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THE SUITABILITY OF VARIOUS TYPES OF DUNG AND VEGETABLE MATTER AS LARVAL BREEDING MEDIA FOR *STOMOXYS CALCITRANS* L. (DIPTERA: MUSCIDAE)

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ABSTRACT

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The dung of 7 species of domestic animals, 4 plant materials, standard larval breeding medium and 3 mixtures of some of these materials were evaluated as breeding media for *Stomoxys calcitrans* larvae.

S. calcitrans could not breed in pure chicken dung or in either of the 2 types of sawdust tested, but *Pinus* spp. sawdust plus chicken dung proved an excellent breeding medium. Of the other media tested, *Pennisetum* spp. clippings were the least favourable for the development of *S. calcitrans* larvae.

None of the media had any effect on the sex ratio of the adults that were cultured or on the viability of their eggs.

Résumé

CONVENANCE DE DIVERS TYPES DE CROTTIN ET MATIÈRES VÉGÉTALES COMME MILIEU DE CULTURE POUR LES LARVES DE STOMOXYS CALCITRANS *L. (DIPTERA: MUSCIDAE)*

On a déterminé la valeur, comme milieu de culture pour larves de Stomoxys calcitrans, *du crottin de 7 espèces d'animaux domestiques, de matières végétales de 4 sortes différentes, du milieu de culture standard et de 3 mélanges de certains de ces composants.*

S. calcitrans *ne se développe ni dans du crottin de poule pur ni dans aucune des 2 espèces de sciure de bois essayées, mais le mélange de crottin de poule et de sciure de* Pinus *spp. s'est avéré un excellent milieu de culture. Des autres milieux qu'on a essayés, les fragments de* Pennisetum *spp. ont été les moins favorables au développement des larves de* S. calcitrans.

Aucun de ces milieux n'a eu un effet quelconque sur la sex-ratio des adultes en élevage ou sur la viabilité de leurs oeufs.

INTRODUCTION

Stomoxys calcitrans can breed in a great variety of media. Most workers refer to organic matter such as dung (Fuller, 1913; Bishopp, 1918; Thomsen, 1934; Hafez & Gamal-Eddin, 1959; Anderson & Poorbaugh, 1964; Hummadi & Maki, 1970; La Brecque, Meifert & Weidhaas, 1972); mixtures of decaying, urine-soaked dung and vegetable matter around animal feeding and drinking troughs or used as bedding (Newstead, 1906; Parr, 1962; Smit, 1964; Todd, 1964; Wang & Gill, 1970; Monty, 1972; Du Toit, 1974; Kunz & Monty, 1976; Howell, Walker & Nevill, 1978); or even accumulations of dead mayflies, *Hexagenia bilineata* (Say.) (Pickard, 1968). Sometimes vegetable matter is utilized. Ware (1966), for example, reported it breeding in lawn clippings and Hafez & Gamal-Eddin (1959) found it breeding in a mixture of sand and vegetable debris moistened by liquid dripping from an injury on the trunk of an adjacent *Eucalyptus* tree. Hafez & Gamal-Eddin (1959) described suitable larval breeding media for *S. calcitrans* as being loose porous material with a high moisture content and moderate internal temperature, preferably lying in shady places in warm regions.

Since the larval breeding medium serves as the habitat as well as the food source for the developing larval stages, a variety of biotic and abiotic factors may affect its suitability for *S. calcitrans*. The investigations described below were aimed at measuring the nutritional value of different larval breeding media under constant environmental conditions.

MATERIALS AND METHODS

The media

The kikuyu grass clippings (*Pennisetum* spp.) used in this experiment were freshly mown and dried at room temperature prior to use. The veld grass (*Paspalum dilatatum*) consisted of wet, freshly cut shoots, which were cut into 20 mm lengths and left to ferment for a week at room temperature in a glass jar covered with muslin. The meranti sawdust (*Shorea* spp.) was collected locally at a carpentry shop, while the pine sawdust (*Pinus* spp.) came from a nearby sawmill. Both types of sawdust were kept at room temperature for a week before use.

All the dung used was freshly collected from animal pens. Water was added to the dry types of dung to prevent desiccation of the test insects.

The breeding experiments

All the experiments, in which glass jars with a volume of 180 ml for larval breeding were used, were performed in an incubator room at 27 °C (±1°), 60–80% relative humidity, and a photoperiod with an 8-hour light and 16-hour dark cycle. The jars were filled with the respective test media and then covered with fine muslin squares secured by elastic bands to prevent contamination by other flies. Water was carefully added to any of the media that had started to dry out. Care was taken not to reduce the available oxygen by not pressing the media too tightly into the jars. When the breeding medium consisted of dung only, it was prepared from a mixture of samples from several animals belonging to the same species.

Eggs were collected in large batches at half-hourly intervals from oviposition dishes exposed in a standard *S. calcitrans* stock colony (Sutherland, 1978), pooled, and then placed in batches of 50 on 225 mm² squares of wet filter paper. One of these squares was then placed on top of the breeding medium in each jar. Forty-eight hours later the filter paper squares were carefully removed from the breeding jars and the hatching rate of each batch of eggs was determined under a stereoscopic microscope.

The development of the immature stages in each of the breeding jars was inspected daily and the adults that had emerged were removed, sexed and counted. After eclosion of the last adult in a particular breeding jar, the jar was left for 14 days, when the medium was carefully inspected and all pupae or pupal casings were collected and counted. When pupae had not moulted, they were opened with a dissecting needle and death confirmed by examination.

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If no live adults emerged from a particular type of dung the experiment was repeated with a 1:1 mixture of the dung and pine sawdust. The suitability of the various breeding media is expressed in terms of the mortality rates of the various immature stages. *Larval mortalities* from all the treatments were taken as the percentage of 1st instar larvae that did not reach the pupal stage, while *pupal mortalities* were based on the percentage of actual formed pupae that did not emerge. *Total immature mortalities* for all the treatments were calculated by subtracting the number of live adult flies from the number of 1st instar larvae that were present at the beginning of a specific experiment.

All the breeding media were evaluated for their acceptability to *S. calcitrans* as egg-laying media. Cages containing gravid females were each provided with a single Petri-dish filled with a particular type of breeding medium for a day and these were carefully inspected for eggs. The presence of any eggs in a dish was taken as an indication that that specific medium was not totally unacceptable to *S. calcitrans*.

Large numbers of *S. calcitrans* were bred in each of the media that had been found acceptable for egg laying. About 400–500 eggs were placed in 2ℓ glass jars which were filled with the acceptable breeding media, covered with fine muslin squares secured by elastic bands, and kept in the incubator room till emergence of the adults. The adults from each medium were caged separately in 0,027 m³ gauze cages and provided daily with citrated cattle blood and an oviposition dish (Sutherland, 1978). For each group of flies the egg viability was determined by transferring large mixed batches of eggs on to wet filter paper in Petri-dishes, keeping these in the incubator room for 48 hours, and counting the larvae that had emerged.

All experiments were repeated 3 times, then an ordinary analysis of variance was done on all the experimental data for a one-way classification model in which all the observations were independent of each other and an F-value was calculated for significance or non-significance between the various treatments. Bonferroni's multiple comparison procedure (Miller, 1966) was used to calculate the least significant differences between each possible pair of treatments.

Results

In the following discussion differences at the 99% probability level (P=0,01) will be referred to as very significant and at the 95% probability level (P=0,05) as significant.

The mean mortality rates of the different developmental stages of *S. calcitrans* on various dung types, vegetable matter and mixtures thereof are listed in Table 1. None of these larval breeding media were repellent to gravid *S. calcitrans* as egg-laying media, nor did they exert any marked effects, via the immature stages, on the sex ratio of the adults or on the viability of the eggs they produced.

Meranti (*Shorea* spp.) and pine sawdust (*Pinus* spp.) and pure chicken dung were unsuitable as larval breeding media. In both types of sawdust the larvae died during the 1st larval instar, and in pure chicken dung they did not survive beyond the 3rd instar. The addition of 50% pine sawdust to the latter turned it into an excellent breeding medium for *S. calcitrans* larvae. The addition of 50% sawdust to pig dung had no significant effect on the suitability as larval breeding medium of this type of dung.

TABLE 1 The suitability of various materials as larval breeding media for *Stomoxys calcitrans*

Material	Mean larval mortality (%)	Mean pupal mortality (%)	Mean immature mortality (%)
DUNG			
Cattle (adult)	39,0	10,4	45,2
Cattle (unweaned calf)	29,6	1,5	31,0
Chicken	Larvae died during 3rd larval instar		
Donkey	4,5	13,3	17,0
Goat	23,3	12,5	32,5
Horse	25,1	10,6	32,9
Pig	9,5	6,1	15,1
Sheep	19,1	13,2	30,1
PLANT MATERIAL			
Kikuyu grass clippings (*Pennisetum* spp.)	82,9	45,2	90,4
Meranti sawdust (*Shorea* spp.)	Larvae died during 1st larval instar		
Pine sawdust (*Pinus* spp.)	Larvae died during 1st larval instar		
Veld grass (*Paspalum dilatatum*)	8,9	6,1	14,4
STANDARD LARVAL* BREEDING MEDIUM	15,0	13,9	27,0
MIXTURES			
Chicken dung+pine sawdust (1:1)	14,4	5,3	18,8
Pig dung+pine sawdust (1:1)	8,5	2,5	10,7
Standard Larval Breeding Medium*+pine sawdust (1:1)	12,7	9,9	20,7

* Chopped dried lucerne 800g+soft wheat bran 200g+water 2 000 mℓ

Larval mortality

No significant differences were observed between the survival rates of larvae reared on dung from adult cattle and those from unweaned domestic calves. Donkey dung proved to be a significantly better larval breeding medium than dung from adult cattle. Kikuyu grass clippings (*Pennisetum* spp.) formed a significantly poorer breeding medium than any of the media in which *S. calcitrans* larvae were able to develop.

Pupal mortality

Pupal mortalities were very significantly higher on kikuyu grass clippings than on the dung of unweaned domestic calves. Pupae originating from larvae reared on kikuyu grass clippings also had significantly higher mortality rates than those originating from mixtures of 50% chicken dung+50% sawdust and 50% pig dung+50% sawdust, also on pure pig dung or veld grass (*Paspalum dilatatum*).

Total immature mortality

The immature stages of *S. calcitrans* suffered very significantly higher mortality rates when kikuyu grass clippings formed the larval breeding medium than on any of the media that were nutritious enough to yield viable adult stable flies.

Discussion

Neither Du Toit (1974) nor the writer recorded the duration of the various developmental stages. It is a factor which depends to a great extent on the temperature conditions inside the larval breeding media, and these in turn are related to the water content and fermentation rates of the media. Neither

the temperature nor the humidity of any of the larval breeding media is thought to have had any lethal effect on the test insects as these 2 abiotic factors were to some extent controlled during this investigation.

The failure of *S. calcitrans* to breed in pure chicken dung could have been due to the effects of the pH, nutritive value or available oxygen of this medium. According to Sturkie (1976), however, the pH-value of chicken dung is 7,1, which excludes the pH as a limiting factor since 7,1 falls within the pH-tolerance range of *S. calcitrans* larvae (Sutherland, unpublished data). The fact that *S. calcitrans* can breed in a mixture of sawdust and chicken dung rather suggests that pure chicken dung is too dense and that the larvae consequently suffer from lack of oxygen rather than malnutrition on this breeding medium. This emphasizes the importance of the physical nature of the larval breeding medium, as stated by Hafez & Gamal-Eddin (1959). It also suggests that Anderson & Poorbaugh (1964) and La Brecque *et al.* (1972) based their observations on accumulations of contaminated chicken dung. It should be noted, though, that the amount of oxygen available in the larval breeding medium has only a limited effect since the addition of equal parts of sawdust to pig dung or to standard larval breeding medium (lucerne 800g, soft wheat bran 200g plus water 2 000 mℓ) had no significant effect on the suitability of these materials.

Nutrition may act as a limiting factor during the development of immature *S. calcitrans* and this inhibiting effect may be transferred from one stage to another. This conclusion is supported by the fact that the mortality rates of the various immature stages differ on a breeding medium of kikuyu grass clippings. The mortality rates of the larvae were higher on this medium than on most of the other media and the pupae also suffered higher mortalities than some of the pupae reared on other media. This suggests that poor larval nutrition may result in the death of the insect during the pupal stages. Du Toit (1974) also showed that a poor quality larval medium produces undersized pupae with lower eclosion rates. It is doubtful whether larval nutrition has any effect on the life history of the adults once these have emerged as none of the media tested produced any marked differences in the sex ratios of the adults or in the viability of their eggs. Du Toit (1974) also proved that the larval breeding media had no effect on the egg viabilities of the adults bred on them.

Although kikuyu grass clippings were as suitable as any other media for oviposition, they formed the least suitable larval breeding medium, yielding only low numbers of fertile adult stable flies. This, however, does not completely exclude the possibility that fermenting accumulations of this material may act as natural breeding sites for stable flies under urban conditions.

It may be concluded that *S. calcitrans* is adapted to utilize various mixtures and types of fermenting organic materials as larval breeding media, provided that the abiotic factors in their habitat are tolerable.

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