STUDIES ON
THE FLIES PRODUCING CUTANEOUS MYIASIS IN DOMESTIC ANIMALS IN TRICHUR

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled STUDIES ON THE FLIES PRODUCING CUTANEOUS MYIASIS IN DOMESTIC ANIMALS IN TRICHUR is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

H. SUBRAMANIAN

Mannuthy,

29-7-1978.

CERTIFICATE

Certified that this thesis, entitled

STUDIES ON THE FLIES PRODUCING CUTANEOUS MYIASIS IN DOMESTIC ANIMALS IN TRICHUR is a record of research work done by Shri.H.Subramanian under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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29-7-1978.

PLATE I *Chrysomyia bezziana* (adult female fly)

PLATE I

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LIST OF TABLES

LIST OF PLATES

Fig. 3. Second larval moulting - showing the development of cephalopharyngeal skeleton of the third stage.
Fig.4 Second larval moulting - showing the development of posterior spiracle of the third stage.

PLATE X — Chrysomyia megacephala

Fig. 1 Cephalopharyngeal skeleton of second stage larva.
Fig. 2 Posterior spiracle of second stage larva.

PLATE XI — Chrysomyia megacephala

Fig. 1 Cephalopharyngeal skeleton of mature larva.
Fig. 2 Posterior spiracle of mature larva

PLATE XII — Chrysomyia megacephala

Fig. 1 Body spines of mature larva
Fig. 2 Fly development inside the pupa
Fig. 3& 4 Process of fly emergence.

PLATE XIII — Chrysomyia megacephala

Fig.1-4 Process of fly emergence, unfolding of wings and development of normal colour.

PLATE XIV — Chrysomyia rufifacies

Fig. 1 Adult fly
Fig. 2 Mature larvae
Fig. 3 Puparium

PLATE XV — Chrysomyia rufifacies

Fig. 1 Cephalopharyngeal skeleton of second stage larva.
Fig. 2 Posterior spiracle of second stage larva
Fig. 3 Second larval moulting - showing the development of posterior spiracle of the third stage.
Fig. 4 Second larval moulting - showing the development of body papillae with spines of the third stage.

PLATE XVI — Chrysomyia rufifacies

Fig. 1 Cephalopharyngeal skeleton of mature larvae
Fig. 2 Posterior spiracle of mature larva

PLATE XXVII — Sarcophaga ruficornis

Fig. 1 Cephalopharyngeal skeleton of second stage larva.

Fig. 2 Posterior spiracle of second stage larva.

PLATE XXVIII — Sarcophaga ruficornis

Fig. 1 Cephalopharyngeal skeleton of mature larva.

Fig. 2 Posterior spiracle of mature larva

PLATE XXIX — Sarcophaga ruficornis

Fig. 1 First larval moulting - showing the development of cephalopharyngeal skeleton of the second stage.

Fig. 2 Second larval moulting - showing the development of cephalopharyngeal skeleton of the third stage.

Fig. 3 Second larval moulting - showing the development of posterior spiracle of the third stage.

Fig. 4 Second larval moulting - cuticle sheading of the larva along with cephalopharyngeal skeleton and posterior spiracle

PLATE XXX — Sarcophaga ruficornis

Fig. 1 Fly development inside the pupa

Fig. 2 & 3 Process of fly emergence and unfolding of wings.

INTRODUCTION

INTRODUCTION

Insects nurture and protect us, sicken us and kill us bringing both joy and sorrow and drive us from fear to hate, then to tolerance. It is a common place where insects are the chief competitors with man for the domination of this planet. Insect destroy man's growing crops, defoliate his forests, spread nearly all the great epidemic feveres of the tropics and subtropics and some of the most fatal infectious diseases of livestock.

India having the largest cattle population in Asia is not standing behind in having diseases also. Parasitic diseases play a very important role in affecting the cattle wealth of our country. Among the parasitic diseases Arthropod pests have greater importance since they not only produce economic loss by morbidity and mortality of animal population but also desseminate disease between animals and man creating public health problems.

Some of the fatal diseases have been tackled by our advancing knowledge in science and improved control techniques, while the rest have not received adequate attention. Of the major arthropod diseases "MYIASIS" is one such, affecting a major part of our animal population. Myiasis is defined as the infestation of live human and vertebrate animals with dipterous larvae which at least for a certain

period, feed on the hosts dead or living tissue, liquid body-substances or ingested food. These larvae can be obligatory or facultative parasites, where, in the former case they live only in the vertebrate live tissues for their complete growth and in the latter, for only a short period during their growth. Among different kinds of myiasis, cutaneous myiasis affecting the dermal and subdermal tissues is common and finds an important place. For cutaneous myiasis, different nomenclature have been used to indicate the region of the body infested.

Myiasis may be classified into specific, semi specific and accidental ones. It may be caused by the larvae of primary flies - those which initiate the process eg. Lucilia cuprina; secondary flies - those which do not initiate but lay eggs on existing wounds caused by the larvae of primary flies. eg. Chrysomyia bezziana and tertiary flies which come at last of all, at the time of healing. eg. Musca species.

The ideal site for the development of cutaneous myiasis is any untreated wounds contaminated with excreta, urine or dirt evincing a putrifying smell. Even specific and non-specific diarrhoeas produce a suitable environment in the skin and pave way for the development or cutaneous myiasis. The majority of the larvae are harmful to the host causing extensive damage to the skin and tissues except some which

are useful in aiding the healing process of the wound by cleaning the necrosed tissue. Extensive wounds are caused by the liquifaction of the tissue which may lead to toxaemic conditions ultimately ending fatally.

The economic aspects of cutaneous myiasis are many fold. It affects the animals health leading to decreased productivity and ability to do work. The meat and hide value are depreciated. The quality and quantity of wool in sheep are reduced considerably. The loss due to the depreciation of hide value was to the tune of Rs 1.5 crores in 1946. (Sen and Fletcher, 1962). Severe cases and fatally due to extensive tissue damage, secondary infection and toxaemia. All these factors in toto reduces the market value of animals, producing economic loss to the owner.

Considerable work has been conducted regarding cutaneous myiasis in Australia, Africa and United Kingdom, where maximum economic loss occur due to loss of wool. A comprehensive treatise on myiasis in man and animals of the old world was brought out by Zumpt (1965). In India, some useful investigations on Indian Calliphoridae were undertaken by Patton (1913), (1920), (1922 a, b, c, d, e and f) and Sinton (1921), Patton and Cragg (1913). Senior White et al.(1940) furnished useful notes on Indian Calliphorinae. Mackerras (1933) studied the life histories and nutritional

requirements of blow flies while, Webber (1958) investigated on the reproduction of blowfly. Sen Gupta et al. (1951) studied the problem of cutaneous myiasis in animals at Izatnagar. In Tamil Nadu, studies were conducted on the incidence and importance of cutaneous myiasis caused by blowflies by Rao and Pillay (1936) and Alwar and Seshaiah (1957) and Nachiappan (1971). Patnayak and Misra (1977) studied the epidemiology, biology and control of bovine cutaneous myiasis in Orissa.

Cutaneous myiasis in animals is a condition highly prevelent in Kerala during the month of October to May. No systematic study has been conducted to identify the causative flies, their pathogenic effects on the hosts, and the practical control measures that can be adopted successfully. Hence a detailed study on the above aspects which are undertaken in the present work, will be of much value to the Veterinarians

MATERIALS AND METHODS

MATERIALS AND METHODS

1. Examination of animals for the presence of maggot wound:

Buffaloes, cattle, goats, pigs, dogs and cats brought to the Kerala Agricultural University Veterinary Hospital at Trichur and Mannuthy for treatment, and those to the Municipal slaughter house, Trichur, for slaughter constituted the main source for collection of data on the incidence of cutaneous myiasis. Few number of cases from other places in and around Trichur and a few cases from Mannuthy area were also included in the survey. The incidence were taken during the period from June, 1977 to May, 1978. The condition was detected by the presence of dipterous larvae in the wound.

2. Collection and identification of the larvae:

The larvae were collected mainly with the use of scoop and forceps. In certain cases a cotton plug dipped in oil of turpentine was applied on the wound for five minutes and the larvae were collected using forceps after removing the plug. At the end of collection the wound was carefully examined for the presence of any more larvae.

The larvae collected from the maggot wound were kept in cold water and carefully examined initially under a binocular microscope.

3. Study of the adult fly:

The larvae collected from the maggot wound were placed in a 500 ml beaker containing sand. The mouth of the beaker was closed using a muslin cloth. After pupation, the pupae were separated and placed on cotton pad in a glass jar measuring 10 x 8 x 30 cms, the mouth of which was closed with a muslin cloth and was tied round.

On emergence of the flies from the pupae, they were anaesthetised using chloroform vapour and were mounted on thermocool sheets using entomological pins. The flies were carefully examined and identified according to the characters mentioned by Senior White et al (1940). Conformation of the result of the identification was done with the help of Zoological survey of India, Culcutta.

4. Collection of flies from nature for identification:

The flies were mainly attracted using bait constituting putrified meat. The bait was kept exposed for a while and when a maximum number of flies came and sit on the bait, a funnel of 20 cms diameter was placed inverted over the bait so that the flies were trapped inside the funnel.

Fly trap was also used for catching the flies. (Plate II). A card board box of 50 cms square was taken, the top of it being covered with plastic paper so that the inside of the box could be seen through the plastic paper. A hole of 2 cms diameter was made on one of the sides of the box and a funnel

was introduced into the hole in such a way that the tail of the funnel was inside the box. Bait constituting 500 gms of putrified meat was placed inside the box to attract the flies. Since the entrance into the box was bigger and outlet smaller the flies were trapped in the box. The trapped flies were anaesthetised using chloroform vapour.

The trap containing the bait was exposed to atmosphere for 12 hours at a time. This trap was used for 15 times repeatedly with fresh putrified meat at each instance. Fly nets were also used for collecting flies. It consisted of a long handle, a wooden frame and a mosquito net fitted to the frame. When the frame was placed over the fly, it was trapped inside the net.

5. Rearing and colonisation of flies in the laboratory:

The flies were reared in the laboratory in glass jars of 20 cms diameter with a height of 35 cms. The mouth of the glass jar was closed using muslin cloth. Sand was provided on the bottom of the jar and few brick pieces were placed inside the jar enabling flies to sit on the bricks as if in natural surroundings. 20 ml of glucose water was provided daily in a petri-dish and 25 gms of fresh moistened meat was also provided daily. The flies were reared in the laboratory in an atmospheric temperature ranging from 23.5°C to 32.0°C and a relative humidity of 72-92. Each jar contained 10 female and 5 male flies. The flies of Chrysomyia megacephala, Chrysomyia nigripes, Chrysomyia rufifacies, Lucilia cuprina

and Sarcophaga ruficornis were reared in the laboratory.

6. Rearing of larvae in the laboratory:

The eggs or larvae collected were placed in 50 gms of moistened meat in a 500 ml beaker. The beaker was placed over sand contained in a glass jar measuring 10 x 8 x 30 cms. The mouth of the glass jar was closed using muslin cloth. This gave way for the escape of the gases of putrification. The larvae after maturing, migrated out of the beaker and pupated in the sand provided in the glass jar. The pupae were collected and placed for fly emergence, as mentioned earlier.

7. Studies on the biology of flies:

The eggs or larvae collected from the reared flies were used for studying its biology. The duration of the egg, larval and pupal stages were noted. The length and breadth of the eggs, larvae pupae and the adult flies were measured using a travelling microscope attached with vernier callipers. The external morphological characters of eggs, larvae, pupae and the adult flies were studied with the help of a Zoom microscope. The percentage of male and female flies obtained during each batch of hatching were also studied. The time and duration of fly matings, the preoviposition period, the number of eggs or larvae deposited, and the longivity of the fly in laboratory conditions, were also studied.

The growth rate of larvae of Chrysomyia megacephala from the hatch of eggs and Sarcophaga ruficornis from larval

deposition till they reach mature stage, and the time and process of moulting of these larvae were studied. For this study 250 larvae were reared in meat contained in a 500 ml beaker. At every 2 hour interval from the hatching of egg or larval deposition, 4 larvae were taken out killed by placing it in water at 50°C and measured till they attained maximum growth. The measurements such as length and breadth of the larvae, length and breadth of posterior spiracles, length of dorsal and ventral cornua of the cephalopharyngeal skeleton. Breadth of the pharyngeal sclerite at the junction of dorsal and ventral cornua, length of the oral hooks and the total length of the cephalopharyngeal skeleton were recorde

The external morphological developments of the fly taking place inside the pupa were studied from the first to the last day of pupal life. For this study the external chitinous covering of the pupa was cut carefully and pealed off. The differentiation of the head thorax and abdomen, the development of eye, mouth parts, wings, legs, external genitalia and the formation of body setae, hairs and bristles were studied.

The fly emergence and the time taken for that process were also studied along with the time taken for the unfolding of wing and the development of normal colour of the fly on the thorax and abdomen.

8. Studies on fly repellency using various oils and chemicals

The substances used for studying the fly repellency were turpentine oil (from the wood of Pinus species), Eucalyptus oil (from the leaves of Eucalyptus species), Lemongrass oil (from the grass of Cymbopogan flexuosus), Neem oil (from the seeds of Azadira indica), Karanji oil (from the seeds of Pongamia pinnata), Pine oil (from the wood of Pinus species), Camphor (from the leaves and twigs of Cinnamomum camphora) Dimethyl Phthalate and copper stearate. The camphor was used as a mixture with Arachis oil at proportion of 2:8. Other materials used in the experiment were mortars, poultry cages, plastic papers, cardboards, 1 ml, 2 ml and 3 ml pipettes and forceps.

250 gms of meat was placed in a mortar with 30 ml of water. The mortar containing the meat was placed inside the plastic cover and made fly proof. To be more sure about the prevention of eggs or larval contamination of flies, they wer again placed inside fly proof netted wooden boxes and allowed to putrify in that condition. When the pH of meat reached 7.8, they were removed from the plastic cover and the materials for testing fly repellency were applied. The pH of meat was determined to get uniformity to the degree of putrifaction for each bait. The pH 7.8 was selected since sufficient amount of smell was noted from the meat which attracted considerable number of flies. The pH of meat was detected

using a pH meter (85 A photovolt). The procedure adopted was as follows:

1. The meat sample was cut into small pieces using scissors and forceps.
2. Homogenised the meat with equal quantity of normal saline of pH 7.00 using a mortar and a pestle.
3. Adjusted the readings of the pH meter to pH 7.00 using a buffer of pH 7.00
4. The pH of the mixture of meat and normal saline was directly recorded using the pH meter.

The repellency potential of the materials to be tested against flies were studied in two different manners. In the first method the material was applied directly over the putrying meat. In the second method, the material was applied over cardboards measuring 12 cms square with 1 mm thickness. Nine holes of 1 cm diameter were made on the cardboard in such a way that the distance between any two holes were 3 cms.

The materials for repellency test was applied over the cardboard and the cardboard was placed over the mortar. Four baits were kept at a time, and the bait one, two and three were treated with a particular oil or chemical in a quantity of 1 ml, 2 ml and 3 ml respectively. The fourth bait was considered as the control on which no chemical was applied. Fresh cardboards were used when the experiment was

repeated. In the direct method the bait was exposed to the atmosphere for 10 hours where as in the indirect application, it was exposed only for 5 hours. Most of the baits were found infested within these periods and the uninfested baits were kept exposed till they got infested and the result were recorded separately.

The bait was placed in poultry cages measuring 50 x 35 cm to avoid birds and animals from eating the meat. The cages were kept at a distance of 20 meters from each other. The following factors were noted in detecting the fly repellency.

1. The time of arrival and sitting of the fly on the bait or over the cardboard.
2. The time of oviposition or larviposition.
3. The number of eggs or larvae deposited on the meat.

The number of eggs deposited were counted immediately when the exposure period of the baits were over. Larvae were counted in its second or third stage, since the process of counting was much easier at these stages. Species of larvae were determined after the emergence of fly from the pupae.

9. Studies on the ovicidal action of various oils on the egg of Lucilia Cuprina:

The oils used in the experiment was turpentine oil, Eucalyptus oil, Neem oil, Lemongrass oil and pine oil.

Distilled water was used as the control. Six groups of one hundred eggs each of Lucilia cuprina were treated in a particular oil mentioned earlier. The first group was only smeared with the oil and the groups two, three, four, five and six were dipped in the oil for one, two, three, four and five minutes respectively. After taking out from the oil, the eggs were placed on blotting paper to absorb the oil present on the external surface of the egg. The eggs used in the experiment were in masses.

The eggs were placed in moist fresh meat and the number of eggs hatched to larva were noted and the percentage of the efficacy of each oil as an ovicidal agent was calculated. The eggs were also treated in the same manner in distilled water which served as the control.

10. Studies on the larvicidal action of various oils against the larvae of Chrysomyia megacephala and Sarcophaga ruficornis:

The oils used in the experiment were Turpentine oil, Eucalyptus oil, Neem oil, Lemongrass oil, Pine oil, Coconut oil, Arachis oil, Kerosine oil and Liquid paraffin. Distilled water was used as the control. The first, second and third stage larvae of Sarcophaga ruficornis and Chrysomyia megacephala were used in the experiment.

The oils were taken in petridishes and 25 larvae of each stage were dipped in it. The time taken for 100% mortality was recorded to determine the efficacy of the oils as larvicidal agents. Control was also treated in the same manner. The larvae were considered dead when they had neither linear movement nor static segmental movement. Further conformation of the larval death was made by placing the larvae on sand.

11. Preparation of permanent mountings of the larvae and the fly:

The larvae of the flies of various species collected were preserved in 10% formalin. More over the larvae were dehydrated and cleared to make permanent mounts on the slides in the following manner.

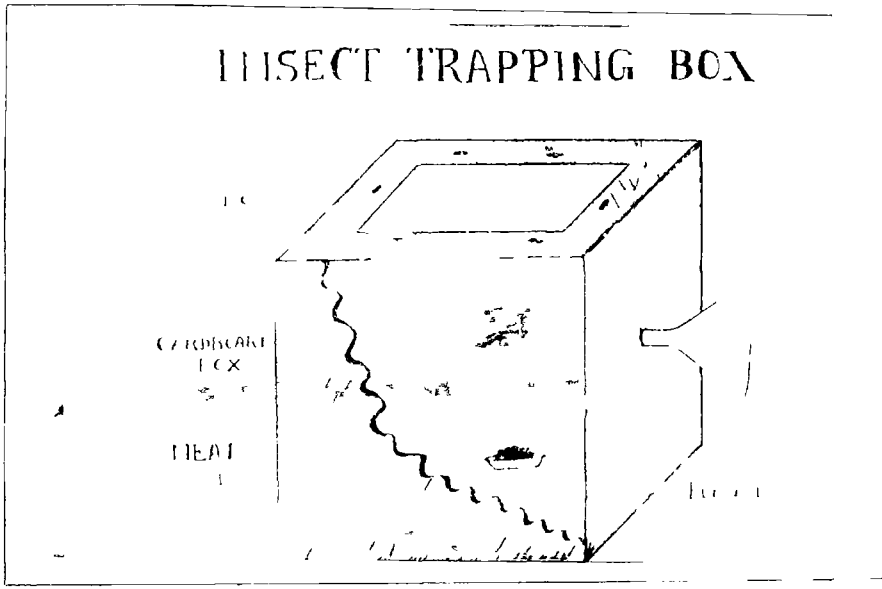
1. Minute pricks were made on the larvae using entomological pins.
2. Boiled the larvae in 10% potassium hydroxide solution till the internal organs got digested and the specimen became clear.
3. Washed in distilled water for 2 hours to remove the potassium hydroxide.
4. Dehydrated for one hour each in 50%, 70%, 90% and absolute alcoholes respectively.
5. Cleared in beechwood creosote for 12 hours.

6. Treated with Xylol for one hour.

7. Mounted in D.P.X. mountant.

The flies which were collected from the laboratory rearing or caught from the environment were anaesthetised using chloroform vapour. When the wings were found spread, they were pinned on the dorsal portion of mesothoracic region on thermocool sheets. The legs and wings were spread and the mouth parts kept streched. They were placed for drying in boxes containing thymol vapour. After drying they were removed from these boxes, pinned and preserved in entomological boxes. The flies were also preserved in small flat round bottomed entomological tubes.

PLATE II



INCIDENCE OF CUTANEOUS MYIASIS IN DOMESTIC ANIMALS

INCIDENCE OF CUTANEOUS MYIASIS IN DOMESTIC ANIMALS

Review of Literature:

Cutaneous myiasis is a condition commonly found in domestic animals. It was Patton (1920 a) who studied for the first time in detail about Cutaneous myiasis and its causative agents. He stated that the common Indian Calliphorinae belonged to 2 genera Lucilia and Chrysomyia and made mention about 16 cases of animal cutaneous myiasis caused by these flies.

Sinton (1921) reported 6 cases of myiasis in India and Persia with the description of the larvae causing myiasis and stated that the common myiasis producing flies in India belonged to the genera Sarcophaga, Lucilia, Calliphora, Pycnosoma and Wohlfartia.

Patton (1922a) recorded 3 cases of cutaneous myiasis in Bombay and Poona due to the infestation of the larvae of Lucilia argyricephala. The above author (1922 b) recorded the larvae of chrysomyia megacephala from 3 cases of myiasis in Poona and Hyderabad, and had also stated that Chrysomyia megacephala is an occasional myiasis producer. He (1922 b) noted that Chrysomyia bezziana and chrysomyia megacephala were the two important myiasis producing flies in India. Although he could state that the most important species of

Lucilia was L. argyricephala which produced occasional myiasis, he could not speciate the fly Sarcophaga which caused myiasis in man and animals. Again, he (1922 c) reported 61 cases of myiasis in animals, mostly from Southern India which were caused by the larvae of Chrysomyia bezziana. He also mentioned about 2 cases of myiasis caused by Chrysomyia rufifacies from Nellore. He (1922 e) recorded 87 cases of cutaneous myiasis out of which 92.5% was due to Chrysomyia bezziana. He (1922 f) further reported 5 cases of myiasis caused by Aphiochaeta Xanthina and 1 case due to A.rufipes, and also recorded 3 cases of mixed infestation by two species of Aphiochaeta along with Chrysomyia bezziana in man and and animals. Later Patton (1924 g) stated that Chrysomyia Bezziana is a specific myiasis producer, and semi-specific myiasis producers included Calliphora erythrocephala, Chrysomyia megacephala, Chrysomyia albiceps, Lucilia serricata, Sarcophaga ruficornis, Aphiochaeta Xanthiana and A.rufipes.

The important species of blow flies producing myiasis in man were identified as Chrysomyia albiceps, Chrysomyia megacephala, Chrysomyia bezziana, Lucilia serricata and Calliphora erythrocephala by Patton (1930). Roa and Pillay (1936) conducted a survey on cutaneous myiasis in animals in Madras presidency by examining the maggots obtained from fly blown wounds of domestic animals. They studied 404 collections,

each containing 10-15 larvae. Out of those collections 401 were the larvae of Chrysomyia bezziana and the rest Lucilia argyricephala. They recorded cases from cattle, buffaloes, goats, dogs, equines, sheeps, camels and fowls. Out of 404 cases, 250 cases were in cattle, 85 cases in buffaloes, 21 cases in dogs and 19 cases in goats. The most important site of infection was skin, where they could record 218 cases. They also recorded 126 cases on mucous surfaces, 37 cases at the base of hoof and 23 cases at the base of horn. The condition was noticed throughout the year but more number of cases occured from December to March. The maximum number of 105 cases occured during December.

Laake (1939) stated that in United States the myiasis producing flies were Cochliomyia americana, Phormia rigina, Chrysomyia macellaria, Lucilia Species and Sarcophaga species. Strikeland and Roy (1941) recorded Muscoidea as myiasis producer in man by examining the larvae collected from cases of myiasis during 1922-1941. They als examined 32 samples received from animals from various parts of India and identified them as Chrysomyia bezziana, Sarcophaga dux, S.ruficornis, S.Ceylonensis, S.Craggii and Anhiochaeta Scalaris.

Sen Gupta et al.(1951) recorded 56 cases of animal myiasis from IndianVeterinary Research Institute, Izatnagar during 1948-1950. They found that the incidence was maximum during

November to March, ie. 47 out of 56 cases. Out of 983 cases recorded at local veterinary hospital at Izatnagar during this period, they could get only the larvae of Lucilia and Calliphora but they have mentioned that Callinhora, Lucilia, Chrysomyia and Sarcophaga were commonly responsible for myiasis in India. Maximum number of cases were obtained at low atmospheric temperature and high humidity. Menon (1953) studied the seasonal incidence of arthropods of veterinary importance at Izatnagar. He recorded the commonest blow fly in that area as Calliphora erythrocephala, though he could get a few Sarcophaga ruficornis flies also.

Alwar and Seshaiah (1958) isolated a few larvae of Sarcophaga dux from cases of cutaneous myiasis in Camels, Buffalocks and cows. Choudhuri (1961) encountered for the first time in India a serious type of body strike in sheep caused by the larvae of Chrysomyia rufifacies. According to the above author, Calliphora erythrocephala, Lucilia cuprina Chrysomyia bezziana and Sarcophaga ruficornis were the other flies known to produce myiasis in live stock in India. Sen and Fletcher (1962) gave a detailed account on Cutaneous myiasis and their causative agents that produced myiasis in India. Norris and Murray (1964) stated that myiasis was a major problem in the teritory of Papua and

New Guinea and the species of fly responsible was identified to be Chrysomyia bezziana. Mindel and Cwilich (1964) recorded 5 cases of myiasis in sheep and calf in Nefuah, caused by the larvae of Wohlfartia magnifica, Calliphora erythrocephala, Lucilia serricata and Chrysomyia albiceps. Zumpt (1965) published an elaborate account of myiasis and the flies responsible for causing that condition in the old world.

Nachiappan (1971) studied the incidence of cutaneous myiasis in Tamil Nadu and has recorded 136 cases caused due to the larvae of Chrysomyia bezziana, 1 case due to Chrysomyia megacephala, and 1 case due to Lucilia cuprina. He recorded cases of cutaneous myiasis in all domestic animals including fowls.

Singh and Chhabra (1973) studied the incidence of arthropod pests at Hissar and out of 100 cases examined 23 cases were cutaneous myiasis which contained Chrysomyia bezziana larvae.

Choudhuri (1976) found that Chrysomyia bezziana, the Indian Screw worm fly, attacked a number of animals but more commonly cattle. He also reported that the common species infesting sheep in India were Lucilia cuprina, Lucilia serricata, Chrysomyia bezziana and Chrysomyia rufifacies.

Patnayak and Misra (1977) studied the epidemiology of bovine cutaneous myiasis and the population of myiasis producing flies. A higher incidence of bovine cutaneous myiasis was encountered in rainy season and the cows were found to be more susceptible. Vulvo-vaginal myiasis in cows were noted predominently in the local area. Calliphora erythrocephala was the only species responsible for causing bovine cutaneous myiasis. The authors concluded that there was a positive correlation between the incidence of Bovine cutaneous myiasis due to Calliphora erythrocephala and the population of this fly in the environment.

INCIDENCE OF CUTANEOUS MYIASIS IN DOMESTIC ANIMALS IN TRICHUR

An investigation was conducted to find out the incidence of cutaneous myiasis among domestic animals in Trichur. In the present study, the condition was noticed in cattle, buffaloes, goats and dogs. The animals were examined for cutaneous myiasis from June 1977 to May 1978. A total number of 155 cases were observed during the month of October 1977 to May 1978. During the months of June, July, August and September no cases could be observed (Table I & II)

The occurrance of cutaneous myiasis showed definite seasonal incidence. The cases were observed only after the rainy season. The temperature and humidity from October to April ranged between 23.65°C-31.9°C and 91 to 80 respectively. Eventhough the condition was noted from October to May, maximum number of cases were recorded during the months of January, February and March with 31, 68 and 41 cases respectively. The number of cases of cutaneous myiasis recorded during October, November, December, April and May were 1, 4, 3, 6 and 1 respectively.

Regarding the incidence of the condition in different hosts, 86 cases were in cattle, 36 cases in buffaloes, 19 cases in goats and 14 cases in dogs were recorded. Cutaneous myiasis was not encountered in pigs and cats.

The sites of infestation were varying with the host. In cattle out of 86 cases observed, 34 were in vulval lips, 20 in nasal septa, 6 in distal end of limbs, 5 in base of the horn/ear and the rest in others regions of the body. In buffaloes, out of 36 cases observed, 17 were in nasal septa, 5 in distal end of limbs, 6 in base of the horn/ear, 1 in vulval lip and the rest in other regions of the body. In goats out of 19 cases recorded, 2 were in distal end of limbs, 5 in vulval lips and the rest in other regions of the body and in dogs out of 14 cases 1 was in paw, 1 in base of the ear, and the rest in other regions of the body.

Studies made to speciate the larvae revealed that 145 cases were due to Chrysomyia bezziana. Besides this, Chrysomyia megacephala, Chrysomyia rufifacies and Lucilia cuprina were also encountered in 7, 1 and 2 nos. of cases respectively. Cutaneous myiasis due to Calliphora and Sarcophaga species of flies were not encountered in animals in this locality.

There were no host or site specificity for the different species of larvae mentioned above. The number of larvae in each case of cutaneous myiasis ranged from 6 to 342. Second and third stage larvae of Chrysomyia bezziana could be isolated from the maggot wound, where as in myiasis due to other flies only 3rd stage larvae only could be isolated.

DISCUSSION

No systematic study has so far been conducted on the incidence of cutaneous myiasis in animals in Kerala. In the present study this aspect is dealt with in detail so that it forms a valuable practical guide to the Veterinarians.

From the studies made now, it is evident that cutaneous myiasis is a very common condition in domestic animals during the period from October to May. Maximum incidence is found in January, February and March and a few cases during October, November, December, April and May. This shows that the occurrence of cutaneous myiasis has got definite seasonal incidence. This observation is in close agreement with Roa & Pillay (1936) and Sen Gupta et al.(1951), but the findings of Patnayak & Misra (1977) is contrary to the present observation. They are of the opinion that the maximum incidence of cutaneous myiasis is during rainy season. Roa & Pillay (1936) and Sen Gupta et al.(1951) reports that the cases are maximum during low temperature and high humidity ranging from 87°F-48°F and 100-61 respectively. In the present study at Trichur, the maximum incidence is found at a temperature and relative humidity ranging from 90°F - 72°F

and 91-78 respectively. With regard to the temperature the present observation is in conformity with the above authors, but the observations on relative humidity is not in agreement with them, since maximum number of cases are recorded at Trichur during lowest relative humidity.

With regard to host animals, maximum number of cases are recorded in cattle and buffaloe at Trichur. A few cases are also recorded in goats and dogs. This is in agreement with Roa & Pillay (1936), Sen Gupta et al. (1951) and Nachiappan (1971). Cases are not encountered in other domestic animals since animals like equines, Camels and sheeps are rare at Trichur.

In cattle the important site of lesion is vulval lip followed by nasal septa in buffaloes and cattle, having nose ropes. The maximum susceptibility of vulval lips for this condition in cattle can be attributed to the unclean nature of the vulval surroundings probably due to genital diseases and diarrhoea. The wound on the nasal septa produced by the chronic irritation of the nose rope leads to infestation with blow flies. Nachiappan (1971) is also of the opinion that vulvo-vaginal myiasis is predominent in bovines. However in the present study maximum number of cases were encountered on mucous surfaces rather than on the skin, which is in contrary to the observations made by Roa & Pillay (1936) who

have stated that maximum incidence was on the skin. The sites of infection in goats and dogs in the present study are not specific.

Chrysomyia bezziana is found to be the commonest blow fly in Trichur producing cutaneous myiasis, eventhough flies like Chrysomyia megacephala, Chrysomyia rufifacis and Lucilia cuprina are also occationally found as myiasis producers. This observation is in agreement with the reports of Patton (1920), (1922 b), (1922 c), (1922 e) Roa & Pillay (1935), Sen Gupta et al.(1957), Choudhuri (1961), Sen & Fletcher (1962), Norris & Murray (1964), Zumpt (1965), Nachiappan (1971), Singh and Chhabra (1973), and Choudhuri (1976) eventhough many workers (as mentioned in the review of literature) have recorded different types of flies as major myiasis producers in different parts of India.

TABLE I

TABLE SHOWING THE NUMBER OF CASES OF CUTANEOUS MYIASIS IN ANIMALS ENCOUNTERED AT SELECTED CENTRES FROM JUNE 1977 TO MAY 1978

Sl. No.	Places at which cases were encountered	Species of animal				TOTAL
		C	B	G	D	
1	2	3	4	5	6	7
1.	Veterinary Hospital Trichur	53	24	8	13	98
2.	Trichur town	--	1	2	--	3
3.	Slaughter house, Trichur	7	2	-	--	9
4.	Patturaikkal, Trichur	--	1	--	--	1
5.	Kuriachira, Trichur	--	--	1	--	1
6.	Kalathode, Trichur	--	1	--	--	1
7.	Veterinary Hospital Mannuthy	24	5	7	1	37
8.	Mannuthy local	2	2	1	--	5
9.	Total	86	36	19	14	155

C - Cattle B - Buffaloes G - Goats D - Dogs

MORPHOLOGY AND BIOLOGY OF FLIES PRODUCING CUTANEOUS MYIASIS

MORPHOLOGY AND BIOLOGY OF FLIES PRODUCING CUTANEOUS MYIASIS

Review of literature:

The biology of a myiasis producing fly was first worked out by Wellman (1906). He artificially produced myiasis, using the fly Sarcophaga near regularis in a goat. Patton and Cragg (1913) briefly described the morphological features of Cutaneous myiasis producing flies, and the methods of diagnosis and treatment of the disease produced by their larvae. Macgregor (1914) classified the posterior stigmata of dipterous larvae into Schizotreme type and ptychotreme type and also mentioned the characters of each type. He gave the measurements of posterior spiracles of Lucilia caesar.

Graham Smith (1915) observed the process of emergence of Calliphora erythrocephala from the puparium. Dunn (1918) studied some aspects on the life cycle of Chrysomyia Macellaria (Fabr) and mentioned that it laid 48-287 eggs at a time in batches. The time required for the egg to hatch varied with an average of 14 hours, and the male-female ratio in one lot of flies emerged from one hatch of pupae was 58:42.

Patton (1920) studied the external morphological features and mentioned the characters for identification of the flies of the genera Lucilia and Chrysomyia. Sinton (1921)

described the structure and measurements of various regions of the larval and pupal stages of Pycnosoma dux and Lucilia serricata. He studied the length and breadth of the larvae, anterior spiracles, distribution of spines on the body, posterior stigmal plates and the length and breadth of pupae.

Patton (1922 a) described the egg, larva, pupa and the adult fly of Lucilia argyricephala. The same author (1922 b) gave notes on the various stages in the life cycle of Chrysomyia megacephala describing the external morphological features of each stage. Patton (1922 c) also described the various stages of the fly Chrysomyia albiceps, and subsequently (1922 d) made studies on larvae of Chrysomyia bezziana, Chrysomyia albiceps, Chrysomyia megacephala, Chrysomyia nigripes Chrysomyia marginalis and Lucilia argyricephala. He also mentioned that larva of Chrysomyia albiceps were hairy and the second stage larvae of Chrysomyia, Lucilia and Sarcophaga had only 2 slit in the posterior spiracles. He further stated that Chrysomyia bezziana larvae grow only in living tissues. Again he (1922 e) studied the various aspects in the life history of the common myiasis producing blowfly, Chrysomyia bezziana and (1922 f) clearly described the characters which help in the identification of the larvae of Aphiochaea Xanthina and A.rufipes. He (1922 g) classified the myiasis producing Diptera into specific, semi-specific and accidental ones and

also described the methods of identification of myiasis producing flies by noting the morphological differences and characters of posterior spiracles, anterior spiracles and cephalopharyngeal skeleton. Patton (1930) concluded his work on this aspect by describing the life history of Calliphora erythrocephala, mentioning the characters of each stage of the larvae.

Hold away (1933) described the morphological differences of Chrysomyia rufifacies, Chrysomyia albiceps and Chrysomyia putoria. Mackerras (1933) studied in detail the life histories, nutritional requirements and fecundicity of Lucilia cuorina, L.serricata, Chrysomyia rufifacies and Calliphora stygia. In his studies it was observed that a single fly oviposited at 2 to 3 days intervel and he could rear L.serricata upto 94 days in the laboratory.

Brannon (1934) made studies on the site of oviposition of the fly Lucilia serricata. Evans (1935) studied some aspects on the biology and physiology of a blow fly. Roa and Pillay (1936) confirmed by doing breeding experiments that Chrysomyia bezziana was obligatory in wounds and that they did not lay eggs in dead tissues. Laake (1939) studied the exudates in myiatic and post myiatic wounds in sheep and goats and found that there was a considerable increase

in the alkalinity of the exudates as the development of the larvae progressed. They also observed that the average number of eggs deposited per wound increased with the increase in alkalinity of the wound.

Senior White et al.(1940) detailed out the characters which help in the identification of a calliphorid fly, their bionomics and methods of preservation. Herms (1953) classified myiasis into different forms and has described the larvae causing that condition. He briefly explained the life history of Callitroga hominivorax. Webber (1955) studied the relationship between larval and adult size of Lucilia cuprina. He observed that when the flies were prevented from oviposition for 17 days, the eggs inside the flies were not viable. Kilpatrick and Bogue (1956) stated that Lucilia cuprina also bred in garbage cans. Wijesundara (1957) studied the life history and bionomics of Chrysomyia megacephala in detail. Alwar and Seshaiah (1958) worked out, the life history and habits of Sarcophaga dux for the first time in India. Browne (1958 a) studied the relationship between the ovarian development and mating of Lucilia cuprina. He stated that 85% of the females of

Lucilia cuprina mated by the end of the 3rd day when the adults were supplied with pieces of liver from the time of emergence. The same author (1958 b) referred to the choice of communal oviposition sites by the fly Lucilia cuprina.

Webber (1958 a) mentioned the effect of nutrition upon reproduction in Lucilia cuprina and stated that protein meal was necessary for egg maturation. He (1958 b) studied the frequency of mating of the sheep blow fly Lucilia cuprina. Hobart (1959) studied on the delayed oviposition in sheep blow fly L. sericata.

Sen and Fletcher (1962) gave keys for the identification, and mentioned about the distribution, life history, breeding techniques, methods of preservation and control aspects of the commonly occuring calliphorid and sarcophagid flies in India. Norris and Murray (1964) studied the life history of Chrysomyia bezziana. Norris (1965) also studied the bionomics of blow flies. Shanahan (1965) reported the first record and spread of the fly strike in sheep, studied the factors influencing strike, economic importance, biology, distribution and ecology of blow fly Lucilia cuprina. Zumpt (1965) gave a detailed account on the biology,

pathogenesis, techniques for collection and method of preservation of flies causing myiasis.

Nachiappan (1971) identified the myiasis producing flies in Tamil Nadu and worked out the life cycle of Chrysomyia megacephala, Lucilia cuprina and Sarcophaga ruficornis. Ash and Greenbug (1975) studied the influence of temperature on the developmental rates of eggs and larvae. Roy and Gupta (1975) reported that Chrysomyia megacephala was the dominant species on trapping using fish baits in siliguri city, West Bengal. Choudhuri (1976) mentioned about the life history and habits of the adult fly of Chrysomyia bezziana, characters of the larvae, and the nature of injury produced on the host.

Kitching (1976) described the egg, three larval stages and puparia of chrysomyia bezziana. He also described and compared the eggs and third stage larvae and puparia of Chrysomyia nigripes, Chrysomyia varipes, Chrysomyia rufifacies, Chrysomyia megacephala and Chrysomyia suffranea. Pathayak and Misra (1977) studied the biology of Calliphora erythrocephala which was the common myiasis producer in Orissa.

Morphology of Chrysomyia Bezziana (Villeneuve, 1914)

The larva:

Second Stage:-

The second stage larvae measured 5-9.5 mm in length and 1-1.75 mm breadth. The first two segments were quite clearly separated from one another and the posterior spiracles had only 2 slits each. The spine bands posterior to the head segment were less pronounced and were composed of 5-6 rows of elongate spines with notched tips. Thoracic segments contained 3 rows of thorn like uniformly sized backwardly directed spines, which, along with their posterior margins formed a dense continuous ring. Abdominal segments carried more or less centrally placed spine bands, which were thorn like laterally, elongate centrally and single pointed. The spines were backwardly directed, except for the single anterior row on abdominal segments, containing 4-7 spines which pointed forwards. A few ventrally directed spines were present just anterior to the protruberence on segment VIII. Cuticle between spine bands was smooth and was without any setae. The cephalopharyngeal skeleton was well chitinised and the prothoracic spiracle had 4 blunt papillae. The posterior disc was surrounded by six short conical papillae arranged at regular intervals. Around

the spiracular region, two small additional papillae were present between two larger ones. Spiracular regions contained irregularly scattered hair like spines. Each spiracle was having 2 oblique slits. The button was present close to the ventral edges of slits in each spiracle. (Plate V, Fig.1).

Third stage larvae: (Plate III, Fig.2)

The larva measured 11-18 mm in length, 2-3.6 mm in breadth and was creamy white in colour. The body was composed of the usual twelve segments that had broad encircling bands of dark spines. The two ends of the larvae were darker. The first 4 segments were seen telescoping at their posterior margins. The anterior end was pointed and bent downwards, with the black oral hooks directed downwards.

The anterior most segment carried 2 small thick fleshy process, the antennae, each of which were guarded by a pair of dark knob-like structures placed one below the other. The oral opening was present subterminally in between the oral hooks. The second segment carried the anterior spiracle on the lateral aspect at its junction with mesothoracic segment. The anterior spracles were fan shaped, yellow in colour, projected outwardly and the

common stalk carried 6 papillae. The upper border of the dorsopharyngeal sclerite was raised anteriorly. The pharyngeal sclerite extended well beyond the cornua. (Plate VI, Fig. 1).

The head segment was with a posterior rim of spines, all thorn like and posteriorly directed. Thoracic segments were having posteriorly directed spine bands composed of irregularly alligned rows of spines. About 3-4 such rows were found on the prothorax, 5-6 rows on the mesothorax and 7-8 rows on the metathorax, each composed of thorn like spines, backwardly directed, largest being anterior, becoming smaller towards the posterior margin of spine bands.

Abdominal segments were having wide and very prominent spine bands occupying about half the width of each segment. The bands composed of 7-9 rows of irregularly alligned, thorn like spines, divisible into anterior and poster or sections, with a narrow spine free area centrally between them. (Plate IV, Fig. 2). All the spines were backwardly directed except for the most anterior rows on abdominal segments VI and VII. Segment VIII was having a central cluster of two rows of backwardly directed spines. The posterior disc had 8 peripheral conical papillae, six dorsal

and 2 ventral with an additional minute pair, ventral to the spiracular region. Subspiracular region was sparsely covered with scattered files of up to ten spines.

The spiracular plates were situated in the upper half of the posterior end and guarded by a thick fleshy cuticular ridge. The posterior spiracles was round in shape. The peritreme was dark brown enclosing 3 straight spiracular slits that converged towards the centre. The peritreme was incomplete at the postero-inferior aspect with both the ends pointed. The button was obsolete. A projection from the peritreme in between the outer and the median slit was present (Plate VI, Fig.2).

The pupa (Plate III, Fig.3).

It measured a length of 5-8 mm and a breadth of 2.5-3.5 mm The pupa was dark brown in colour, and was rounded smoothly at both ends with no thoracic constriction. Spine bands were very similar to those of the larvae, consisting of distinctive uniform thorn like spines. The anterior end didn't possess distinguishable prothoracic spiracle. The posterior end had the spiracles in a shallow depression but details of the spines and papillae were not distinct.

Adult fly: (Plate III, Fig.1)

The flies measured a length of 9-11 mm. The eyes were seperated in male by rather less than one half the width

of the third antennal segment and in females by one quarter of the total width of head. Facets were small and uniform in both sexes. Parafrontalia was much narrow in male but not reduced to a fine line. The vertex was black in females. The frons were more or less parallel sides and parafacialia and jowls were bright orange in colour, the latter clothed with golden hairs. The antennae, face, epistome and palpi were orange in colour.

The thorax was green to bluish purple in colour, lightly silver dusted anteriorly. Prothoracic stigmata was dark brown and a prostigmatic bristle was present. Chaetotaxy on the thorax was, acrostichals 0:1, dorsocentrals 2:3, Intra alars 1, supra alars 2, post alars 2, presutural intra alars 0, humerals 2, post humerals 1, and sterno pleurals 1:1.

The abdomen was also green to bluish purple in colour and the posterior margins of the second and third visible segments were generally dark margined. The hypopygium was inconspiquous. The male genitalia was strongly chitinised, and was broad with hairs. The wings were hyalinised, squama was white, and the lower lobe was covered with black hairs. The legs were black.

Biology of Chrysomyia bezziana (Table V)

The flies could not be collected from the environment by trapping methods. The larvae collected from the maggot wound were allowed to pupate and the flies were collected from the pupa after emergence. Only a few larvae of the second stage which were isolated from the maggot wound attained maturity by growing in meat provided in petridish. The second stage larvae just before moulting measured 9.50 mm in length and 1.75 mm in breadth. The hooks of the third stage larvae developed in the second stage itself, two hours before moulting (Plate IV, Fig.1). All the three slits of the posterior spiracles of third stage larvae developed in the second stage, one hour before moulting without any sign of the peritreme (Plate V, Fig.2).

The third stage larvae measured 11.0 mm to 18.0 mm in length and 2.00 mm to 3.6 mm in breadth. The pupae measured 6-8 mm in length and 2.5-3.5 mm in breadth. The third stage larvae isolated from the wound showed a greater tendency to migrate to the sand, than to remain in meat any further. The prepupal period of the mature larvae in sand was 30-42 hours and the pupal period was 5 days.

The biology of this fly could not be studied in detail since they did not lay eggs in meat.

Morphology of Chrysomyia megacephala (Fabricius, 1794)

The egg:- (Plate VII, Fig.1)

The egg measured a length of 1.4 - 1.5 mm and a breadth of 0.5 mm. The egg was coloured pearly white. The general shape of the egg was elongate, cylindrical and slightly tapering at the ends. It was slightly convex ventrally and concave dorsally. The median stripe was very narrow which appeared simply as a groove extending almost the full length of the egg from a point just in front of the posterior pole. The micropilar pit was smooth and without any chitinous fringing. Chorion was smooth.

The larva

First stage:- (Plate VIII, Fig.2)

The first stage larva was very small and measured 2.0-4.5 mm in length and 0.60-1.25 mm in breadth. The antenna was prominent and surmounted with 2 knob like structures. The oral hooks were ill developed and the cephalopharyngeal skeleton was not well developed. The ventral cornua was not clear and the pharynx had no ridge. (Plate IX, Fig.1). The anterior spiracle was absent. Abdominal segments I to VIII possessed ventral and lateral pads. The posterior extrimity carried soft tubercles. The posterior spiracles was present with ill defined spiracular slits.

Second stage: (Plate VIII, Fig.3)

The second stage larvae measured 7.00-11.25 mm in length and 1.50-2.25 mm in breadth. The antennae possessed 2 knobs each. The oral hooks of the cephalopharyngeal skeleton were well developed and the pharyngeal ridges were well marked (Plate X, Fig.1). The anterior spiracles had 11 papillae each and the abdominal segments I to VIII possessed ventral as well as lateral pads. The posterior spiracles were having 2 well defined spiracular slits each, and the peritreme was incomplete (Plate X, Fig.2).

Third stage larvae: (Plate VII, Fig.2)

They measured 12.5 to 20.00 mm in length and 2.5 to 3.5 mm in breadth. The larvae were whitish yellow in colour and the antenne were well developed. The prothorax was provided with a belt of several rows of recurved brown spines. The anterior spiracles were yellow in colour and fan shaped. They carried 13 papillae at their junction with mesothorax, on the lateral aspect. The pharynx possessed ridges and the shape of the cephalopharyngeal skeleton was characteristic, the pharyngeal sclerite ended a little beyond the ventral cornua. The upper border of the dorsopharyngeal sclerite was raised (Plate XI, Fig.1).

The body of the larvae were lacking in prominent papillae. The spine bands were sparse having short blunt simple spines with single or bifid tips, mostly tending to form files of 2-5 (Plate XII, Fig.1).

The girdle of spines present from the prothorax to Vth abdominal segment, were absent on segments VI and VII. The lateral pads were seen on segments I to VI while the ventral pads were seen on segments II to VIII. The end of the VIIIth adbominal segment was concave and possessed the anterior and posterior lips. The anterior lip and 3 pointed fleshy tubercles on either side, of which the inner was smaller. The angle between the spiracular plates was wider when compared to Chrysomyia bezziana. The peritreme was thin and lightly chitinised with one of its ends bearing a cleft and the other end pointed. The button was faintly visible. The posterior subspiracular region was densely setulose (Plate XI, Fig.2).

The pupa (Plate VII, Fig.3).

The pupa measured 6-9 mm in length and 3-4 mm in breadth. The pupa was mahogony brown in colour. The anterior spiracles, which were projecting from the puparia were fan shaped. They retained the characteristic pattern of setae on parts of the posterior spiracular area as in the larva. The posterior spiracles were visible externally.

Adult fly:- (Plate VII, Fig.4)

The fly measured a length of 10-12 mm. The eyes were holoptic in male and dicoptic in female. In males, the facets of the upper two thirds were greatly enlarged and sharply demarkated from small facets of lower third. The parafrontalia in male was reduced to a fine line and in female, each of the parafrontalia was slightly narrower than the width of frons. It appeared black towards the vertex. Frons in males were entirely obliterated throughout its length and in female approximately parallel sided, reddish to black with small hairs on the upper part. Parafacialia, jowls, face, epistome, antennae, antennal arista and palpi were orange in colour.

Thorax was grecnish blue in colour with purple reflections. Mesonotum was with two short and narrow longitudinal black stripes anteriorly and a small dark triangle situated in the postero-medial position to each humeral callus. Prothoracic spiracles was dark brown.

Abdomen was also coloured greenish blue with purple reflections, the second and third segment were black banded in its posterior margins. Hypopygium was slightly projecting. The male genitalia was very lightly chitinised.

The wings were hyalinised and slightly darkened at its base. The basicostal scale was black. The upper squama was white and the lower squama brown. Legs were black.

Biology of Chrysomyia megacephala (Table III & V)

Only 7 cases were encountered as cutaneous myiasis due to this species, but the flies were abundant in the nature. Out of 7 cases recorded 4 cases were in cattle, 2 cases in buffaloes and 1 in a goat. By trapping method, 1098 flies of this species were caught in which 963 were females and the rest were males. The flies could easily be bred in meat so that the biology of this fly could be studied in detail. The flies developed from the larvae collected from myiasis conditions, resembled in all details with the flies caught from the surroundings.

The flies mated from the 3rd day of emergence and mating lasted upto the 8th day. The duration of mating ranged from 30 seconds to 3 minutes. The preoviposition period for this species was 10 days. The mature females fly laid a maximum of 392 eggs. The average time taken for the fly to lay 100 eggs was 3½ minutes. A single female fly laid 2861 eggs throughout its life span. From the 10th day onwards it laid eggs only on alternate days and the

maximum number of eggs were laid in between 15 and 23 days after emergence. From 30th day onwards, it laid eggs only once in 4-5 days. The number of eggs laid were also found reduced gradually. It stopped laying eggs from 52nd day onwards and died on 69th day. The males lived only upto 15 days under captivity. The eggs laid by the flies hatched in 12-15 hours time.

First stage larvae (0-11.00 hrs)

The egg hatched splitting the median stripe at its anterior end. The larva migrated out of the egg, when it was split half way (Plate VIII, Fig.1). The first stage larvae grew gradually from 2.00 to 4.50 mm in length and 0.66-1.25 mm in breadth during their first stage. No considerable variation was observed in the measurements of posterior spiracles and cephalopharyngeal skeleton. But an increase of 0.014 mm was observed in the length of dorsal cornua, 0.007 mm in the breadth of pharyngeal sclerite at the junction of dorsal and ventral cornua, and 0.014 mm in the total length of cephalopharyngeal skeleton. The first moulting took place between 10.30 to 11.30 hours after hatching. The oral hooks of the second stage larva appeared in the first stage larva even at the 8th hour. (Plate IX, Fig.2). The posterior spiracle consisted of 2

oval fleshy openings. In the process of moulting, the loosening of the cuticle was observed even 1 hour before shedding the cuticle of the first stage larva. The larva took only 10-20 seconds to shead the cuticle.

Second stage larvae (11.00 to 28.00 hours)

There was a sudden increase in the size of the larvae, its posterior spiracles and cephalopharyngeal skeleton after the first moult. Just after moulting, the increase in the length and breadth of the larvae, were 2.50 mm and 0.25 mm respectively. The length and breadth of the posterior spiracles were increased by 0.117 mm and 0.129 mm respectively. The length of the dorsal and ventral cornua, the breadth of the pharyngeal sclerite at the junction of dorsal and ventral cornua, the length of the oral hooks and the total length of the cephalopharyngeal skeleton were increased by 0.314 mm, 0.186 mm, 0.079 mm, 0.057 mm and 0.554 mm respectively.

The larvae grew gradually from 7.00 mm to 11.25 mm in length and 1.50 mm to 2.25 mm in breadth during the second stage. There were also variations observed in the measurements of posterior spiracles and different parts of the cephalopharyngeal skeleton. The length and breadth of the posterior spiracles increased from 0.172 to 0.200 mm and 0.172 mm to 0.185 mm respectively. An increase of 0.030 mm

was observed in the length of dorsal and ventral cornua of the cephalopharyngeal skeleton. The breadth of the pharyngeal sclerite at the junction of dorsal and ventral cornua and the length of the oral hooks were increased by 0.014 mm. The total length of the cephalopharyngeal skeleton was increased by 0.100 mm. The second moulting took place between 27.00 and 28.00 hours. The oral hooks of the third stage larvae appeared in the second stage 3 hours before moulting (Plate IX, Fig.3). The posterior spiracle consisted of partially chitinised incomplete peritreme with 2 well developed oblique slits. The posterior spiracles of the third stage larvae with 3 slits and without a peritreme appeared in the second stage larvae 1 hour before sheading of the larval skin (Plate IX, Fig.4). The loosening of the cuticle was observed even 4 hours before moulting. The larvae took 15-30 seconds for sheading the cuticle.

Third stage larva (28.00 hours - Maturity)

Eventhough no marked changes were observed immediately after the process of moulting on the length and breadth of the third stage larvae, there were sudden variations in the measurements and morphology of posterior spiracles and the cephalopharyngeal skeleton. The length and breadth

of posterior spiracles were increased by 0.115 mm and 0.158 mm respectively. The length of dorsal and ventral cornua, breadth of the pharyngeal sclerite at the junction of dorsal and ventral cornua, length of the oral hooks and the total length of cephalopharyngeal skeleton were increased by 0.994 mm, 0.542 mm, 0.186 mm, 0.071 mm and 0.944 mm respectively.

The third stage larvae grew gradually from 12.50 mm to 20.00 in length till 50.00 hours of age and no further increase was observed later. The breadth of the larvae increased from 2.40 mm to 3.50 mm till 48.00 hours and hardly any increase was noted thereafter. The posterior spiracle showed an increase of 0.014 mm both in length and breadth. An uniform increase of 0.014 mm was observed in the length of dorsal cornua and in the breadth of the pharyngeal sclerite at the junction of dorsal end ventral cornua. The total length of cephalopharyngeal skeleton showed an increase of 0.027 mm. The cephalopharyngeal skeleton was well developed. The posterior spiracle consisted of well developed peritremes with 3 slits in each. The peritreme, which was partially chitinised at 28.00 hours, became fully chitinised by 34.00 hours.

The larvae readily pupated when placed on sand at the 50th hour of their larval period. But they continued to feed for 75-90 hours before naturally migrating from the meat to the sand for pupation. The prepupal period of the mature larva in sand was 24-36 hours. The larvae below 50 hours of age took much more time for pupation; 40-50 hours old larvae took 36-72 hrs, and 28-40 hours old larvae took 72-100 hrs. The average pupal period of the fly was observed to be 3 days and twelve hours.

The external morphological changes of the fly taking place inside the pupae were studied during their 3 days of pupal life (Plate VII, Fig.2).

Pupa at 24 hours:

The body of the developing fly inside the pupa was differentiable into head thorax and abdomen, and was whitish yellow in colour. The eyes were not differentiated. The mouth parts were observed as a conical pad extending to the thorax on the ventral aspect of the body. Wings were seen folded as pads on the lateral sides of the thorax. The legs were found to be developed even with faint differentiation of the segments.

48 hours:

The developing fly insde the pupa was whitish yellow in colour. The eyes were demarkated, slightly protruding

on the dorso-lateral aspects of the head. A li ht pink colour was found developed on the eyes. The mouth parts still appeared as a conical pad but antennae could be differentiated. The main veins of the wings were found partially chitinised. The segments of the legs were also partially chitinised.

72 hours:

The developing fly was whitish yellow in colour. The eyes were very well demarkated by the develop nt of reddish colour on them. The facets were clearly visible in the eyes. The develo ment of the ptilinal sac was visible. The appendages on the head were also well differentiable into antennae, palpi and proboscis. Even the arista on the antennae was well differentiated. Thorax was differentiated into protrorax, mesothorax and metathorax. The main veins of the wings and the segments of the legs were well chitinised. The development of the setae, hairs and bristles could be clearly observed. The development of the external genitalia was also observed.

The fly took a total time of 10-20 seconds foremerging from the pupa. The anterior end of the pupa was broken vertically and the fly was seen to emerge inflating the

ptilinal sac. (Plate XII, Fig. 3 & 4), (Plate XIII, Fig.1, 2, 3 & 4).

Just after the emergence, the fly could only walk and they tried to hide in dark corners. The wings were found folded. The fly was dark grey in colour. By 9 mts the wings started unfolding gradually and the process of unfolding was completed by the 20th minute. Along with the unfolding of skin, faint but shining pink colour began to develop on the thorax of the fly. At the 30th mt pink colour also began to develop on the abdomen. Greenish tinge started to develop gradually when the fly reached 45 minutes of age. With this green colour, slight bluish colour also began to develop strongly and the pink colour faded off with the domination of bluish green colour. Full and normal development of the colour on the thorax and abdomen of the fly was evident at the 75th minute.

The male female ratio of the emerged flies was 46:54.

Morphology of Chrysomyia rufifacies (Macquart, 1842).

The egg

The egg measured 1.2 mm in length, 0.45 mm in breadth and was white in colour. The shape of the egg was elongate and cylindrical. The median stripe ran upto about three

quarter the length of the egg from a point well anterior to the posterior pole and was very narrow, appearing simply as a groove. The chorion showedd faint but distinct hexagonal sculpture. The micropilar pit was with chitinous fringing.

The larvae

First stage

The first stage larva measured 1.5-3.0 mm in length and 0.5-1.0 mm in breadth. They did not show the characteristic fleshy processes of the following stages but was provided with tiny triangular discs. They presente eleven bands, the five anterior ones being complete where as the next six were interrupted on the dorsal side. The cephalopharyngeal skeleton was well developed. Posterior spiracles were tube like and the anterior spiracles were absent.

Second stage:-

The larva measured a length of 3.5 to 8.5 mm and a breadth of 1.00-2.40 mm. The antennae were prominent in the cephalic segment. The anterior spiracles were seen projecting from the lateral aspect of the mesothoracic segment, bearing 6 papillae. The cephalopharyngeal skeleton was well developed and the oral hooks very prominent. (Plate XV, Fig.1).

The body was covered with spines and fleshy processes which also carried spines at their tips. The thoracic segments contained only bands of spines on the dorsal aspect. The abdominal segments had 3 rows of spines anteriorly, followed by 8 fleshy processes with 10-15 spines each at their tips. A single row of minute spines were seen ventrally on the abdominal segment. The posterior spiracle were seen on the upper part of the posterior most segment with the lower lip much more extended posteriorly. The spiracles possessed well developed peritreme with 2 slits (Plate XV, Fig.2).

Third stage (Plate XIV, Fig.2).

The third stage larvae measured 10 - 13 mm x 2.5 - 3.6 mm and were light brown in colour. The brownish colour deepened gradually as the larvae matured. The anterior end was very narrow. Each antenna was surmounted with 2 cone shaped knob like processes. The pharynx was ridged. The cephalopharyngeal skeleton was well developed and presented a characteristic appearance. The pharyngeal sclerite was prominent, and the dorsal cornua very long and tapered horizontally. The ventral cornua was prominent and was as long as the dorsal cornua. The oral hooks were well

developed. (Plate XVI, Fig.1). The anterior spiracles were seen projecting from the rear end of the prothorax, bearing 9 papillae.

The prothoracic segment in its anterior end carried a thick band of backwardly directed spine on the dorsal aspect. Posterior to the band of spines, dorsally, there was a row 8 small papillae. On the ventral aspect, there was a triangular pad of small spines. On the mesothoracic segment, there was a thick band consisting of 9 rows of spines on the dorsal aspect. The papillae which were comparatively larger than the prothoracic papillae were 8 in number and were seen posterior to the spines. The papillae on the prothoracic and mesothoracic segments did not contain any spines at their tips. The spine band on the mesothoracic segment was seen encircling the segment with one row of spines lesser on the ventral aspect. The metathoracic segment possessed 7 rows of spines anteriorly on the dorsal aspect and 5 rows of spines ventrally. The 8 papillae following this carried 20-30 spines at their tips. (Plate XVII, Fig.1). Small spines in 5 rows were also seen encircling the finger like papillae. The lateral most papillae on both the sides had an additional small papillae originating

from its base which also possessed spines at their tips. A row of six papillae were also seen ventrally corresponding to the dorsal papillae, carrying spines at their tips. Brown coloured bands were seen on the dorsal aspect of the segments of the larvae on which these papillae were observed. The abdominal segments I to VIII contained similar papillae as seen on the metathoracic segment, but the spines anterior to them became smaller from the second abdominal segment onwards. On the ventral aspect of the first three abdominal segments, 2 separate rows of spines were present corresponding to the rows of spines on the dorsal aspect. It became one row from the 4th abdominal segment onwards. On the lower half of the 12th segment an encircling band of stout spines were present.

The posterior spiracles was present in the 12th segment of the body. The peritreme was much thicker, well chitinised and dark brown in colour. It was incomplete and the gap between the two ends was small. The ends of the peritreme were forked. (Plate XVI, Fig.2).

The pupa: (Plate XIV, Fig.3)

The pupa measured 7-8 mm x 3.5 - 4 mm and coloured dark brown. It was slightly convex dorsally and concave

ventrally. As in the case of the larva, the pupa of Chrysomyia rufifacis was readily recognisable by their body papillae which were present all round the segment.

Adult fly (Plate XIV, Fig.1)

The flies measured a length of 9-11 mm. The eyes were seperated in male by a distance approximately equal to one-fourth the width of the third antennal segment and in female, by slightly more than one-quarter the total width of the head. Facets in both sexes were small and uniform. Parafrontalia in male was narrow, black on the upper half, and covered with silver tomentum on the lower half, where upstanding white hairs and a few fine black bristles were observed. Frons were reddish above the point of insertion of the antennae. In females, frons and parafrontalia were approximately equal in width, the frons being greyish black in colour. The parafacialia and jowls were reddish yellow but densely covered with silver tomentum and white hairs. Epistome and palpi were orange in colour.

Thorax was greenish blue in colour with purple reflection. It had short narrow stripes anteriorly, and

indefenite dark patches behind the humeral calli along the suture. Prothoracic spiracle was white and the prostigmatic bristle was clear.

Abdomen was coloured similar to the thorax. The first visible segment was black in male and greenish in female. Second and third segments were black banded on the posterior margins. Hypopygium was inconspiquous. In the male genetalia, the two halves of the mesolobes were united and the paralobes were widely seperated at their base. The wings were hyalinised. The basi-costal scale was dark brown and subcostal sclerite was bare but for a few soft haris. The upper end of the lower squama was white.

Biology of Chrysomyia rufifacies (Table V)

Only one case of cutaneous myiasis due to this species of fly was recorded, even though the fly was abundant in the surroundings. By trapping, 328 females and 68 males of this species were collected. These flies were found to lay eggs on baits much more quicker than Chrysomyia megacephala, even though a greater number of the latter species of flies were attracted to the baits along with

the former species. The flies and the larvae caught from the nature resembled the one which was isolated and reared from a case of cutaneous myiasis.

The flies started mating from the third day, which lasted upto the 7th day. The duration of mating was found to be 1-2 mts. The average preoviposition period of this species was observed to be 8.5 days. The mature female fly laid a maximum of 268 eggs. The average time taken for a fly to lay 100 eggs was 3 mts. The eggs hatched within a period of 10-12 hrs. The first moulting of the larva took place at 11.00 hrs and the second moulting at 26.00 hrs. The oral hooks and the posterior spiracles of the developing third stage larvae were observed in the second stage, at first and second hour respectively before sheading of the larval skin.(Plate XV, Fig.3). The skin started to loosen 2 hours before sheading. The cuticle of the second stage larvae became loose gradually and the spines and papillae of the third stage larvae developed exactly at the same place underneath the spines and papillae of the second stage larvae. (Plate XV, Fig.4). The larvae attained maximum size by 40.00 hrs but they fed on the meat up to 60.00 to 70.00 hrs. The larvae aged

over 60.00 hrs pupated readily. The pre-pupal period of the mature larvae in sand was very short, ranging from 16.00 - 24.00 hrs. The pupal period of the fly was observed to be 3 days.

An interesting observation recorded was that, from a batch of eggs laid at a time, all the flies developed were either males or females.

The process of fly emergence was also studied (Plate XVIII, Fig. 1 & 2). The fly took 30-60 seconds for the emergence from the pupa. The process of emergence was similar to that of Chrysomyia megacephala. The wings were completely unfolded by the 15th minute and the normal colour developed on the body by the 50th minute.

The larvae of this species were reared in vitro along with the larvae of Lucilia cuprina, and Sarcophaga ruficornis from the first stage onwards. Chrysomyia rufifacies larvae did not cause any harm to other larvae in the presence of sufficient meat. But when the meat was not enough for this species, they attacked other larvae, destroyed and ate them. This larvae were also observed

to prey on Chrysomyia bezziana larvae, when there was scarcity for meat (Plate XVII Fig.2).

Morphology of Chrysomyia nigripes (Aubertin, 1932)

The egg (Plate XIX)

The egg measured 1 mm in length, 0.3 mm in breadth and was white in colour. The shape of the egg was elongate and cylindrical. The median stripe did not run the full length of the egg, but extended from a point just in front of the posterior pole to the micropilar region. Hatching lines were having distinct chorionic thickening. The characteristic hexagonal sculpturing of the chorion outside the median stripe was very distinct.

The larva

Third stage (Plate XX, Fig.2)

It measured 10-17 mm in length and 1.5-2.5 mm in breadth. The anterior end was narrow. The most characteristic and interesting feature of this larvae was that they had brownish rectangular bands on the dorsal aspect from the mesothoracic to the 7th abdominal segments. The cephalopharyngeal skeleton was also characteristic in that the tip of the dorsal cornua was extended by a

partially chitinised portion (Plate XXI, Fig.1). The anterior spiracles projected to the prothorax and carried 10 papillae. The spine bands which graded laterally into dense mats of setae, spreaded over the lateral sunfaces of the segment. Spine bands on the dorsal aspect composed of elongate structures with pointed tips and files of larger spines with tripple or multiple tips, and flies of setae anteriorily and posteriorly (Plate XIX, Fig.4). The posterior most segment had a row of short papillae around the spiracular region. The posterior spiracle was small, peritremes thick, well chitinised and incomplete enclosing 3 slits. (Plate XXI, Fig.2).

The pupa: (Plate XX, Fig.3).

The pupa measured 4.0-6.5 mm x 1.5 - 2.5 mm in size and was light brown in colour. They retained the rectangular dark brownish bands present on the dorsal aspect of the larvae. They had a very prominent thoracic constriction and retained the prothoracic spiracles. In addition, the posterior spiracles were situated in a deep fringed pit.

Adult fly: (Plate XIX, Fig.1)

The flies measures a length of 7-8 mm. The space in between the eyes in male was equal to the length of the third antennal segment, and in females, to one third the width of the head. Facets were small and uniform. Frons had parallel sides and was dull dark reddish in colour. In male the width of frons was equal to one of the parafrontalia, but in female it was slightly narrow. Parafrontalia was covered with grey tomentum anteriorly and was metallic at vertex. Parafacialia was covered with grey hairs, jowls metallic and grey dusted. Antennae were dark brown in colour and the palpi yellowish.

Thorax was coloured greenish and prothoracic stigmata white. A prostigmatic bristle was present. Abdomen was greenish and the hind margin of the second and third visible segments were having dark bands. Hypopygium was inconspiquous. The wings were hyalinised and the basicostal scale was dark brown. Subcostal sclerite was having few hairs. The squamae were whitish and the halters yellowish.

Biology of Chrysomyia nigripes (Table V)

Eventhough no cutaneous myiasis was encountered due to this larvae, flies were caught from the nature. Fifteen female and two male flies were caught by trapping. The flies were bred in meat.

The flies mated from 4th day after emergence. The preoviposition period the species was observed to be 10 days. The mature female fly laid a maximum number of 162 eggs at a time. The eggs hatched within a period of 8.00 to 11.00 hours. The larvae after 70.00 hours in meat migrated to the sand for pupation. The prepupal period of the mature larva in sand was 36-48 hrs and the average pupal period was 5½ days. The duration of the process of emergence was 2-3 mts. The time taken for the unfolding of wing and the development of the greenish colour on the body was 20 and 60 mts respectively.

Morphology of Lucilia Cuprina (Wiedemann, 1830).

The egg:

The egg measured 1 mm in length, 0.35 mm in breadth and was pale yellow in colour. The chorion was very thick, striated and faintly reticulated. The median stripe was narrow which extended throughout the length of the egg.

The larva

First stage:

The larvae measured 1.5-3.5 mm in length and 0.4-0.8 mm in breadth. The oral hooks were not well developed and

bluntly pointed. The cephalopharyngeal skeleton was not well chitinised. The pharynx presented few grooves. The anterior spiracle was absent. Segments II to VII were provided with girdles of lightly pigmented spinules. From segment VIII spinules were absent except on the ventral aspect of this segment. The posterior spiracle had ill defined spiracular slits. The peritreme was not clear.

Second stage:

The second stage larvae measured 4-8 mm in length and 0.8 - 1.25 mm in breadth. The two antennae were provided each with two knobs. The oral hooks were prominent with pointed ends. The dorsopharyngeal sclerites were connected anteriorly by an arched splint. The dorsopharyngeal sclerite, pharyngeal sclerites and the dorsal and ventral cornua were prominent. The pharyngeal ridges were not well developed. The anterior spiracle was provided with 7 papillae. Segments I to VII possessed complete anterior bands of spinules. On the segment VIII, this band was interrupted. Segments IX to XII had spinules ventrally but segment XI showed a complete band at the posterior border. The posterior spiracles had 2 clearly defined spiracular slits. The peritreme was incomplete and the button was not present.

Third stage: (Plate XXIII, Fig.1).

The larvae measured 10-16 mm in length, 1.5-2.5 mm in breadth and was creamy white in colour. The cephalic segment was provided with a pair of well developed antennae, each with 2 minute knobs at their tips. The oral hooks were prominent and the pharynx presented well developed ridges. The prothorax was not provided with spinules and was smooth. It carried a pair of anterior spiracles on the lateral aspect at its junction with the mesothorax, each possessing 7-8 papillae. The cephalopharyngeal skeleton was well chitinised (Plate XXIV, Fig.1). The mesothorax, metathorax and the first 8 abdominal segments possessed belts of 6-7 rows of minute, yellow, recurved spines along their anterior margins. The abdominal segments had, thick ventral pads with inconspiquous spines on them. The posterior spiracles were placed on the upper half of the last segment. The anterior lip had 3 pointed fleshy tubercles on each side of the midline, of which the median tubercle was smaller than the other two. The median tubercle was placed close to the inner tubercle than to the other ones. The posterior lip also possessed 3 tubercles on each side.of which the outer tubercles were the largest. The median tubercles were slightly anterior to the border. The oral tubercles were comparatively larger and the anal opening was very conspiquous with two raised lips.

The posterior spiracles were placed at wider angle. The brown peritreme at the postero-inferior portion enclosed a complete button. The peritreme at the antero-external aspect took smooth curves along the edges of the spiracular slits. The thickness of the peritremal ring was uniform throughout. The 3 slits were straight and lay parallel to each other. The middle one was longer than the other two, which were of the same length. (Plate XXIV, Fig.2).

The pupa (Plate XXIII, Fig.2).

The pupa was 4.0-6.5 mm x 1.5-2.5 mm in size and was dark brown in colour. The puparium was smooth, and the posterior spiracle were situated in a deep pit. The anterior spiracle was also seen projecting from the puparium.

Adult fly: (Plate XXII)

The adult flies measured 6.0-8.0 mm in length. The eyes in male were seperated by a distance equal to double the width of the third antennal segment. In male the frons at the narrowest point was about twice the width of one of the parafrontalia at the same point. In females the frons had one-third the width of the head. The parafrontalia in male was having five hairs outside the frontal bristles and bare except for the frontal bristles in female.

Thorax was coppery green in colour. The males had a much more deeper coppery colouration than the females. Chaetotaxy on the thorax was as follows:

Humerals 3:4, notopleurals 2, Supra alars 2:4, intra alars 2:2 post alars 3, acrostichials 2:3:3, dorsocentrals 3:3, and the marginal scutallar 4. Abdomen was arched in profile, sternites with tufts of long hairs and hypopygium prominent. Wings were hyalinised, basicostal scale yellow and the squama was white. Legs were black in colour with one of the antero-dorsal bristle at the middle of the tibia.

Biology of Lucilia cuprina (Table V)

Two cases of cutaneous myiasis cases due to the larvae of this flies were encountered. The population of this fly in nature was very low. Only 3 female flies could be trapped.

The flies mated from the second day to 8th day after emergence. The flies were found to mate only once during its life. The duration of each mating ranged from 6-15 mts. The preoviposition period of this fly was found to be 9 days. The mature female fly laid a maximum number of 216 eggs at a time. The time taken for the fly to lay 100 eggs was 3 mts. The flies that had only glucose food, did not

lay any eggs. The flies were not found to lay eggs in fresh meat. They laid eggs on meat after it had attained slight putrifaction, and a maximum number of eggs were laid in putrified meat with good smell.

The flies laid eggs near the sites where a fly had already laid eggs. The eggs were laid in small crevices on the surface of the meat. The flies did not lay eggs on garbage. A single fly observed, was found to lay eggs on 10th day, 12th, 15th, 18th, 21st, 26th, 30th, 36th and 43rd day. It did not lay eggs any further and the fly died on 71st day. The male flies lived only upto 18 days. The maximum number of eggs were laid on the 2nd and 3rd weeks after the onset of egg laying. A maximum number of 1528 eggs were laid by a single fly during its life span.

The eggs hatched within a period of 8-10 hrs. The first moulting of the larva took place at 14.00 hrs and the second moulting at 32.00 hrs. The larvae attained maximum growth by 48.00 hrs but they started leaving the bait only from 68.00 hrs. The prepupal period of the mature larva in sand was 36-48 hrs and the pupal period 5 days. The flies took a total period of 10 days from the egg to fly stage in its life cycle. The flies started emerging from the puparium in the early morning of the day and continued

to emerge throughout the day. The percentage of male and female flies emerged was observed to be 49.6% and 50.4% respectively. No appreciable difference could be observed in the emerging time for male and female flies. The size of the flies were smaller when starved at their larval stage.

The fly took a total time of 1-5 mts to emerge from the pupa. It emerged in a similar fashion to that of Chrysomyia megacephala. The wings were completely unfolded by 10 mts and the normal coppery greenish colour appeared on the body in one hour.

Morphology of Sarcophaga ruficornis (Fabricius, 1794)

The larva:

First Stage: (Plate XXVI, Fig.1)

The larva measured 3.00-5.5 mm in length 0.60-1.00 mm in breadth, and was yellowish white in colour. The anterior end possessed 2 antennae each surmounted with two knobs. The oral hooks were prominent. The cephalopharyngeal skeleton was well developed with its dorsopharyngeal sclerite pointing forwards (Plate XXVI, Fig.3). The pharynx possessed faint ridges. Anterior spiracles were absent. The first 7 abdominal segments were having ventral and lateral pads. The anal tubercles were prominent. The posterior spiracles were devoid of peritreme and were

provided each with 2 slits. The tubercles were on the circular ridge and were not prominent (Plate XXVI, Fig.4).

Second Stage: (Plate XXVI, Fig.2)

The larva measured 6.5-11.50 mm in length and 1.25-2.50 mm in breadth. The larvae possessed well developed oral hooks and cephalopharyngeal skeleton with its upper cornua divided into upper and lower halves. (Plate XXVII, Fig.1). The pharynx presented well marked ridges. The anterior spiracles carried 13 papillae each which rose from the rear margin of prothorax. Abdominal segments I to VII had ventral as well as lateral pads. The posterior cavity presented vestigeal tubercles and the posterior spiracles. The posterior spiracles were provided with 2 spiracular slits having incomplete peritreme which were not well chitinised (Plate XVII, Fig.2).

Third stage: (Plate XXV, Fig.3).

The larvae measured 12.00-24.5 mm x 3.00-4.50 mm and were dirty white in colour. They were bigger than those of Chrysomyia sp. and Lucilia sp. The cephalic segment was provided with a well developed antenna and a pair of strong oral hooks. The antenna possessed 2 small knobs situated one below the other. The buccal orifice was seen in between the oral hooks. The cephalopharyngeal skeleton was not well chitinised and hence flexible. The dorsopharyngeal sclerite at its posterior half was provided into two

halves, the upper and lower. The two halves united at their posterior most points. (Plate XXVIII, Fig.1). The anterior spiracles were very broad, each with 14 papillae and projected from the rear margin of the second segment at its junction with the third segment. The spines on the body were blunt, smooth and weak.

The posterior end carried the posterior spiracles in a cavity formed by a stout ridge all around which was divided into anterior and porterior lips by a shallow cleft. The anterior lip had 3 tubercles on either side. The inner and outer tubercles were connected by a thick ridge running outer to the median tubercle which was smaller than the other two. The posterior lip carried a smooth vertical groove in its middle. This lip also possessed 3 tubercles on either half. The median tubercle was larger than the inner and outer ones, and was situated close to the vertical groove. The outer tubercle, was smaller than the median, and was placed within the outer margin of the outer tubercle of the anterior lip. The median and outer tubercles were connected by a thin ridge. The inner tubercles was the smallest and was placed at the lower margin of the vertical groove. The inner tubercles of the posterior lip were connected by a stout ridge, which ran downwards and then forwards on the ventral aspect in between the anal

tubercles of the last segment.

The posterior spiracles were situated in the posterior cavity, each with 3 elongate characteristically curved slits. The peritreme was incomplete at the posterio-inferior border with both ends blunt and broad. There were 2 projections from each peritremal ring at the speric-lateral aspect which projected in between the slits (Plate XXVIII, Fig.2). On the ventral surface of the IX abdominal segment there was an enlarged portion, the anal area, which terminated into 2 sharp, lateral tubercles. The anal opening was seen in between these tubercles, guarded by a pair of prominent vertical lips.

The pupa (Plate XXV, Fig.4)

It measured 9.5-13.5 mm x 3.5-5.0 mm in size. The pupa was much bigger than all the previous species and darker in colour and was more or less barrel shaped. The puparium was smooth. Anterior spiracles were visible. Posterior spiracles were situated on the upper half of the posterior end and was found in a pit.

The Adult fly: (Plate XXV, Fig.1 & 2)

The flies measured a length of 12-15 mm. The eyes were well seperated in both sexes. In males frons was equal to two-thirds of an eye width. In female the frontal

width was equal to that of an eye. Frontals in male was strongly diverging. The genals were whitish. One row of post ocular cilia was present. Frontal stripe was black. The parafrontalia was yellowish above and silvery in the face and below. Antennae and palpi were orange in colour. Third segments of the antennae were twice in length of the second segment.

Thorax was ash grey in colour and possessed longitudinal black stripes. Chaetotaxy of the thorax was propleura bare, acrostichials only present as one small prescutellar pair, posterior dorsocentrals five in number in which the front four were very weak. In females no acrostichials but only one dorsocentral was present. Abdomen was chequered but the spots patern was reduced and was smaller than usual. The first genital segment was red, the posterior dorsal edge of which was darkened. In wings the costal bristle was absent and the segment 3 of the costa was twice as long as the 5th. In legs, the midfemur contained the comb and a few long basal hairs. Mid tibiae were bare. Hind femur with a lower hind macrochaetal row was present.

Biology of Sarcophaga ruficornis (Table IV & V)

Cutaneous myiasis due to this species was not encountered in this locality. The flies were abundant in nature especially in place were Putrified meat was discarded. The biology of this fly was studied in detail since the fly was readily available in nature and was very easy to breed in the laboratory. By trapping, 594 female and 143 male flies of this species were caught.

The flies mated from the third day after emergence and this lasted upto the 25th day. It was obvious from this fact that the fly mated more than once. The duration of mating ranged from 10-55 mts. The average prelarvipo-sition period of this species of flies was 9.5 days. The mature female fly laid 10-73 larvae at a time for which it took 10-30 seconds. The female flies lived upto 46 days, during which a single fly laid a maximum of 479 larvae. The male flies lived only upto 28 days. The larvae were laid in masses and immediately after laying the larvae migrated to various sides for feeding.

First stage larva (0-9.30 hrs)

The larvae grew from 3.00 mm to 5.50 mm in length and from 0.60 mm to 1.00 mm in breadth during the first stage period. Increases were observed in the length and

breadth of posterior spiracles, length of dorsal and ventral cornua, breadth of the pharyngeal sclerite at the junction of dorsal and ventral cornua, and inthe total length of cephalopharyngeal skeleton, at the rate of 0.014 mm, 0.014 mm, 0.091 mm, 0.077 mm, 0.014 mm and 0.071 mm respectively. The moulting of the larvae took place between 9.00 hrs and 10.00 hrs. before [illegible]. The oral hooks of the second stage larva appeared in the first stage 2 hrs before first moulting (Plate XXIX, Fig.1). The larvae took 10-15 seconds to shead the cuticle of the first stage.

Second stage larva (9.30-23.30 hrs)

Not much of variations were observed in the length and breadth of the larvae just after moulting. But definite changes were observed in the measurements of posterior spiracles and cephalopharyngeal skeleton at this stage. The length and breadth of the posterior spiracles, the length of dorsal and ventral cornua, the breadth of the pharyngeal sclerite at the junction of dorsal and ventral cornua, length of the oral hooks and the total length of the cephalopharyngeal skeleton were increased by 0.114 mm, 0.128 mm, 0.227 mm, 0.166 mm, 0.099 mm, 0.022 mm and 0.312 mm respectively

The larvae grow from 6.50 mm to 11.50 mm in length and 1.25 mm to 2.50 mm in breadth. During growth, there was an increase in the length and breadth of posterior spiracle by 0.056 mm and 0.018 mm respectively. The length of dorsal and ventral cornua, the breadth of the pharyngeal sclerite at the junction of dorsal and ventral cornua, the length of oral hooks and the total length of cephalopharyngeal skeleton were increased by 0.029 mm, 0.003 mm, 0.029 mm 0.008 mm, and 0.029 mm respectively. The cuticle of the second stage larva started loosening from 4.00 before sheading of the cuticle. The oral hooks and the posterior spiracles of the third stage larvae appeared in the second stage 2.00 hrs and 1.00 hr respectively before sheading of the cuticle (Plate XXIX, Fig.2& 3). The larvae were seen breaking the cuticle of the second stage at the anterior end and migrating out of the cuticle even discarding the cephalopharyngeal skeleton and posterior spiracles along with the larval skin (Plate XXIX, Fig.4). The time taken for completion of the moulting was observed to be 30 seconds.

Third stage larvae (23.30 hrs . maturity)

The larvae moulted between 23.00 hrs and 24.00 hrs. Considerable variations were observed due to the effect of moulting in the measurement of posterior spiracles and

cephalopharyngeal skeleton. An increase of 0.242 mm and 0.213 mm were observed to the length and breadth of posterior spiracles. The length of dorsal and ventral cornua, breadth of cephalopharyngeal skeleton at the junction of dorsal and ventral cornua, length of the oral hooks and the total length of cephalopharyngeal skeleton were increased by 0.553 mm, 0.139 mm, 0.144 mm, 0.099 mm and 0.795 mm respectively.

The larvae grew from 12.00 mm to 24.5 mm in length upto 50.00 hrs of age and were not found to grow anyfurther. In breadth the larvae increased from 3.00 mm to 4.50 mm till 42.00 hrs of age and there after no further growth was observed. There was no change observed in the measurements of posterior spiracles, length of the ventral cornua and in the length of oral hooks during growth. But an increase was observed in the length of dorsal cornua, breadth of the pharyngeal sclerite at the junction of dorsal and ventral cornua and in the total length of cephalopharyngeal skeleton by 0.015 mm, 0.028 mm and 0.028 mm respectively. The peritreme of the posterior spiracle was well chitinised even just after moulting.

The developmental changes of the fly inside the pupa was studied during their 10.5 days of pupal life (Plate XXX, Fig.1)

Developments inside the pupa

First day (24.00 hrs) (Plate XXX, Fig.1)

The body shape of the developing fly inside the pupa was oval, and it was brownish in colour. Segmentation of the larvae were clear and still present on the pupa. On the body of developing fly inside, there was a clear cut depression in the segment I to III so that it was seperated from the rest of the body. No differentiation as head, thorax and abdomen was observed. The moutparts were seen as 4 pair of segmanted buds on the anterio-ventral aspect. Coxa of the legs were visible on the ventral portion.

Second day (48.00 hrs)

The pupa was coloured brownish yellow. Inside the puparium, the head, thorax and abdomen were demarkated, the head portion being triangular in shape. The dorsolateral portion of the head in the region of the eye was slightly protruded. The mouth parts were found as a conical flap which lay ventrally covering a portion of prothorax. The segmentation of the 3 pair of legs were clear from the coxa to the tarsals. The wings were observed as elongated pads on the sides of the thorax. The demarkation of prothorax, mesothorax and metathorax was

becoming clear. A pair of small knobs were seen on the anterior and posterior corners of the mesothorax. The differentiation of different segments of the abdomen was also becoming clear. Genitalia was observed as a prominent knob.

Third day (72.00 hrs)

In the head, the development of ptilinal sac was observed. The antennae were visible as 2 bands. There was a pair of longitudinal depressions on the dorsal surface of thorax. The segmentation of the abdomen was well visible only from the sides. The prothoracic spiracle was seen as a yellow round object. The knobs on the mesothorax were still visible.

Fourth day (96.00 hrs) (Plate XXX, Fig.1)

The mouth parts still appeared as a conical pad on the ventral aspect of head extending to the prothorax and the antennae were differentiable. Vague black strips appeared on the longitudinal depression. The knobs on the misothorax were still visible. Segmentation of the abdomen were very clear and visible from the dorsal side.

Fifth day (120.00 hrs)

The eyes were seperated and well demarkated with slight protruberance on the dorsolateral aspect of the head.

The proboscis, palpi and the antennae were seperable in the conical flap. Vibrissae were clear but white in colour. Prothorax, mesothorax and metathorax could be well differentiated. One more black stripe appeared in between the other two on the thorax totalling it to three.

Sixth day (144.00 hrs)

The wings were seen developed as folds from the pads.

Seventh day (168.00 hrs) (Plate XXX, Fig.1)

The males and females were differentiable from the sub-holptic and dicoptic character of the eye. The longitudinal stripe became much more darkened, on the thorax. The fifth tarsal segment was bifurcated into a pair of pads. The external genitalia still appeared as a prominent knob.

Eighth day (192.00 hrs)

The eye was well demarkated with a brownish colour over the orbit of the eyes. The hairs and bristles throughout the body were white but clear. The costa of the wing was chitinised. The segments of the legs were also partially chitinised. Sternites were differentiable on the ventral aspect.

Nineth day (216.00 hrs)

The eyes were very clearly demarkated and coloured red. The longitudinal black stripes on the thorax were very clear. The hairs and bristles on the head, thorax and abdomen were darkened with chitinisation. The ocelli on the head were not clear. Longitudinal black spots on the sides with a central longitudinal black line was observed on the abdomen of the developing fly. In the genitalia, the accessory forceps and the superior claspers were clear and demarkated.

Tenth day (240.00 hrs) (Plate XXX, Fig.1)

The eyes were brownish in colour. The ptilinal sac was prominent and was found slightly inflate . The ocelli and ocellar triangle were clearly visible. The parafrontalia, parafacialia, frons, face, epistome, buccae, vibrissae, antennae, arista, palpi and the proboscis could be well differentiated. The bristles throughout the body of the fly were very clear so that the chaetotaxy could be studied easily. The prothoracic spiracle was round when compared to the oval one in adult fly. The veins of the wings and the segments of the legs were fully chitinised. The wings and legs were found folded on the ventral aspect. The superior claspers of the genitalia was full chitinised.

The larvae migrated to sand only after 90-110 hours. The prepupal period of the mature larva in sand was observed to be 30-45 hrs. The larvae were removed from bait and put in sand to study the age at which they pupated. The larvae from 24-30 hrs of age did not pupate at all. The larvae of 30-45 hrs and 45-60 hrs pupated by 60-120 hrs and 40-75 hrs respectively. The average pupal period of the fly was observed to be 10.5 days.

The flies took 2-6 mts for emergence from the puparium. The process of fly emergence was similar to Chrysomyia megacephala (Plate XXX, Fig.2 & 3). The wings were completely unfolded by 20 mts. The normal colour was found partially developed on the fly even at the time of its emergence. Normal colour appeared completely over the body along with the unfolding of wings.

The percentage of male flies and female flies emerged from the puparium were 42% and 58% respectively.

DISCUSSION

Studies on the various aspects of the morphology and bionomics of Chrysomyia bezziana, Chrysomyia megacephala Chrysomyia rufifacis, Chrysomyia nigripes, Lucilia cuprina and Sarcophaga ruficornis are made in the present work. Various workers have described the morphology and characters of identification of the above mentioned flies, but the information on their biology lacks in literature.

The characters of the eggs of the flies studied are in conformity with the description of Patton(1920),Sen and Pletcher (1962), Zumpt (1965), Nachiappan (1971) and Kitching (1976).

As regard to the larvae, the third stage larvae of Chrysomyia bezziana measured 11-18 mm in length, in contrary to the description given by Nachiappan (1971) who has recorded the length of the larvae as 11-16 mm. Nachiappan (1971) has also reported that the second stage larvae of Chrysomyia megacephala possessed ill developed oral hooks where as in the present study it is found to possess well developed oral hooks.

The complete description of the first, second and third stage larvae of Chrysomyia rufifacis are not sufficient from the available literature, although Nachiappan (1971)

tried to describe the larvae. He has not mentioned anything about the number of papillae, number of spines on the papillae, the additional papillae seen at the base of the lateral most papillae on either side on the dorsal aspect, the brown bands on the dorsal aspect of the mature larvae on which the papillae are arranged in a row and the ventral papillae on the abdominal segments containing spines. Kitching (1976) described the characters of the larvae of Chrysomyia nigripes, but does not mention anything regarding the presence of dark brown rectangular bands, on the dorsal aspect which are observed in the present study. The mature larvae of Lucilia cuprina possesses 3 pairs of tubercles on the posterior lip, which is contrary to Pattons (1922 a) observation of 2 pairs. In general the morphological characters of the larvae of the species studied are identical with the observations of Macgregor (1914), Patton (1920), Sinton (1921), Patton (1922 a), (1922 b), (1922 c), (1922 d), Holdway (1933), Sen and Fletcher (1962), Zumpt (1965), Nachiappan (1971), Choudhuri (1976) and Kitching (1976).

The observations made on morphological characters of the pupa are in agreement with those of Patton (1922 a), Zumpt (1965), Nachiappan (1971) and Kitching (1976)

As regards to the morphology of the flies studied, it is broadly in conformity with Patton (1920), (1922 b), (1922 d), (1922 e), Senior White et al.(1940), Sen and Fletcher (1962), Zumpt (1965), Nachiappan (1971) and Choudhuri (1976). But additional characters observed in the present study with regard to Lucilia cuprina is that the males possess a deeper coppery colour on the thorax and abdomen than the females. The halters of Chrysomyia nigripes are yellow in colour.

Regarding the biology of the flies studied, the observations are almost similar to those made by Smith (1916), Dunn (1918), Patton (1922 c), Mackerras (1933), Brannon (1934), Evans (1935). Laake (1939), Webber (1955), Wijesundra (1957), Browne (1958 a) (1958 b), (1958 c), Webber (1958), Hobart (1959), Sen and Fletcher (1962), Norris (1965), Zumpt (1965), Nachiappan (1971), Ash and Greenbug (1975), Roy and Gupta (1975) and Choudhuri (1976).

Patton (1922a) mentions that Lucilia cuprina has laid 346-460 eggs in 24-36 hrs in contrary to the present observation where the maximum number of 216 only. Lucilia cuprina lays a maximum of 1528 eggs throughout its life

span, but according to the reports of Mackerras (1933) hybrid and non hybrid L.serricata have laid 3171 and 2373 eggs respectively. Lucilia cuprina does not lay eggs in garbage whichis against the reports of Kilpatrick and Bogue (1956). Vijesandra (1957) has not mentioned anything about the prepupal period of Chrysomyia megacephala.

The pupal period of Chrysomyia bezziana as stated by Patton (1922 e) and Norris and Murray (1964) are 6-8 and 7-9 days respectively at 24-32°C, whereas in the present observation it is observed to be 5 days only. Herms (1953) mentions about the biology of Callitroga hominivorax which appears almost similar to the biology of Chrysomyia species of flies studied. Alwar and Seshaiah (1958) have studied the life history of Sarcophaga dux which is different in all aspects to that of Sarcophaga ruficornis. The flies of Lucilia cuprina could live in the laboratory for 71 days but as per the reports of Norris (1965) the flies live for only 42 days.

The detailed studies on the development of larvae invitro, duration and the processes of emergence of Chrysomyia megacephala and sarcophaga ruficornis are new

to science as observed from the available literature, though Smith (1916) has described the process of emergence of Calliphora erythrocephala from the puparium.

From the present studies it can be concluded that Chrysomyia rufifacies takes the minimum time and Sarcophaga ruficornis the maximum duration for the completion of their life cycle. Of the different species of larvae studied, Chrysomyia rufifacies seemed to be the most voracious and harmful one, for it was found to eat even chrysomyia bezziana larvae, when there was scarcity of food.

PLATE III *Chrysomyia bezziana*

Fig. 1 Adult fly
Fig. 2 Mature larvae
Fig. 3 Puparium

Fig. 1

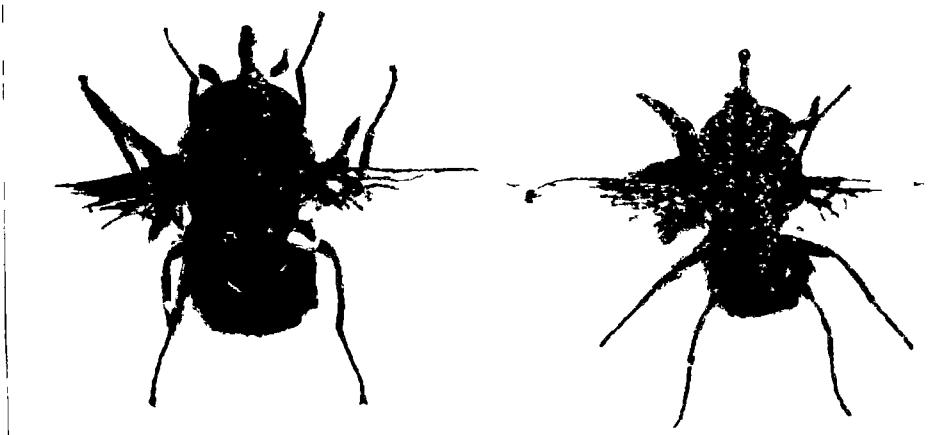


Fig. 2

Fig. 3

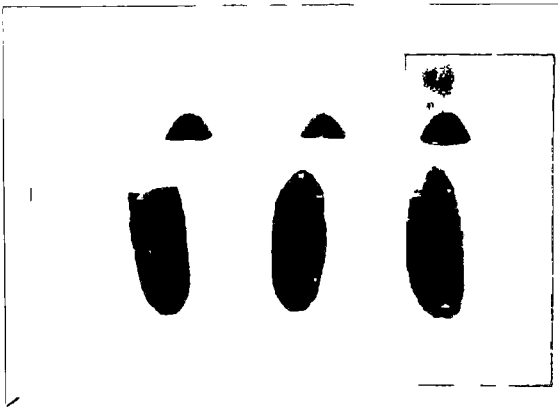


PLATE IV Chrysomyia bezziana

Fig. 1 Second larval moulting - showing the development of cephalopharyngeal skeleton of the third stage 30 X

Fig. 2 Body spines of mature larvae 100 X

Fig. 1

Fig. 2

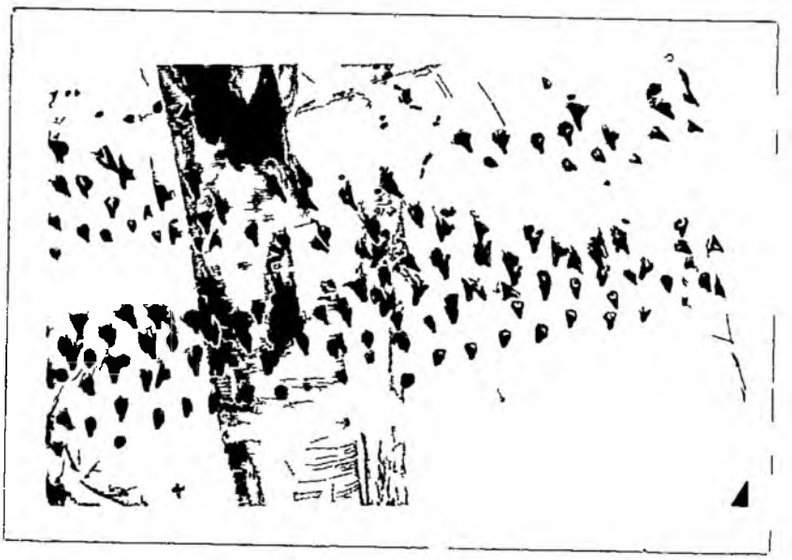


Fig. 1

Fig. 2

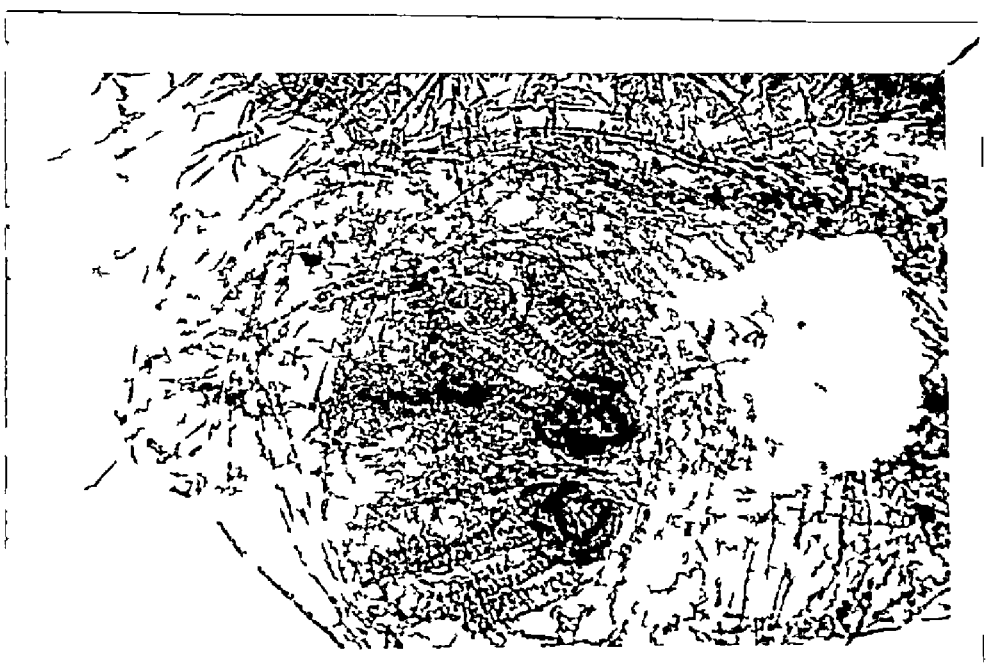


Fig. 1

Fig. 2

Fig. 1

Fig. 2

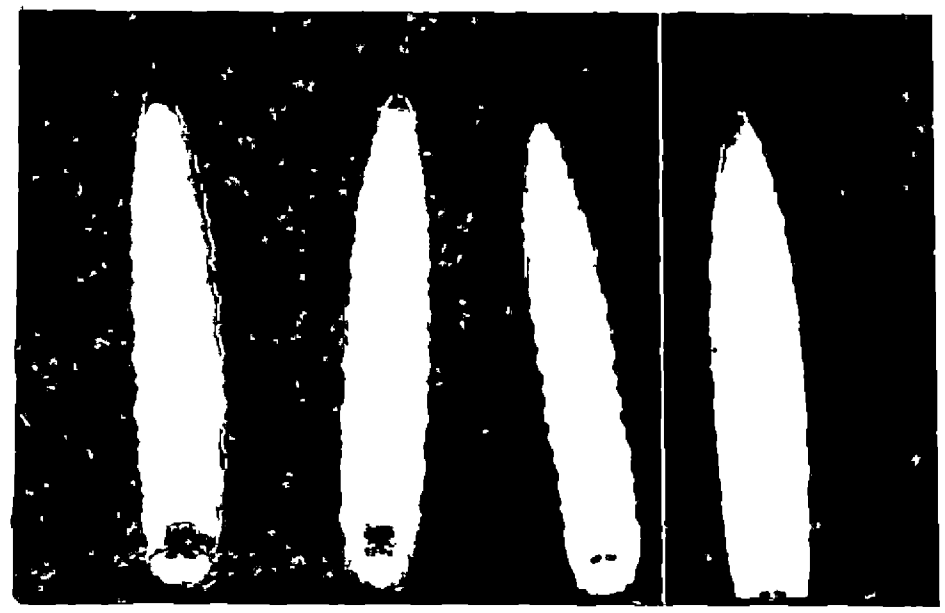


Fig. 3

Fig. 4

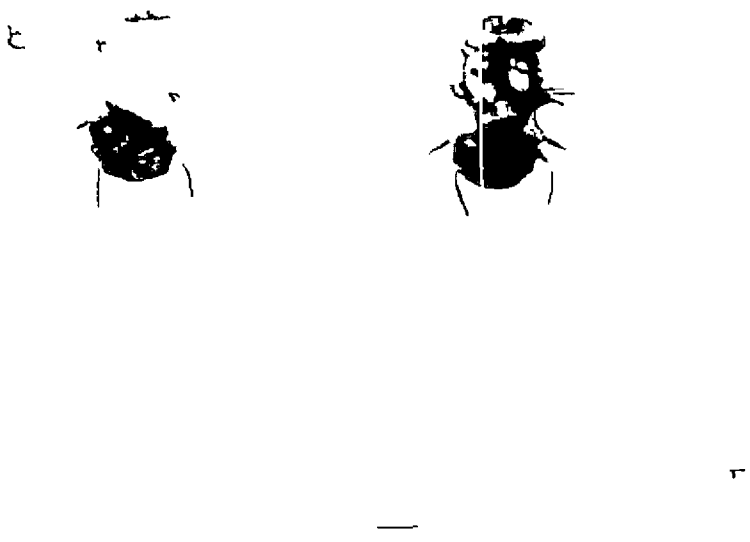


Fig. 1

Fig. 2

Fig. 3

PLATE X Chrysomyia megacephala

Fig. 1 Cephalopharyngeal skeleton of second stage larva 80X

Fig. 2 Posterior spiracle of second stage larva 160 X

PLATE X

Fig. 1

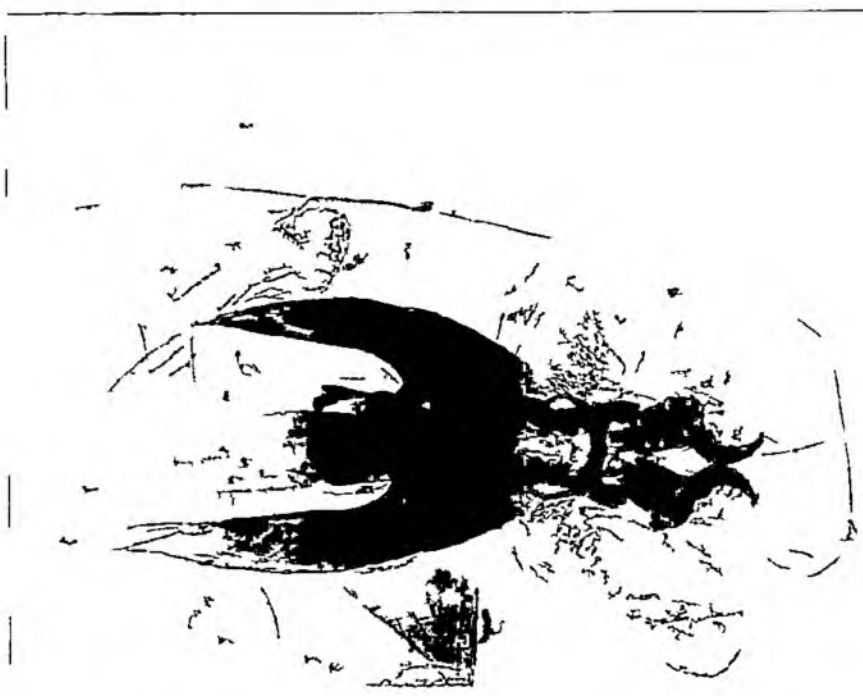


Fig. 2

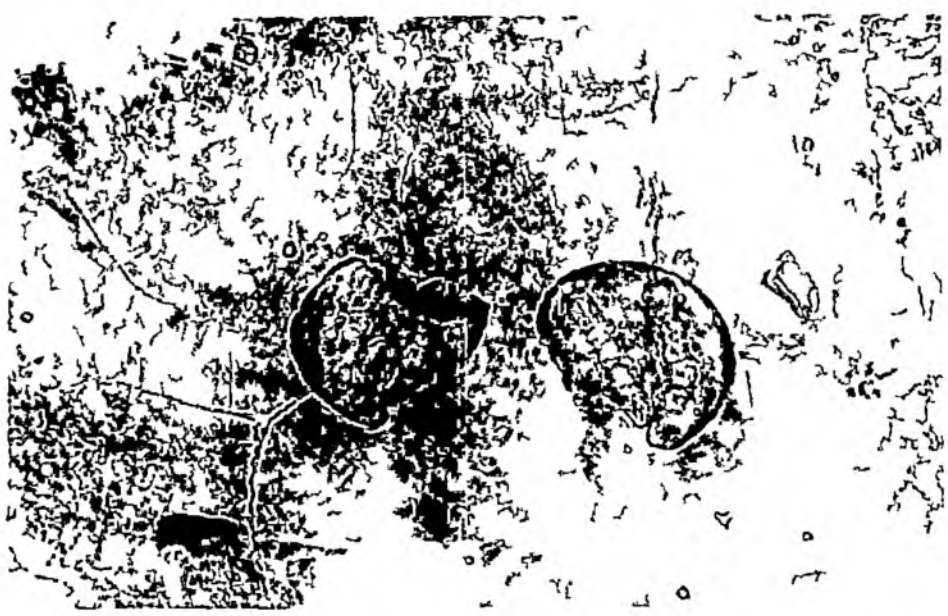
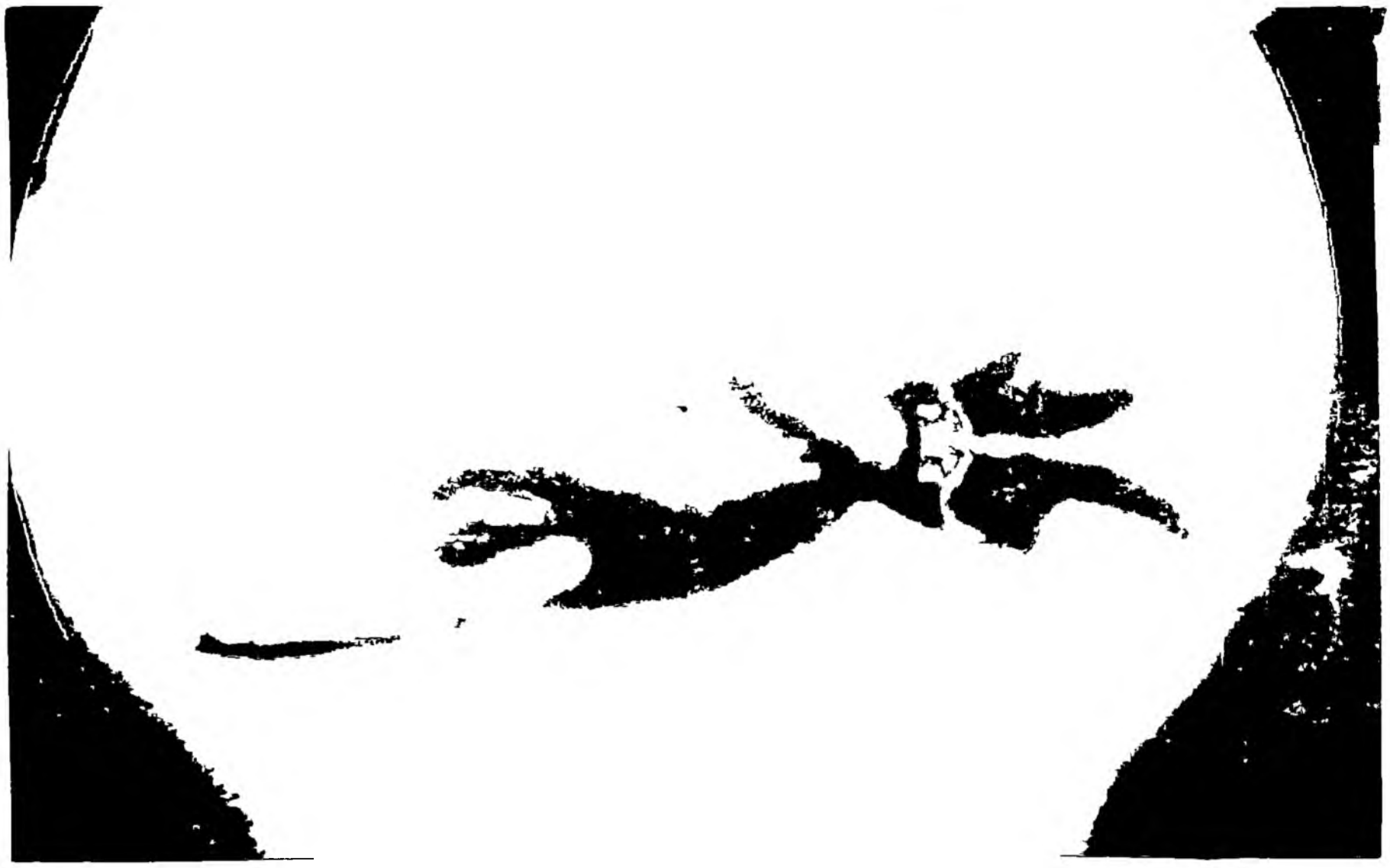


Fig. 1



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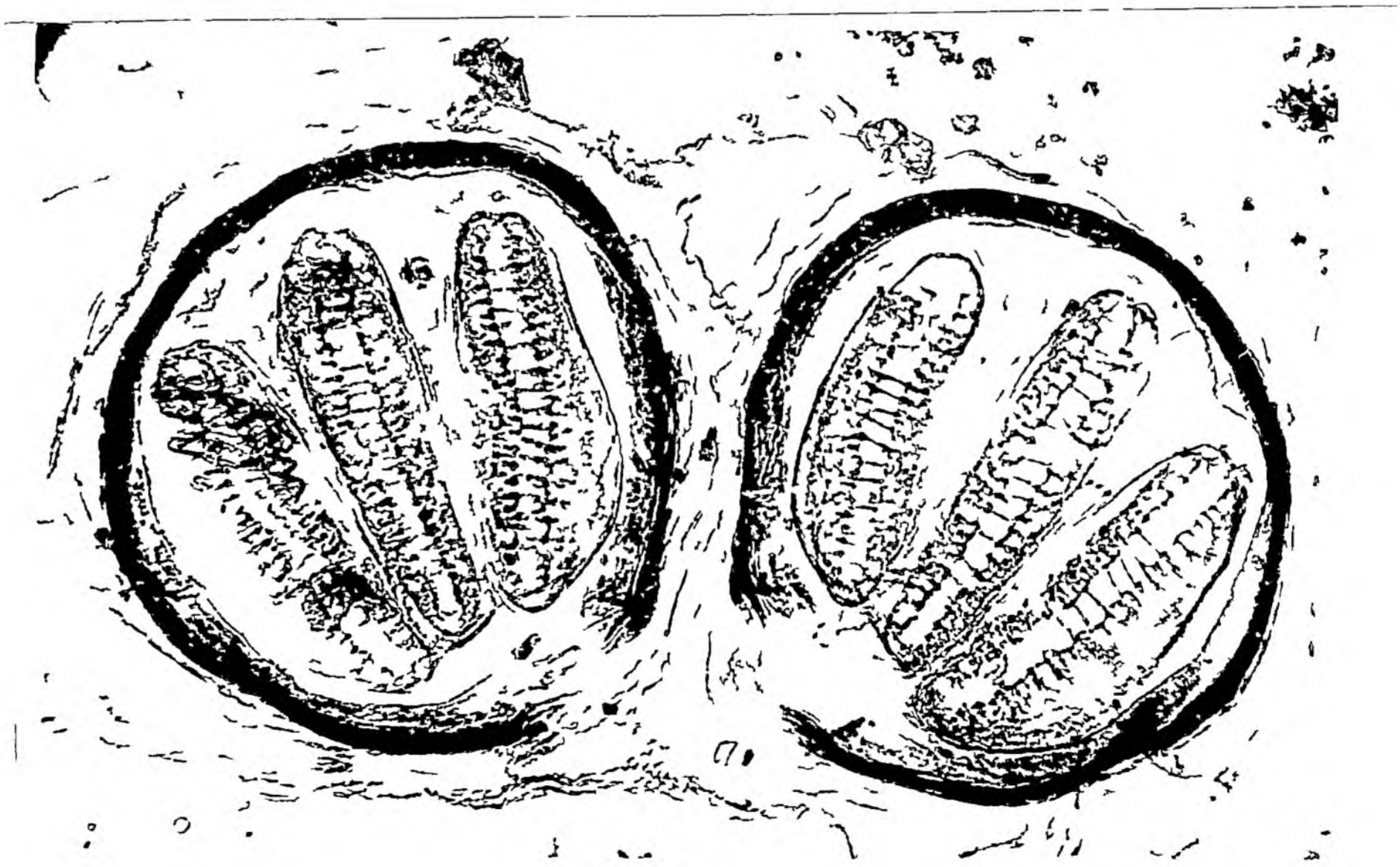

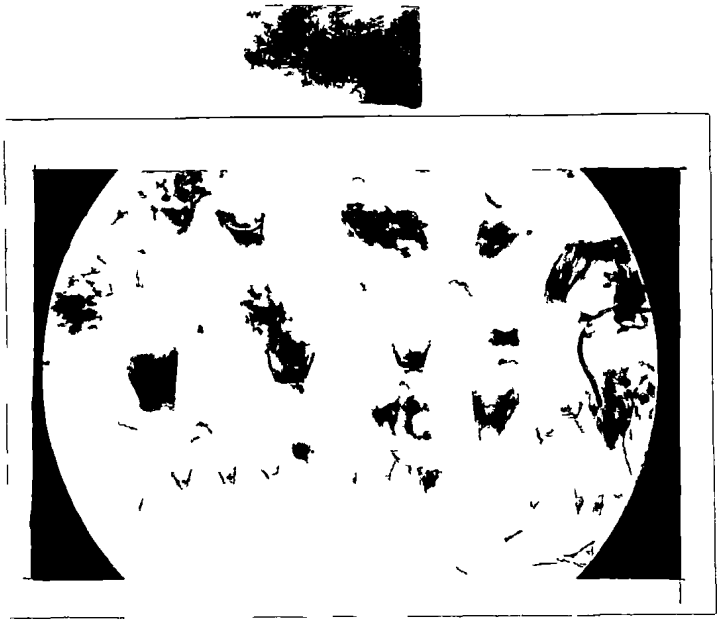

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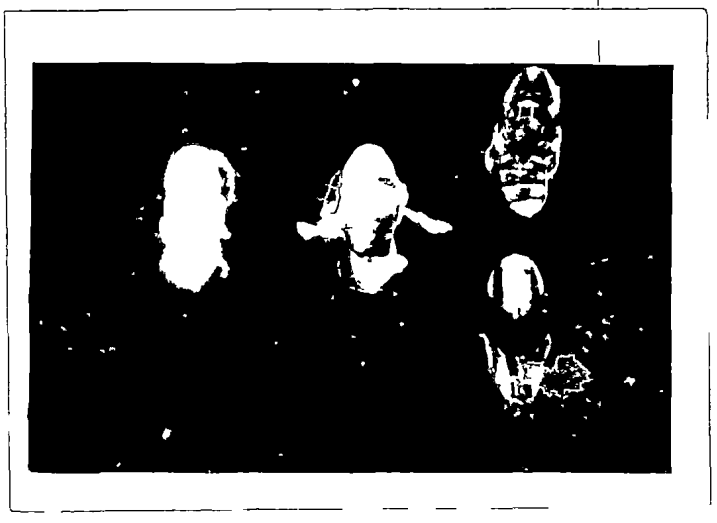


Fig. 3

Fig. 4

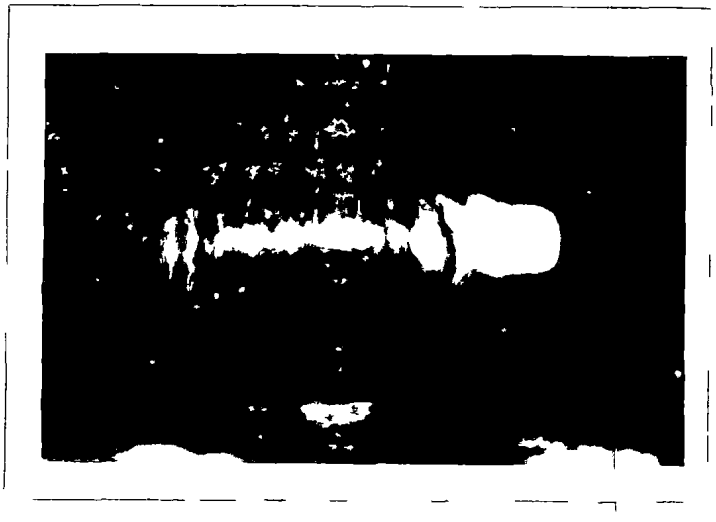


Fig. 1

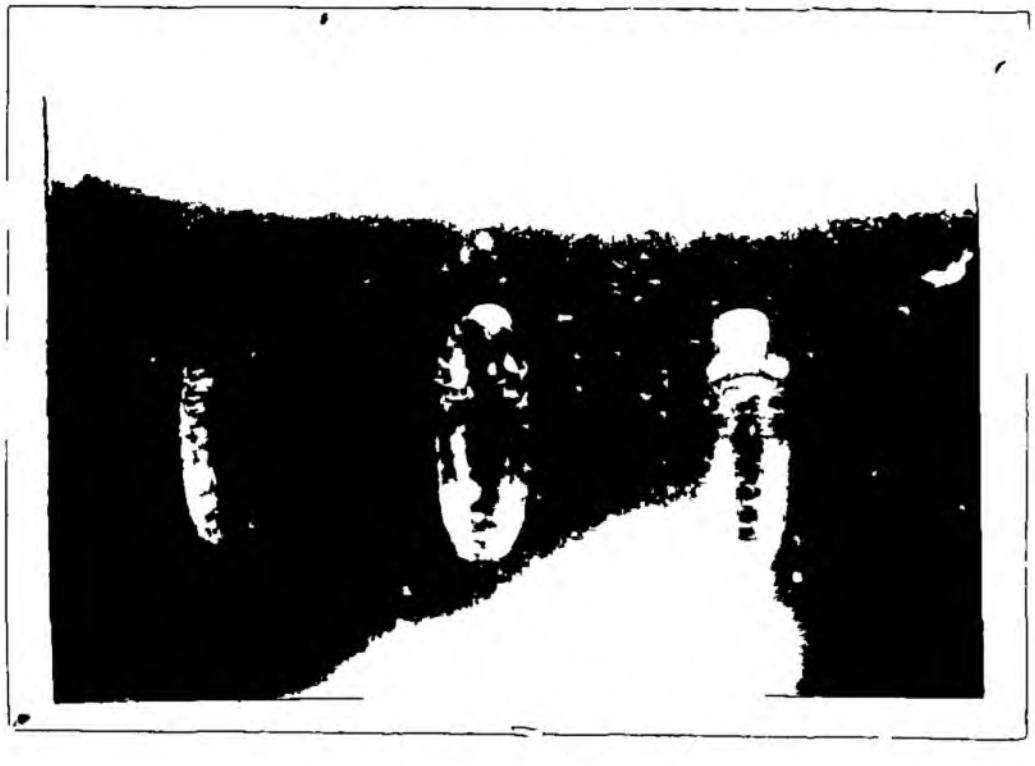


Fig. 2

Fig. 3

Fig. 4

Fig. 1

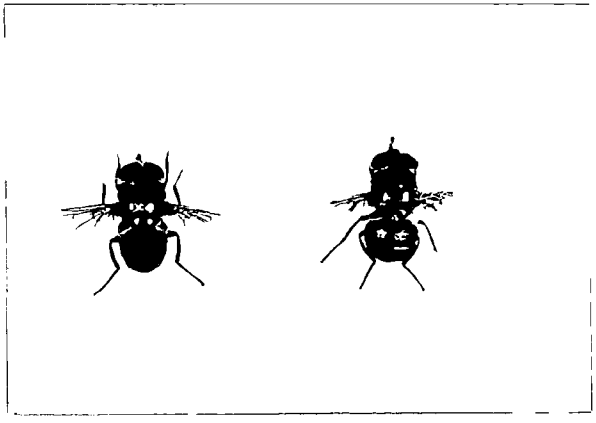
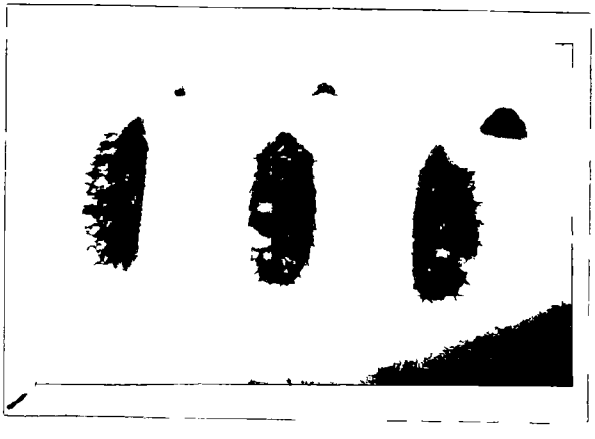


Fig. 2

Fig. 3



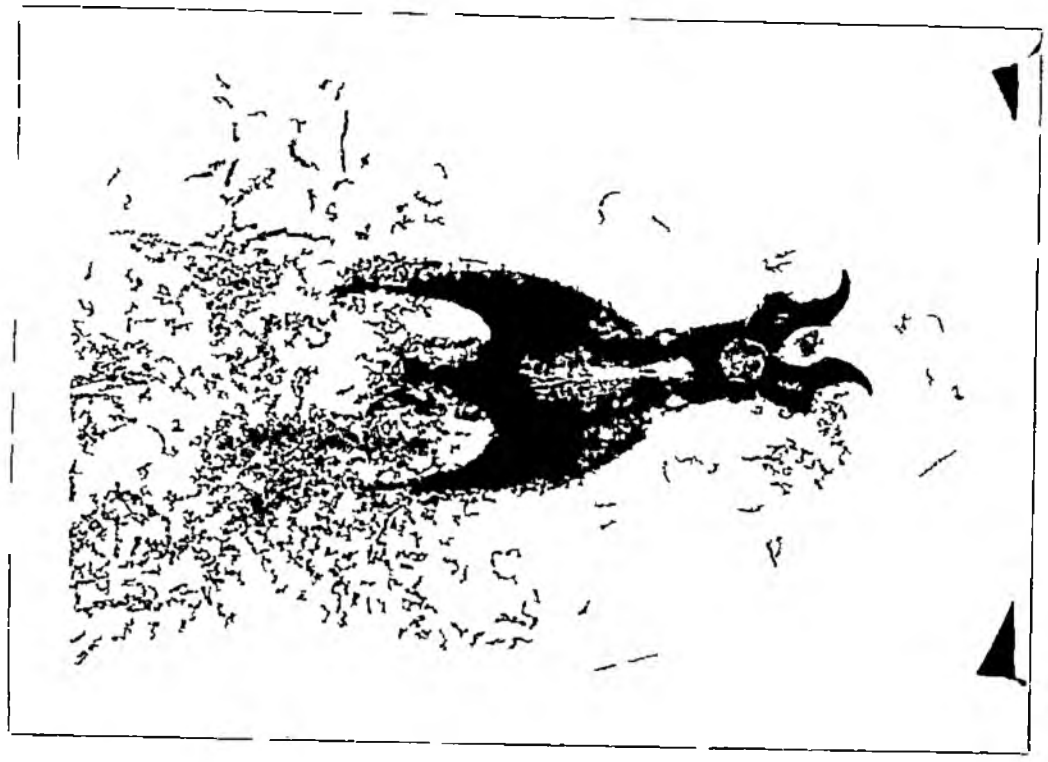


Fig. 3

Fig. 4

Fig. 2

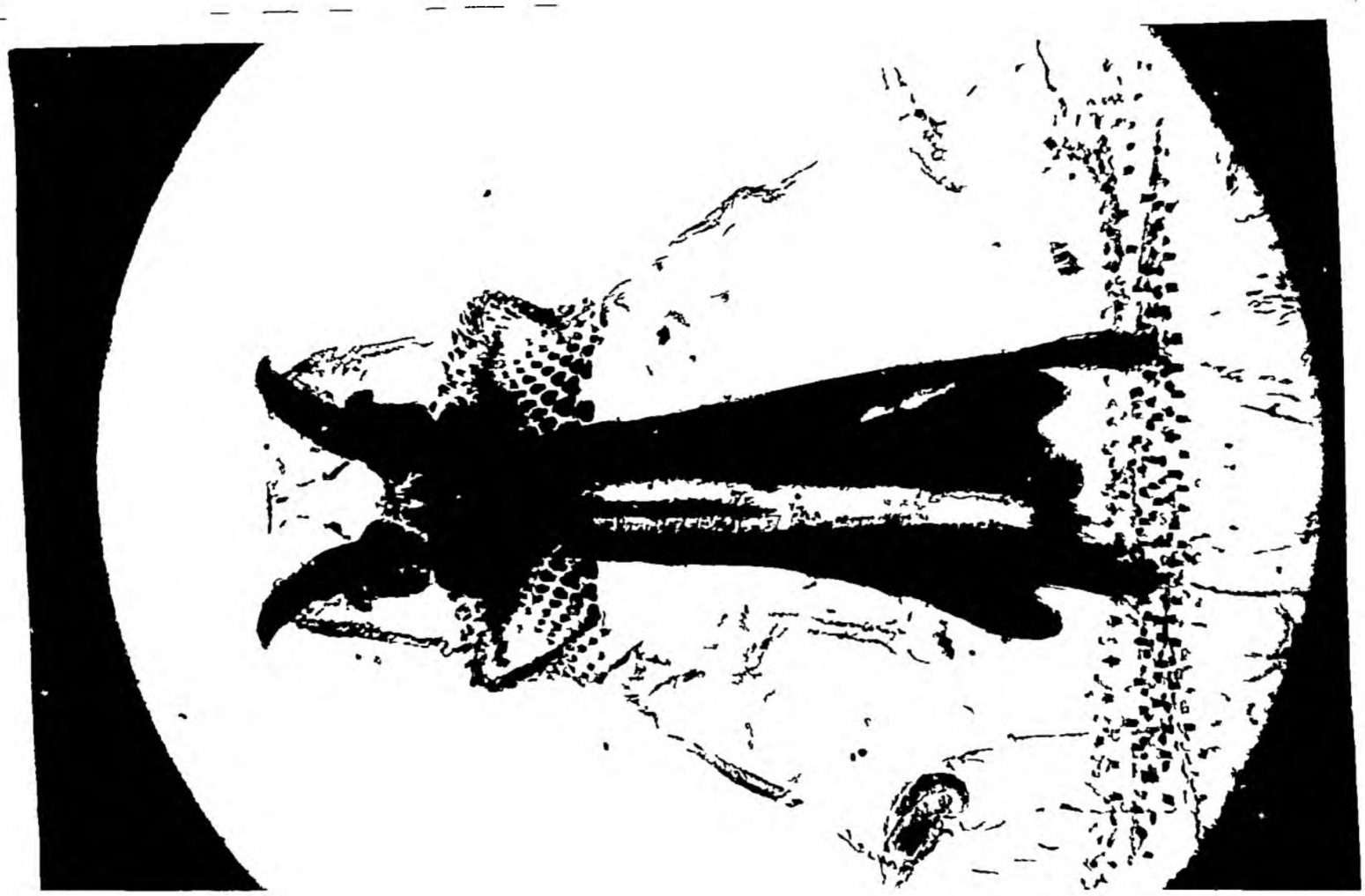


Fig. 3

PLATE XVI

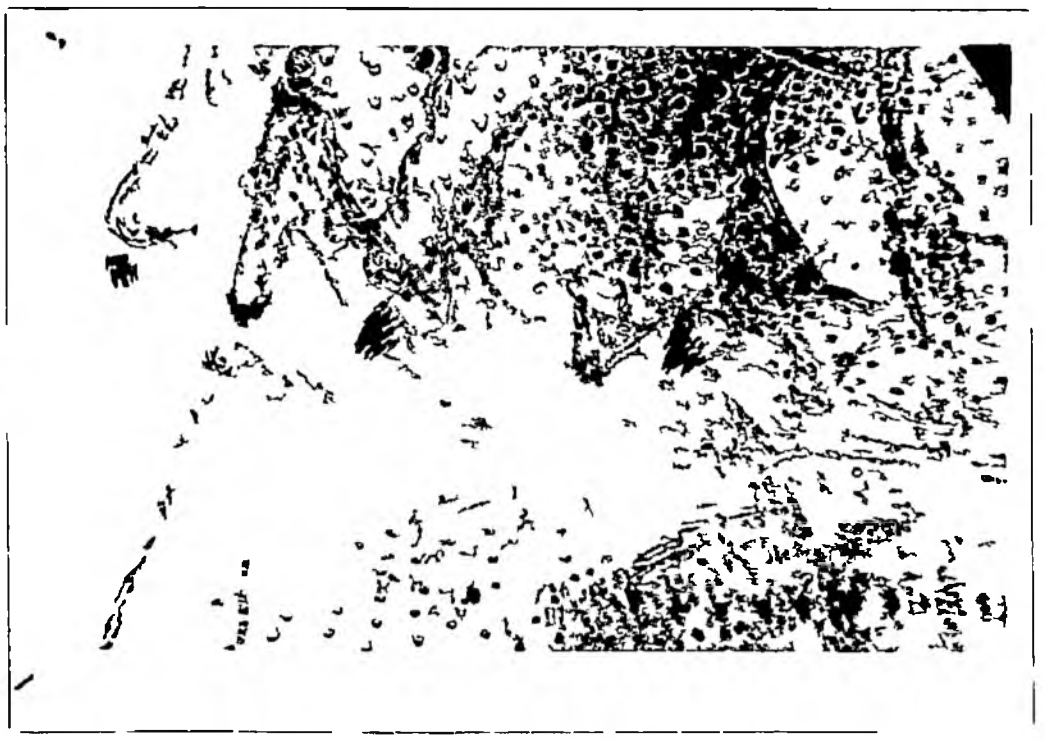
PLATE XVII *Chrysomyia rufifacies*

Fig. 1 Body papillae with spines of mature larvae 80 X

Fig. 2 Larval cannibalism

PLATE XVII

Fig. 5



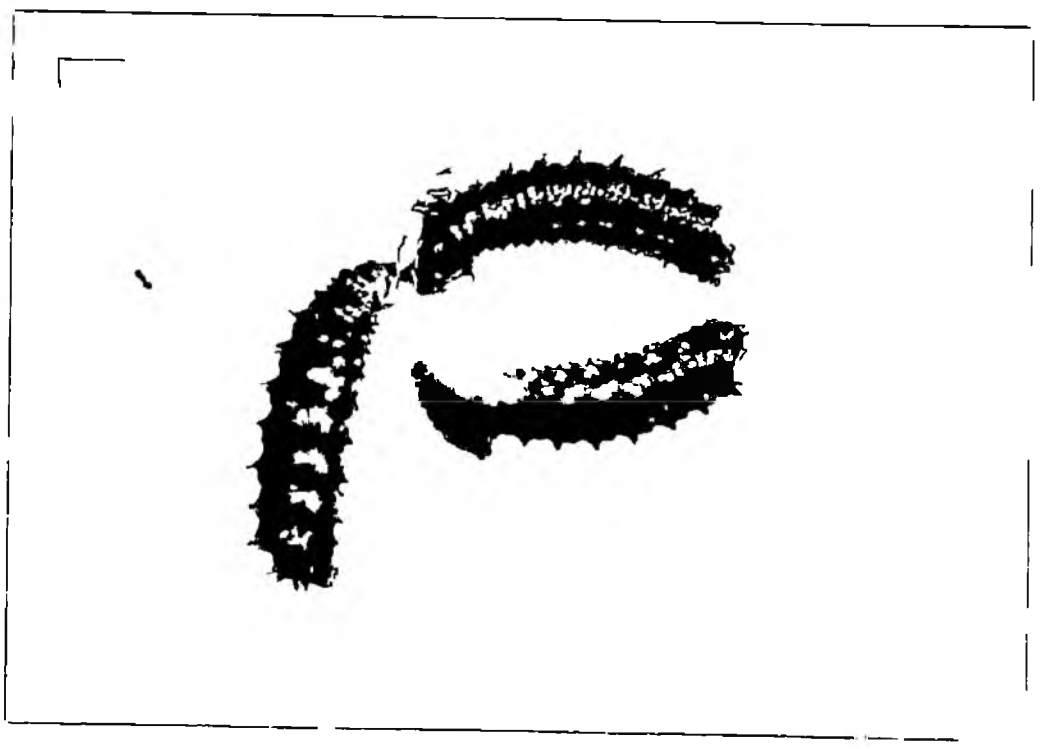


Fig. 1

PLATE XX

Fig.1

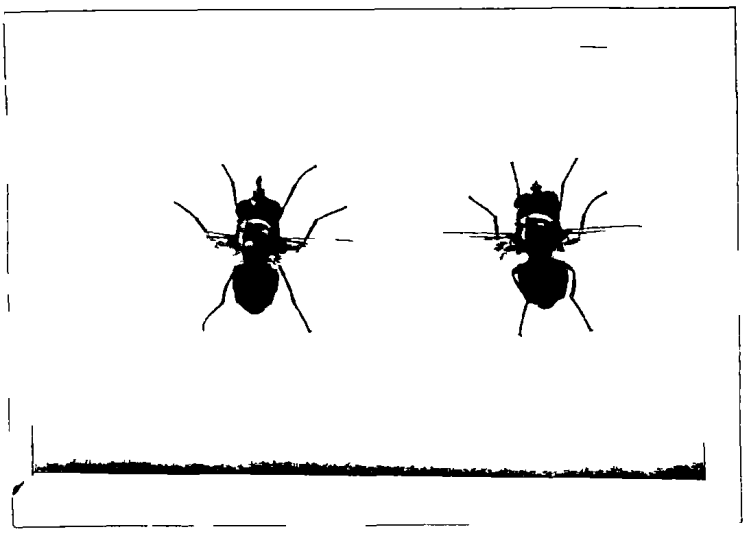


Fig. 2

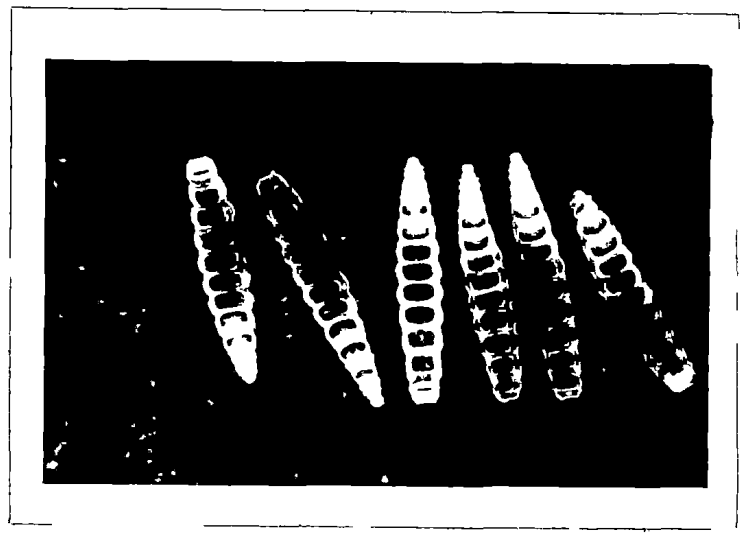


Fig. 3

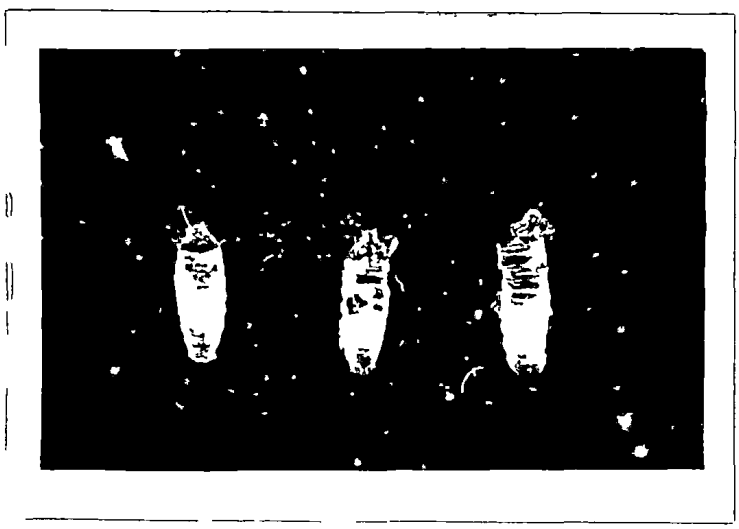


Fig. 4

Fig. 1

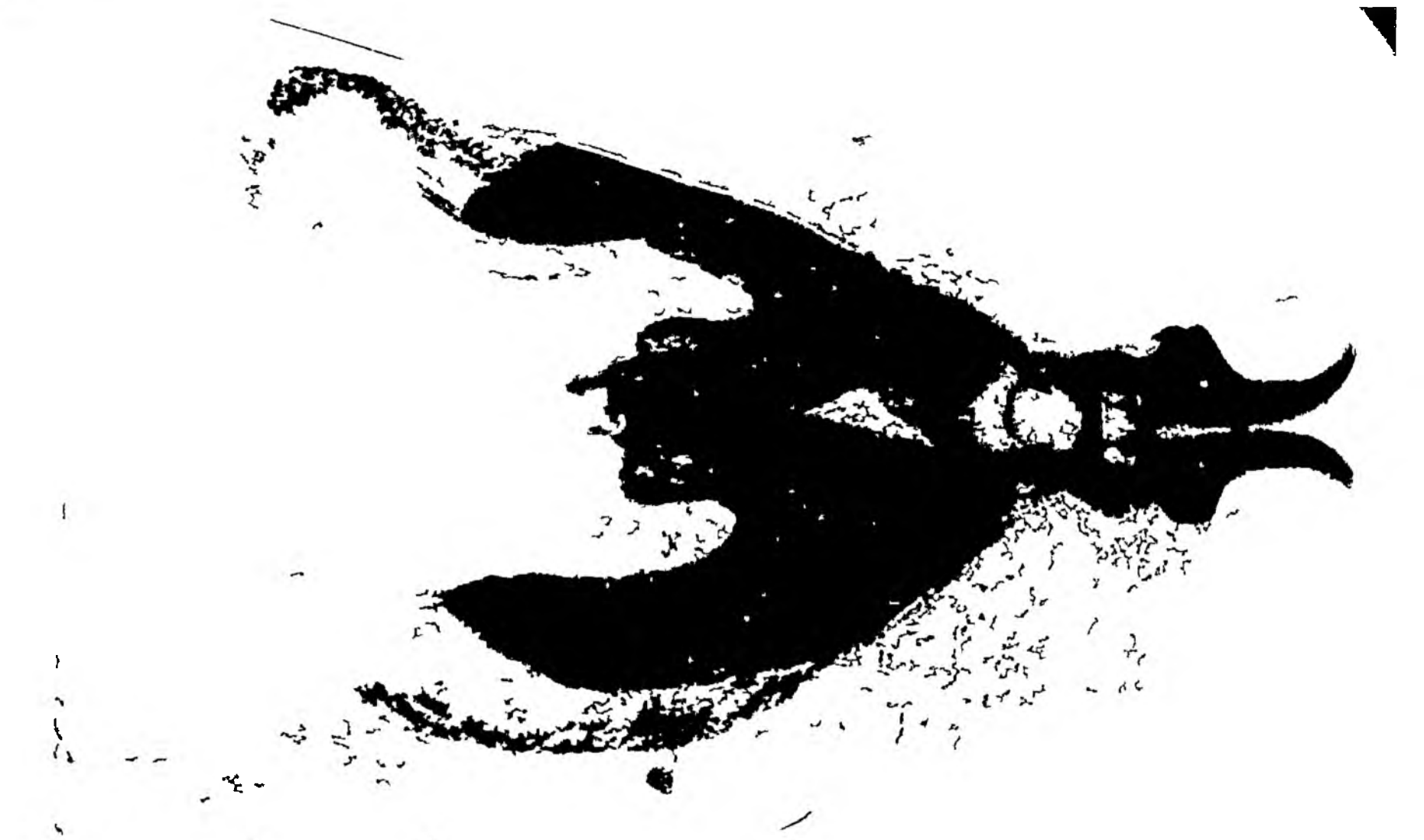


Fig. 2

PLATE XXII

PLANT

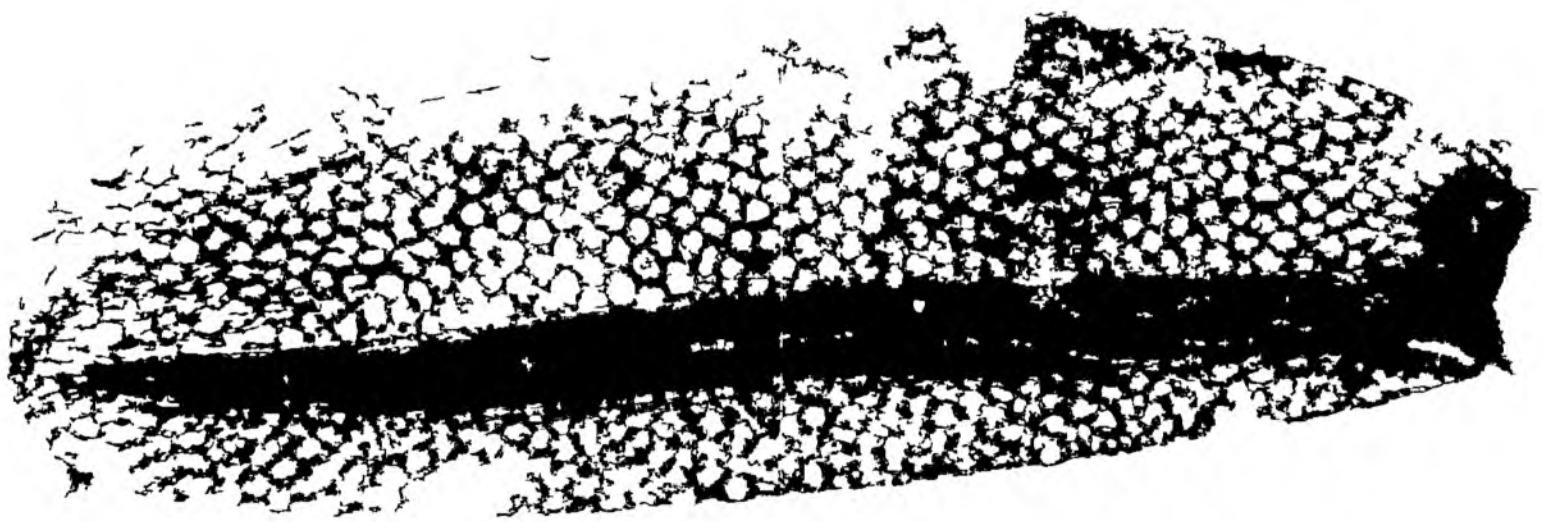
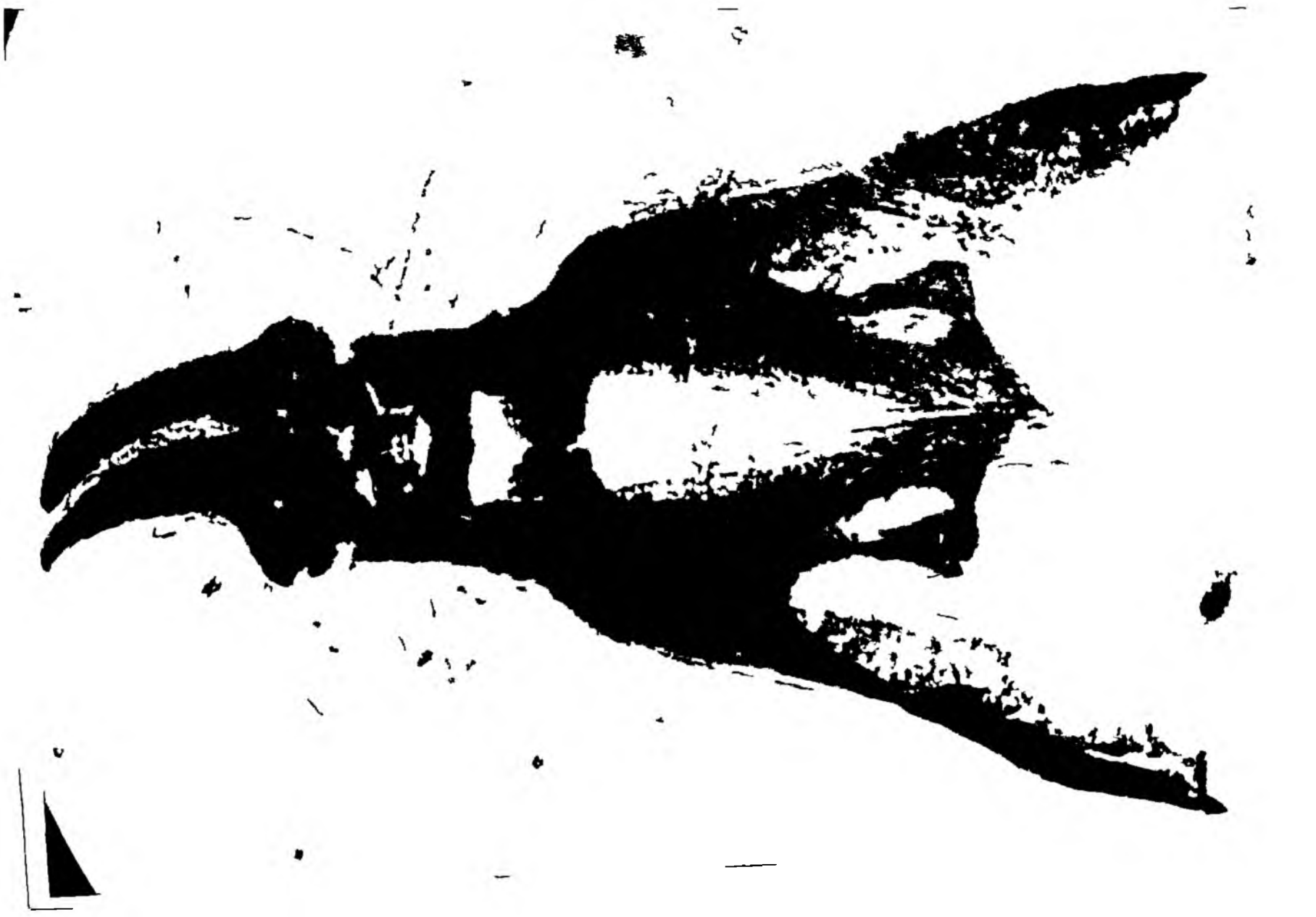


Fig. 1



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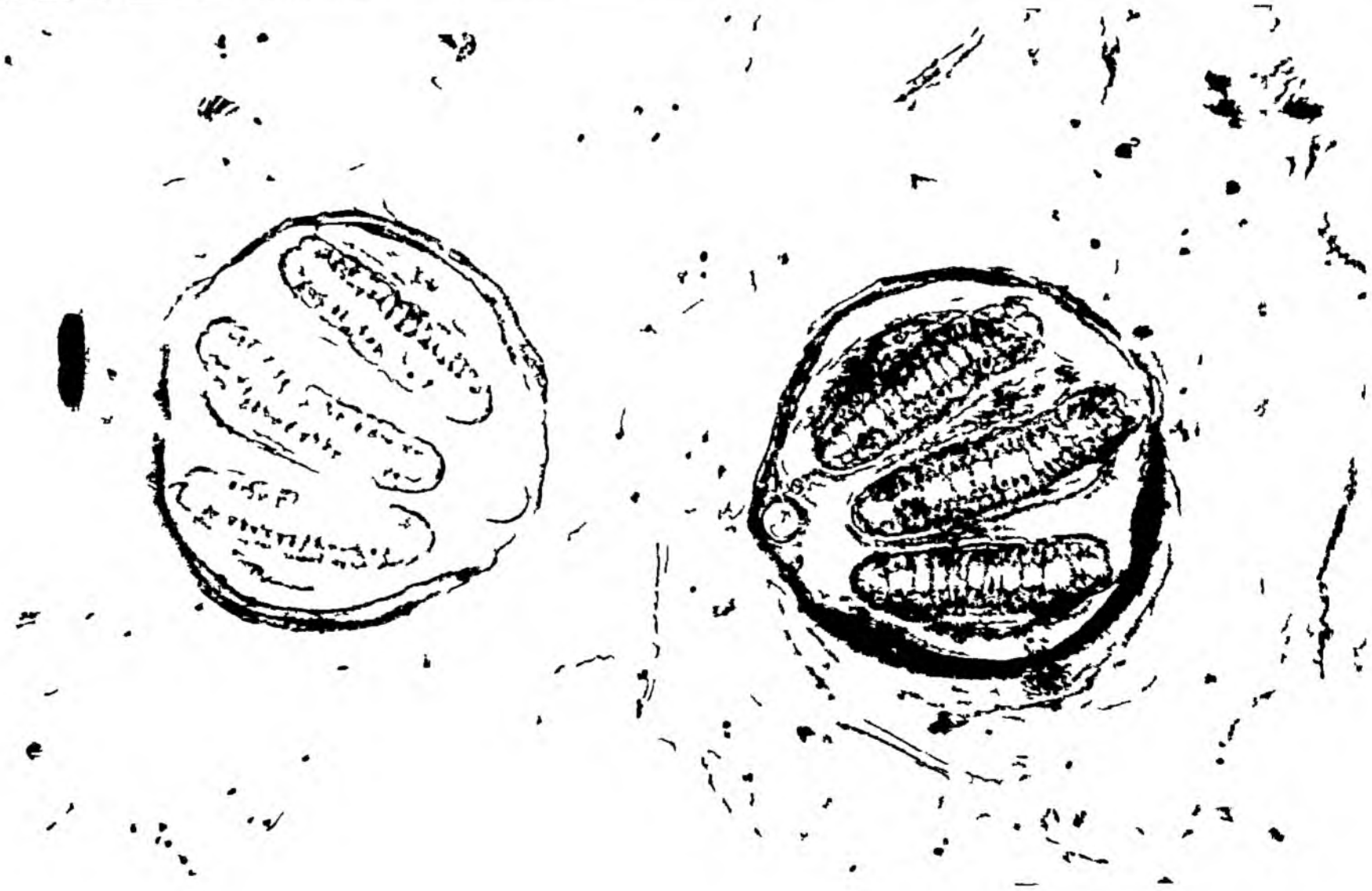
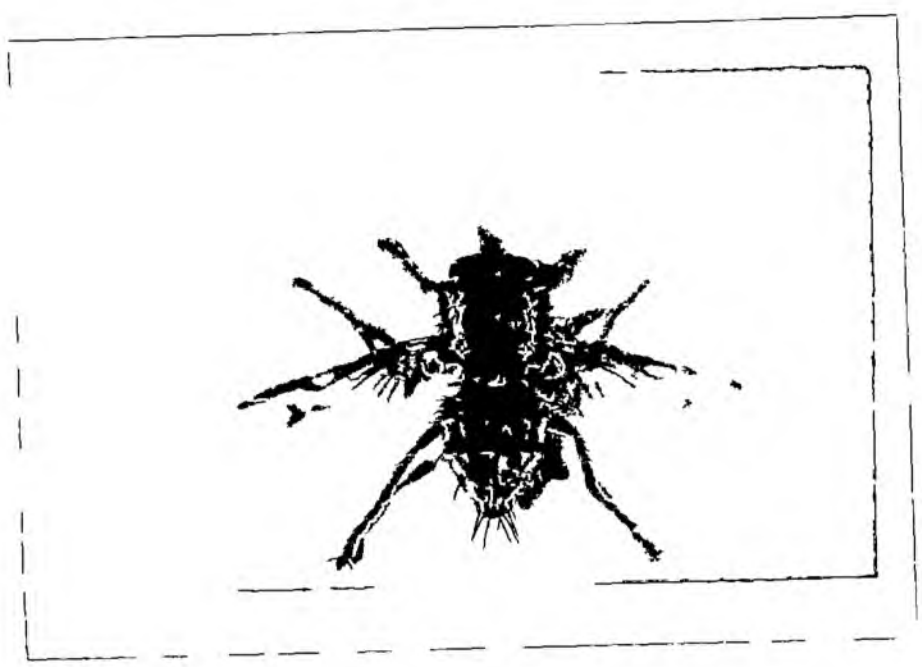


Fig. 1



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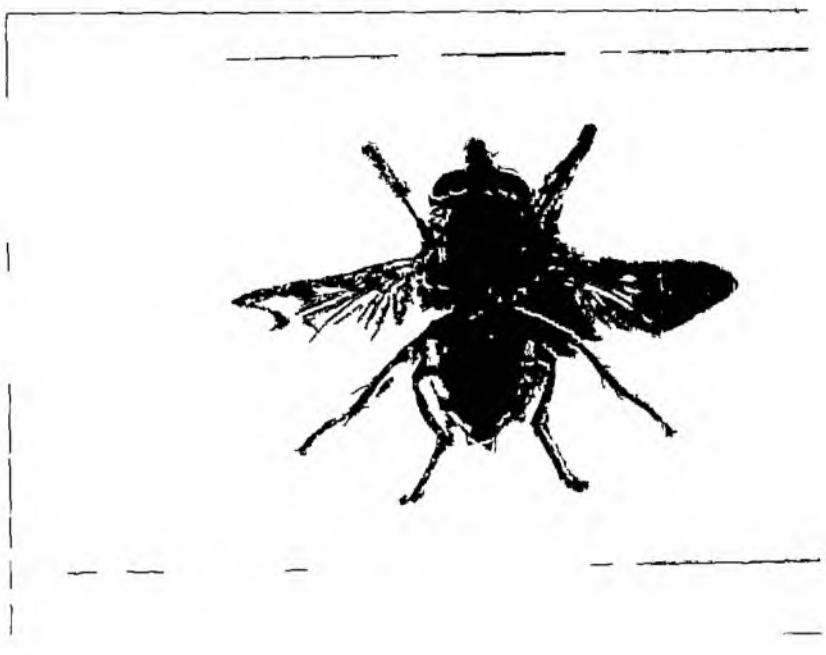


Fig. 3

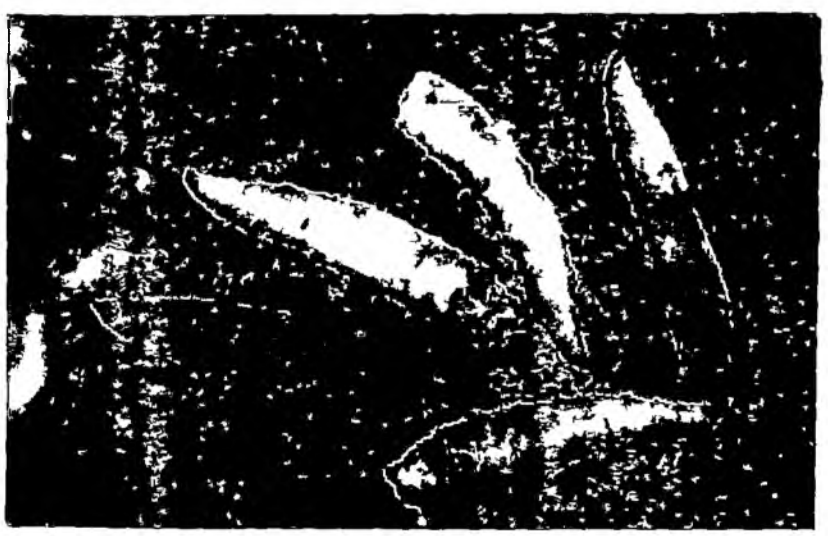


Fig. 4.

PLATE XXVI

Fig. 2

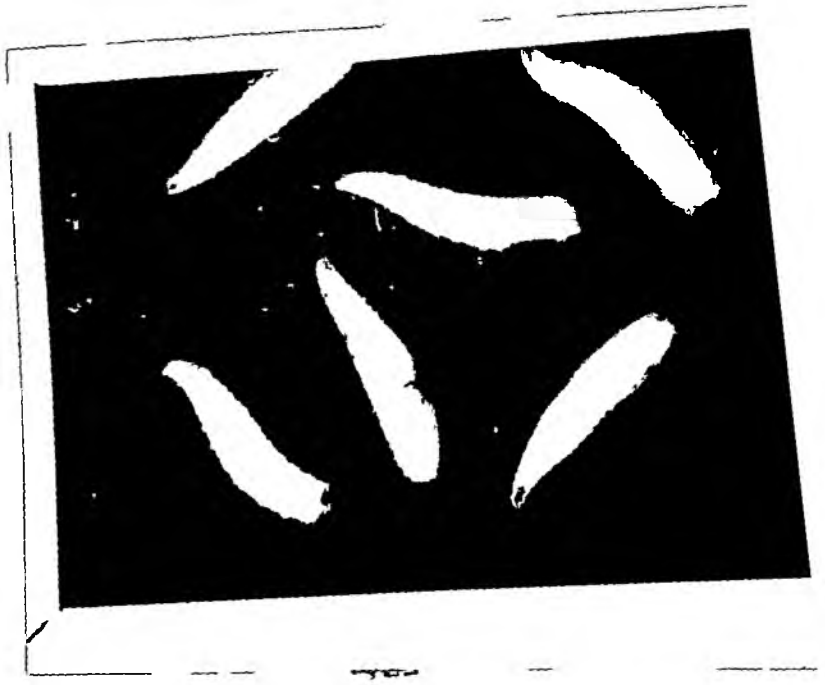
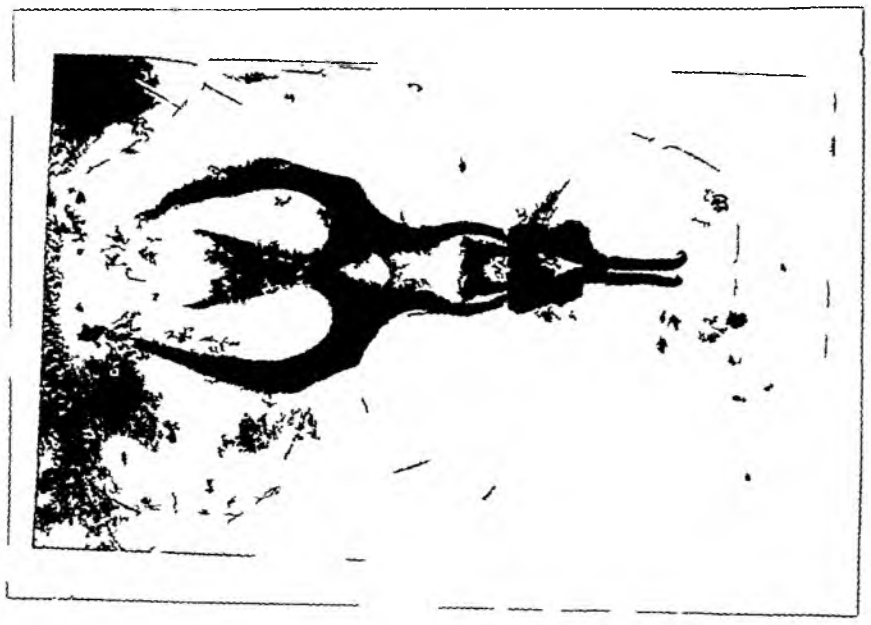


Fig. 3



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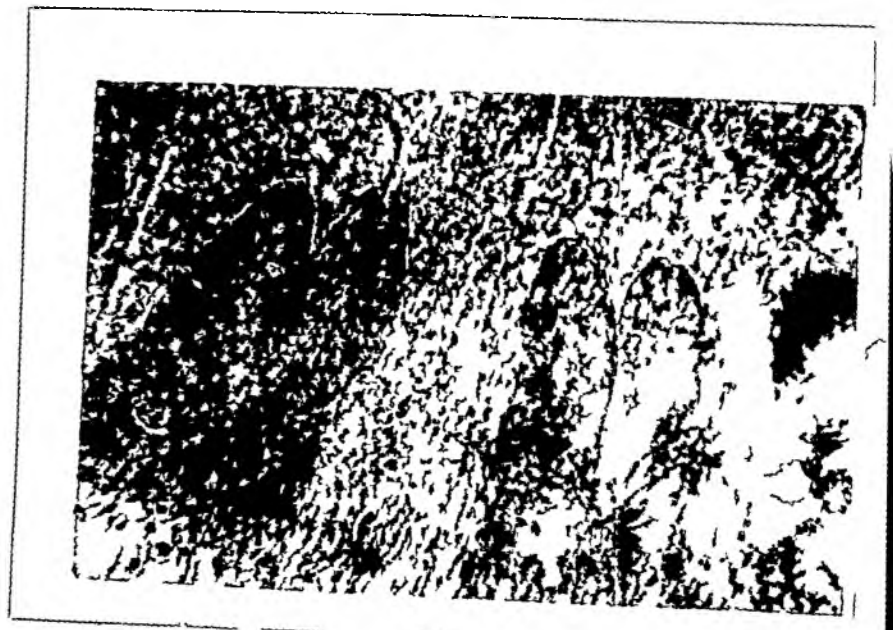

Fig. 1.

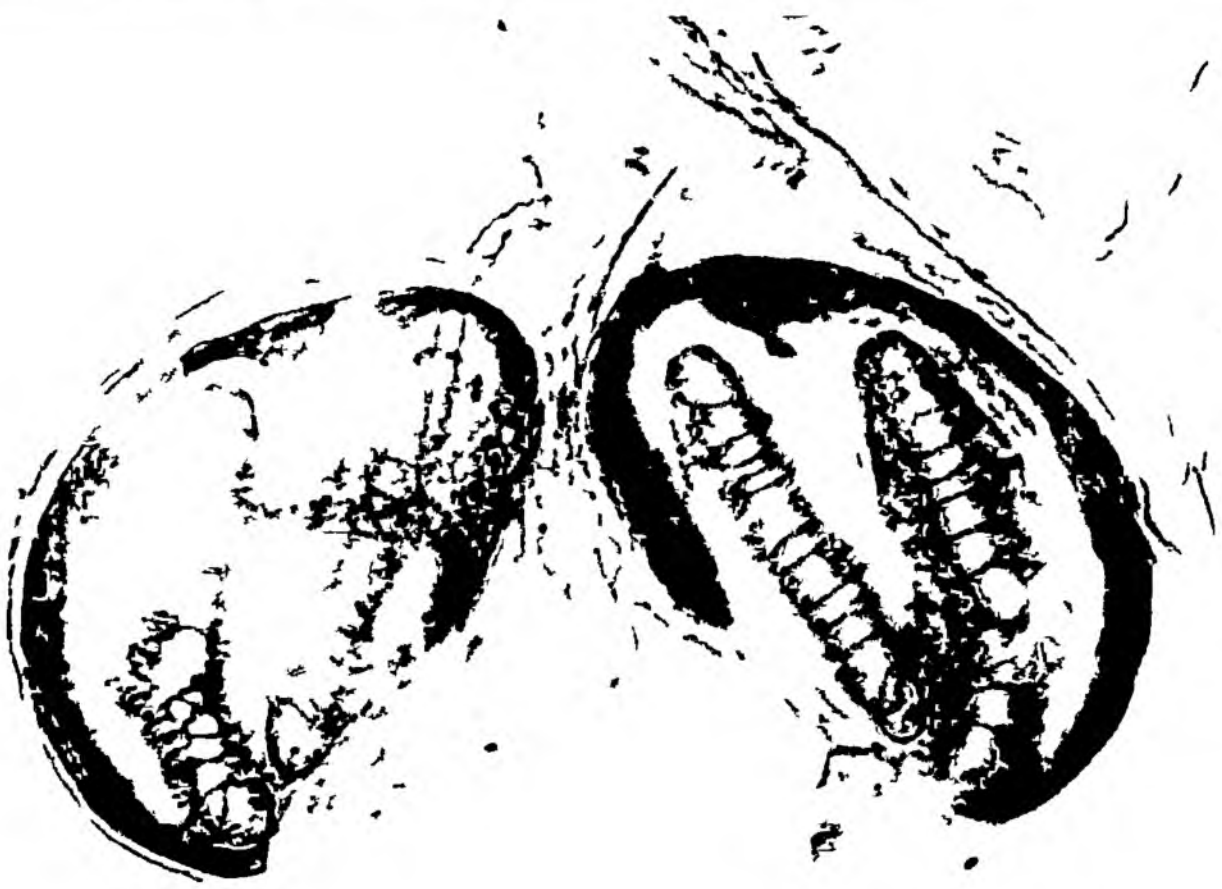

PLATE XXVIII *Sarcophaga ruficornis*

Fig. 1 Cephalopharyngeal skeleton of mature larvae 100 X

Fig. 2 Posterior spiracle of mature larvae 175 X

PLATE XXVIII

Fig. 1

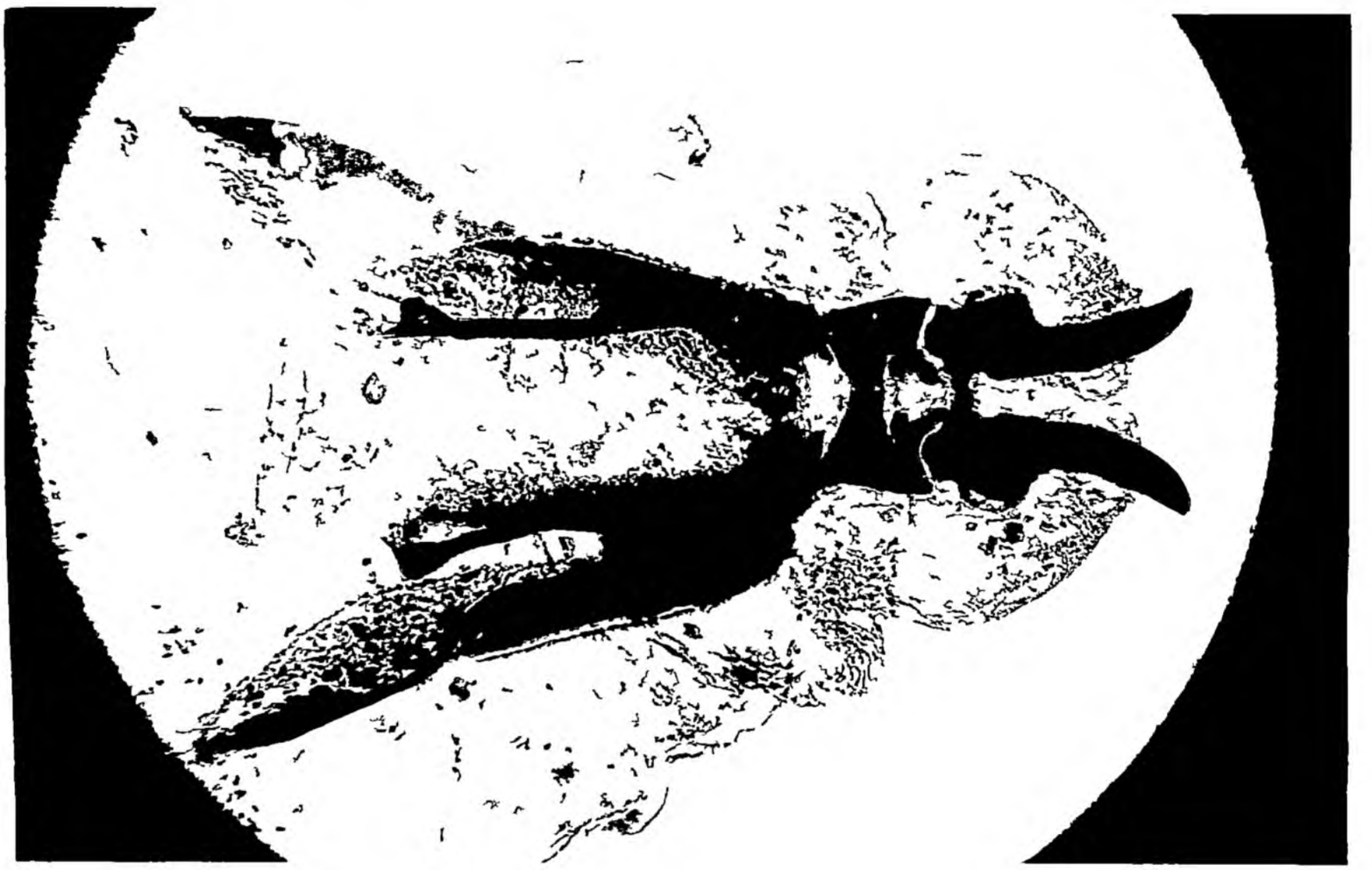

Fig. 2

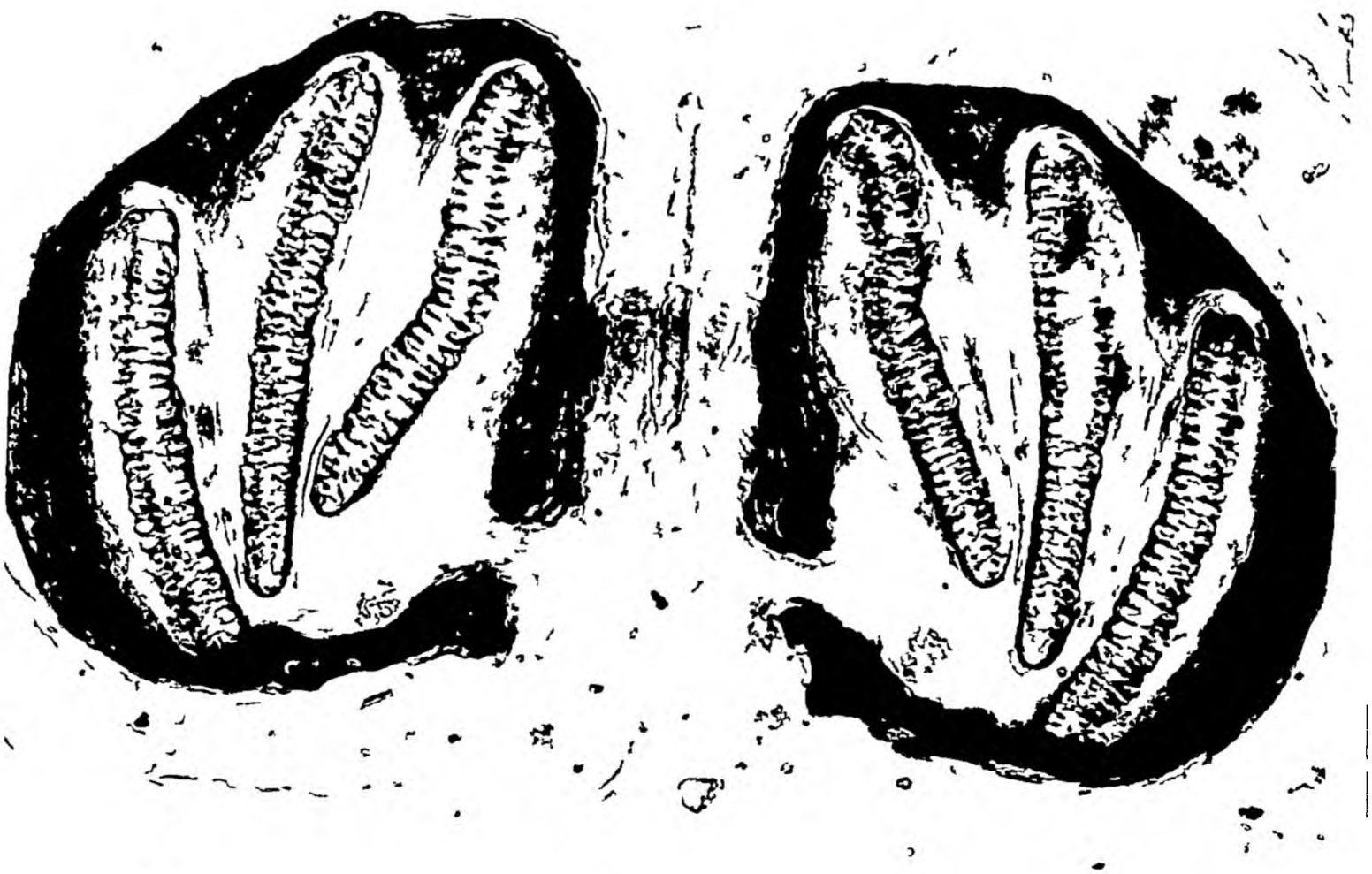

PLATE XXIX

Fig. 1

Fig. 2

Fig. 3

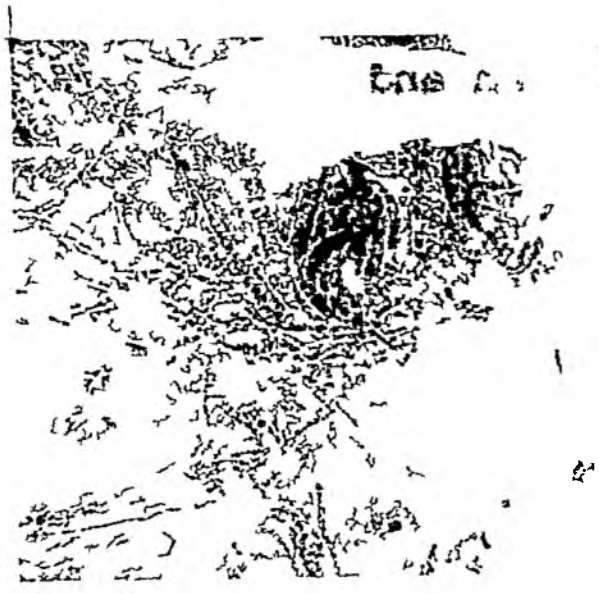

Fig. 4

Fig. 1

Fig. 2

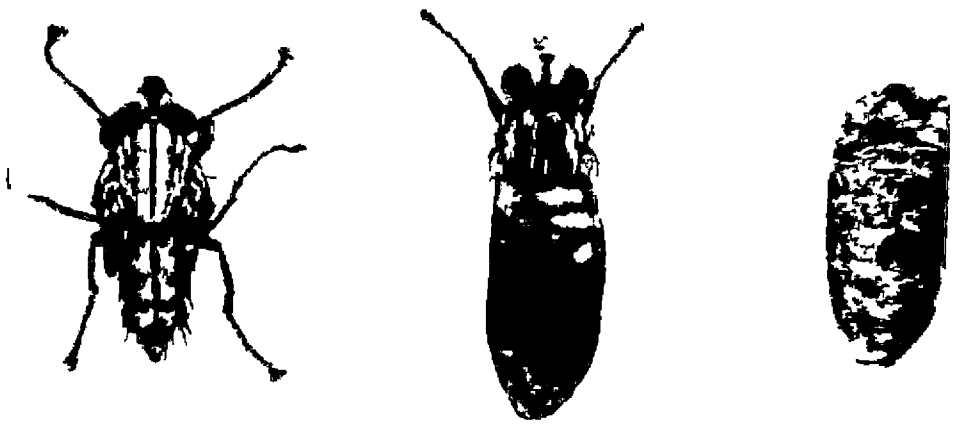

Fig. 3

EVALUATION OF THE FLY REPELLENT ACTION OF VARIOUS INDIGENOUS OILS AND CHEMICALS

STUDIES ON THE EFFICACY OF INDIGENOUS OILS AND CHEMICALS AS REPELLENTS OF MYIASIS PRODUCING FLIES

Review of literature

Lennox (1940) studied for the first time, the efficacy of oil of citronella as a fly repellent against sheep blow fly Lucilia cuprina. He found that the application of solutions of the oil to the fleece and other attrative areas on sheep reduced fly oviposition in these areas. It was Sastri (1948) who made the first report on the efficacy of Neem oil extracted from the seeds of Azadira indica as a fly repellent. The same author (1950) reported that Camphor oil extracted from the twigs and leaves of Cinnamomum Camphora had deodourent property. He (1952) further mentioned about the deodourant and mosquito repellent property of eucalyptus oil, which is extracted from several species of Eucalyptus tree, the important in India being E.globusus, E.bicolor, E.sideroxylon, and E.elaephora.

Altman and Smith (1953) investigated on a few repellents for protection against mosquitoes, and found a preparation containing 30% dimethyl phthalate to be very effective. Kalmykov (1954) studied the effectiveness of the

application of Dimethyl phthalate to the skin for individual protection against mosquitoes, Simulids and Ceratopoganids. He found that under field conditions 100% protection was possible against mosquitoes for 3 hours while repellency upto 4½ hours were observed against simulids and ceratopoganids. Sollman (1957) reported that dimethyl phthalate was a potent repellent against mosquitoes, mites and leeches and it remained effective even after three or four washings. Gilbert (1957) studied the repellency of a standard mixture of dimethyl phthalate, dimethyl carbate and ethyl hexanediol in a ratio of 4:3:3 and found that this mixture gave protection for nearly 3½ nours against mosquitoes and for about half that time against Chrysops.

Ikeda (1958) found that dimethyl ester of camphoric acid proved superior to all other esters and to dimethyl phthalate but both were inferior to camphor oil, though long acting against mosquitoes. Osmani et al. (1958) studied the toxicity of chlorinated turpentine against eggs and different instar larvae of Musca nebulo and 100% mortality was observed in the mixture even in lower concentrations.

Marion (1959) reported that citronella oil combined with boric acid was superior to DDT, BHC and Pine oil in its fly repellent action when applied to fly blown wounds. Later in an attempt to find a satisfactory substitute for citronella oil, he found that dimethyl phthalate gave good but slightly inferior results. Quadri et al. (1967) demonstrated that a cream containing 18% citronella oil, 4% clove oil, and 1% powdered rhizome of Kaempferia galanga gave better protection against mosquitoes than the standard cream containing 11% dimethyl phthalate. Dremova (1967) showed that a preparation containing 48% dimethyl phthalate gave protection upto 4 hrs against mosquitoes and simulids.

Kale and Panchegaonkar (1969) studied the effifacy of Karanji oil isolated from the seeds of the plant Pongamia pinnatta in goats, affected with Sarcoptes scabei, and found that it was 100% effective. He was also of opinion that it was superior to sulphur ointment, benzyle benzoate 28%, and malathion 1%. Guenther (1972) mentioned the fly repellant property of Lemongrass oil isolated from the plant Cymbopogan flexuosus and C.citratus. He also stated that the odour of the oil was due to the presence of citral at 70-80% concentration. The same author (1972) mentioned about the fly repellent property of turpentine as well as pine oils.

Crovetti (1973) showed that Nash's insect repellent mixture constituting 40% citronella oil, 40% spirit of camphor and 20% oil of cedar was very effective and potent as a fly repellent. Choudhuri (1976) mentioned about a dressing material, "EQ 335" containing 3% lindane, 35% pine oil, 40-44% mineral oil, 8-12% emulsifier and 8% silica aerogel which gave satisfactory results when applied at weekly intervals to maggot wounds caused by Callitroga hominivorax.

Satoskar and Bhandarkar (1976) mentioned about the efficacy of a mixture containing cedarwood oil 18 ml, citronella oil 42 ml and spirit of camphor 10 ml as a fly repellent. They stated that citronella oil can also be applied as vanishing cream, being nontoxic and non irritant. They also mentioned that 35% emultion of dimethyl phthalate was more effective, it being an irritant to the insects feet. Patnayak and Misra (1977) studied the efficacy of 5 substances on maggots and confirmed that turpentine oil was highly effective in destroying maggots of calliphora erythocephala within a very short time.

Evaluation of the fly repellent action of various indigenous oils and chemicals

Indirect method:

In the indirect method materials such as Turpentine oil, Lemongrass oil, Neem oil, Camphor in oil, pine oil, Eucalyptus oil, Karanji oil, Dimethyl pthalate and copper stearate were applied on cardboards covering the bait, to test their fly repellent effect. The baits were exposed only for five hours. The duration of fly repellency increased with the increase in the quantity of oils or chemicals used. All the control baits were found readily infested by the flies within a very short time after the exposure (Table VI).

By indirect application Lemongrass oil proved tobe the best one possessing maximum duration of fly repellency. Eventhough the flies infested the baits treated with 1 ml of the oil in 280 mts, they did not infest at all on the baits treated with 2 ml and 3 ml of this oil. These two baits were continuously exposed for 15.00 hrs and found that they were infested with the larvae of Sarcophaga ruficornis in 440 mts and 610 mts respectively.

Camphor in oil proved to be the next best in possessing fly repellent property. Even though the flies arrived

on bait treated with 1 ml and 2 ml of this substance by 110 mts and 280 mts respectively, the former bait was only found infested in 150 mts. The baits treated with 2 ml and 3 ml of this oil were free of any larvae or egg within the exposure period of five hours. These baits were continously exposed for 10.00 hrs and found that they got infested by the flies by 320 mts and 460 mts respectively.

Pine oil ranked third in the repellent property, where the flies infested the 3 ml treated baits by 260 mts. Turpentine oil, Dimethyl phthalate, Eucalyptus oil, Copper stearate, Neem oil and Karanji oil possessed fly repellency in descending order (Table VI).

Direct application

The same materials used in the indirect application were also used in the direct application in studying their fly repellency. The oils and chemicals were directly applied over the putrified meat and exposed for 10.00 hrs. The duration of fly repellency increased with the increased quantity of oils or chemicals applied on it. All the control baits were readily infested with the eggs or larvae of the flies within a very short time after exposure (Table VII

In the direct application also, Lemongrass oil proved to be the best one in repelling flies. The flies did not even arrive on the treated baits within the exposure period of 10.00 hrs, where as the controls got readily infested within 12 mts after exposure. On continuous exposure of 1 ml, 2 ml and 3 ml treated baits, they were found infested in 12.45 hrs, 28.00 hrs and 48.00 hrs respectively.

Even though camphor in oil could not prevent the fly infestation on the bait treated with 1 ml of the oil in 6.5 hrs, it prevented the infestation of the flies till 12.00 hrs and 23.5 hrs in 2 ml and 3 ml treated baits.

Eucalyptus oil ranked third in possessing the fly repellency. The flies arrived on the 1 ml, 2 ml and 3 ml treated baits by 120 mts, 120 mts and 210 mts respectively. The flies infested only on the 1 ml and 2 ml treated baits by 310 mts and 445 mts respectively, whereas the baits treated with 3 ml of the oil were not found infested. These baits got infested only in 11.30 hrs on continuous exposure upto 15.00 hrs.

Pine oil, Turpentine oil, Copper stearate, Dimethyl phthalate, Neem oil and Karanji oil possessed fly repellency in descending order (Table VII).

In the direct as well as indirect application of oils and chemicals, most of the control baits were found infested with the larvae of Sarcophaga ruficornis, the eggs of Chrysomyia megacephala, Chrysomyia rufifacies and Chrysomyia nigripes, the majority being S.ruficornis larvae. In majority of baits treated with oils or chemicals, only S.ruficornis larvae were found infested. In general, the direct application of the oils or chemicals on the bait showed increased duration of fly repellency than indirect application.

Ovicidal effect of various indigenous oils on the egg (Table IX)

The oils used in the experiment were turpentine oil, Eucalyptus oil, Lemongrass oil, Neem oil and Pine oil. Distilled water served as the control. The eggs of Lucilia cuprina were either smeared or dipped in the oil for 1 mt, 2 mts, 3 mts, 4 mts and 5 mts duration. Control was also treated in a similar manner. Turrentine oil was proved to be the best one in possessing the ovicidal action. Only 10% of the smeared eggs hatched and no hatching was observed when the time of treatment was increased. Pine oil was also proved to be equally effective. It killed 80% of the eggs on smearing. Lemongrass oil and Eucalyptus oil, possessed more or less equal ovicidal effect. They

prevented hatching of 75% and 90% of the eggs respectively in 1 mt treatment. Neem oil possessed minimum ovicidal effect. In the control group, all the eggs hatched even in treatment upto 5 mts.

Larvicial action of various indigenous oils (Table VIII)

Chrysomyia megacephala:

The first, second and third stage larvae of this species of flies were dipped in Turpentine oil, Lemongrass oil, Neem oil, Coconut oil, Eucalyptus oil, pine oil, Arachis oil, Kerosine oil and Liquid paraffin, till the larvae we re found dead, to study their comparative larvicidal effect. Distilled water was used as the control. Oils such as Kerosine oil, Coconut oil, Arachis oil and Liquid paraffin were used in the experiment just to make a comparative study with the other oils.

Kerosine oil could produce 100% mortality of the first, second and third stage larvae in 25, 30, and 40 mts respectively. Turpentine oil was also found equally effective in causing mortality to the larvae. Lemongrass oil and Pine oil could destroy the larvae of first, second and third stages only around 30, 50 and 80 mts respectively. Neem oil Coconut oil, Arachis oil and Liquid paraffin gave similar poor results but could kill the larvae after a prolonged period of treatment. In the control the larvae died between 2-3 hrs.

Sarcophaga ruficornis

The above methods and materials were utilised for this species of larvae also, in studying the larvicidal effect

Of the oils tested, kerosine oil proved to be the best one destroying the first, second and third stage larvae, in 20, 30 and 30 mts respectively. Turpentine oil, pine oil and Lemongrass oil showed similar better result by destroying the larvae of first, second and third stage around 30, 35 and 40 mts respectively. Nem oil, Eucalyptus oil, Coconut oil, Arachis oil and Liquid paraffin took much higher time to destroy the larvae proving that they possessed lesser larvicidal effect. In the control, the first stage larvae did not die even after 240 mts of treatment and second and third stage larvae lived even after 300 mts of dipping in distilled water.

In general, the first, second and third stage larvae of both the above mentioned species proved to possess resistance in ascending order of their stage, against larvicidal agents. The larvae of Chrysomyia megacephala possessed greater resistance against the larvicidal agents than S.ruficornis larvae. But in distilled water larvae of S.ruficornis showed nearly double the resistance of the other species.

DISCUSSION

The study on the comparative fly repellency potential of various oils and chemicals like Turpentine oil, Lemongrass oil, Neem oil, Camphor in oil, Eucalyptus oil, Pine oil, Karanji oil, dimethyl phthalate and copper stearate is a new piece of work as observed from the available literature.

From the data obtaining in the present study it is evident that Lemongrass oil is superior in its action as a fly repellent. Camphor in oil and pine oil possesses marked fly repellent potentiality both on direct and indirect application. Eucalyptus oil shows fly repellent potentiality on direct application only. Other oils such as Turpentine oil, Neem oil and chemicals like dimethyl phthalate and copper stearate possess least repellency potential. Karanji oil does not possess any fly repellency.

The results are in conformity with the reports of Lennox (1940), Sastri (1950) and (1952), Ikeda (1958), Marion (1959), Quadri *et al.*(1967), Crovetti (1973), Choudhuri (1976) and Satoskar and Bhandarkar (1976) in that either Citronella oil or a preparation containing Citronella oil are superior in repelling myiasis producing flies. Literature

is available on Citronella oil only and not on Lemongrass oil. Both the oils are isolated from plants of common genera Cympopogan and possess similar aroma. Sastri (1948), in contrary to the present observation, reports that Neem oil has good fly repellent property. Altman and Smith (1953), Kalmykov (1954), Solman (1957), Gilbert (1957) and Dremova (1967) have reported the efficacy of Dimethyl phthalate as an effective repellent against mosquitoes, simulids, ceratopoganids and chrysops with varying duration of repellency ranging from 3-4½ hrs when applied to the skin, but in the present study this substance is found as inferior as a fly repellent. Karanji oil is not found to possess any fly repellent action eventhough it is reported to be effective against Sarcoptes scabei by Kale and Panchagoankar (1969).

From the studies conducted it is obvious that direct application of fly repellents on the bait, retains its potency double the time when compared to the application on the surroundings of the bait. Moreover the duration of fly repellency is directly proportional to the quantity of the repellents applied. The results also prove that preparations containing Lemongrass oil and Camphor in oil will give satisfactory duration of protection for the wounds to heal by preventing cutaneous myiasis producing flies getting attracted to it, eventhough repeated application is essential.

The studies made on the larvicidal action of indigenous oil reveal that Kerosine oil and turpentine oil are superior in action. Since the larvae are killed even in liquid paraffin it is yet to be confirmed whether the action is due to intoxication or suffocation. Any work on this line is of little practical importance since, in myiasis conditions mechanical removal of larvae and then dipping them in oils is a mere waste of time, energy and material. However, the result obtained in the present study is in agreement with the report of Osmani et al.(1958).and Patnayak and Misra (1977).

No literature is available on the ovicidal action of Turpentine oil, Lemongrass oil, Neem oil, Eucalyptus oil and Pine oil in the eggs of Lucilia cuprina. The experiment proves that Turpentine oil and Pine oil are very effective even on smearing as ovicidal agents, followed by Eucalyptus oil and Lemongrass oil. Neem oil possess least ovicidal action. The result is in conformity with Osmani et. al. (1958) who has reported that chlorinated turpentine was toxic to the eggs of Musca nebulo.

It is evident from the above study that turpentine oil or pine oil applied over the wounds can destroy the eggs of myiasis producing flies.

TABLE VI

EVALUATION OF REPELLENT ACTION OF VARIOUS INDIGENOUS OILS AND CHEMICALS AGAINST BLOW FLIES AND SARCOPHAGA SPECIES BY INDIRECT APPLICATION ON THE BAIT
(Mean values)

Parameters	Quantity applied	Turpentine oil	Lemongrass oil	Neem oil	Camphor in oil	Pine oil	Eucalyptus oil	Karanji oil	Dimethyl phthalate	Copper stearate
1	2	3	4	5	6	7	8	9	10	11
Time of fly arrival and sitting on the bait	1 ml	50 mts	210 mts	2 mts	110 mts	90 mts	25 mts	20 mts	12 mts	20 mts
	2 ml	128 mts	Not arrived	2 mts	280 mts	110 mts	40 mts	20 mts	10 mts	25 mts
	3 ml	150 mts	,,	6 mts	Not arrived	180 mts	50 mts	18 mts	15 mts	25 mts
	Control	4 mts	2 mts	4 mts	7 mts	4 mts	2 mts	15 mts	8 mts	5 mts
Time of Oviposition or Larviposition	1 ml	70 mts	280 mts	20 mts	150 mts	125 mts	60 mts	40 mts	90 mts	30 mts
	2 ml	145 mts	Uninfested	35 mts	Uninfested	190 mts	75 mts	30 mts	125 mts	80 mts
	3 ml	190 mts	,,	40 mts	,,	260 mts	110 mts	35 mts	160 mts	100 mts
	Control	12 mts	15 mts	10 mts	13 mts	10 mts	5 mts	20 mts	14 mts	9 mts
Number of Larvae or Egg collected	1 ml	129	17	136	69	143	118	109	113	123
	2 ml	56	Nil	103	Nil	92	72	107	89	62
	3 ml	24	Nil	100	Nil	34	48	238	60	58
	Control	248	194	189	224	198	278	183	186	239

Time of exposure of the Bait : Five hours

TABLE VII

EVALUATION OF REPELLENT ACTION OF VARIOUS INDIGENOUS OILS AND CHEMICALS AGAINST BLOW FLIES AND SARCOPHAGA SPECIES BY DIRECT APPLICATION ON THE BAIT

(Mean Values)

Parameters	Quantity applied	Turpentine oil	Lemongrass oil	Neem oil	Camphor in oil	Pine oil	Eucalyptus oil	Karanji oil	Dimethyl phthalate	Copper stearate
1	2	3	4	5	6	7	8	9	10	11
Time of Fly arrival and sitting on the bait	1 ml	5 mts	Not arrived	15 mts	330 mts	180 mts	120mts	1 mt	2 mts	20 mts
	2 ml	15 mts	,,	15 mts	Not arrived	220 mts	120mts	4 mts	7 mts	90 mts
	3 ml	30 mts	,,	20 mts	,,	320 mts	210mts	2 mts	10 mts	140 mts
	Control	9 mts	3 mts	2 mts	5 mts	10 mts	1 mt	1 mt	4 mts	8 mts
Time of Oviposition or Larviposition	1 ml	60 mts	Uninfested	20 mts	390 mts	240 mts	310mts	35 mts	75 mts	50 mts
	2 ml	150 mts	,,	50 mts	Uninfested	350 mts	445mts	20 mts	110 mts	140 mts
	3 ml	270 mts	,,	80 mts	,,	400 mts	Uninfested	40 mts	115 mts	200 mts
	Control	15 mts	12 mts	10 mts	6 mts	25 mts	15 mts	20 mts	12 mts	16 mts
Number of Larvae or Egg collected	1 ml	186	Nil	342	64	169	185	383	236	263
	2 ml	104	Nil	293	Nil	85	92	312	158	210
	3 ml	82	Nil	190	Nil	52	Nil	490	143	187
	Control	312	297	436	349	389	446	410	410	284

Time of exposure of the bait: Ten hours

TABLE VIII

INVITRO COMPARATIVE LARVICIDAL EFFECTS OF VARIOUS INDIGENOUS OILS ON THE LARVAL STAGES OF CHRYSOMYIA MEGACEPHALA AND SARCOPHAGA RUFICORNIS

	CHRYSOMYIA MEGACEPHALA LARVAE			SARCOPHAGA RUFICORNIS LARVAE		
Oils	First stage (Five hrs)	Second stage (Twenty hrs)	Third stage (Sixty hrs)	First stage (Four hrs)	Second stage (Eighteen hrs)	Third stage (Fifty hrs)
1	2	3	4	5	6	7
Turpentine	25 mts	35 mts	50 mts	30 mts	35 mts	40 mts
Lemongrass	30 mts	60 mts	80 mts	40 mts	40 mts	45 mts
Neem	45 mts	100 mts	120 mts	40 mts	60 mts	75 mts
Eucalyptus	35 mts	100 mts	130 mts	45 mts	30 mts	60 mts
Pine	35 mts	50 mts	85 mts	30 mts	35 mts	38 mts
Coconut	50 mts	125 mts	130 mts	40 mts	60 mts	70 mts
Arachis	45 mts	105 mts	105 mts	40 mts	50 mts	50 mts
Keresine	25 mts	30 mts	40 mts	20 mts	30 mts	30 mts
Liquid paraffin	55 mts	125 mts	140 mts	50 mts	65 mts	70 mts
Control (Distilled Water)	130 mts	170 mts	190 mts	Not dead even after 240 mts	Not dead even after 300 mts	

TABLE IX

THE COMPARATIVE OVICIDAL EFFECT OF VARIOUS INDIGENOUS OILS ON THE EGG OF LUCILIA CUPRINA STUDIED INVITRO

Oils	TIME OF TREATMENT					
	Smearing	One minute	Two minute	Three minute	Four minute	Five minute
1	2	3	4	5	6	7
Turpentine	10% hatch	No hatch	No hatch	No hatch	No hatch	No hatch
Lemongrass	100% "	25% "	"	"	"	"
Neem	100% "	100% "	50% hatch	"	"	"
Pine	20% "	No hatch	No hatch	"	"	"
Eucalyptus	50% "	10% "	"	"	"	"
Control (Distilled water)	100% "	100% "	100% "	100% "	100% "	100% "

SUMMARY

SUMMARY

1. The incidence of cutaneous myiasis among domestic animals was studied at Trichur during 1977-78. The cases were mainly recorded at Kerala Agricultural University hospitals at Trichur and Mannuthy, though a few cases were encountered at other places in Trichur and Mannuthy.

2. A maximum number of 140 out of 155 cases were recor ded between January to March, eventhough few cases occur red during October, November, December, April and May. The temperature and humidity during the season varied between 23.65°C - 31.9°C and 91-80 respectively. The condition was observed in cattle, buffaloes, goats and dogs where 86, 36, 19 and 14 cases respectively were re-corded. As regard to the site of infection, maximum num-ber of cases were observed in vulval lips in cattle, nasal septa in buffaloes, and over different areas of the skin in goats and dogs. Out of 155 cases obtained 145 cases were due to Chrysomyia bezziana and the rest due to Chrysomyia megacephala, Chrysomyia rufifacies and Lucilia cuprina.

3. The morphology of the different stages in the life-cycle of the flies Chrysomyia bezziana, Chrysomyia megacephala, Chrysomyia rufifacies, Chrysomyia nigripes,

Lucilia cuprina and Sarcophaga ruficornis were studied. The eggs of Lucilia cuprina and Chrysomyia nigripes measuring 0.1 x 0.3 mm were the smallest, whereas that of Chrysomyia megacephala measuring 1.5 x 0.5 mm was the largest. The larvae of Lucilia cuprina and Sarcophaga ruficornis were almost smooth, Chrysomyia bezziana, Chrysomyia megacephala and Chrysomyia nigripes were spiny and Chrysomyia rufifacies hairy in appearance. The pupa of various species of flies were dark brown in colour and resembled very much with the larvae in the presence of papillae and spines on the external surface.

4. The adult Lucilia cuprina had coppery colouration, Chrysomyia bezziana and Chrysomyia megacephala were greenish blue, Chrysomyia rufifacies and Chrysomyia nigripes, shining green and Sarcophaga ruficornis grey in colour with longitudinal black, stripes on the thorax. The abdomen of S.ruficornis had check marks. The prothoracic spiracle of Chrysomyia rufifacies and Chrysomyia nigripes were white. Chrysomyia nigripes and Lucilia cuprina were the smallest of the flies.

5. The various aspects in the biology such as longi-vity of the fly in the laboratory, mating, egg or larval deposition, egg, larval, prepupal and pupal period and the process of fly emergence of Chrysomyia megacephala, Chrysomyia rufifacies, Chrysomyia nigripes, Lucilia cuprina and Sarcophaga ruficornis were studied.

6. Of all the flies studied Lucilia cuprina lived for a maximum period of 71 days. The mating started from the 3rd day onwards in all the species of flies studied. Of the flies studied, Chrysomyia megacephala laid the maximum number of 392 eggs. The flies which lacked meat meal did not lay any eggs. The minimum preoviposition period was 8.5 days in case of Chrysomyia rufifacies where as Chrysomyia megacephala and Chrysomyia nigripes took 10 days. Lucilia cuprina larvae were the smallest and Sarcophaga ruficornis larvae were the largest in size and measurements. The invitro development of the larvae and pupae of Chrysomyia megacephala and Sarcophaga ruficornis were studied in detail. A minimum duration of larval, prepupal and pupal period were observed with Chrysomyia rufifacies and the maximum periods were observed in case of Sarcophaga ruficornis. The duration of fly emergence was also

maximum with Sarcophaga ruficornis. The duration of egg to egg or larval to larval stage was 16 days in Chrysomyia rufifacies and 26 days in case of Sarcophaga ruficornis. All the flies emerged from a single lot of C.rufifacies were either males or females alone. The difference in male female percentage on emergence was marked in Chrysomyia megacephala and Sarcophaga ruficornis and almost nil in case of Lucilia cuprina.

7. The fly repellency potential of Turpentine oil, Lemongrass oil, Neem oil, Pine oil, Camphor in oil Eucalyptus oil, Karanji oil, Dimethyl phthalate and copper stearate were evaluated against blow flies and Sarcophaga species by direct and indirect application on the bait constituting putrified meat. The duration of fly repellency was directly proportional to the quantity of repellent applied on the bait. Direct application of the repellent proved more effective than indirect application. In the direct application Lemongrass oil proved to be the best one followed by Camphor in oil and Eucalyptus oil. In the indirect application also Lemongrass oil proved to be most effective, followed by Camphor in oil and pine oil.

8. The larvicidal property of Turpentine oil, Lemongrass oil, Neem oil, Pine oil, Eucalyptus oil, Kerosine oil, Coconut oil, Arachis oil and Liquid paraffin were studied on the 3 stages of the larvae of Chrysomyia megacephala and Sarcophaga ruficornis, by dipping them in the oils mentioned. Eventhough Kerosine oil and Turpentine oil killed the larvae in quicker time, other oils were also able to destroy the larvae.

9. The ovicidal action of Turpentine oil, Lemongrass oil, Pine oil, Eucalyptus oil and Neem oil were studied on the eggs of Lucilia cuprina. Turpentine oil and Pine oil proved to be the best one, for they had marked ovicidal action even on smearing.

ABSTRACT

STUDIES ON
THE FLIES PRODUCING CUTANEOUS MYIASIS IN DOMESTIC ANIMALS IN TRICHUR

BY
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ABSTRACT OF A THESIS

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ABSTRACT

A detailed study on the incidence of cutaneous myiasis among domestic animals in Trichur, the morphology and biology of the causative flies and the efficacy of indigenous oils and chemicals as repellents against these flies were undertaken. Cutaneous myiasis was found common among domestic animals in Trichur during the months of October to May, the maximum number being, during January to March. The cases were observed in cattle, buffaloes, goats and dogs. The most common causative fly was Chrysomyia bezziana, but other flies such as Chrysomyia megacephala, Chrysomyia rufifacies and Lucilia cuprina were also observed. In cattle and buffaloes, the lesions were noted mostly in vulval lips and nasal septa where as in goats and dogs the cases were observed on the body skin. The flies of Chrysomyia megacephala, Chrysomyia rufifacies, Chrysomyia nigripes, Lucilia cuprina and Sarcophaga ruficornis were reared in the laboratory to study their morphology and biology. The larvae of Lucilia cuprina and Sarcophaga ruficornis were smooth. Chrysomyia bezziana, Chrysomyia megacephala and Chrysomyia nigripes

were spiny and Chrysomyia rufifacies hairy. Chrysomyia rufifacies had the shortest life cycle period of 16 days and Sarcophaga ruficornis had the longest of 26 days. Lucilia cuprina could be reared in the laboratory for 71 days. The invitro development of the larvae, the development of the pupae and the process of fly emergence of Chrysomyia megacephala and Sarcophaga ruficornis were studied in detail. Among the fly repellents tested, lemongrass oil proved to be the best one in possessing fly repellent potentially followed by camphor in oil and Eucalyptus oil against blowflies and Sarcophaga species. Kerosine oil and Turpentine oil possessed the maximum larvicidal action on the larvae of Chrysomyia megacephala and Sarcophaga ruficornis. Turpentine oil and pine oil possessed excellent ovicidal action on Lucilia cuprina eggs even on smearing.

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STUDIES ON THE FLIES PRODUCING CUTANEOUS MYIASIS IN DOMESTIC ANIMALS IN TRICHUR

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ABSTRACT OF A THESIS

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ABSTRACT

A detailed study on the incidence of cutaneous myiasis among domestic animals in Trichur, the morphology and biology of the causative flies and the efficacy of indigenous oils and chemicals as repellents against these flies were undertaken. Cutaneous myiasis was found common among domestic animals in Trichur during the months of October to May, the maximum number being, during January to March. The cases were observed in cattle, buffaloes, goats and dogs. The most common causative fly was Chrysomyia bezziana, but other flies such as Chrysomyia megacephala, Chrysomyia rufifacies and Lucilia cuprina were also observed. In cattle and buffaloes, the lesions were noted mostly in vulval lips and nasal septa where as in goats and dogs the cases were observed on the body skin. The flies of Chrysomyia megacephala, Chrysomyia rufifacies, Chrysomyia nigripes, Lucilia cuprina and Sarcophaga ruficornis were reared in the laboratory to study their morphology and biology. The larvae of Lucilia cuprina and Sarcophaga ruficornis were smooth. Chrysomyia bezziana, Chrysomyia megacephala and Chrysomyia nigripes were spiny and Chrysomyia rufifacies hairy. Chrysomyia rufifacies had the shortest life cycle period of 16 days and Sarcophaga ruficornis had the longest of 26

days. Lucilia cuprina could be reared in the laboratory for 71 days. The invitro development of the larvae, the development of the pupae and the process of fly emergence of Chrysomyia megacephala and Sarcophaga ruficornis were studied in detail. Among the fly repellents tested, lemongrass oil proved to be the best one in possessing fly repellent potentially followed by camphor in oil and Eucalyputs oil against blowflies and Sarcophaga species. Kerosine oil and Turpentine oil possessed the maximum larvicidal action on the larvae of Chrysomyia megacephala and Sarcophaga ruficornis. Turpentine oil and pine oil possessed excellent ovicidal action on Lucilia cuprina eggs even on smearing.