Honeydew Production by the Mealybug, Dysmicoccus neobrevipes Beardsley[1]

BY
TOSHIYUKI NISHIDA AND RICHARD KURAMOTO[2]
UNIVERSITY OF HAWAII
HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII

(Submitted for publication December, 1962)

INTRODUCTION

Honeydew is a viscous liquid of complex composition excreted as clear droplets by homopterous insects. Known since Biblical times (Essig, 1942), this sweet material, called "manna," was used for food in early days. Aside from general observations, relatively little scientific work was carried out by early investigators, and much of our current scientific knowledge is of recent origin. Developments in the use of chromatographic techniques have contributed much toward the identification of the chemical constituents of honeydew. However, information is needed on other aspects such as its physical properties, rate of excretion by various taxonomic groups, and factors associated with excretion.

As the result of recent investigations by various workers, the constituents of honeydew not known previously have been identified. Originally it was thought that honeydew consisted only of sugar; however, today it is known to contain, among other constituents, 22 amino acids (Maltais and Auclair, 1952) and five carbohydrates (Gray and Fraenkel, 1953, 1954; Ewart and Metcalf, 1956). According to Maltais and Auclair, the honeydew of aphids contains 13.2 percent amino acids and 35.7 percent invert sugars.

From our current knowledge of insect nutrition it is now clear that carbohydrates and amino acids are essential to the diet of many insects (Lipke and Fraenkel, 1956; House, 1961). Furthermore, the finding that honeydew contains both carbohydrates and amino acids has made ecologists aware of the importance of this excreted material as an ecological factor.

---

[1]Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 606.

[2]The junior author participated in the Undergraduate Research Participation Program, National Science Foundation, under the direction of Dr. D. Elmo Hardy. The authors wish to express their thanks for this assistance which made this work possible. The authors are also grateful to Mr. John W. Beardsley, Hawaiian Sugar Planters' Association, for identifying the mealybug.

The tephritid fruit fly environment in Hawaii contains many native and exotic plants which are hosts of homopterous insects. Honeydew producers, such as aphids, leafhoppers, and scales, are found so abundantly on these plants that the leaves are covered by a layer of sticky honeydew and sooty mold. Tephritid fruit flies and other insects, including flies, ants, bees and wasps, have been observed to congregate on such plants to feed on honeydew.

Honeydew has been studied by various investigators, each with a different purpose in mind. This study was undertaken because of our interest in honeydew as a component of the ecosystem of tephritid fruit flies. Importance of honeydew to tephritid fruit flies has been suggested by various investigators (Back and Pemberton, 1917; Kamal, 1954; Hagen, 1956; and Matsumoto and Nishida, 1962). The present paper reports results of studies conducted on the growth of and honeydew production by the mealybug, *Dysmicoccus neobrevipes* Beardsley. Data on the density of honeydew are also presented.

METHOD OF STUDY

The insect used in these experiments was *D. neobrevipes*, a mealybug found abundantly on a species of *Yucca*, a xerophyte with leaves that can be kept alive for long periods, growing on the University of Hawaii campus. Stock cultures of the mealybugs were maintained in the laboratory on *Yucca* plants grown from cuttings, while the experimental mealybugs were reared on cut leaves.

To study the relationship between mealybug growth and honeydew production, fully developed, gravid females were placed in 4-dram shell vials. As each crawler appeared, it was transferred to a small plastic cage one-half inch in height and in internal diameter, one end of which was attached by means of melted paraffin to cut *Yucca* leaves with the cut end placed in moist vermiculite and the other end of the cage tightly corked (fig. 1). Widths and lengths of the mealybugs were measured daily by use of an ocular micrometer, and the exuviae were counted to determine number of instars. In long-term experiments the mealybugs were transferred to new leaves every three weeks.

The amount of honeydew produced was determined by first establishing a volume-weight relationship by a method similar to that of Auclair (1958), Mittler (1958), and Mittler and Sylvester (1961). Volume was determined by measuring the diameter of the spherical droplets on the posterior end of the mealybug. With the known diameter, the volume was calculated by use of the formula, $V = \pi \frac{d^3}{6}$. The weight of the droplets was determined by collecting them in tared capillary tubes and weighing them, using an analytical balance. Two methods were used in collecting the samples: in one, the droplets were collected singly in a tared capillary tube; in the other, two to five were collected in a single tube. The density of the honeydew was then calculated from the known volume and weight.

Original attempts to correlate growth and honeydew production by use of individually caged crawlers were later abandoned for, although the mealybugs appeared to grow normally, a high percentage of them failed to produce honeydew. Subsequently, as it was observed that honeydew production was higher when the mealybugs occurred in colonies, they were confined to restricted areas of the leaf. This procedure con-

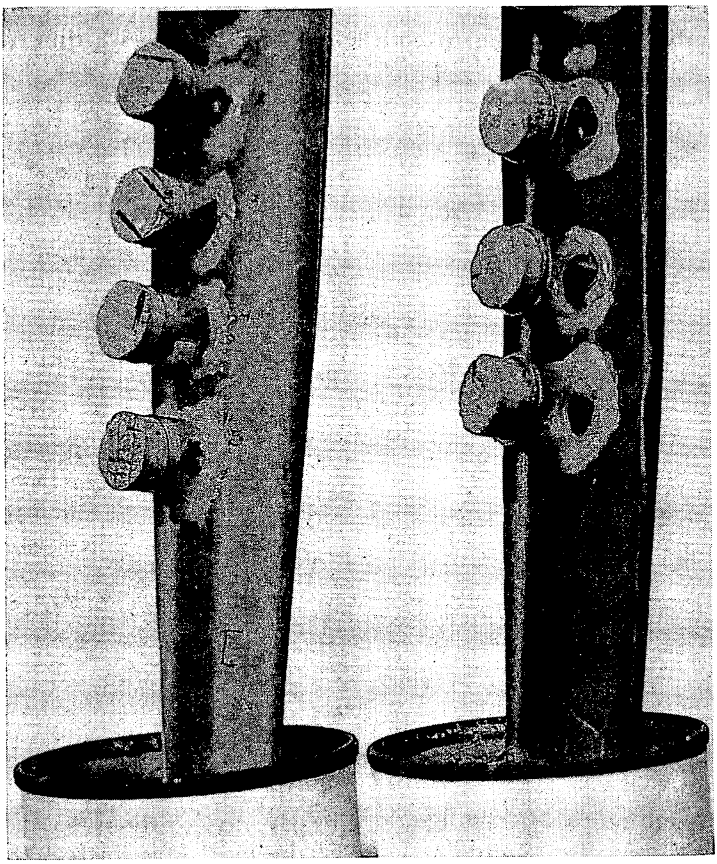

FIGURE 1.—Method of caging individual mealybugs on *Yucca* leaves set in moist vermiculite.

sisted of placing a narrow vaseline barrier approximately two inches in diameter on the adaxial side of the *Yucca* leaf, and the mealybugs placed within this circular enclosure. Prior to taking measurements, all previously excreted honeydew and other debris were removed. Twenty-four hours later the width of each mealybug that excreted honeydew and the diameter of the droplets produced were measured.

Though these studies were conducted in a laboratory in which temperature and humidity conditions were not controlled, data obtained from hygrothermograph records showed that the temperature ranged between 76°F. and 89°F. and the relative humidity between 56 and 75 percent.

RESULTS

Growth Rate and Honeydew Production

The data obtained on growth rate by caging 25 individuals singly on *Yucca* indicate the changes in both length and width with time (fig. 2).

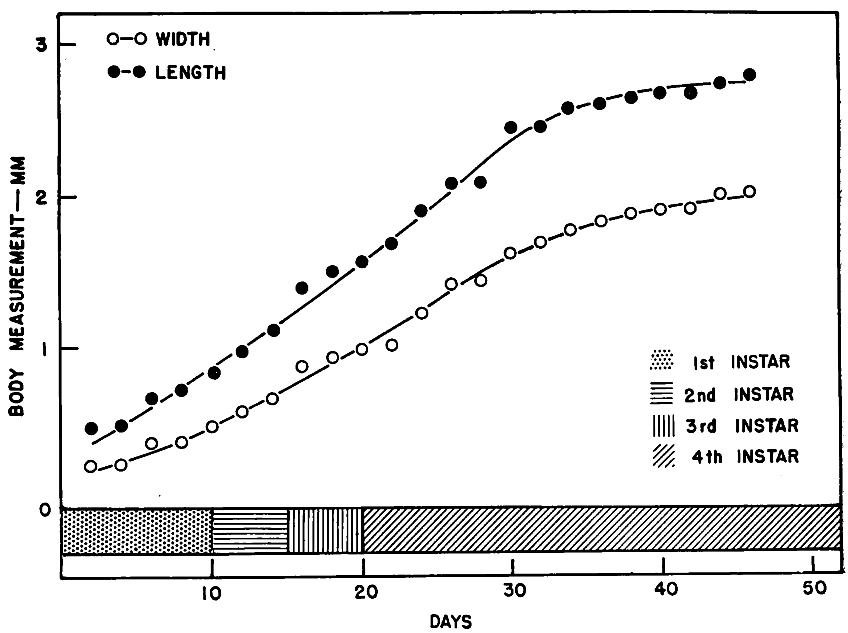

Figure 2.—Growth rate and number of instars of *Dysmicoccus neobrevipes*.

Both dimensions increased almost linearly up to about 35 days and leveled off thereafter. Individual size of the mealybugs increased within each of the four instars and continued to increase even after reaching maturity. Data on honeydew production could not be obtained in this experiment because very few individuals produced honeydew when caged individually. However, it was noted that honeydew production was less among nearly full grown individuals than among immature.

Density of Honeydew

The density of honeydew was determined by the single and multiple sampling methods. The values obtained by these two procedures were very close. The mean densities, determined by the single and multiple droplet samples, were 1.40±0.00 and 1.39±0.03, respectively. Samples were taken from individuals which were not segregated according to size. In general, single droplet samples were taken from larger mealybugs; droplet samples from the smaller individuals (cf. body size and honeydew production). (See table 1.)

TABLE 1.—Density of honeydew produced by Dysmicoccus neobrevipes*

Droplets per sample	Number of droplets per determination	Number of Samples	Mean volume (mm^3/droplet)	Mean weight (mg/droplet)	Mean density (mg/mm^3)
Single	1	14	0.06±0.02	0.09±0.03	1.40±0.00
Multiple	2–5	16	0.17±0.04	0.24±0.05	1.38±0.03

*Determined by single and multiple droplet samples.

To determine whether or not the density of honeydew varied with the population density of mealybugs, samples were taken from colonies with various numbers of individuals. The number of individuals per colony were 1, 10–19, 20–29 and 40–49 and the corresponding densities of honeydew were 1.40±0.06, 1.40±0.02, 1.40±0.01, and 1.40±0.01 (table 2). These results indicate that there was no difference in density of honeydew produced by individuals in colonies of different sizes.

TABLE 2.—The density of honeydew from mealybug colonies of various sizes.

Number of Mealybugs/colony	Number of Samples	Mean Density (mg/mm^3)	St. Error	Coef. Var. (percent)
1	13	1.40	.06	15.2
10–19	5	1.40	.02	2.9
20–29	14	1.40	.01	3.4
30–39	—	—	—	—
40–49	5	1.40	.01	2.2

BODY SIZE AND HONEYDEW PRODUCED

The relationship between size of the mealybugs and the amount of honeydew produced during a 24–hour period was determined by measuring the width of the mealybug and the diameter of the spherical droplets of honeydew produced. This relationship is shown in figure 3 where the amount of honeydew per mealybug is expressed in terms of volume and weight. The weights were calculated by use of the density value, 1.40 mg/ mm^3.

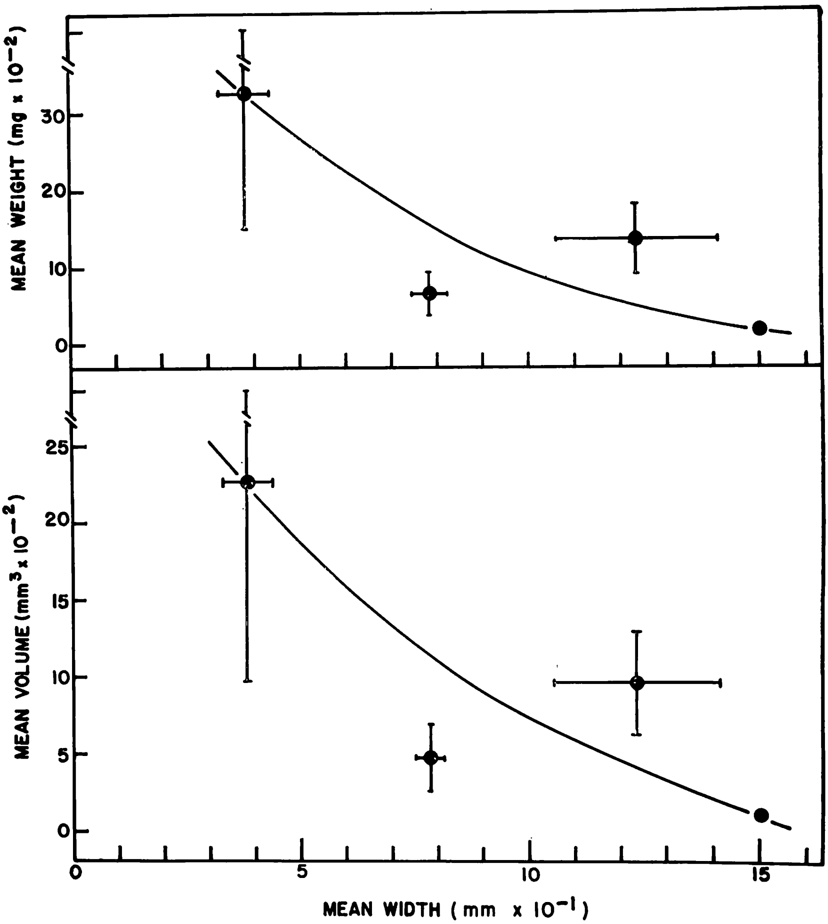

FIGURE 3.—Relationship between size and quantity of honeydew produced by *Dysmicoccus neobrevipes*. Vertical and horizontal bars at each point represent standard errors of quantity of honey dew and size of mealybug, respectively.

The data indicate that as the mealybugs grew larger they produced smaller amounts of honeydew. It is also evident that the variation, as indicated by the magnitude of the standard errors, in the amount of honeydew produced was greatest among individuals less than 0.5 mm in body width. This suggests that although honeydew production was generally high, there were inherent differences among small individuals in their ability to produce honeydew, and that this variation became smaller as the individuals grew larger.

DISCUSSION

Apparently, the chemical composition of honeydews varies for Ewart and Metcalf (1956) state that the honeydew of *Icerya purchasi* crystallizes in a few hours while that produced by other insects remains as sticky syrup. The honeydew produced by *D. neobrevipes* evidently differs from that of *I. purchasi* for no crystallization was observed. However, the density of honeydews from aphids and *D. neobrevipes* appears to be similar. Auclair (1958) reported that the density of the honeydew produced by the pea aphid was 1.3 mg/mm^3 while in the present study the value obtained for the honeydew of *D. neobrevipes* was 1.4.

The reason for the failure of a high percentage of mealybugs placed singly in cages to produce honeydew is not understood. Perhaps there was mutual stimulation among mealybugs in colonies to feed, which resulted in increased feeding and excretion rates. This explanation seems plausible in view of the work of Banks and Nixon (1958) who found that ants increased the excretion rates by stimulating the feeding activity of the bean aphid.

The literature on honeydew production leaves one with an impression that copious excretion is the rule rather than the exception. Such an impression no doubt stems from the fact that the literature contains reports on spectacular honeydew production because it is readily observable and most workers prefer to study species that produce large amounts of honeydew for practical reasons. In spite of the reports in the literature, no doubt there are species that produce very little honeydew as well as those that produce large amounts. For example, Michel (1942) found that the aphid, *Lachnus roboris* L., produced as much as 3.4 mg. of honeydew per 24 hours. In the present study the maximum production of honeydew by the best producers was found to be less than 0.5 mg. per 24 hours. Thus the relative abundance of high and low producers may be an important factor in determining the trophic level of an ecosystem of tephritid fruit flies.

In this study the amount of honeydew produced was found to decrease as the size of the mealybugs increased. Mittler (1958) and Mittler and Sylvester (1961), on the other hand, found that the quantity of honeydew produced by aphids increased with successive instars. These differences, no doubt, are related to the differences in the metabolism of the insects involved. Aphids continue to feed as they grow; the pineapple mealybugs, however, decrease feeding as they approach maturity (Ito, 1932). Beardsley (1962) also observed that the pink sugar cane mealybug withdraws the mouthparts from the host tissue and stops feeding when it becomes sexually mature. This decrease in feeding may be the cause of the decrease in honeydew production by *D. neobrevipes*.

Although comparative studies have not been made, general observations based on the amount of sticky deposition on the host plant indicate that the amount of honeydew produced by different species of mealybugs varies considerably. The mealybug used in this study appears to produce less honeydew than other species such as the sugar cane mealybug. With the procedures developed in this study comparative studies on honeydew production among different species are possible.

SUMMARY

Studies on honeydew production by the mealybug, *Dysmicoccus neobrevipes* Beardsley, which occurs abundantly on the *Yucca* plant, were conducted. There were four instars and the growth rate was linear up to about 35 days and leveled off thereafter. The density of honeydew produced was 1.4 mg/mm^3. Density determinations made by single and multiple honeydew droplets gave essentially the same value. Studies on the relationship between size of the mealybug and honeydew production indicated that, unlike aphids, the rate of honeydew production decreased with an increase in age. This decrease was attributed to decreased feeding rates as the mealybugs approached maturity.

LITERATURE CITED

AUCLAIR, J. L. 1958. Honeydew excretion in the pea aphid, *Acyrthosiphon pisum* (Harris) (Homoptera: Aphididae). JOUR. INSECT PHYSIOL. 2:330–337.

BACK, E. A. and C. E. PEMBERTON. 1917. The melon fly in Hawaii. U. S. DEPT. AGRIC. BULL. 491.

BANKS, C. J. and H. L. NIXON. 1958. Effects of the ant, *Lasius niger* L., on the feeding and excretion of the bean aphid, *Aphis fabae*. SCOP. JOUR. EXPT. BIOLOGY 35 (4) :703–711.

BEARDSLEY, J. W. 1962. Notes on the biology of the pink mealybug, *Saccharicoccus sacchari* (Cockerell) in Hawaii. (Homoptera:Pseudococcidae). PROC. HAW. ENT. SOC. 18 (1) :55–59.

ESSIG, E. O. 1942. COLLEGE ENTOMOLOGY. MacMillan Co. 900 pp. New York.

EWART, W. H. and R. L. METCALF. 1956. Preliminary studies of sugars and amino acids in the honeydew of five species of coccids feeding on Citrus in California. ANN. ENT. SOC. AMER. 49:441–447.

GRAY, H. E. and G. FRAENKEL. 1953. Fructomaltose, a recently discovered trisaccharide isolated from honeydew. SCIENCE 118:304–305.

———— 1954. The carbohydrate components of honeydew. PHYSIOL. ZOOL. 27:56–65.

GRAY, REED A. 1952. Composition of honeydew excreted by pineapple mealybugs. SCIENCE 115:129–133.

HAGEN, K. S. 1956. Honeydew as an adult fruit fly diet affecting reproduction. PROC. TENTH INTERN. CONG. ENT. 3:15–30.

HOUSE, H. L. 1961. Insect Nutrition. ANN. REV. ENT. 6:13–26.

ITO, K. 1932. Studies on the life history of the pineapple mealybug, *Pseudococcus brevipes* (Ckll.). JOUR. ECON. ENT. 31 (2) :291–198.

KAMAL, ADEL S. 1954. Ecological and nutritional studies on the cherry fruit fly. JOUR. ECON. ENT. 47 (6) :959–965.

LIPKE, H. and G. FRAENKEL. 1956. Insect nutrition. ANN. REV. ENT. 1:17–44.

MALTAIS, J. B. and J. L. AUCLAIR. 1952. Occurrence of amino acids in the honeydew of the crescent-marked lily aphid, *Myzus circumflexus* (Buck.). CANADIAN JOUR. ZOOL. 30:191–193.

MATSUMOTO, B. and T. NISHIDA. 1962. Food preference and ovarian development of the melon fly, *Dacus cucurbitae* Coquillett, as influenced by diet. PROC. HAW. ENT. SOC. 18 (1) :137–144.

MICHEL, E. 1942. Beitrage zur kenntnis von *Lachnus* (*Pterochlorus*) *roboris* L. einer wichtigen Honigtauerzeugerin an der Eiche. Z. ANGEW. ENT. 29:243.

MITTLER, T. E. 1958. The excretion of honeydew by *Tuberolachnus salignus* (Gmelin) (Homoptera:Aphididae). PROC. ROY. ENT. SOC. LONDON (A) 33:49–55.

MITTLER, T. E. and EDWARD S. SYLVESTER. 1961. A comparison of the injury to alfalfa by the aphids, *Therioaphis maculata* and *Macrosiphum pisi*. JOUR. ECON. ENT. 54 (4) :615–622.