JOURNAL OF INVERTEBRATE PATHOLOGY 24, 349-356 (1974)

Yeasts Isolated from Honey Bees, *Apis mellifera*, Fed 2,4-D and Antibiotics[1,2]

MARTHA GILLIAM, L. J. WICKERHAM, HOWARD L. MORTON, AND RICHARD D. MARTIN

Agricultural Research Service, U.S. Department of Agriculture, Tucson, Arizona 85719

Received April 18, 1974

Yeasts belonging to seven species were isolated and identified from the intestines of 388 adult worker honey bees. *Apis mellifera*. *Torulopsis magnoliae*, *Candida parapsilosis*, and *Torulopsis grabrata* were found in bee guts most frequently. The intestines of bees from colonies fed a combination of Terramycin and Fumidil B contained few or no yeasts. More guts of bees from colonies fed 2,4-D contained yeasts than those examined from bees from control colonies.

INTRODUCTION

For several years we have been investigating the microflora of honey bees, *Apis mellifera* (Gilliam, 1971, 1973; Gilliam and Prest, 1972; Gilliam and Valentine, 1974; Gilliam and Morton, 1974; Gilliam et al., 1974). As a result, in a previous publication (Gilliam, 1973), it was suggested that yeasts in adult worker honey bees may be indicators of a stress condition since few, if any, yeasts remain viable in the intestines of bees from healthy free-flying colonies.

Although yeasts are abundant in nectar and honey, few reports exist on yeasts isolated from honey bees. Table 1 summarizes the available data on yeasts found in honey bees. Organisms in the genera *Candida* and *Torulopsis* appear to dominate the yeast flora.

Since we were unable to isolate yeasts from bees obtained from healthy, free-flying colonies (Gilliam, 1973), we report here the results of the examination of the yeast flora of the intestinal contents of adult worker bees from caged colonies fed (2,4-dichlorophenoxy)acetic acid (2,4-D), a combination of Terramycin (oxytetracycline) and Fumidil B (fumagillin), or untreated pollen patties. These materials were selected because (1) antibiotics have been reported to decrease the bacterial flora of bees and to increase the yeast flora (Hajsig, 1959; Mitroiu et al., 1966; Tomasec, 1957) and (2) because 2,4-D has a variety of effects on plants, animals, and microorganisms (Barrier et al., 1970; Parry, 1973). Also, we had previously examined Enterobacteriaceae (Gilliam and Morton, 1974) and fungi (Gilliam et al., 1974) from bees fed these antibiotics and 2,4-D.

MATERIALS AND METHODS

Colonies were established, caged, maintained, and fed 2,4-D and the antibiotics TM-25 (25 g oxytetracycline/1-lb formulation) and Fumidil B as previously described (Gilliam and Morton, 1974). In the first test, 2,4-D and the antibiotics were initially fed on July 14, 1971. In the second

[1] In cooperation with the Arizona Agricultural Experiment Station.

[2] Mention of a proprietary product or company name does not constitute an endorsement of this product by the U.S. Department of Agriculture.

Copyright © 1974 by Academic Press, Inc.
All rights of reproduction in any form reserved.

TABLE 1

YEASTS ISOLATED FROM HONEY BEES

Yeast	Source of yeast	Reference
Brettanomyces sp.	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
Candida sp.	—do—	—do—
	Intestines of adult bees	Egorova and Bab'eva, 1967
	Guts of diseased adult bees	Vecchi, 1959
	Intestinal contents of larvae	Hajsig and Kamburov, 1966
Candida albicans	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
Candida brumptii	Intestines of adult bees	Egorova and Bab'eva, 1967
Candida guilliermondii	—do—	—do—
	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
Candida guilliermondii var. *membranefaciens* (=*Pichia ohmeri*)	Digestive tracts of adult bees	Hajsig, 1959
Candida krusei	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
Candida lipolytica	—do—	—do—
Candida macedoniensis	—do—	—do—
Candida parapsilosis	—do—	—do—
	Intestines of adult bees	Egorova and Bab'eva, 1967
Candida pelliculosa (=*Hansenula anomala*)	Digestive tracts of adult bees	Hajsig, 1959
Candida pulcherrima (=*Metschnikowia pulcherrima*)	Digestive tracts of adult bees	Hajsig, 1959
Candida reukaufii	Intestines of adult bees	Egorova and Bab'eva, 1967
(=*Metschnikowia reukaufii*)	Intestinal contents of larvae	Hajsig and Kamburov, 1966
Candida rugosa	Honey stomach of adult bees	Batra et al., 1973
Candida scottii	Intestines of adult bees	Egorova and Bab'eva, 1967
Candida solani	Intestines of larval and adult bees	—do—
Candida tenuis	Intestines of adult bees	—do—
Candida tropicalis	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
Cryptococcus sp.	—do—	—do—
Cyrptococcus alvearis	Diseased larvae	Vecchi, 1959
Debaryomyces disporus (=*Pichia dispora*)	Intestines of adult bees	Egorova and Bab'eva, 1967
Debaryomyces hansenii	Intestinal contents of larvae	Hajsig and Kamburov, 1966
Debaryomyces kloeckeri (=*Debaryomyces hansenii*)	Intestines of adult bees	Egorova and Bab'eva, 1967
Hansenula anomala	Midgut of adult bees	Batra et al., 1973
	Intestines of adult bees	Egorova and Bab'eva, 1967
Kloeckera sp.	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
Kloeckera apiculata	Honey stomach of adult bees	Batra et al., 1973
Metschnikowia pulcherrima	—do—	—do—
Metschnikowia reukaufii	Honey stomach and midgut of adult bees	—do—
Mycoderma cerevisiae (=*Candida vini*)	Guts of adult bees	Burnside, 1930
Pityrosporum sp.	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
Rhodotorula sp.	Discolored drone and worker larvae and worker pupae	Prest et al., 1974

TABLE 1 (*Continued*)

Yeast	Source of yeast	Reference
Rhodotorula glutinis	Honey stomach and feces of adult bees	Batra et al., 1973
Rhodotorula mucilaginosa (= *Rhodotorula rubra*)	Intestines of diseased larvae	Egorova and Bab'eva, 1967
	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
Saccharomyces apiculatus	Intestinal canal of bees	Burnside, 1930
Saccharomyces cerevisiae	Honey stomach of adult bees	Batra et al., 1973
	Digestive tracts of adult bees	Hajsig, 1959
Saccharomyces ellipsoideus (= *Saccharomyces cerevisiae*)	Honey stomach of adult bees	Burnside, 1930
Saccharomyces fructuum (= *Saccharomyces chevalieri*)	Intestines of larvae	Egorova and Bab'eva, 1967
Saccharomyces rouxii	—do—	Batra et al., 1973
	Intestinal contents of larvae	Hajsig and Kamburov, 1966
Saccharomycodes ludwigii	Honey stomach, midgut, and excreta of adult bees	Batra et al., 1973
Schizosaccharomyces sp.	Honey stomach of adult bees	—do—
Torulopsis sp.	Intestines of adult bees	Egorova and Bab'eva, 1967
	Digestive tracts of diseased bees	Giordani, 1952
	Digestive tracts of adult bees	Hajsig, 1959
	Intestinal contents of larvae	Hajsig and Kamburov, 1966
	Intestinal contents of adult bees fed antibiotics or sulfathiazole	Mitroiu et al., 1966
	Guts of diseased adults	Vecchi, 1959
Torulopsis apicola	Digestive tract of adult bees	Hajsig, 1959
Torulopsis bacillaris (= *Torulopsis stellata*)	Intestinal contents of larvae	Hajsig and Kamburov, 1966
Torulopsis famata (= *Torulopsis candida*)	Intestines of adult bees	Egorova and Bab'eva, 1967
	Digestive tracts of adult bees	Hajsig, 1959
Torulopsis etchellsii	Intestines of adult bees	Egorova and Bab'eva, 1967
Torulopsis magnoliae	Digestive tracts of adult bees	Hajsig, 1959
	Intestinal contents of larvae	Hajsig and Kamburov, 1966
	Guts of bees	van Uden and Vidal-Leiria, 1971
Torulopsis molischiana	Intestines of adult bees	Egorova and Bab'eva, 1967
Torulopsis sake (= *Candida sake*)	—do—	—do—
Torulopsis stellata	Intestines of larval and adult bees	—do—
Torulopsis versatilis	Intestines of adult bees	—do—
Willia anomala (= *Hansenula anomala*)	Intestines of bees	Vecchi, 1959
Zygosaccharomyces sp.	Honey stomach of adult bees	Batra et al., 1973

test, they were fed for the first time on September 17, 1971.

Briefly, the procedure was to feed all colonies 1-lb pollen patties (maintenance diet), which were replenished weekly. Colonies receiving the herbicide were fed the dimethylamine salt of 2,4-D at a concentration of 1000 ppm active ingredient by weight in 60% sucrose–water solution from a jar placed directly above the frames containing brood (Morton and Moffett, 1972). The mixture of herbicide and syrup was replenished twice a week. Colonies fed antibiotics were given the maintenance diet plus 15 g TM-25 and 15 g Fumidil B in addition to 60% sucrose–water solution. Control colonies received the maintenance diet and 60% sucrose–water solution. Fresh water was available to all colonies.

Hives were placed outdoors in 12 × 12 × 9-ft Saran mesh cages. In the first test, we placed each of the three hives

TABLE 2

YEASTS ISOLATED FROM CONTROL BEES, BEES FED 2,4-D, AND BEES FED OXYTETRACYCLINE AND FUMAGILLIN

Organism	Number of bee guts containing the organism
Torulopsis magnoliae Lodder et Kreger-van Rij	97
Torulopsis glabrata (Anderson) Lodder et de Vries	41
Candida parapsilosis (Ashford) Langeron et Talice	36
Hansenula anomala (Hansen) H. et P. Sydow	13
Saccharomyces bailii Lindner var. *osmophilus* van der Walt	2
Rhodotorula minuta (Saito) Harrison var. *minuta*	2
Cryptococcus albidus (Saito) Skinner var. *aerius* (Saito) Phaff et Fell	1
Unidentified	2

receiving a different treatment in a separate cage. In the second test, three colonies receiving the same treatment were placed in the same cage. Altogether we examined bees from 12 colonies: four control colonies, four colonies treated with 2,4-D, and four colonies fed antibiotics.

In the first test, three adult worker bees from each colony were examined weekly. The intestinal tracts were aseptically removed and individually homogenized in 2.5 ml of sterile 0.85% NaCl as previously described (Gilliam and Prest, 1972). A loopful of the homogenate from each bee was streaked in duplicate on each of the following solid media in petri dishes: trypticase soy agar (BBL), Lindegren yeast agar (Difco), and Czapek solution agar (Difco). All plates were incubated under aerobic conditions at 25°C for 14 days.

In the second test, every 3 wk the intestines of two bees from each colony were individually homogenized in 2.5 ml of sterile thioglycollate 135C medium (BBL). Each homogenate was streaked in duplicate on trypticase soy agar, eugonagar (BBL), and Czapek solution agar. One plate was incubated at 25°C and one at 37°C under aerobic conditions for 14 days.

Selected yeast colonies were restreaked for purity on malt extract–yeast extract agar plates containing 1% glucose and were maintained on slants of this medium (Wickerham, 1951). Morphological and physiological tests were conducted according to Wickerham (1951), and isolates were identified according to Lodder (1970).

In the first test, bees were sampled from July, 1971 to January, 1972, when the herbicide-fed and antibiotic-fed colonies died. In the second test, bees were sampled from September, 1971 to August, 1972, though all herbicide-fed colonies had died by April, 1972, one of the antibiotic-fed colonies died in June, 1972, and a control colony died in May, 1972.

RESULTS

Yeasts belonging to seven species were isolated and identified from the 388 bees that we examined (Table 2). The two unidentified yeasts belong to the same species. *Torulopsis magnoliae*, *Candida parapsilosis*, and *T. glabrata* were found in bee guts most frequently. Isolations were made on all media used and at both 25° and 37°C incubation temperatures.

Table 3 shows the organisms isolated in the first test. Fifty-three isolates were from bees fed 2,4-D, 14 from control bees, and only six were from bees fed antibiotics. Therefore, in this test 2,4-D increased the number of bee guts containing yeasts and the antibiotics decreased the number. All organisms, including the yeasts, were eliminated from the bees fed with antibiotics approximately 3 mo after the antibiotics were incorporated in the diets. *Torulopsis magnoliae* was the yeast found most frequently in the first test.

Table 4 gives the results of isolations in the second test. Although the colonies fed 2,4-D were sampled for only 7 mo, 72 isolates were from these bees, 43 isolates were

TABLE 3

YEASTS ISOLATED FROM HONEY BEES—FIRST TEST

Organism	Treatment[a]	Date isolated	Number of bee guts containing the yeast
Torulopsis magnoliae	H	8/23/71	1
T. magnoliae	H	9/13/71	3
T. magnoliae	H	9/20/71	3
T. magnoliae	H	9/27/71	3
T. magnoliae	H	10/4/71	3
Saccharomyces bailii var. *osmophilus*	C	10/4/71	1
Hansenula anomala	A	10/4/71	3
T. magnoliae	H	10/12/71	3
H. anomala	A	10/12/71	3
Saccharomyces bailii var. *osmophilus*	C	10/12/71	1
H. anomala	C	10/18/71	1
Cryptococcus albidus var. *aerius*	C	10/18/71	1
Rhodotorula minuta var. *minuta*	C	10/18/71	2
T. magnoliae	H	10/18/71	3
T. magnoliae	H	10/26/71	3
T. magnoliae	H	11/1/71	3
T. magnoliae	H	11/8/71	3
T. magnoliae	H	11/15/71	3
T. magnoliae	H	11/22/71	3
T. magnoliae	H	11/29/71	3
T. magnoliae	H	12/6/71	3
T. magnoliae	H	12/13/71	3
T. magnoliae	C	12/13/71	2
Unidentified	C	12/13/71	2
T. magnoliae	H	12/20/71	3
Torulopsis glabrata	H	12/20/71	1
T. magnoliae	H	12/27/71	3
T. glabrata	H	12/27/71	3
T. glabrata	C	12/27/71	1
T. magnoliae	C	12/27/71	3

[a] C = control; H = 2,4-D; A = antibiotics.

from control bees that were sampled for 9 mo, and only six isolates were obtained from bees treated with antibiotics which were sampled for 11 mo. Thus, the results of both tests demonstrated that 2,4-D increased the number of bee guts containing yeasts and that antibiotics decreased the number. *Torulopsis magnoliae, T. glabrata,* and *Candida parapsilosis* were isolated most frequently in this test.

Saccharomyces bailii var. *osmophilus, Rhodotorula minuta* var. *minuta,* and *Cryptococcus albidus* var. *aerius* were isolated infrequently in the first test but were not found in the second test. *Candida parapsilosis* was isolated frequently in the

TABLE 4

YEASTS ISOLATED FROM HONEY BEES—SECOND TEST

Organism	Treatment[a]	Date isolated	Number of bee guts containing the yeast
Torulopsis magnoliae	H	10/18/71	6
T. magnoliae	C	10/18/71	3
T. magnoliae	C	11/9/71	1
T. magnoliae	H	11/9/71	1
T. magnoliae	H	11/30/71	3
T. magnoliae	C	12/21/71	6
T. magnoliae	A	12/21/71	3
Torulopsis glabrata	H	12/21/71	6
T. glabrata	H	1/11/72	6
T. magnoliae	A	1/11/72	1
T. magnoliae	C	2/1/72	5
T. magnoliae	H	2/1/72	6
T. magnoliae	A	2/1/72	1
T. glabrata	H	2/1/72	6
Candida parapsilosis	H	2/1/72	6
C. parapsilosis	H	2/23/72	6
T. glabrata	H	2/23/72	6
C. parapsilosis	C	2/23/72	1
T. magnoliae	C	2/23/72	6
T. glabrata	H	3/14/72	6
C. parapsilosis	H	3/14/72	4
C. parapsilosis	H	4/4/72	4
T. glabrata	H	4/4/72	6
C. parapsilosis	C	4/25/72	4
Hansenula anomala	C	4/25/72	2
H. anomala	C	5/16/72	4
C. parapsilosis	C	5/16/72	5
C. parapsilosis	C	6/6/72	4
C. parapsilosis	C	6/28/72	2
T. magnoliae	A	8/8/72	1

[a] C = control; H = 2,4-D; A = antibiotics.

second test but not at all in the first test. *Torulopsis magnoliae, T. glabrata, C. parapsilosis,* and *Hansenula anomala* were isolated from bees in both tests.

Discussion

Yeasts were more prevalent than Enterobacteriaceae (Gilliam and Morton, 1974) or fungi (Gilliam et al., 1974) in caged bees fed 2,4-D, antibiotics, or pollen patties. Yet, Enterobacteriaceae (Gilliam and Valentine, 1973) and fungi (Gilliam and Prest, 1972) were present in more guts of bees from free-flying colonies than in guts of bees from caged colonies. However, we have been unsuccessful in attempts to isolate yeasts from the intestines of adult worker bees from free-flying colonies (Gilliam, 1973). In the present experiments, yeasts did not appear in bee guts until the colonies had been caged and fed experimental diets for 30–40 days. Therefore, the intestinal yeast flora of adult worker bees in Arizona appears to develop under conditions of stress such as caging of colonies, feeding artificial diets, or feeding 2,4-D to colonies. However, not all bee guts we examined in these experiments contained yeasts.

We were interested in determining the number of guts containing yeast cells, but not the total number of yeast cells per bee gut. To adequately estimate the number of species present, more isolates were identified than are shown in Tables 3 and 4. Generally, the bee guts that contained yeasts yielded plates which were covered with yeast colonies.

We identified 125 isolates from bees fed 2,4-D, 57 from control bees, and only 12 from bees fed antibiotics. In both tests, the guts of bees from colonies treated with antibiotics contained few or no yeasts. The combination of oxytetracycline and fumagillin depressed not only the yeast flora but also the fungal and bacterial flora (Gilliam and Morton, 1974; Gilliam et al., 1974). In fact, we have been able to eliminate all the microflora of adult worker bees by feeding caged colonies large amounts of oxytetracycline and fumagillin over long periods (Gilliam and Taber, unpublished).

More guts of bees from colonies fed 2,4-D contained yeasts than those examined from bees from control colonies. The herbicide did not decrease the number of bee guts containing Enterobacteriaceae or fungi (Gilliam and Morton, 1974; Gilliam et al., 1974). However, colonies fed 2,4-D survived only 6 mo in the first test and 7 mo in the second test. We attribute the death of these colonies to the ovicidal and larvicidal effects of the herbicide (Morton and Moffett, 1972).

Torulopsis magnoliae has been isolated from flowers, insects, nectar, and human sources (Cook, 1958; Lodder, 1970). *Torulopsis glabrata* has been isolated from soil, shrimp, orange juice, human sources, sea gulls, elephants, baboons, cattle, monkeys, pigs, hedgehogs, wart hogs, sheep, fowl, sparrows, and baker's yeast (Cook, 1958; Lodder, 1970; Rose and Harrison, 1969). *Hansenula anomala* occurs in soil, syrups, gums of trees, insect frass, stored grain, sewage, and lakes and streams, on fruits, vines, and shrubs, and in the bodies of warm-blooded animals (Cook, 1958; Lodder, 1970; Rose and Harrison, 1969; Wickerham, 1951). *Candida parapsilosis* occurs commonly on healthy human skin as well as in lesions, in insect frass, in the digestive tract of pigs, baboons, horses, and cows, on fruit, and in bark beetles (Cook, 1958; Lodder, 1970; Rose and Harrison, 1969). *Saccharomyces bailii* var. *osmophilus* has been associated with soy mash, fermenting cucumbers, and grape must (Lodder, 1970). *Rhodotorula minuta* occurs in human and animal sources, air, flowers, sea water, marine animals, ocean plant life, and moss (Lodder, 1970; Rose and Harrison, 1969). *Cryptococcus albidus* occurs in soil, air, and sea water and is associated with moss, apples, vine, and other plants producing sugary fruits (Cook, 1958; Lodder, 1970; Rose and Harrison, 1969).

Torulopsis magnoliae was the organism

found in the most bee guts in our tests. This yeast has been found in the intestines of adult bees (Hajsig, 1959; van Uden and Vidal-Leiria, 1971) and larvae (Hajsig and Kamburov, 1966).

Candida parapsilosis was found frequently in bee guts in the second test but was not isolated in the first test. It did not appear in bee guts until February, 1972. Perhaps, if the first test had extended beyond January, 1972, this organism would have been isolated. *C. parapsilosis* has been isolated from the intestines of adult bees (Egorova and Bab'eva, 1967) and from the intestinal contents of bees fed antibiotics (Mitroiu et al., 1966). We isolated this yeast from control bees and from bees fed 2,4-D but not from bees fed antibiotics. *Hansenula anomala* has been found in the digestive tracts of adult bees (Batra et al., 1973; Egorova and Bab'eva, 1967; Hajsig, 1959; Vecchi, 1959).

Therefore, *Torulopsis glabrata*, *Saccharomyces bailii* var. *osmophilus*, *Rhodotorula minuta* var. *minuta*, and *Cryptococcus albidus* var. *aerius* are new records of yeasts found in bee guts. Of these yeasts, only *T. glabrata* was isolated frequently. It appeared in bees in both tests in December, 1971.

Only *Torulopsis magnoliae* was isolated from control bees, bees fed 2,4-D, and bees fed antibiotics. *Torulopsis glabrata* and *Candida parapsilosis* were isolated from control bees and from bees fed 2,4-D. Perhaps the antibiotics had a detrimental effect on the growth and survival of these organisms. *Hansenula anomala* was found in control bees and in bees fed antibiotics. Therefore, 2,4-D might have affected this organism.

Acknowledgment

We thank Dr. C. P. Kurtzman, U.S. Department of Agriculture, Northern Regional Research Laboratory, Peoria, IL, for his cooperation.

References

Barrier, G. E., Hilton, J. L., Frans, R. E., Hull, H. M., Jackson, W. T., Knake, E. L., and Moreland, D. E. 1970. "Herbicide Handbook of the Weed Science Society of America," 2nd ed. Humphrey, Geneva New York.

Batra, L. R., Batra, S. W. T., and Bohart, G. E. 1973. The mycoflora of domesticated and wild bees (Apoidea). *Mycopathol. Mycol. Appl.*, **49**, 13–44.

Burnside, C. E. 1930. Fungous diseases of the honeybee. *U.S. Dep. Agr. Tech. Bull.*, **149**, 1–42.

Cook, A. H., Ed. 1958. "The Chemistry and Biology of Yeasts." Academic Press, New York.

Egorova, A. I., and Bab'eva, I. P. 1967. Yeast flora of the honey bee (*Apis mellifera* L.). *Akad. Nauk Arm. SSSR (Ser. Biol.—Med. Nauk)*, **2**, 127–132.

Gilliam, M. 1971. Microbial sterility of the intestinal content of the immature honey bee, *Apis mellifera*. *Ann. Entomol. Soc. Am.*, **64**, 315–316.

Gilliam, M. 1973. Are yeasts present in adult worker honey bees as a consequence of stress? *Ann. Entomol. Soc. Am.*, **66**, 1176.

Gilliam, M., and Morton, H. L. 1974. Enterobacteriaceae isolated from honey bees, *Apis mellifera*, treated with 2,4-D and antibiotics. *J. Invertebr. Pathol.*, **23**, 42–45.

Gilliam, M., and Prest, D. P. 1972. Fungi isolated from the intestinal contents of foraging worker honey bees, *Apis mellifera*. *J. Invertebr. Pathol.*, **20**, 101–103.

Gilliam, M., and Valentine, D. K. 1974. Enterobacteriaceae isolated from foraging worker honey bees, *Apis mellifera*. *J. Invertebr. Pathol.*, **23**, 38–41.

Gilliam, M., Prest, D. B., and Morton, H. L. 1974. Fungi isolated from honey bees, *Apis mellifera*, fed 2,4-D and antibiotics. *J. Invertebr. Pathol.*, **24**, 213–217.

Giordani, G. 1952. Alcune osservazioni su lieviti rinvenuti nell'apparato digerente di api ammalate. *Ann. Sper. Agrar. (Rome)* **7**, 633–646.

Hajsig, M. 1959. Contribution to the knowledge of yeasts from the intestinal content of bees. *Vet. Arhiv.*, **29**, 145–156. (In Serbo-Croatian, English summary.)

Hajsig, M., and Kamburov, G. 1966. Yeasts from the larvae of healthy honey bee colonies. *Vet. Arhiv.*, **36**, 66–69. (In Serbo-Croatian, English summary.)

Lodder, J., Ed. 1970. "The Yeasts: A Taxonomic Study." North-Holland, Amsterdam.

Mitroiu, P., Popa, M., Serban, M., and Toma, C. 1966. Étude sur la flore "mycosique" intestinale des abeilles soumises aux traitements aux antibiotiques et sulfathiazol. *Bull. Apicole*, **9**, 43–65.

Morton, H. L., and Moffett, J. O. 1972. Ovicidal

and larvicidal effects of certain herbicides on honey bees. *Environ. Entomol.*, 1, 611–614.

PARRY, J. M. 1973. The induction of gene conversion in yeast by herbicide preparations. *Mutat. Res.*, 21, 83–91.

PREST, D. B., GILLIAM, M., TABER, S., AND MILLS, J. P. 1974. Fungi associated with discolored honey bee, *Apis mellifera*, larvae and pupae. *J. Invertebr. Pathol.*, in press.

ROSE, A. H., AND HARRISON, J. S., EDS. 1969. "The Yeasts," Vol. 1. Academic Press, New York.

TOMASEC, I. 1957. The action of certain antibiotics on bees. *Vet. Arhiv.*, 27, 71–80. (In Serbo-Croatian, German summary.)

UDEN, N. VAN, AND VIDAL-LEIRIA, M. 1971. Genus 10. *Torulopsis* Berlese. *In* "The Yeasts: A Taxonomic Study" (J. Lodder, Ed.), p. 1283. North-Holland, Amsterdam.

VECCHI, M. A. 1959. La microflora dell'ape mellifica. *Microbiol. Enzimol.*, 9, 73–86.

WICKERHAM, L. J. 1951. Taxonomy of yeasts. *U.S. Dep. Agr. Tech. Bull.*, 1029, 1–56.