the feral population grows rapidly and the encounter rate with people increases sharply. Both the bee population and the number of incidents, nearly all of which involve feral colonies, increase through the third year and sometimes the fourth. However, beginning in the fourth or fifth year, the number of incidents declines to a relatively low level. The reasons for the pulse of incidents which follows the invading front are not known but a substantial part of the decline might be due to an increasing awareness that African bees are sometimes dangerous and should not be disturbed. It may also be that the feral African population declines. This is suggested from the records of swarms and colonies killed by fire departments in South American cities and by the observations of numerous beekeepers.

Recognition of this time course and that most incidents are caused by feral bees could provide the basis for a strategy by the honeybee industry to avoid overreaction by the public and the legislators. It seems desirable to do some of the following: 1) inform the public of the potential dangers of African bees; 2) provide assurance that the number of stinging incidents will decline over time; 3) demonstrate that beekeepers are managing European and not African bees and that it is the feral and not the manged bee that is sometimes dangerous; and 4) clearly establish that bees are a national and local asset and that unnecessary restrictions will not protect the public and will result in decreased production of honey and bee-pollinated crops.

Africanization

A threat posed by feral African bees is the "Africanization" of managed apiaries. There are two primary means by which "Africanization" occurs: 1) through matings of virgin European queens with feral African drones; and 2) through the "take-overs" of European colonies that lack mated and laying queens by small swarms of African bees. In the lowlands of South America, where beekeepers have traditionally relied on natural requeening through supercedure, apiaries are usually thoroughly Africanized within 18–24 months after African bees move into an area.

The "take-over" of existing European colonies by African swarms leads to even more rapid Africanization than hybridization. In normal beekeeping practices take-overs are subtle and are often indistinguishable from hybridization. As a result, the importance of this phenomenon is not well understood. However, during periods of extensive swarming, beekeepers have reported high incidences of take-overs in queen rearing operations (Vogel, personal communication).

Because the rates of hybridization and take-over are probably a function of the density of the feral population, it follows that the primary control of Africanization will involve suppression of wild populations. Secondary control will involve programs, and perhaps regulations, to assure that all beekeepers requeen annually or as needed with marked and clipped European queens, produced and mated in areas outside the zone of Africanization. Such regulations would serve to protect beekeepers and the industry, safeguard the public, and to keep apiaries from becoming a source of African (or F_1) swarms or drones.

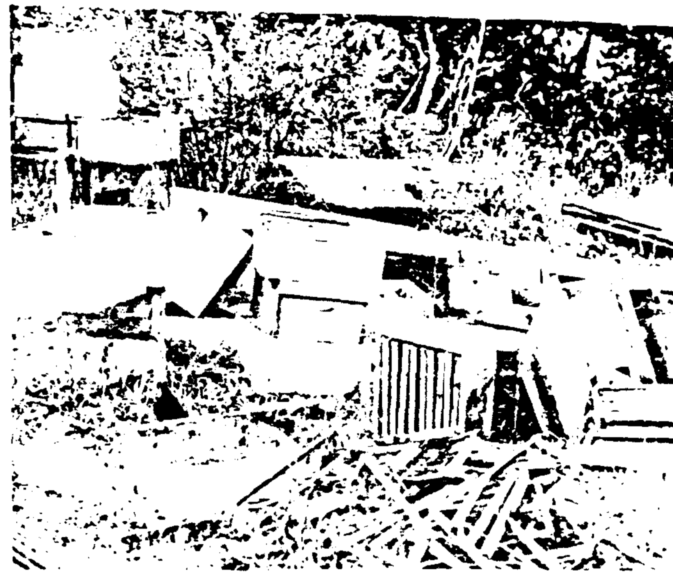
Maintenance of pure breeding stock. Because protection of the industry and the public will involve maintenance of African-free apiaries through requeening, it will be necessary to maintain pure breeding stocks of European bees. Given the potential for shipments of undetected hybrids or African bees throughout the country and hybridization with European stocks that might follow, how could we assure the purity of European stocks? The answer is that with few exceptions, this probably cannot be done. Thus far, all the traits that differentiate these races are quantitative and although it is possible to develop probability statements based on morphological (Daly and Balling 1978, Daly et al. 1982), electrophoretic (Nunamaker and Wilson 1981, Sylvester 1982), or cuticular hydrocarbon (Carlson and Bolten 1984) measurements that given individuals (and colonies) are African or European, it does not appear possible to differentiate phenotypes that are 75% European (e.g. offspring from an F_1 queen backcrossed to European drones) from those that are 100% European. Although future developments may provide improvements in our ability to estimate the "purity" of a line, it appears likely that we will still be left with probability statements that contain an undesirable amount of uncertainty (see also Page and Erickson 1985). As a result "pure" stocks will have to be derived from European bee populations completely isolated from the influence of African bees or from stocks maintained by instrumental insemination. Fortunately, instrumental insemination, particularly when used in conjunction with the closed mating system developed by Page and Laidlaw (1982a, b), provides a means of complete control of the maternal and paternal genotypes used in each cross and the maintenance of highly diverse yet genetically uncontaminated stocks. Pure breeder queens could be produced by instrumental insemination from such stocks and could be disseminated to queen breeders. Unfortunately, instrumental insemination is not perfected (e.g., Harbo and Szabo 1984) to the extent that is could be used to supply the 2–3 million queens that are needed annually in the United States and Canada and therefore virgin queens raised from the breeders would still have to be naturally mated. This reintroduces uncertainty of the pruity of the crosses unless there is complete control of the drones that mate with the queen. Thus, it appears that although it should be possible to maintain pure European stocks, large scale production of purely mated queens within the continental United States remains in some doubt. A partial solution to this problem may lie in developing the means of saturating all congregation areas within 3 km of the breeding stations with drones of a desired genotype. Such a procedure, in combination with a program to remove or eliminate all other bee stocks or wild colonies from the area, should assure that queens mate predominantly, if not exclusively, with European drones (Taylor et al. in press).

Regulation of shipments and inspection services. Because it will not be possible to distinguish pure European bees from those that are up to 25% African, the arrival of African bees could lead to dissemination of African genes throughout the United States and Canada. The obvious reaction to this possibility will be to create quarantines and embargos on the shipments of *all* bees from affected areas. The question that remains is whether such restrictions will be successful. Generous funding at both the federal and state levels would be needed to enforce these programs but even if funds and personnel are available the embargos are likely to be "leaky" unless there is complete cooperation by the industry and the individual beekeepers.

Funding of research. The USDA has sponsored research on African bees since 1974. Although this research has been very productive, its extent and diversity has been limited. Much of the effort to date has focused on basic rather than applied biology, and it is my opinion that a substantial increase in funding both within and outside the USDA and a shift in emphasis to applied research is desperately needed. Given the pace of research the current levels of funding will not be sufficient to provide the solutions that will be demanded by the public as African bees approach our border by the end of this decade. Crisis management of the African bee problem has failed in Latin America and is likely to be costly, inefficient, and ineffective in the United States as well.

Adjustments in the honeybee industry. Although many aspects of the honeybee industry could be negatively affected by African bees, the greatest concern is the impact on the production of queens and package bees throughout the Gulf States, Georgia, the Carolinas, Arizona, and California. The vast majority of the queen breeding enterprises lie within the prospective overwintering zone for African bees. At present the honeybee industry in the United States and Canada (Winston 1983) is highly dependent on the spring production of queens and packages in these regions. Management is geared to requeening and the replacement of winter killed or depopulated colonies with package bees in the spring. Failure of programs to suppress African bees, rapid spread of these bees throughout the South, and rapid spring build-up of the feral African population could lead to a succession of regulations eliminating shipment of *all* bees from zones of Africanization. This would be a severe blow, not only to the queen and package producer, but to the industry which has evolved a need for spring queens and bees.

As I alluded to earlier, there is some hope for queen and package producers lying between the zone of saturation (66°F) and the overwintering limit (60°F), if suppression is effective and spring build-up of the African population is very slow. However, there could still be a decline in the availability of queens and packages. The issue is how rapid and severe this decline will be. The rate of the decline will be determined by the rate of colonization of the southern states. If the spread of the African bees toward the Atlantic coast is slow, queen and package producers in advance of the front and in Hawaii and northern California would probably increase production sufficiently to offset the losses occurring in Africanized areas. Further, if the economic incentives exist, queen rearing operations could be developed more extensively in Puerto Rico, Hawaii, and in northern California. It might also be possible to shift queen rearing to more northerly states if beekeepers can revamp their management programs to incorporate fall rather than spring requeening. Alternatives are available for the production of the equivalent of package bees in the northern states and Canada (Winston 1983) such as summer and fall divisions that are over-wintered indoors, and intensive management to increase the number and growth rate of spring divisions. Selection of bees for more efficient use of stores and higher overwintering survival (Szabo, personal communication), combined with better management, could substantially reduce the demand for packages and nucleus colonies. Indoor overwintering as practiced by some beekeepers in the United States and many in Canada (McCutcheon 1984) could be a valuable alternative to northern beekeepers and may be a realistic solution for the migratory beekeeper who will be excluded from overwintering in areas occupied by African bees. Overall, the industry appears to have the capacity to adjust to a slow change in the availability of queens and package bees.



Abandoned apiary in Costa Rica. Two years after infestation only 20 of 75 colonies still had bees.

Conclusions

It should be apparent from this discussion that whether African bees will have a strong or a weak impact on beekeeping and agriculture depends on: 1) certain key assumptions concerning the dynamics of the invasion and the biology of the bees at their climatic limits; and 2) the collective responses by federal and state agencies, local governments, the public and beekeepers to the presence of African bees.

A review of the 16 assumptions in Table 1 shows that the first seven describe potential biological attributes of feral African bees. My assessment of these possibilities is that the strong alternative is less likely than the weak alternative in six of the seven cases. Only in the case of climatic limits have I given equal weight to the two possible outcomes. Nevertheless, given that the current predictions for the United States are consistent with climatic limits of African bees in South Africa and Argentina, it seems unlikely that these limits are substantially over or underestimated. If I am correct in these evaluations, the African bee invasion will be manageable. However, to make this a tractable problem, steps must be taken to assure that each of the assumptions in the weak scenario that depend on human responses (8–16) become the most likely outcome. Managing this invasion and reducing the impact of African bees is not an impossible task.

Nevertheless, even under the best circumstances, numerous serious consequences are certain to develop. The majority of the queen and package bee producers in the zone of Africanization will be strongly affected and many will be forced out of business. Migratory beekeeping, as we know it, will cease until an acceptable African or African-European hybrid stock is developed. Beekeeping and honey production will decline in the African zone. Many beekeepers, particularly the inefficient or the fearful, will drop out of beekeeping. Honey production will decline as a result of reductions in the number of managed bees but will also decline because of reduced yields due to competition of managed bees with the feral African population. McDowell (1985) estimated that the losses to the honeybee industry and agriculture, due to such affects, could range from 26–58 million dollars per year.

The possible effects of African bees on the production of bee pollinated crops is less certain than their effects on beekeeping. The impact of African bees on crop production will be indirect and the magnitude of this impact is more likely to be determined by the economic health of the industry than the biology of the African bee. As I have pointed out, after African bees invade the United States, beekeepers will continue to manage European bees for pollination and honey production. Therefore, whether African or European bees are better pollinators will be less important than whether African bees interfere significantly with the nationwide availability of queens and packages of European bees that can be used for pollination and honey production. Although the industry has the capacity to adjust to a slow decline in the production of queens and packages, whether it will do so will depend on economic conditions. At present there are a number of unfavorable economic factors which, in concert with African bees (or even independently), could depress the honeybee industry. Such a depression could lead to a number of disincentives to compensate for lost queen and package production in the South and the result could be significant reductions in the availability of bees for pollination. Although an increase in pollination fees would follow this decline, there would still be a deficiency in pollination leading to decreased crop yields and increasing costs of production. The economic factors to which I refer are the inability of the American honey producer to compete on the world market, the lack of significant tariffs or quotas on relatively cheap imported honey, the potential loss of the current Commodity Credit Corporation loans on honey, and the rapid spread of the honey bee tracheal mite with associated increased costs of production. The level of the wholesale (or support) price of honey determines the health of the industry and it seems clear that a sharp increase in the cost of production and/or the loss of support pricing will of themselves lead to a significant decline in commercial beekeeping. It follows from this that the wholesale price of honey, or more correctly, the profit margin in beekeeping, will determine the availability of bees for pollination and thus, in part, the retail value of bee-pollinated crops. The impact of African bees on agriculture will therefore be largely determined by the economic health of the industry at the time this problem develops. If the economic incentives exist for increasing the production of queens and package bees, the impact will be minimal. However, if combined with several economic disincentives their impact will be substantial.

Up to this point I have concentrated on the relatively short-term (10–15 yr) consequences of an African bee invasion. It is also important to consider the long-term prospects. There is considerable evidence that beekeeping in southern Brazil has recovered from the early depressing effects of African bees during the last 15 years (Gonçalves 1975, Michener 1975, De Jong 1984). Presently there are more beekeepers, more managed colonies and increased honey production in this region than prior to the advent of African bees. This turnabout has occurred only as far north as 20°S and therefore does not extend substantially into tropical Brazil, rather, it is confined to the region where European bees were used most extensively prior to Africanization. The reasons for this improvement include: 1) better management; 2) improved roads; 3) development of commercial orange and apple orchards; 4) government assistance in the development of beekeeping; 5) increased migratory beekeeping; 6) increase in the manageability and productivity of hybrid and African bee stocks; and 7) the emergence of a new generation of beekeepers with no prior experience with European bees (Gonçalves 1975, De Jong 1984, Gonçalves, Kerr, Ramirez, and Wiese, personal communication). Of these, the most important to future developments in the United States is the improvement in the manageability and productivity of bees in southern Brazil. This raises the possibility that a long-term (>15 yr) solution in the United States might be the production of a "southern" bee, derived either from hybridization or from improved lines of African bees, that would be suitable for honey production and pollination within the zone defined by the overwintering limit of African bees.

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ORLEY R. "CHIP" TAYLOR received his Ph.D. degree from the University of Connecticut in 1970. Chip considers himself an insect ecologist, evolutionary biologist and through his long association with the Organization for Tropical Studies, a de facto tropical ecologist. His research efforts have included studies of reproductive isolating mechanisms in the sulfur butterflies, reproductive and life history patterns in plants and comparative biology of European and African honeybee races. He is presently a professor in the Departments of Entomology and of Systematics and Ecology at the University of Kansas, Lawrence.

American Bee Research Conference, Louisiana State Univ., Oct. 6-7, 1986

17. Rinderer, T. E.[a] — RECENT DEVELOPMENTS IN THE MORPHOMETRIC IDENTIFICATION OF HONEY BEES — In the last 2 years the morphometric analysis of honey bees has been further tested and expanded. In a cross fostering experiment, changes in morphology caused by nutrition (nurse-bee type) and comb cell-size were sufficiently trivial that identification procedures still correctly identified Africanized and European bees.

Novel discriminate analysis comparing Africanized and African bees showed that the two groups were completely seperate. Africanized bees were more similar to African bees than they were to European bees but were distinctly different from either parental type. Thus, the name "Africanized" is the best term for this population of bees.

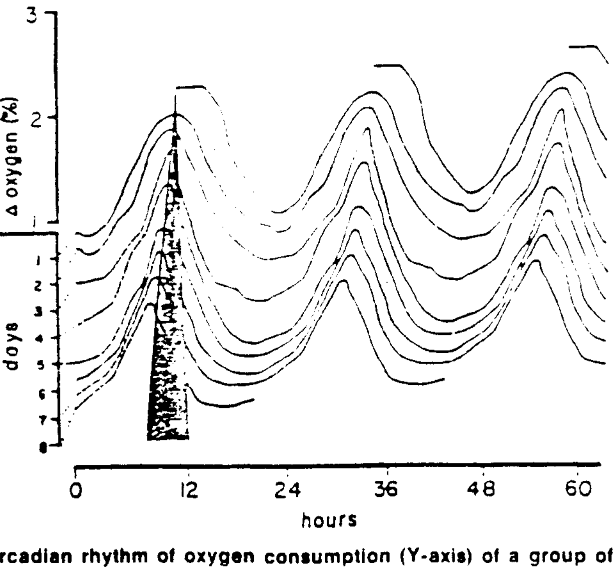
A new analysis has been developed which distinguishes between Africanized, European, and F_1 hybrids.

18. Southwick, E. E.[g] — COLONIAL SYNERGISM OF RHYTHMS IN HONEY BEES — Honey bees are highly social organisms with many physiological and behavioral functions that occur only when they are in the colony or a group. They show daily rhythms in behavior (*Apidologie* 15:278-280) and oxidative metabolism (*Comp. Biochem. Physiol.* 71A:277-281). Therefore, I investigated how honey bee workers in a group synchronize individual circadian rhythms.

Nucleus colonies consisting of a fertile queen, brood and about 2500 workers were housed outdoors or in a flight room with a light cycle 12 hr out of phase. All bees were free to fly. Indoor bees were provided milled pollen and 50% sugar *ad libitum*. After six weeks, tests were run on group metabolic rhythms by placing groups of 100 workers in metabolic chambers in constant dark, and monitoring their group metabolism continuously for ten consecutive days.

Test groups from outdoor and indoor colonies showed typical circadian rhythms of oxygen consumption in the dark (Fig.). The figure shows peaks of metabolism corresponding to subjective "day" time, and troughs during the "night." When successive days are lined up vertically, the shaded triangle indicates a phase advance of about three hours over nine days, giving a free-running rhythm in metabolism of 23 hr. 40 min.

Test groups from the indoor (DL) colonies had metabolic rhythms about 12 hr. out of phase with those housed outdoors (LD). Yet when indoor and outdoor groups were mixed, they showed a coordinated group rhythm with peaks and troughs falling inbetween those of the "pure" groups. This suggests



Circadian rhythm of oxygen consumption (Y-axis) of a group of honey bees in constant dark (X-axis = time in hours) monitored over 10 consecutive days.

that the clocks of the individuals were re-entrained and synergistically synchronized. When groups were tested with a double screen separating them, preventing physical contact, there was no group rhythm.

The results reported here demonstrate that honey bees synchronize their individual cycles in an overall group cycle, an endogenous synergistic circadian rhythm. Re-entrainment to an overall group rhythm takes place by physical social interactions such as tactile and trophallactic behaviors known to be important in colonial communication (*Insectes Soc.* 29:209-211). This, then, serves as the likely mechanism in the synergistic control of group metabolic rhythm in honey bees.

19. Spivak, M.[h] — RELATIVE SURVIVORSHIP OF AFRICANIZED AND EUROPEAN HONEY BEES IN THE HIGHLANDS OF COSTA RICA — This study was designed to determine the relative survivorship and reproductive success of Africanized and European honey bees over an elevational gradient in Costa Rica. My observations in Peru (13° S) in 1980 and 1982 showed that neither feral nor hived Africanized colonies were found above 2300m. Whereas below that elevation, the area was saturated with Africanized bees. In contrast, hived European colonies were relatively common above 2300m (determinations confirmed morphometrically by Dr. H. Daly). These results seemed to indicate that there may be climatic or resource factors limiting the survival or movement of Africanized bees at higher elevations.

A comparative study was initiated in Costa Rica in 1984, when Africanized bees were just moving into the area. Queens were reared from either Costa Rican-European breeders, or from Africanized swarms recently entering the area. The virgins were taken to be mated in areas either predominantly Africanized or not yet Africanized. In this way, all daughter queens were approximately the same age, and displayed characteristics as far towards the extremes of the Africanized-European continuum as possible.

The first half of the study extended from July through November, 1985 (wet season). Three apiaries were established at 900m, 1800m, and 2300m, each with 10 Africanized and 10 European colonies. In the second half of the study, all colonies were relocated into two apiaries, situated in an agricultural area at 900m and in a cloud forest at 2800m, from December 1985 to July 1986 (dry season and first two months of the wet season) to test the effects of more extreme climatic and resource conditions on colony survivorship.

Every two weeks over the year, all colonies were weighed, and measured for pollen, nectar, honey, worker and drone brood areas, using 3 and 5 cm^2 grids as needed. Reproductive swarms, supersedures and absconding colonies were recorded.

Data show that Africanized colonies maintain large brood areas, and have high incidences of swarming at all elevations, even at 2800m where resource conditions are poor, and climatic conditions are unfavorable. Africanized colonies also rear drones and issue swarms earlier in the season than European colonies, which increases their reproductive potential. While European colonies performed poorly at lower elevations relative to Africanized colonies, the differences between Africanized and European colonies were not so pronounced at higher elevations. Further analyses and discussion of these results will be published at a later date.

The most important implication of these findings is that Africanized bees may not tend to swarm up to higher elevations, but when moved there in man-made "nests" are able to survive. Distinguishing between feral and manipulated movements may help explain the seemingly contradictory observations on the distribution and survivorship of Africanized bee populations in different areas. Since a large part of the beekeeping industry in the United States is based on migratory practices, it is important to consider that under these circumstances, Africanized bees may become established in areas where previously they were not expected to survive.

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Health Problems Associated with African Bees

ALTHOUGH MANY popular and technical articles have been published on African bees, there is no credible literature concerning human health problems arising from their stinging behavior. In their report on acute renal failure due to bee stings, Mejia and associates (1) emphasize that the advance of African bees is accompanied by numerous cases of severe multiple stinging with various manifestations that have not been reported. Renal failure is considered to be rare (2) and is not listed as a cause of death in 400 fatal reactions to *Hymenoptera* stings (3).

There are many reasons for the lack of documentation of African bees as a human health problem. Most stinging incidents in South America occur in the countryside where victims receive minimal or no medical attention. Mortality records are incomplete and few autopsies have been done on sting victims in South and Central American countries. The physiologic reactions of victims to large doses of bee venom have not been reported.

Because of the lack of medical statistics, it is difficult to establish the severity of multiple stinging as a human health problem at present, and even more difficult to estimate the seriousness of this problem in the future. By estimate from accounts in newspapers, magazines (4), and contacts with government officials, at least 350 people have been killed by African bees since their escape in southern Brazil in 1957 (5). Because these accounts deal with less than half the geographic area invaded by African bees and there are many years for which no information is available, a more realistic estimate of mortality is probably 700 to 1000 persons. This figure is not large considering the time period (28 years), geographic area, and size of the human population. More impressive statistics would be the ratio of the number of cases of stinging requiring medical treatment to population size. Unfortunately such statistics are not available, but there are probably 100 to 200 cases for every fatality. As African bees move into a new area, the increase in the number of encounters with honey bees can be dramatic. In Venezuela, a country of 14 million people and 35 000 managed colonies of European bees, stinging incidents and mortality due to bee stings were virtually unknown before African bees arrived. African bees spread through most of Venezuela in 1977-78, and from mid-1978 to mid-1981 at least 70 people were killed by African bees; on one large construction project stingings were almost a daily occurrence (Gomez R, Ministerio de Agricultura y Cria of Venezuela. Personal communication). Two aspects of the Venezuelan experience are important. First, most of the severe stinging incidents occurred in only two areas where a high number of feral bee colonies coincided with a high human density. Second, the number of incidents reached a peak 3 to 4 years after African bees arrived and then declined; this decline appears to be attributable to a slight decrease in the number of feral colonies and a growing awareness by the public that these insects can be dangerous.

African bees will probably reach Brownsville, Texas, in late 1988 or early 1989 (6). In the United States the bees should become permanently established in areas with mean high temperatures of at least 60 °F (16 °C) for January (7). The 60 °F isocline encompasses coastal California as far north as Hayward; the lower half of Arizona and Texas; most of Louisiana; the southern halves of Mississippi, Alabama, Georgia, and South Carolina; a small portion of North Carolina; and all of Florida. Within this area there are three regions where the density of the feral population and the number of stinging incidents is likely to be high: Brownsville and Corpus Christi, Texas; southern Louisiana including New Orleans; and southeast Georgia and all of Florida. Serious problems with feral bees also may develop in Galveston, San Diego, and the Los Angeles basin.

The rate of spread of African bees should decrease as they approach their ecological limits and, if unaided by humans, it should take at least 8 years for the feral population to expand from Brownsville to their climatic limits on the coasts (8).

When disturbed, African bees often respond with such swiftness and intensity (9) that persons caught unaware can receive hundreds of stings within 1 to 2 minutes. Occasionally, incidents on bridges, in cities, schoolyards, and other public places have resulted in the treatment of dozens of people for bee stings. In South America deaths due to bee stings usually involve older men, people with infirmities, children under 8 years, and healthy people unable to flee. Most bee incidents have involved chance encounters with feral bee nests whose location was unknown to the victim. Managed bee colonies are less commonly the source of stinging cases.

The commonly held view that there is little or no difference between the venom of European and African bees (1) may be incorrect. Shipman and Vick (10) reported numerous quantitative differences and obtained different median lethal doses of isolated venom fractions injected into mice. Although there is an extensive literature on the composition of venom (as in *Apicultural Abstracts*), the physiologic responses to various venom fractions are less well known. More research appears to be needed on the toxicologic and pathologic characteristics associated with bee venom and particularly that of African bees.

Investigators interested in problems associated with *Hymenoptera* stings will find ample opportunities for research in Mexico. African bees will reach that country in the coming months and stinging incidents should begin to increase in Chiapas, Campeche, and Yucatan in 1987. (ORLEY R. TAYLOR, JR., Ph.D.; *University of Kansas; Lawrence, Kansas*)

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BILL SUMMARY
(HB 461)

Prepared by Tom Gomez, Staff Researcher
Montana Legislative Council

HB 461 is a bill that generally revises the laws regulating the keeping and caring of apis bees.

As introduced, HB 461 contains the following main provisions:

-- Provides for control and inspection of apiaries to prevent the spread or entry into the state of "pest" bees, which are defined as any African honeybee or bee Africanized by interbreeding with the African honeybee;

-- Prohibits issuance of certificates of registration for new apiaries located in close proximity to established registered apiaries if there may be danger of the spread of pest bees to the established apiaries;

-- Revises the penalty for late registration of an apiary so that late registration will result in a penalty of $10 or 10% of the regular registration fee, whichever is greater;

-- Increases fees for registration of apiaries, based on a schedule of fees for the total number of bee colonies in the apiary;

-- Raises fees from $20 to $50 for inspection of beekeeping equipment transported between states;

-- Permits the seizure of any apiary that poses a threat to control of pest bees or that is not properly registered;

-- Provides for the destruction or sale of any equipment in an apiary infected with pest bees;

-- Allows the Department of Agriculture to quarantine and order the transfer of bees in order to prevent the spread of pest bees among other bees and apiaries;

-- Authorizes the Department to maintain and operate a lab to test for diseases and pest bees; and

-- Grants the Department of Agriculture authority to adopt rules to establish quarantines to prevent the entry or spread of diseases or pest bees that are not known to occur in Montana.

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VISITORS' REGISTER

Ag, Livestock & Irrig. COMMITTEE

BILL NO. 446 - 461 DATE January 30, 1987

SPONSOR

NAME (please print)	RESIDENCE	SUPPORT	OPPOSE
Bob Barnes Bill 461	Dillon, MT. MT. St. Beekeepers	✓	
Ron Barnett Bill 461	Belgrade, MT. MT. ST. BEEKEEPERS	✓	
Stuart Doggett HB 446	Mt Chamber of Commerce	✓	
Les Graham HB446	Dept of Livestock	✓	
Claribel Downie HB446	W.I.F.E.	✓	
Ray Dawes HB 461	FT Shaw MT	✓	
Kim Enkerud	MT Stockgrowers	446 ✓	
Gary Murphy	Livingston	461 ✓	
Rep Dick Corne	Bozeman	461	
Mons Teigen	Mt. Beef Council	446 ✓	
Roy Bjornson	Mt. Dept.	461	

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