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The floral biology of cacao. 1. Attractants and food substances for adult midges[1]

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Abstract

Hypothesis that such compounds as butyric acid, amyl acetate, propionic acid, gerániol, hydrolized protein, ethyl alcohol, eugenol methyl ether, anethol U.S.P., eugenol U.S.P. extra, trimed-lure and sugar cane molasses were efficient as adult midge attractants were rejected after field tests in cacao plantations in Turrialba, Costa Rica.

New approaches of research such as fractional analysis of flower tissues are consequently proposed to find out the kind of compounds that are involved in attracting the midges to the cacao flowers. This method replaces that of random choice of chemicals which proved efficient for dipterans of other families but not for ceratopogonid midges.

Key words: Forcipomyia midges Floral biology Attractants *Theobroma cacao*

A biologia floral do cacaueiro: testes de atratividade para *Forcipomyia* no campo

Resumo

Ácido butírico, acetato de amila, ácido propiônico, geraniol, proteína hidrolizada e melaço de cana foram ensaiados em armadilhas de pavio para testar a hipótese de que as mosquinhas *Forcipomyia* são atraídas por estes produtos. Num segundo ensaio, os produtos ether metílico de eugenol, anethol U.S.P., eugenol U.S.P. extra, geraniol, trimedlure, proteína hidrolizada e sucrose foram ensaiados com o mesmo propósito.

Os resultados, em ambos os ensaios, indicaram que os produtos testados não foram atrativos para as mosquinhas *Forcipomyia*. Ceratopogonídeos de outros gêneros, que não *Forcipomyia*, foram encontrados em números pequenos nas armadilhas com sucrose e melases. Drosophilideos foram os dípteros capturados em maior número, representando 23,8% da população capturada.

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Para determinar compostos envolvidos na atração das mosquinhas pelas flores do cacaueiro sugere-se utilizar métodos mais objetivos, tais como a análise química fracionada dos compostos existentes nos diferentes tecidos da flor, particularmente os tecidos que integram as arestas internas dos èstaminóides e as chamadas linhas-guias, que são os tecidos específicos procurados pelas mosquinhas *Forcipomyia*.

Palavras-chave: Forcipomyia midges Biologia floral Atraentes *Theobroma cacao*.

Introduction

Hernandez (1965) noted an apparent attraction of *Forcipomyia* midges to 20% sucrose solutions in laboratory studies. No other record could be found regarding *Forcipomyia* responses to attractants. It is known that various insect species respond quite differently to different compounds and therefore the reaction of *Forcipomyia* midges to several possible attractants was tested in preliminary trials.

Literature Review

This review examines the evidence that midges visit flowers in search of food substances.

Hernandez (1965) tested several kinds of diets for keeping *Forcipomyia* adults alive inside small individual cages. When midges were supplied with small discs of white filter paper soaked in 20% sucrose solution, their longevity was similar in tests with unpainted discs and in tests with discs painted to resemble the pigmented parts of the cocoa flower. Painted discs soaked in a water extract of the staminodes did not render them specially attractive to the midges. However, Hernandez noted that those filter paper discs imitating staminodes were visited sooner by the midges than unpainted discs.

They always preferred discs containing 20% sucrose solution. This fact suggested to Hernandez (1965) the idea that midges visit cacao flowers looking for some kind of specialized food.

Based upon the knowledge that midges look for the staminodes and guide lines in the flowers, it seems practical to propose a biochemical fractional analysis using gass chromatography techniques, to find out which compounds are present in these tissues and which of these are active as attractants to the midges.

Shimoya (1965) dissected the staminodes and found each one to be a trilobed body consisting of parenchyma surrounded with epidermis, a vascular axis at its center and vacuum spaces at both sides.

Taylor* (personal communication, 1966) found in a series of microtome dissections of cacao flowers the same characteristics as described by Shimoya (1965) regarding the vacuum spaces and in addition found simple glandular hairs in most of the floral parts. But he believes that these vacuum spaces really contain some resinous or mucilaginous substance of an unknown chemical nature. These details are important in the analyse of the insect/host relationship between flowers and *Forcipomyia* midges. It is thought in the present

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report that the resinous or mucilaginous substance existing in the staminodes might secrete attractive odors for *Forcipomyia* midges. Midges probably visit the cacao flowers looking for some food source.

The colour of cacao flowers was thought to exercise an influence in attracting midges toward the flowers. Posnette (1950) expressed the opinion that the cacao flower is ideally constructed for pollination by *Forcipomyia* midges, since "they appeared to be attracted by the deeply pigmented tissue of the staminodes which surrounds the style and by the "guide lines" which run inside of the petal hood from the base of the ovary to the anthers". This hypothesis was rejected when information was obtained comparing natural pollination in albino versus coloured flowers. Pollination was equaly efficient in both kinds of flowers (Soria, 1970).

Material and Methods

The materials tested in the field in 1967 included sugar cane mollases, butyric acid, amyl acetate, propionic acid, geraniol, and hydrolized protein, all diluted to 50% concentration. Water and ethyl alcohol, the solvents for the above compounds, were included as checks.

To release the attractant and catch insects that might be attracted, traps were constructed by inserting the mouth of 20 cm diameter funnels (with inner surfaces covered with tanglefoot) into 50 ml erlenmeyer flasks. Forty ml of the attractant solution was placed in the flask and a cotton wick was inserted into the solution with the upper end about 5 cm into the funnel (Figura 1).

Individual traps for each attractant were placed at random in trees containing considerable numbers of flowers in the Pejivallal cacao plantation near Turrialba. Traps were left in the field for one week during the three-week sampling period from August 13 to September 3, 1966. Each attractant

Figure 1 – Trap used for attracting *Forcipomyia* midges at Pejivallal plantation. Turrialba, Costa Rica. 1966.

was tested once in each of three locations. Twice a week, while attractants were renewed in the field, all insects trapped in the tanglefoot were removed and identified with the aid of a hand lens.

In April, 1969, specially made bottles were used for testing seven chemicals as attractants for *Forcipomyia* midges at the Pejivallal plantation. The bottles were 16 cm high by 16 cm in diameter, with a rised opening on the underside (Figura 2). A 5% concentration of each of the following chemicals was used: Eugenol Methyl Ether, Anethol U.S.P., Eugenol U.S.P. Extra, Garaniol, Tri-med-lure, Hydrolized Protein and Sucrose.

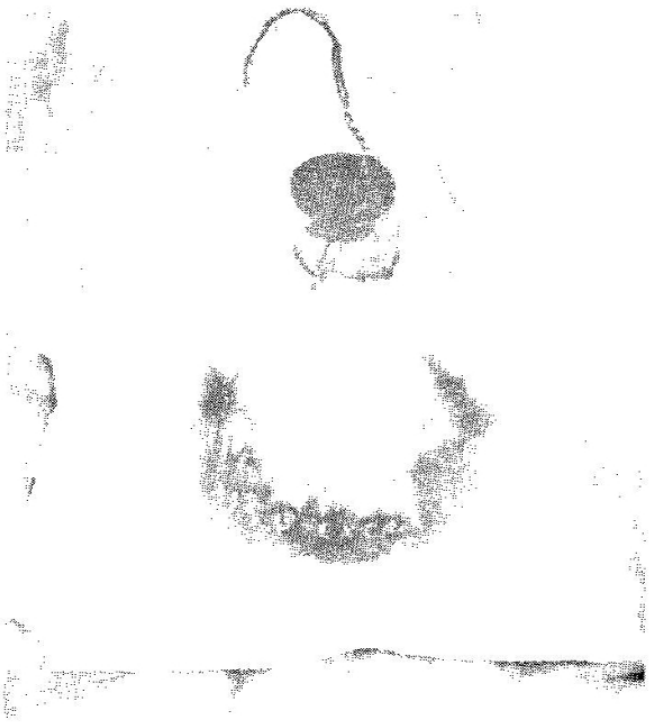

Figure 2 -- Trap used for attracting *Forcipomyia midges* at Pejivallal cacao plantation, Turrialba, Costa Rica. 1969.

Results and Discussion

Ceratopogonid midges represented 4.6% of the total of dipterans captured in the traps (Table 1). In no case, however, was any *Forcipomyia* pollinator midge caught in the traps. Drosophilidae were the most numerous dipterans representing 23.8% of the total population captured. A brief sampling at San Isidro del General, Costa Rica, showed greater numbers of Ceratopogonids in the tanglefoot of the traps than at Turrialba, but again no pollinators were caught.

Of the attractants tested, sugar cane mollases showed the strongest attraction for most of the dipterans. The fact that no pollinator *Forcipomyia* midges could be found in the traps suggested that more specific attractants are needed for them. Knowledge of the specific diets for *Forcipomyia* midges is greatly needed for planning studies of attractiveness.

Species identification of the collected samples was difficult because of the trouble of handling the tiny midges imbedded in the tanglefoot. It is believed that the trap design was inefficient and a different type might result in more efficient attraction to the sample compounds.

Results proved negative regarding trapping of *Forcipomyia* midges in test of April, 1969 (Table 2). The sampling was fortunate on the other hand in finding Eugenol U.S.P. Extra to be a highly specific attractant for Euglossini, a neotropic subtribe of bees with a long proboscis, that pollinate ordhids (Vogel, 1966, and Dodson, 1969). One hundred and eighty-five bees were collected in two trials with the attractant.

It was concluded that studies on attractants for *Forcipomyia* midges

Table 1 - Diptera caught in tanglefoot covered funnel-traps baited with various attractants. Turrialba, Costa Rica. August 13 - September 3, 1966.

Attractants	No. of Diptera trapped [a]							
	Miscell-aneous	Cyclo-rrapha	Simuli-dae	Chirono-midae	Psycho-didae	Ceratopo-gonidae	Culi-cidae	Total
Sugar-cane mollases	6	26	0	0	5	2	0	40
Butyric Acid	19	5	8	2	0	4	1	39
Amyl Acetate	11	13	4	5	1	1	1	36
Propionic Acid	10	7	4	3	0	2	0	26
Geraniol	11	3	3	1	2	1	3	24
Hydrolized Protein	10	9	3	0	2	0	0	24
Ethyl Alcohol	7	2	4	1	0	0	0	14
Water	2	4	4	1	0	0	0	11
Total	76	70	30	13	10	10	5	214

[a] Mean from 6 counts.

Table 2 - Numbers of different insects caught in traps baited with various attractants. Pejivallal, Turrialba, Costa Rica. April 4 - April 16, 1969.

Chemical tested	No. of specimens collected in each group								
	Brachicera	Nematocera	Clyptogastra	Calastogastra	Coleoptera	Orthoptera	Lepidoptera	Homoptera	Thysanoptera
Eugenol Methyl Ether	19	15	1	7	45	1	0	1	14
Anethol U.S.P.	32	10	0	0	3	2	1	0	18
Eugenol U.S.P. Extra	29	1	1	185	7	0	2	0	1000
Geraniol	41	5	12	0	5	0	0	2	35
Tri-med-lure	9	7	1	1	0	0	2	0	0
Hydrolized Protein	16	0	35	0	0	0	0	0	0
Sucrose	22	0	5	4	0	0	0	0	0

should be approached from a new angle. Midges are highly attracted to the flowers during pollination suggesting the presence of luring substances. It might be more profitable to isolate various aromatic substances from the cacao flower by some type of fractional analysis and test the resultant fractions for their ability to attract *Forcipomyia* pollinators.

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