Table 1. Summary of data on the attraction of hypopi to a volatile substance produced by pupae of *Muscina stabulans.*

Groups*	Number of observations	Average number of hypopi (±S.E.*)	Range
Exposed to light			
A. Tubes with pupae	33	30.2±5.2	10–150
B. Tubes without pupae (control)	25	3.5±0.5	0–8
Exposed to dark			
C. Tubes with pupae	19	18.8±3.4	7–64
D. Tubes without pupae (control)	16	1.3±0.4	0–5

* Significance: between groups A and B, $p < 0.001$; between groups C and D, $p < 0.001$; between groups A and C, $p > 0.1$.

within the cocoons and on the pupal case. The cocoons are mite-tight but for a few interstices through which mites can enter. Hypopi are not attracted to the prepupa within its cocoon. Less than an hour after pupation, however, they begin to cluster on the anterior end of the pupa. In moderately heavy aggregations, mites pile up three or four deep on the anterior third of the pupa (Fig. 1), while in occasional very heavy infestations they may cover the entire pupa. Those in contact with the puparium are quiescent; the others are more active and mobile. No other stage of the mite is attracted to the pupa, nor is the hypopus attracted to the food which attracts the other stages. It was the regular occurrence of these aggregates on pupae which led us to test for the presence of an attractant.

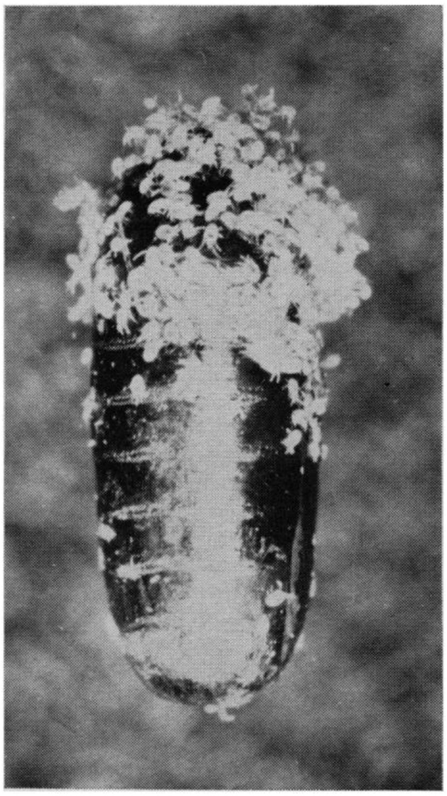

Fig. 1. Pupa of *Muscina stabulans* with hypopi typically aggregated at cephalic end.

Pupae were washed free of mites in cold running tap water, dried on paper toweling, and placed around the periphery of a piece of dry filter paper cut to fit the bottom of a 15-cm petri dish. Hypopi were taken from the medium and deposited at the center of the paper. The dish was covered and kept at 22° C and 20 percent relative humidity. The following observations are based on this method. The attractivity of individual pupae varies, but usually, after 1½ hours, about 30 to 50 hypopi collect on the anterior end of the pupa; about one-fifth as many are found on the rest of the pupa. The following factors had no effect on the polarity of attraction: age of pupae, plane of orientation, and direction or absence of light.

Pupae of several fly species maintained in our laboratory were similarly treated and placed in alternating sequence around the petri dish. Pupae of *Stomoxys calcitrans* (*7*), *Musca domestica,* and *Lucilia sericata* were attractive, and those of *Fannia canicularis* and *Drosophila melanogaster* were not. These results are confirmed by our observations of mite and fly associations in the laboratory media. Pupae of *Muscina stabulans* which were killed with cyanide gas or washed in acetone and then thoroughly air dried retained their attractivity. Those which were boiled in water or acetone for 15 minutes, rinsed several times, and thoroughly air dried had no attraction.

The volatility of the attractant was established in the following way. Plastic tubes, with an inside diameter of 7 mm, were diagonally cut at each end so that the side view had the form of a trapezoid. This provided sloping ends and maximum and minimum tube lengths of 28 mm and 8 mm, respectively. Eight pupae of *M. stabulans* were washed free of mites, dried, and placed in a tube. The tube was closed at each end with a piece of filter paper affixed with paraffin. Controls contained no pupae but were otherwise the same. Three controls and three tubes with pupae were placed alternately in the petri dish setup described above. With the aid of a dissecting microscope, hourly counts were made of mites on each end of the tube. After each count, the mites were brushed from the ends of the tubes and the tubes placed in different positions in the dish. Series of counts were recorded for both light and dark situations. The experiment was repeated three times with different pupae and tubes. The data indicate that pupae produce a volatile substance which is attractive to hypopi (Table 1). Mites are attracted as readily in the dark as in the light (*8*).

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7. Pupae of this species were generously supplied by Dr. R. C. Bushland, Agricultural Research Service, Kerrville, Tex., and Dr. L. D. Goodhue, Phillips Petroleum Co., Bartlesville, Okla.
8. This work was supported by National Science Foundation grant G9934, made to the senior author. We acknowledge with gratitude the statistical analysis prepared by Dr. Allan M. Burkman of this College, and the identification of the mite by Dr. Roscoe D. Hughes, Medical College of Virginia. The photograph was prepared by Mr. Luis de la Torre of our department.

13 July 1960

Licking Rates of Albino Rats

Abstract. Local licking rates of eight albino rats, when the rats were given tap water at the end of a short runway after 23 hours of water deprivation, averaged a little over seven licks per second. Small variations within sessions were found, rates being slightly but consistently higher at the beginning than later on in sessions. Inter-session and individual differences were also observed, but were only of the order of one lick per second. Within practical limits, it appears that licking rates of rats are constant.

When licking rates of four albino rats were measured by means of a cumulative recorder, it was reported that "the local rate of drinking an acceptable solution was constant for each animal," and that the "local rates of responding remained between five and six licks per second for all animals under all conditions" (*1*). The animals drank by licking the fluid under test from a drinking tube with a 3-mm opening. The data reported were utilized to show that local licking rate, or rate of consummatory behavior, is not a function of size of reward and hence cannot be related to other behavior variations which do accompany changes in reinforcement magnitude (*2*).

The statements about the constancy of licking rates are, however, imprecise.

In the one case licking rates are said to be *constant,* but specification of this constant is left at "between five and six licks per second." We are, then, obliged to specify more precisely the "degree" of constancy of licking rates of rats over a period of time, and also to present data, lacking in the earlier report, on variations between animals.

Four male and four female albino rats from the colony maintained by the University of Sydney were used in the experiment. The animals were approximately 180 days old at the beginning of the experiment, 5 of them being studied over a period lasting 38 days. The apparatus was an enclosed straight alley 1 m long; a drinking tube with a 4-mm opening was inserted at one end. When an animal reached this end it stood on a metal plate from which a small electric current passed through the rat whenever its tongue touched the tap water in the tube. This current was amplified to activate a Both polygraph which recorded tongue laps on a paper moving at 5 cm/sec. Before each test the animals were deprived of water for approximately 23 hours. The experimental room was air-conditioned, and the temperature was maintained between 81° and 83°F.

As in earlier studies (*1, 3*) the animals engaged in alternate bouts of licking and resting. Figure 1*a* shows the distribution of mean local rates of licking for all eight animals over a period of 5 successive days. Each animal was left in the apparatus for 5 minutes and permitted to drink or explore freely. The data shown in Fig. 1*a* were computed by dividing the total number of licks made by each animal in a session by the total time spent licking in that session. Intrasession variability data are presented in Fig. 1*b* in the case of two males. These graphs are based upon the licking rates of the animals in each run of licks lasting 1 second or longer. Thus rat M4 engaged in 24 bouts of licking lasting at least 1 second, and rat M1 licked for at least this time on 13 occasions, and the rates in each session ranged from 6.0 to 7.8 and 6.0 to 7.0 licks per second for rat M4 and rat M1, respectively. For both animals the fastest rates occurred near the beginnings of the sessions. The two fastest rates for rat M4, 7.8 and 7.6 licks per second, were the rates of its first two bouts of licking. The fastest rates for rat M1 were on its second and third licking runs.

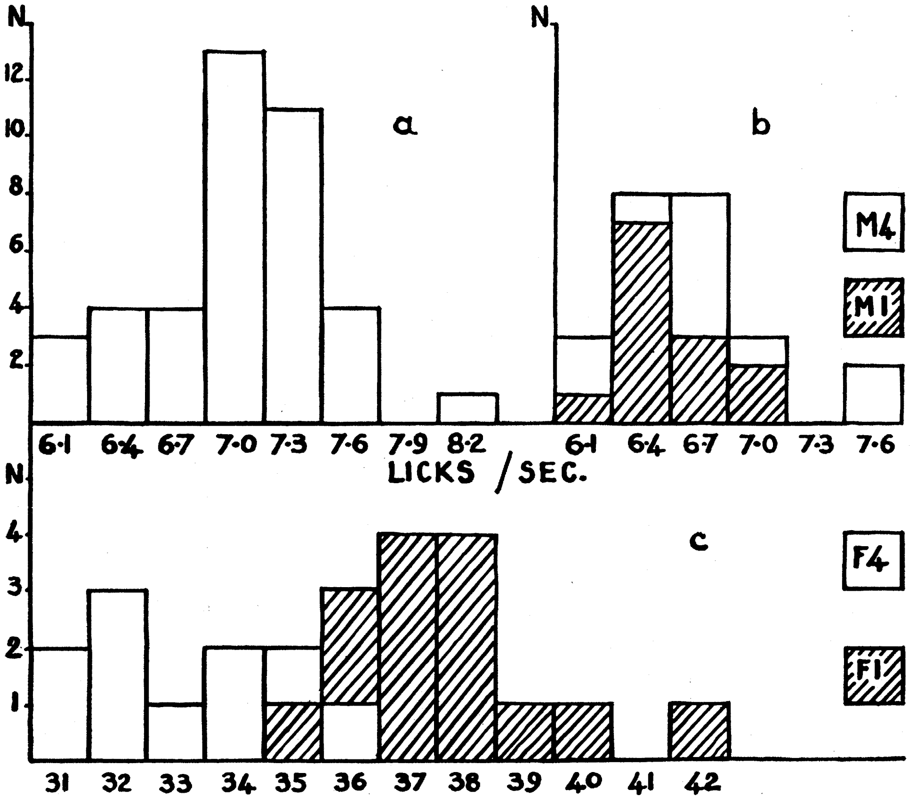

Fig. 1. (*a*) Distribution of mean licking rates of eight animals over five successive daily drinking sessions. (*b*) Distribution of licking rates of two animals during a single drinking session lasting 5 minutes. Mean licks per second were computed from each bout of sustained licking lasting 1 second or longer. (*c*) Distribution of licking rates of two animals computed by counting the number of licks in 5-second periods chosen from portions of records obtained over five successive daily sessions.

The above data include all the tongue laps made by the animals in the particular sessions. They incorporate a slight degree of error because some records were not clear enough to allow accurate counts to be made throughout their length. To remedy this and to check on the possibility that systematic variations occurred from the beginning to the end of each session, the records were examined by counting the number of licks made in 5-second periods in clear parts of the beginning, middle, and end of each record.

Of 76 complete triplets so obtained from all eight animals over 5 successive days, and from five of the animals on nine other occasions spaced irregularly over a period of 23 days, the number of responses made in the 5-second period taken from the beginning of the record was larger than the number in the final period on 59 occasions, equal to it 9 times, and smaller only 8 times. These data are highly significant and show that licking rates are faster at the beginning than at the end of sessions. However, the absolute difference is small. Averaged across all animals from the total 76 triplets, the rate dropped from 7.67 licks per second at the beginning to 7.14 licks per second at the end of the sessions.

The distributions of licks per 5-second period for the extreme animals are shown in Fig. 1*c*. The mean rate over all sessions ranged from 6.64 licks per second for rat F4 up to 7.52 for rat F1. The difference between licking rates of these two animals is statistically significant ($p < .001$). The mean licking rate for all the animals in the first 5 days of the experiment was 7.03 licks per second. The mean licking rate derived from 43 samples of 5-second licking periods of five animals after about a month's training was 7.52 licks per second. Hence there is little variation in licking rate over time, and the licking rate of just over 7 licks per second is a little higher than that reported by Davis and Keehn (*1*). This difference might be due to the difference in drinking tube aperture, 3 mm versus 4 mm, in which case the volume of fluid obtained per lick might affect rates of licking, or it might be a function of strain differences, or it might result from the different recording techniques used in the two experiments.

In summary, the licking rate of rats when they drink is not *absolutely* constant, although variations are small. Rates of lapping vary within sessions and between sessions for individual animals, and between animals, in a consistent way. However, these variations are extremely small compared with those found along other dimensions of behavior. The fastest and slowest drinkers in the present sample differed by less than 1 lick per second, on the average, and individual variability was of the same order of magnitude (*4*).

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23 May 1960

Some Moral and Technical Consequences of Automation—A Refutation

Abstract. The machine is not a threat to mankind, as some people think. The machine does not possess a will, and its so-called "conclusions" are only the logical consequences of its input, as revealed by the mechanistic functioning of an inanimate assemblage of mechanical and electrical parts.

In an article entitled "Some moral and technical consequences of automation" (*1*), Norbert Wiener has stated some conclusions with which I disagree. Wiener seems to believe that machines *can* possess originality and that they *are* a threat to mankind. In ascribing a contrary opinion to the man in the street—to wit, "that nothing can come out of the machine which has not been put into it"—he overlooks or ignores the fact that there is a long history of the acceptance of this more reassuring view by scientific workers in the field, from the time of Charles Babbage to the present (*2*). Apparently Wiener shares some of the lack of understanding which he ascribes to the public, at least to the extent that he reads implications into some of the recent work which the workers themselves deny.

It is my conviction that machines cannot possess originality in the sense implied by Wiener and that they cannot transcend man's intelligence. I agree with Wiener in his thesis that "machines can and do transcend some of the limitations of their designers, and that in doing so they may be both effective and dangerous." The modern automobile travels faster than its designer can run, it is effective, and the records of highway fatalities attest to the dangerous consequences. However, a perusal of Wiener's article reveals that much more than this is meant, and it is to this extension of the thesis that I wish to take exception.

Wiener's reference to the "Sorcerer's Apprentice," and to the many tales based on the assumption that the agencies of magic are literal-minded, might almost lead one to think that he attributes magic to the machine. He most certainly seems to imply an equality between man and the machine when he states "disastrous results are to be expected not merely in the world of fairy tales but in the real world wherever two agencies essentially foreign to each other are coupled in the attempt to achieve a common purpose." In relationships between man and a machine the machine is an agency, but only an agency of man, entirely subservient to man and to his will. Of course, no one will deny that "we had better be quite sure that the purpose put into the machine is the purpose which we really desire and not merely a colorful imitation of it." If we want our house to be at 70°F when we get up in the morning, we had better set the thermostat at 70° and not at 32°. But once the thermostat is set at 70° we can go to sleep without fear that the genie in the furnace controls might, for some reason of his own, decide that 32° was a better figure. In exactly the same way and to the same degree we must anticipate our own inability to interfere when we instruct a modern digital computer (which works faster than we do) and when we instruct a thermostat (which works while we sleep).

Wiener's analogy between a machine and a human slave is also quite misleading. He is right in his assertion that "complete subservience and complete intelligence do not go together" in a human slave with human emotions and needs and with a will of his own. To ascribe human attributes to a machine simply because the machine can simulate some forms of human behavior is, obviously, a fallacious form of reasoning.

A machine is not a genie, it does not work by magic, it does not possess a will, and, Wiener to the contrary, nothing comes out which has not been put in, barring, of course, an infrequent case of malfunctioning. Programming techniques which we now employ to instruct the modern digital computer so as to make it into a learning machine *do not* "remove from the mind of the designer and operator an effective understanding of many of the stages by which the machine comes to its conclusions." Since the machine does not have a mind of its own, the "conclusions" are not "its." The so-called "conclusions" are only the logical consequences of the input program and input data, as revealed by the mechanistic functioning of an inanimate assemblage of mechanical and electrical parts. The "intentions" which the machine seems to manifest are the intentions of the human programmer, as specified in advance, or they are subsidiary intentions derived from these, following rules specified by the programmer. We can even anticipate higher levels of abstraction, just as Wiener does, in which the program will not only modify the subsidiary intentions but will also modify the rules which are used in their derivation, or in which it will modify the ways in which it modifies the rules, and so on, or even in which one machine will design and construct a second machine with enhanced capabilities. However, and this is important, the machine *will not* and *cannot* do any of these things until it has been instructed as to how to proceed. There is (and logically there must always remain) a complete hiatus between (i) any ultimate extension and elaboration in this process of carrying out man's wishes and (ii) the development within the machine of a will of its own. To believe otherwise is either to believe in magic or to believe that the existence of man's will is an illusion and that man's actions are as mechanical as the machine's. Perhaps Wiener's article and my rebuttal have both been mechanistically determined, but this I refuse to believe.

An apparent exception to these conclusions might be claimed for projected machines of the so-called "neural net" type. These machines were not mentioned by Wiener, and, unfortunately, they cannot be adequately discussed in the space available here. Briefly, however, one envisions a collection of simple devices which, individually, simulate the neurons of an animal's nervous system and which are interconnected by some random process simulating the organization of the nervous system. It is maintained by many serious workers that such nets can be made to exhibit purposeful activity by instruction and training with reward-and-punishment routines similar to those used with young animals. Since the internal connections would be unknown, the precise behavior of the nets would be unpredictable and, therefore, potentially dangerous. At the present time, the largest nets that can be constructed are nearer in size to the nervous system of a