Studies on the life histories of blowflies

Beryl A. Thurston

STUDIES ON THE LIFE HISTORIES OF BLOWFLIES

by

BERYL A. THURSTON.

- being a thesis presented in candidature for the Degree of Master of Science in the University of Durham, 1950.

The work described in this thesis was carried out under the direction of J.B.Cragg, M.Sc., at the Science Laboratories of the Durham Colleges in the University of Durham (October 1947 - December 1949).

The author is indebted to Professor J.B. Cragg, M. Sc., for his ready help, guidance and encouragement.

C O N T E N T S

General Introduction.

PART 1.

FIELD STUDIES ON THE PREPUPAE AND PUPAE OF BLOWFLIES.

In studying the life history of blowflies, particularly from the ecological point of view, it is not enough to obtain laboratory information on the effects of various environmental factors on stages in the life history. Whilst such observations are important they can give no more than a very approximate indication of the behaviour of the various stages under field conditions. In spite of the economic importance of various species of blowflies very little information has been collected from field studies and it has been the aim of this investigation to obtain information from field studies in order to fill up what are quite extensive gaps in our knowledge of the ecology of some of our common blowflies.

INTRODUCTION (Historical)

For a full understanding of this investigation it is necessary to take into account information made available in the course of other studies in blowflies. These related investigations fall into four classes:-

1. Field studies on the viability of blowflies
2. Diapause and related phenomena
3. Laboratory studies on the effect of temperature and humidity.
4. Parasites and Predators.

1. FIELD STUDIES ON THE VIABILITY OF BLOWFLIES

Some of the most important investigations were carried out at the beginning of the present century when the blowfly problem received a considerable amount of attention in connection with the spread of disease. Graham-Smith (1915) observed the effect of weather conditions on blowfly prepupae and pupae. The flies which he studied were those which oviposited on small carcasses contained in vertically placed drain-pipes half buried in the soil. When the carcasses had been thoroughly fly-blown he covered the tops of the pipes with butter muslin and was thus able to record all emergence. Subsequent generations were obtained by introducing further carcasses into the pipes. He found that heavy or continuous rain associated with cold weather caused a high mortality, but that heavy rain of short duration in mild weather was not unfavourable. He postulated that the rapid decline of a blowfly population in Autumn was partly due to an increase in mortality and partly to non-emergence. He suggested that there was a critical emergence temperature for such species, and probably also a pupation temperature, slightly below that for emergence. This meant that those species which appeared first would disappear last.

Field experiments on the role of water in insect development have been carried out in America by Hedson (1937). He suggested that the climate factors influencing soil moisture were temperature, relative humidity, saturation deficiency, sunshine and wind. He maintained that these were more important in spring and summer than in autumn and winter, when there would be only gradual changes in these factors. Thus, although the absolute humidity may decrease as winter approaches, this would be of little importance, because as the temperature decreases, the ability of hygroscopic materials (e.g. soil) increases. Taking soil samples and determing their wet and dry weights, he found that 'plain' soil contained less than 100% water (expressed as a % of dry weight) whereas bog soil may have 300 - 700 % water in it. He also found that although Lucilia sericata (Mg.) prepupae were normally found in a saturated atmosphere, it was possible to keep them at 20% R.H. and $2^{o}C$ for five months. There was a mortality of only 12% although the larvae lost up to 50% of their weight in the process. On the effects of moisture on survival at low temperatures, he came to the conclusion that whereas a wet environment was favourable for temperatures above zero, a moderately dry environment was not favourable for sub-zero temperatures. Mortality of L. sericata prepupae at sub-zero temperatures was high when they were kept in sand at 2.5% R.H. but low when kept in other types of soil (e.g. loam) at the same humidity. The low hygroscopic coefficient of sand had resulted in free water which had frozen and pierced insect tissues, possibly diluting the body fluids.

Bruce (1939) buried pupae of three species, namely Haematobia irritans (L), Callitroga americana (C.&P.) and Musca Domestica L., in jars of fine sand and added known amounts of water. He weighed each batch daily and added the amount of water needed to make up the desired percentage of moisture. He found that C.americana and M.domestica had a high emergence when the sand contained less than 14% water and that no flies emerged from soils containing more than 16.1%. For H.irritans the percentage of adult emergence was distinctly highest from sand containing 7% moisture and there was no emergence when it was less than 0.25% or greater than 14.5%.

Recent field studies in America on the screw-worm C.americana by Lindquist & Barrett (1945), Deonier (1945) and Parman (1945) have shed further light on the problem. Prepupae and pupae of this species were placed on the surface of the soil and at varying depths at intervals throughout the cool season. Thus the duration of prepupal and pupal stages at various temperatures was determined. Prepupae deposited at temperatures of 15-20°F usually died and the pupal stage was found to be even more sensitive, as the individuals were unable to move and choose their environment. Pupae were nearly always killed at sub-zero temperatures when there was sufficient moisture content to freeze the soil solid. Pupal development did not occur below 55°F. When cold temperatures prolonged the duration of the pupal stage to more than 40 days, the percentage of adults emerging dropped rapidly. In fact, the effective maximum generation span in nature was estimated at less than a 100 days. C.americana rarely established itself in an area with a rainfall of more than 5" per month. The type of soil also affected winter survival - well rotted manure was found to be the best protection. Comparison of results from many different States indicated that C.americana did not exhibit true hibernation tendancies and mortality was high in regions with an average mean daily winter temperature below 50°F. Infestation in these regions was mainly caused by spring migration of adults or by the accidental transportation of feeding larvae.

2. Diapause and Related Phenomena.

Practically all the work which has been carried out on diapause phenomena in the case of blowflies has taken the form of laboratory investigations. Cousin (1932), Burtt (1937), Fraenkel (1938), Mellanby (1938), Dennel (1945) and Dickson (1949) have covered various aspects of this problem.

In relation to the present problem, information on the environmental conditions which cause diapause is of especial interest. Diapause has been defined by Cousin (1932) as arrested development accompanied by a decrease in metalolic rate. But Dickson (1949) did not consider arrested development produced by low temperature and capable of being brought to an end whenever the temperature rose, as diapause, but merely as 'quiescence'. Low temperatures could, however, induce true diapause, not immediately broken by a return to optimum conditions. Cousins described this type of diapause as 'permanent'. She found the prepupal stage of L.sericata to be particularly sensitive to unfavourable factors, (experienced either at that stage or at an earlier stage) - in fact, she could induce 'permanent' diapause only at that stage. Later workers, namely Wiggleworth (1934) Fraenkel (1935) and Burtt (1937) have shown that diapause is probably due to the inhibition of the hormone produced by Weissman's ring. Short, temporary diapause may be the result of a mere retarding effect. Dennell (1949) suggested that a juvenile hormone was present in all stages of blowfly larvae and that this hormone was eliminated at the beginning of pupation. Cousin (1932), found that ill-fed larvae or even the eggs from badly fed flies gave rise to prepupae which were liable to enter diapause for a few days. She also found that temperatures below the threshold of development (<u>6°C for L.sericata</u>) or above the optimum (36°C for <u>L.sericata</u>) endured during the larval stage could cause a diapause of up to 12days. Poor quality food, asphyxiation, excessive dampness, or pressure could all cause a brief diapause, but larvae which had suffered dryness entered a permanent diapause, which Cousin found very difficult to break. The proportion of dry to wet matter in the prepupae was important - above 29% of dry matter, pupation was impossible. Such prepupae, could, provided they had previously lost some of their fat reserves, drink water until they had reached the necessary proportions and then pupate. The cuticle was apparently not sufficiently distensible to permit drinking before some fat reserves had been lost.

Mellanby (1938) suggested that in nature diapause was frequently caused by overcrowding on carcasses or by too dry conditions during larval or prepupal stage. It is doubtful whether August and September larvae are particularly liable to dessication. The average rainfall for these months is high and remains so throught the winter. However, the prepupae are normally situated within the top few inches of soil, which may undergo rapid reductions in humidity in hot sunny weather. Mellanby also suggested that in spring the prepupae, after having drunk sufficient water to remove any effects of dessication, are stimulated to pupate by a suitably warm temperature. Certainly the rainfall in March and April is normally low, but the temperatures would probably not be sufficiently high to cause a deficiency of water at this time.

It is doubtful however, whether blowfly prepupae do normally suffer from lack of water and undergo 'permanent diapause' in the sense that Cousin used the expression. She herself kept blowfly prepupae at 5^oC and optimum humidities for six or more months. They remained at the same stage but continued development when returned to optimum conditions. Such behaviour has been defined by Cousin as 'temporary diapause', and it seems probable that this is essentially the type of diapause which blowfly prepupae undergo during the winter months. Graham-Smith (1915) found that C.erythrocephala could pupate and actually emerge at very low temperatures. He even recorded emergences in the field during January.

Dickson (1949) found that diapause in Grapholitha molesta (Busch) was regulated by the number of hours of daylight per day, maximum diapause being producted when the daylight lasted about 12 hours. He found that light had no such effect on L.sericata larvae. It is possible however, that other stages of this species may be affected by light in this manner.

3. Laboratory Studies on Temperature and Humidity.

Blowfly larvae and prepupae were among the first organisms whose development was studied in relation to temperature and humidity. Peairs (1914 & 1927) was perhaps the first investigator of the problem and he was followed by Cousin (1932). The general importance of temperature and humidity has been given considerable attention by many other workers. From the point of view of the present work the salient features are as follows:-

Rate of Development at Constant Temperatures

Peairs (1927) found that over a medium range of temperature, the rate of development of insects was directly proportional to the temperature. Cousin (1932) found that this held good for L.sericata larvae between 15^oC and 36^oC, provided that other conditions were optional. Plotting temperatures against the reciprocal of the time taken to complete development, she obtained a straight line which cut the temperature axis at 7·6°C. This was taken to be the theoretical threshold of development, below which no development would occur. The real threshold of development she found experimentally to be 6°C. Peairs also determined thresholds of development experimentally and found that the calculated threshold was usually higher than the actual threshold.

Cousin derived similar data for the prepupal and pupal stages of L.sericata Prepupal development was most rapid at 35 - 36°C, pupae were not usually formed above 38°C and the theoretical threshold of development was 9·4°C. The theoretical threshold for pupal development was 9·3°C, whereas in actual practice, metamorphosis was effected in several months at 9°C. At 40°C, although metamorphosis was completed, the adults failed to emerge.

Peairs pointed out that the temperature at which the greatest member of insects completed development was not always the temperature at which they completed development with the greatest speed.

Rate of Development at Fluctuating Temperatures.

Peairs found that temperatures fluctuating about a mean caused slower development for some insects than an equivalent constant temperature. The development of blowfly larvae was, however, accelerated by fluctuating temperature. Pradhan (1945) working on the cotton boll-worm, came to the conclusion that development was quicker under variable temperatures when the general temperature was low, but that the effect was reversed at higher temperatures. Mellanby (1937) studied the effect of rate of change of temperature on insects. He found that the chill-coma temperature (i.e. the temperature at which the insect made no spontaneous movement) and cold death-point were affected by the temperature from which the insect was removed. An insect could normally be acclimatized to a different enviromental temperature within 24 hours. Therefore only large and rapid temperature fluctuations would seriously affect the economy of the species. In the course of studies on Arctic insects (Mellanby 1940), found that those forms likely to be active during the winter (e.g. mosquito larvae and stonefly nymphs) were most fitted to survive fluctuating and/or low temperatures such as would be caused by melting snow. Mellanby (1933) also suggested that there were often large discrepancies between the temperatures recorded by meteorological apparatus and the temperatures actually prevailing in the microhabitat of an insect. Large insects might keep cool by evaporation from their bodies. Small insects would have to rely on evaporation from their microclimate. Meadow grass registered a temperature 7°C less than air temperature. The amount of evaporation from a surface would depend not only on temperature but also on saturation deficiency. In moving air, even greater cooling would be obtained. Thus, when an insect appeared to be attracted by moisture or some chemical stimulus, it may actually have been attracted by the low temperature. Bodenheimer (1938) came to the conclusion that the duration of the life cycle of the oriental red spider *Anychus orientalis* was influenced more by temperature than by any other factor. He claimed that one could determine periods of peak population of an insect from a knowledge of the temperature and humidity of the area concerned.

3. Effect of Relative Humidity on Cold Hardiness

Payne (1927) studied the effect of water-content of insects on their cold-hardiness and found that insects which had been partially dehydrated were more resistant to cold. If the body fluids were concentrated, then the depression of freezing point would be great and the death point consequently lower. This would be true for pure salts. Sacharov (1930) pointed out that the body fluid was not a simple saline solution, but that it contained particles of fat and protein and that the freezing point would partly depend on these. Uvarov (1931) from a review of the literature on insects and climate, came to the conclusion that the adipose tissue of an insect functions as a colloid, capable of maintaining a balance between free, readily freezable water and water which is adsorbed by the colloid particles and which remains liquid until about - 20°C. Thus, the proportion of water to adipose tissue would be of great importance in resistance to cold. Death would ultimately be caused by damage to the tissues caused by ice crystals. Pfadt (1947) found that while larvae of Hypoderma lineatum (De Villers) could normally survive a temperature of - 15°C, if they be well wetted by rain or melted snow and then subsequent freezing occurs, the larvae can be killed at a temperature not much below 0°C.

4. Effect of Relative Humidity at High Temperatures

Buxton (1933) studied the part played by relative humidity on the development of insects at high temperatures. He classified insects into "spenders" and "savers". "Spenders" used much water and lost much. They often died at high temperatures as a result of dessication and not from the heat. Thus L. sericata prepupae could survive high temperatures for 1 hour but not for 24 hours. "Savers", on the other hand, could survive on very little water and their lethal temperature was not affected by the relative humidity.

5. Effect of Relative Humidity at Medium Temperatures

Evans (1935) found that blowfly prepupae lost more weight at low humidities than at high ones and that the maximum loss was high at the beginning of the pupal stage, then lower, and then it increased again. The weight loss was due almost entirely to loss of water and was associated with periods of active metabolism. During these periods, the organism would be particularly susceptible to low humidities. Wardle (1930) found that prepupae pupated more rapidly at low humidities than at high (provided they were not low enough to cause diapause). Pupal development was most rapid at medium humidities, and humidity had no effect on survival of pupae. Evans found this to be true for temperatures between 20°C and 30°C, but at higher temperatures he found that high saturation deficiencies brought rapid death and at lower temperatures the slow development at high saturation deficiencies caused death by dessication. Death by dessication could be brought about in two ways, namely, failure to develop owing to a greater loss of water than the animal could survive, or failure to emerge owing to the too-rapid drying up of the moulting fluid secreted just before emergence is about to occur. Development could proceed over a much wider range of temperature and humidity than emergence.

IV. Parasites and Predators.

Graham-Smith (1915) in his field experiments showed quite clearly that both parasites and predators could cause a high mortality in both blowfly prepupae and pupae. Type and proportion of parasitism varied with certain weather conditions (e.g. sunshine or shade). More recently, Varley (1947) working on the Knapweed Gall-Fly, Urophora jaceana (Hering) has shown that an unfavourable non-specific mortality factor, such as bad weather might be, may actually increase the density of a host, whereas a specific factor (e.g. the action of a parasite, which would increase in severity when the population was high) would be much more effective in reducing a host population. The theoretical work of Nicholson (1935) and Nicholson & Bailey (1937) has emphasised the great importance of parasite and predator relationships in the control of insect populations. The effect of such things as control of populations which have been used in these investigations must play an important part in interpreting the field data which has been collected on blowfly mortality.

PART 1.

FIELD STUDIES OF PREPUPAE AND PUPAE OF BLOWFLIES

INTRODUCTION.

The field studies consisted of an investigation into the viability and duration of the prepupal and pupal stages of six species of blowflies in an environment as near to their natural one as possible.

The species studied were Lucilia sericata (Mg.), Lucilia illustris (Mg.), Lucilia caesar (L.), Calliphora vomitoria (L.), Calliphora erythrocephala (Mg.) and Protophormia terranovae (R.D). Batches of fully-fed larvae of these species were deposited at two field stations:-

Durham Station.

A site was chosen in the grounds of the Science Laboratories. The area was in the open, free from shade and eight yards from the nearest building, which was a greenhouse. The soil at the beginning of the experiment was practically bare.

Moorhouse Station.

The site was on open moorland at 1840' above sea level and about 100 yards away from the shooting box, Moorhouse, Westmorland. The soil was covered with rough moorland grass (mainly Nadus and Fescu), Juncus squarosus and the moss Polytrichus. There was no shade.

The prepupae were deposited in the natural soil contained in large cylindrical tins. All emergence from these tins was recorded, and later, the soil was searched for empty and any remaining full pupae. The time each batch spent in the soil and the mortality it suffered during that period could thus be determined. The subsequent soil sampling gave some indication of the cause of mortality and of the stage at which it occurred.

1. METHODS USED FOR FIELD INVESTIGATIONS

(i) Maintenance of Blowfly Cultures

Eggs were obtained from the cultures by introducing small pieces of warmed sheeps' 'lights' on petri dishes into the blowfly cages, and allowing the gravid females to oviposit. This took from a ½ hour to several hours, according to the fertility of the flies. When several large batches had been obtained, the petri dish was removed, a piece of damp cotton wool laid across the meat in order to ensure a high humidity and the whole placed in a large closed vessel to prevent further oviposition by "strays". This was then placed in a breeding cupboard running at 26½°C. Hatching occured in approximately 12½ hours.

The feeding tins were approximately 45 cms square and 15 cms deep, with a 2 cm flange turned in all the way round to prevent escape of larvae. A layer of damp sawdust, approximately 4 cms thick was added, and on this was placed the young larvae together with the piece of "lights" on which they had hatched. Further "lights", thinly sliced and and warmed, were added as required during the next few days. The tin was kept covered with several layers of butter muslin, tied around with string in order to prevent possible contamination. The Lucilia larvae moved off the "Lights" into the sawdust on the fourth day after egg-laying and the Calliphora and Protophormia larvae on the fifth day. Some of the Protophormia larvae tended to remain clustered on the meat, but they could be readily shaken off into the sawdust.

The sawdust and fully-fed larvae were then transferred into pupation tins. These were approximately 30 cm in diameter and 30 cm deep and the lids were pierced by emergence tubes about 10cm in diameter. The hole at the top of the emergence tube was covered with several thicknesses of butter muslin, tied around with string. The pupation tins were placed in the breeding cupboard and examined daily in order to check that the sawdust was sufficiently moist. This was important, as Lucilia larvae tended to enter diapause if the sawdust was too dry or too wet. Even after successful pupation dry conditions caused failure to emerge, and wet conditions caused the pupae to become diseased or very fragile. If an accident occurred and the larvae entered diapause, it could often be broken by submitting them to a low temperature for some hours and then returning them to the breeding cupboard.

The period from leaving the meat until emergence of the imogo was approximately 10 days, although it was rather less for Protophormia terranovae.

The blowfly cages were made from a metal tray 50 cm X 40 cm supporting a metal frame 75 cms high, covered with mosquito netting. Two sleeves were inserted in the mosquito netting to facilitate introduction of flies and food materials. The cages were kept in a constant temperature room at 24°C, and furnished with one petri dish containing sugar, another containing a small piece of "lights" and a drinking vessel consisting of a jar of water inverted on to a tile covered with a piece of filter paper. The humidity was kept between 50 and 60% R.H. by means of open dishes of water placed around the room.

The emerging flies were introduced into the cage by removing the butter muslin from the top of the tin and enclosing the latter in a cage sleeve. The cages were well illuminated by day but the lights were turned off at night. About a week after emergence the flies laid their first eggs.

(ii) Preparation and Deposition of Prepupae

Larvae were reared as described in the preceding section. The fully-fed larvae were counted into four groups as follows:-

(a) 200 for deposition at Durham

(b) 200 for deposition at Moorhouse

(c) 50 for rearing under control conditions

(d) 25 or 50 for use in determining mean fresh and dry weight of the batch.

Each group was placed in a separate jar with a small quantity of sawdust and left overnight at approximately 5°C. The following day groups (a) and (b) were deposited at the two field stations and group (c) was put into an incubator running at 22°C. Group (d) was enclosed in a small bag and killed in a cyanide killing bottle.

The soil tins were approximately 25cm in diameter and 60cm deep with perforated metal bottoms to ensure drainage. The tins were sunk in the soil to a depth of about 5cm from the top, and filled with soil to the same level. The prepupae were placed on the surface, and then, at Durham only, they were covered with a light sprinkling of soil. At Moorhouse, the original sod, removed whilst inserting the tin, was placed over the prepupae. Perforated metal lids were added and, to ensure that no prepupae escaped, the join between tin and lid was covered with elastoplast, secured on either side of the join with a loop of string.

During 1948, up to 1,345 larvae were placed in one tin, although there were more often only 600 - 800. In 1949, not more than 800 and more often 600 were placed in one tin. L. caesar and L. illustris were not deposited in the same tin, owing to the difficulty of sorting the adult female.

(iii) Emergence Recording

Mosquito netting traps.

This type was mainly used at the Durham field station, where there was no interference from animals and the traps could be examined daily for holes. They resembled the types used by Cragg and Ramage (1945), and consisted of a cylinder of mosquito netting, 40cm high and 30cm in diameter and inside this a cone of the same material, the opex forming the fly enterance. About a week after deposition the metal lid was removed from the soil tin and a trap placed over the top, its base being firmly tied around the tin. The trap was supported by means of a metal frame. (see Fig. 1.)

Perforated Metal Tube Traps

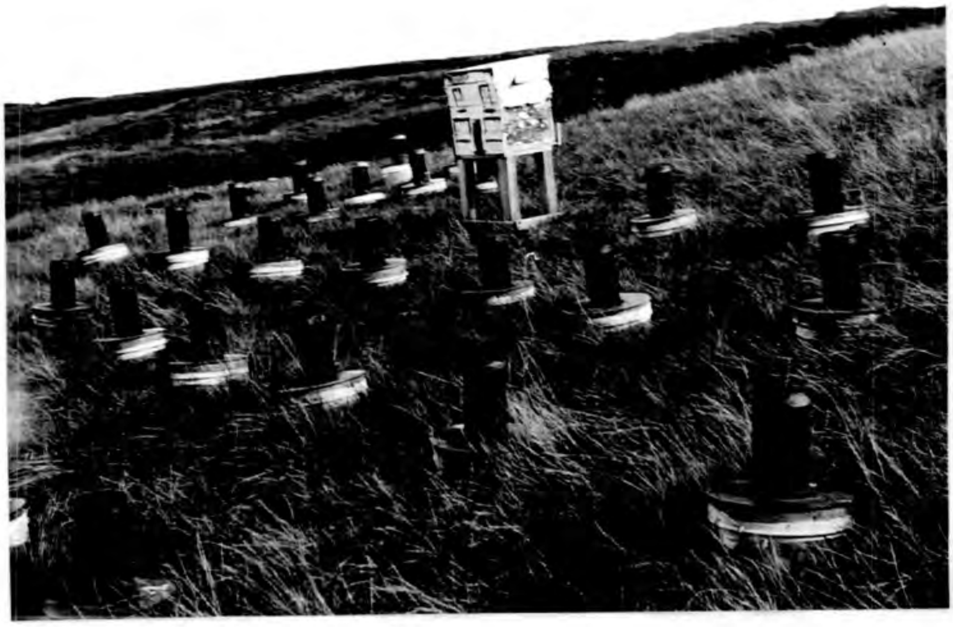
This type was used at the Moorhouse field station, in order to avoid damage by dogs, sheep, goats etc. Special lids of non-perforated metal were made to fit the soil tins. These had a central hole, 10 cms in diameter, into which was fitted a metal collar. A tube trap was fitted over this collar.

The tube traps consisted of a cylinder of perforated metal 20 cms high with a cone of metal gauze attached to the inside, the apex of the cone forming the fly entrance. Metal gauze lids were made to fit over the top of the cylinders and the bottom and fitted over the collar of the soil tin lid.

(See Fig. 2)

FIG. 1. THE DURHAM FIELD STATION

FIG. 2. THE MOORHOUSE FIELD STATION



Examination of Traps

Durham Station

All traps were examined daily between 9 and 10 a.m. Records of numbers and species of flies were made on the spot, with the following exceptions:-

(i) Although L.illustris and L.caesar were never placed in the same field tin, the males of these species were examined under a binocular microscope in order to check their species.

(2) Where large number of flies were emerging daily, it was found easier to remove the whole top, replacing by a spare and to anaesthetize the flies (still contained in the trap) before removing and sorting them.

Moorhouse Station

Traps were examined on every visit to Moorhouse. These occurred at approximately fortnightly intervals during the summer of 1948 and at weekly intervals during the summer of 1949. Where emergences where heavy, the traps were changed and the flies and trap were brought back to the laboratory for anaesthetization and sorting.

(iv) Meteorological Equipment

Durham.

1947 From August 10th., daily records were made of the maximum and minimum temperatures in an exposed position 2 feet from the ground near the Durham site. 4" and 8" soil thermometers were also set up. A Stevenson screen was erected and a weekly thermohygrograph used to obtain continuous records.

1948 In January 1948, a 1" soil thermometer and a minimum thermometer were placed in the screen. In April a maximum thermometer was added.

1949 The weekly thermohygrograph was replaced by Cambridge mercury-in-steel thermometers recording screen temperatures and 2" soil temperatures. The outside maximum and minimum thermometer was dismantled in August 1949.

Moorhouse

1947 No continuous records were obtained, but a few records of maximum and minimum air temperatures and 4" and 8" soil temperatures were made in September and October. A thermohygraph was started in November. It was placed in a Stevenson screen at a height of about six feet from the ground and 100 yards from the soil tins. This was the same position as that used by Mannley (1942).

1948 4" and 8" soil temperatures were taken on every visit to Moorhouse. The thermohygrograph was maintained. In November 1948, a Cambridge mercury-in-steel thermometer recording air temperatures was also placed in the Stevenson screen.

1949 On 7th. May, 1949, the Cambridge mercury-in-steel thermometer was removed up to the site of the soil tins and it now recorded 2" soil temperatures. Weekly rainfall was also measured.

(v) Meat Traps. Blowfly traps baited with sheeps' "lights" were maintained in the vicinity of the soil tins throughout the blowfly seasons of 1948 and 1949 at Durham and for 1949 only at Moorhouse. The Durham traps were made of mosquito netting and resembled the type used at Durham for emergence. They were supported on cylindrical frames by means of 6 strings at the base and a further 6 two-thirds way up the trap. They were placed over a maggot-proof box partially filled with water. A tin containing sheeps' "lights" was placed in the centre. Traps were changed daily and the "catch" killed, sorted and recorded. Moorhouse traps were made of metal gauze and were cylindrical in shape, being approx. 50 cms. high and 25 cms. in diameter. They fitted over bait pans containing a tin of "lights". The traps were changed at every visit to Moorhouse and the "catch" recorded as before. Two traps were maintained at Durham, but only one at Moorhouse. The "lights" were changed at weekly intervals.

11. BEHAVIOUR OF CONTROL BATCHES KEPT AT 22°C.

(i) Experimental procedure

When the batches of field prepupae prepared for field deposition were counted, 50 individuals of each species were placed in a glass jar (with lid) about ½ full of damp sawdust. Normally, the field samples were placed in the bottom of a refrigerator overnight (5°C). If this was the case, the 'control' prepupae were also put there for the night. As near to the time of deposition of field prepupae as possible, the jar was transferred to an incubator, running at 22°C. The contents of the jars were examined daily by tipping out the contents on a large sheet of paper. When the sawdust became slightly dry, the jar was rinsed out with water. Until August 1948 only emergence was recorded, but after that both pupation and emergence were recorded in an attempt to determine the cause of death.

(ii) Viability of Prepupae and Pupae under Control Conditions.

Table 1 shows the percentage viability of the prepupae, that of the pupae, and the over-all viability of the two stages taken together. The mean viability and standard deviation for each stage of every species was also determined (Table 2).

With the exception of L. caesar and L. illustris all species had a mean viability of over 95% in the prepupal stage and of from 80 to 90% in the pupal stage. The actual viabilities of the four species concerned did not differ significantly from each other. The viability of the pupal stage of L. illustris and the prepupal and pupal stages of L. caesar was significantly less, and the standard deviation high.

The following conclusions can be reached from these results:

(1) The pupal stage appeared to be less robust than the prepupal stage.

(2) The viability was high and fairly constant for P. terranovae, C. erythrocephala, C. vomitoria, L. sericata, so that any large variations in viability in the field

TABLE 1. **THE VIABILITY OF BATCHES**

Date on which Batch put into Incubator	L. SERICATA			L. ILLUSTRIS		
	(1)	(2)	(3)	(1)	(2)	(3)
28. 7.47	-	-	-	-	-	-
15. 8.47	-	-	84	-	-	-
30. 8.47	-	-	86	-	-	-
6. 9.47	86	84	72	88	82	72
20. 9.47	98	68	66	97	83	80
6.10.47	-	-	-	-	-	-
16–20.10.47	96	81	78	96	100	96
1.11.47	100	-	-	100	92	92
30.11.47	100	92	92	86	79	68
27.12.47	98	92	90	-	-	-
24. 1.48	92	96	88	-	-	-
20. 2.48	100	76	76	94	55	52
24. 3.48	98	76	74	100	92	92
19. 4.48	100	88	88	92	44	40
26. 4.48	-	-	-	96	-	-
3. 5.48	98	82	80	-	-	-
15. 6.48	100	72	72	-	-	-
5. 7.48	100	82	82	-	-	-
16. 7.48	-	-	-	100	84	84
4. 8.48	92	98	90	92	65	60
28. 8.48	90	96	86	-	-	54
10. 9.48	98	94	92	-	-	-
25. 9.48	100	94	94	-	-	-
23.10.48	100	88	88	-	-	-
20.11.48	96	83	80	-	-	-
18.12.48	98	61	60	-	-	-
16. 1.49	-	-	-	-	-	-
12. 2.49	-	-	-	-	-	-
12. 3.49	94	70	66	-	-	-

OF BLOWFLY PUPAE AND PREPUPAE KEPT AT 22° C.

L. CAESAR.			C. VOMITORIA.			C. ERYTHROCEPHALA			P. TERRANOVAE.		
(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	100	95	95	100	95	95	-	-	-
96	79	76	100	90	90	-	-	-	-	-	-
-	-	-	98	88	86	100, 100	60, 98	60, 98	-	-	-
-	-	-	92	91	84	100	-	-	100	100	100
92	72	66	-	-	-	-	-	-	100	94	94
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	100	88	88	100	68	68	100	100	100
-	-	-	94	75	70	88	-	-	100	92	92
-	-	-	-	-	-	96	71	68	90	98	88
82	56	46	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	100	90	90	100	84	84
-	-	-	-	-	-	100	-	-	100	82	82
96	46	44	-	-	-	100	76	76	100	98	98
88	86	76	-	-	-	100	78	78	-	-	-
-	-	-	100	92	92	100	84	84	100	84	84
94	87	82	92	87	80	96	88	84	96	96	92
-	-	-	96	84	80	96	90	86	-	-	-
100	88	88	100	90	90	-	-	-	96	96	92
-	-	-	-	-	-	-	-	-	94	89	84
96	83	80	-	-	-	84	93	78	100	66	66
94	70	66	100	96	96	100	65	65	100	84	84
94	-	-	-	-	-	-	-	-	-	-	-
94	75	70	-	-	-	-	-	-	-	-	-
-	-	-	100	76	76	100	94	94	100	94	94
-	-	-	100	80	80	100	86	86	-	-	-

TABLE 1 (Contd.) THE VIABILITY OF BATCHES

Date on which Batch put into Incubator	L. SERICATA.			L. ILLUSTRIS		
	(1)	(2)	(3)	(1)	(2)	(3)
9. 4.49	-	-	-	-	-	-
16. 4.49	100	-	76	-	-	-
7. 5.49	94	-	86	-	-	-
18. 5.49	94	94	88	-	-	-
11. 6.49	96	81	78	96	67	64
25. 6.49	98	-	-	-	-	-
9. 7.49	100	43	45	100	100	100
25. 7.49	100	100	100	-	-	-
8. 8.49	98	61	60	-	-	-
20. 8.49	92	85	78	100	-	-
27. 8.49	-	-	-	94	43	40
3. 9.49	82	88	72	-	-	-
10. 9.49	98	86	84	-	-	-
17. 9.49	-	-	-	-	-	-
24. 9.49	80	93	74	98	57	56
8.10.49	93	100	92	94	60	56
15.10.49	-	-	-	-	-	-
22.10.49	94	92	86	98	65	64
29.10.49	-	-	-	-	-	-
1.11.49	-	-	-	-	-	-

OF BLOWFLY PREPUPAE AND PUPAE KEPT AT 22° C.

L. CAESAR.			C. VOMITORIA.			C.ERYTHROCEPHALA			P.TERRANOVAE.		
(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
-	-	-	100	82	82	93	80	78	98	90	88
92	91	84	-	-	-	-	-	-	-	-	-
-	-	-	98	90	88	100	-	-	100	84	84
90	-	-	90	65	58	100	62	62	-	-	-
-	-	-	98	88	86	100	66	66	-	-	-
100	74	74	94	53	50	100	-	-	96	92	88
-	-	-	98	84	82	96	69	66	98	72	70
-	-	-	-	-	-	100	72	72	-	-	-
88	55	48	98	98	96	100	100	100	100	100	100
82	54	44	98	88	86	96	73	70	-	-	-
-	-	-	-	-	-	-	-	-	98	96	94
88	73	64	100	98	98	100	86	86	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	98	90	88	100	100	100
-	-	-	96	100	96	-	-	-	-	-	-
-	-	-	98	86	84	100	76	76	-	-	-
90	80	72	-	-	-	-	-	-	100	98	98
-	-	-	-	-	-	-	-	-	100	98	98
-	-	-	100	90	90	100	64	64	-	-	-
-	-	-	-	-	-	100	82	82	-	-	-

KEY: (1) = % Pupae / Prepupae

(2) = % Adults / Pupae

(3) = % Adults / Prepupae.

TABLE 2.

THE MEAN VIABILITY OF BLOWFLY PREPUPAE AND PUPAE KEPT AT 22° C.

Species.	Prepupae.	Pupae.	Both Stages.
P. terranovae.	98.5 ± 2.6	91.5 ± 4.6	89.8 ± 10.2
C. vomitoria.	97.4 ± 3.0	88.7 ± 3.3	86.8 ± 7.2
C. erythrocephala.	98.4 ± 3.6	80.1 ± 6.0	78.6 ± 11.6
L. sericata.	95.3 ± 4.9	84.5 ± 5.3	80.3 ± 9.8
L. illustris.	95.7 ± 4.2	73.5 ± 9.2	68.8 ± 9.5
L. caesar.	92.0 ± 5.1	73.5 ± 7.0	67.5 ± 14.7

TABLE 3.

DURATION OF PREPUPAL PHASE

(Expressed as the number of days fully-fed larvae into the

Date of Pupation	L. SERICATA			L. ILLUSTRIS			L. CAESAR.		
	Onset	50%	90%	Onset	50%	90%	Onset	50%	90%
3. 8.48	3	4	6	6	14	-	4	8	10
24. 8.48	3	4	5	3	45	-	-	-	-
10. 9.48	2	3	4	-	-	-	7	11	75
25. 9.48	1	3	5	-	-	-	-	-	-
23.10.48	3	6	8	-	-	-	3	8	65
20.11.48	1	3	6-9	-	-	-	2	3	6-9
18.12.48	3	6	10	-	-	-	2	6	54
15.1. 49	2	3	4	-	-	-	2	5	26
12. 2.49	3	4	6	-	-	-	-	-	-
12. 3.49	3	4	7	-	-	-	-	-	-
9. 4.49	-	-	-	-	-	-	-	-	-
16. 4.49	2	6	9	-	-	-	3	9	45
7. 5.49	3	4	5	-	-	-	-	-	-
18.5.49	-	-	-	-	-	-	2	6	43
11. 6.49	2	4	17	4	73	94	-	-	-
25. 6.49	2	3	3	-	-	-	2	8	9
9. 7.49	1	3	9	3	3	4	-	-	-
25. 7.49	-	-	-	-	-	-	2	-	-
8. 8.49	3.	4	6	-	-	-	15	56	61
20. 8.49	3	5	49	6	9	-	3	53	-
27. 8.49	-	-	-	4	103	-	-	-	-
3. 9.49	2	3	5	-	-	-	15	56	74
10. 9.49	2	-	-	-	-	-	-	-	-
17. 9.49	-	-	-	-	-	-	-	-	-
24. 9.49	3	4	5	3	72	-	-	-	-
8.10.49	2	3	8	3	7	93	-	-	-
15.10.49	-	-	-	-	-	-	9	69	-
22.10.49	2	3	4	5	74	-	-	-	-
29.10.49	-	-	-	-	-	-	-	-	-
1.11.49	-	-	-	-	-	-	-	-	-
MEAN:	2.3 ±0.7	3.9 ±1.0	6.0 ±2.0	4.1 ±1.3	8.3 ±5.3	-	2.9 ±2.3	7.1 ±2.4	-

OF BLOWFLY PREPUPAE AT 22° C.

which elapsed between placing the incubator and pupation).

C. VOMITORIA			C. ERYTHROCEPHALA			P. TERRANOVAE.		
Onset	50%	90%	Onset	50%	90%	Onset	50%	90%
4	5	8	2	3	4	2	2	2
2	4	6	2	3	5	-	-	-
4	5	5	2	3	3	0	1	2
3	4	5	-	-	-	1	2	3
-	-	-	2	2	-	2	2	2
2	3	3	1	1	2	1	1	1
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
2	3	4	1	2	2	2	2	2
3	4	5	2	2	2	-	-	-
2	3	3	2	2	2	1	1	2
-	-	-	-	-	-	-	-	-
3	3	4	1	2	2	1	1	1
3	4	-	2	2	3	-	-	-
3	4	5	3	4	4	-	-	-
2	3	9	2	2	3	2	3	3
2	3	4	1	2	3	1	1	2
-	-	-	2	3	3	2	2	2
4	5	7	2	2	2	2	3	3
2	3	4	1	2	3	-	-	-
-	-	--	-	-	-	-	-	4
-	-	-	2	3	3	3	5	6
-	-	-	-	-	-	-	-	-
-	-	-	2	2	3	2	2	2
2	3	4	-	-	-	-	-	-
2	3	5	2	2	3	-	-	-
-	-	-	-	-	-	1	1	1
-	-	-	-	-	-	2	2	2
2	2	3	2	2	3	-	-	-
-	-	-	3	3	4	-	-	-
2.5 ±0.7	3.6 ±0.9	4.9 ±1.7	1.9 ±0.6	2.3 ±0.7	3.0 ±0.8	1.6 ±0.8	1.9 ±1.1	2.4 ±1.4

TABLE 4.

DURATION OF PREPUPAL PLUS

(Expressed as the number of days
the fully fed larvae into

EMERGENCE Date	L. SERICATA Onset	L. SERICATA 50%	L. SERICATA 90%	L. ILLUSTRIS. Onset	L. ILLUSTRIS. 50%	L. ILLUSTRIS. 90%	L. CAESAR Onset	L. CAESAR 50%	L. CAESAR 90%
28. 7.47	12	14	-	-	-	-	-	-	-
15. 8.47	11	13	-	-	-	-	-	-	-
30. 8.47	13	16	-	10	-	-	-	-	-
6. 9.47	-	-	-	11	17	-	-	-	-
20. 9.47	11	13	-	10	11	-	-	-	-
6.10.47	-	-	-	-	-	-	33	43	-
18-20 10.47	9	12	-	9	11	17	-	-	-
1.11.47	-	-	-	-	-	-	-	-	-
1.11.47	8	-	-	11	18	58	-	-	-
30.11.47	9	12	30	8	34	-	18	23	-
27.12.47	8	12	26	8	13	-	-	-	-
24. 1.48	11	13	-	-	-	-	-	-	-
20. 2.48	11	16	-	12	137	-	-	-	-
24. 3.48	11	12	-	9	10	13	-	-	-
19. 4.48	11	13	16	22	-	-	17	61	-
26. 4.48	12	13	-	15	128	-	-	-	-
13. 5.48	13	15	-	-	-	-	22	-	-
15. 6.48	10	13	-	-	-	-	14	-	-
5. 7.48	12	13	-	-	-	-	14	-	-
16. 7.48	-	-	-	13	17	-	-	-	-
4. 8.48	13	15	18	17	25	-	15	19	-
24. 8.48	13	14	-	12	90	-	-	-	-
10. 9.48	11	13	16	13	-	-	18	79	-
25. 9.48	11	13	15	9	11	-	-	-	-
23.10.48	13	16	-	-	-	-	13	17	-
20.11.48	11	13	-	-	-	-	11	13	-
18.12.48	11	18	-	14	-	-	-	-	-
16. 1.49	-	-	-	-	-	-	11	14	-
12. 2.49	13	14	-	-	-	-	-	-	-

PUPAL PHASE AT 22° C.

which elapsed between placing the incubator and emergence.)

C. VOMITORIA			C. ERYTHROCEPHALA			P. TERRANOVAE.		
Onset	50%	90%	Onset	50%	90%	Onset	50%	90%
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
13	14	-	11	12	13	-	-	-
11	12	13	-	-	-	-	-	-
11	11	-	11	13	-	-	-	-
-	-	-	13	13	14	-	-	-
12	12	13	13	15	-	8	9	9
-	-	-	-	-	-	8	8	9
-	-	-	-	-	-	-	-	-
12	13	14	14	-	-	9	9	10
14	14	-	12	14	-	9	10	11
-	-	-	14	16	-	9	9	9
-	-	-	-	-	-	10	10	-
-	-	-	15	16	18	-	-	-
-	-	-	14	-	-	10	10	-
-	-	-	14	16	-	10	10	10
-	-	-	14	15	-	-	-	-
14	15	15	14	14	-	10	11	-
15	16	-	14	16	-	10	10	11
14	15	-	13	15	-	-	-	-
14	15	18	14	15	-	8	9	10
-	-	-	-	-	-	9	11	-
-	-	-	13	14	-	9	9	-
13	14	-	11	13	-	8	8	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
13	14	-	12	13	14	10	10	11

TABLE 4

EMERGENCE Date	*L. SERICATA* Onset	50%	90%	*L. ILLUSTRIS.* Onset	50%	90%	*L. CAESAR.* Onset	50%	90%
12. 3.49	12	14	-	-	-	-	-	-	-
9. 4.49	-	-	-	-	-	-	-	-	-
16. 4.49	12	17	-	-	-	-	13	50	-
7. 5.49	12	14	-	-	-	-	-	-	-
18. 5.49	-	-	-	-	-	-	16	-	-
11. 6.49	13	14	-	11	88	-	-	-	-
25. 6.49	-	-	-	-	-	-	12	18	-
9. 7.49	11	-	-	11	12	12	-	-	-
23. 7.49	13	13	14	-	-	-	12	16	16
6. 8.49	13	15	-	-	-	-	18	70	-
20. 8.49	14	16	-	20	-	-	13	-	-
27. 8.49	-	-	-	12	-	-	-	-	-
3. 9.49	12	14	-	-	-	-	46	68	-
10. 9.49	13	15	-	14	-	-	-	-	-
17. 9.49	-	-	-	-	-	-	-	-	-
24. 9.49	11	13	-	11	106	-	-	-	-
8.10.49	11	13	-	12	93	-	-	-	-
15.10.49	-	-	-	-	-	-	18	86	-
22.10.49	11	13	-	13	81	-	-	-	-
29.10.49	-	-	-	-	-	-	-	-	-
18.11.49	-	-	-	-	-	-	14	17	-
MEAN:	11.5 ±1.4	13.9 ±1.5	15.6 ±1.1	11.8 ±2.2	13.3 ±3.1	-	15.6 ±2.4	16.8 ±6.8	-

(Continued)

C. VOMITORIA			C. ERYTHROCEPHALA			P. TERRANOVAE.		
Onset	50%	90%	Onset	50%	90%	Onset	50%	90%
14	15	-	12	13	-	-	-	-
14	-	-	13	13	-	9	10	-
-	-	-	-	-	-	-	-	-
14	14	16	13	16	-	8	9	10
14	15	-	-	-	-	-	-	-
13	15	-	15	15	-	-	-	-
13	15	-	12	-	-	11	11	8
13	14	-	12	14	-	8	8	-
-	-	-	14	16	-	10	-	-
15	17	19	13	14	14	10	11	-
13	14	-	13	15	-	-	-	-
-	-	-	-	-	-	11	11	12
14	16	18	14	14	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	13	14	16	8	9	9
14	14	15	-	-	-	-	-	-
14	15	-	13	14	-	-	-	-
-	-	-	-	-	-	9	10	10
-	-	-	-	-	-	9	10	10
13	14	15	13	14	-	-	-	-
-	-	-	15	16	-	-	-	-
13.8 ±1.0	14.3 ±1.3	15.6 ±2.0	13.2 ±1.1	14.4 ±1.2	14.7 ±1.8	9.2 ±1.0	9.7 ±1.0	10.07 ±0.9

TABLE 5.

DURATION OF PUPAL PERIOD

(Obtained by subtracting the figures

Pupation Date	L. SERICATA.			L. ILLUSTRIS.			L. CAESAR.		
	Onset	50%	90%	Onset	50%	90%	Onset	50%	90%
3. 8.48	10	11	12	11	21	-	11	11	-
24. 8.48	10	10	-	9	45	-	-	-	-
10. 9.48	9	10	12	-	-	-	11	68	-
25. 9.48	10	10	10	-	-	-	-	-	-
23.10.48	10	10	-	-	-	-	10	9	-
20.11.48	10	10	-	-	-	-	9	10	-
18.12.48	8	12	-	-	-	-	-	-	-
16. 1.49	-	-	-	-	-	-	9	9	-
12. 2.49	10	10	-	-	-	-	-	-	-
12. 3.49	9	10	-	-	-	-	-	-	-
9. 4.49	-	-	-	-	-	-	-	-	-
16. 4.49	10	13	-	-	-	-	10	41	-
7. 5.49	10	10	-	-	-	-	-	-	-
18. 5.49	-	-	-	-	-	-	14	-	-
11. 6.49	11	10	-	7	15	-	10	10	-
25. 6.49	-	-	-	-	-	-	10	-	-
9. 7.49	10	-	-	8	9	8	3	14	-
25. 7.49	-	-	-	-	-	-	10	-	-
8. 8.49	10	11	-	-	-	-	31	15	-
20. 8.49	11	11	-	14	-	-	-	-	-
27. 8.49	-	-	-	8	-	-	-	-	-
3. 9.49	10	11	-	-	-	-	-	-	-
10. 9.49	11	-	-	-	-	-	-	-	-
17. 9.49	-	-	-	-	-	-	-	-	-
24. 9.49	8	9	-	8	34	-	-	-	-
8.10.49	9	10	-	9	84	-	-	-	-
15.10.49	-	-	-	-	-	-	9	17	-
22.10.49	9	10	-	8	7	-	-	-	-
29.10.49	-	-	-	-	-	-	-	-	-
1.11.49	-	-	-	-	-	-	-	-	-
MEAN:	9.8 ± 0.9	10.4 ± 0.9	11.3 ± 1.1	9.1 ± 2.1	10.3 ± 4.2	-	9.6 ±2.5	11.9 ± 3.0	- -

AT 22^{0} C. (IN DAYS)

in Table 3 from those in Table 4).

C. VOMITORIA.			C. ERYTHROCEPHALA.			P. TERRANOVAE.		
Onset	50%	90%	Onset	50%	90%	Onset	50%	90%
11	11	-	12	13	-	8	8	9
12	11	-	11	12	-	-	-	-
10	10	13	12	12	-	8	8	8
-	-	-	-	-	-	8	9	-
-	-	-	11	12	-	7	7	-
11	11	-	10	12	-	7	7	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
11	11	-	11	11	12	8	8	9
11	11	-	10	11	-	-	-	-
12	-	-	11	11	-	8	9	-
-	-	-	-	-	-	-	-	-
11	11	12	12	14	-	7	8	9
11	11	-	-	-	-	-	-	-
10	11	-	12	11	-	-	-	-
11	12	-	10	-	-	9	8	-
11	11	-	11	12	-	7	7	-
11	12	12	12	13	-	8	-	-
11	11	-	11	12	-	8	8	-
-	-	-	12	13	-	-	-	-
-	-	-	-	-	-	-	-	8
-	-	-	12	11	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	11	12	13	6	7	7
12	11	11	-	-	-	-	-	-
12	12	-	11	12	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	8	9	9
11	12	12	11	12	-	-	-	-
-	-	-	12	13	-	-	-	-
11.1 ±0.6	10.8 ±0.6	12.0 ±0.7	11.4 ±0.7	12.1 ±0.9	12.5 ±0.7	7.6 ±0.8	7.9 ±0.8	8.4 ±0.8

batches could be accounted for by conditions suffered after, and not before, deposition.

(3) The viability was lower and rather variable for L.illustris and L.caesar and therefore the performance of the corresponding control batch would have to be borne in mind when studying the behaviour of the field batches.

(iii) Rate of Pupation and Emergence

Duration of Pupal Phase The number of days which elapsed between placing the larvae in the incubator and the appearance of the first pupa was recorded. Similarly, the time which elapsed before 50% and 90% pupation occurred was determined and the results were all tabulated (Table 3). The mean number of days and the standard deviation from that mean were calculated in each case.

Duration of Prepupal plus Pupal Phase Table 4 shows the number of days which elapsed before placing the jars in the incubator and emergence. The mean number of days and standard deviation were calculated as before.

Duration of Pupal Phase By subtracting the duration of prepupal phase from the equivalent duration of prepupal plus pupal phase, the duration of the pupal period was determined. This was done for the first pupa, for the first 50% of the pupae and for the first 90% of the pupae (See Table 5). The figures obtained in the three cases did not differ significantly i.e. length of prepupal life had no effect on length of pupal life. In a few batches of the species L.caesar and L.illustris, the pupal life as calculated from the first 50% of the pupae was abnormally long. This was found to be due to a considerable mortality in the pupal stage which caused the completion of 50% of the emergence to be delayed until some of the remaining prepupae had pupated and emerged.

Variability in Length of Prepupal and Pupal Life of Blowflies at 22°C.

For L.sericata, C.vomitoria, C.erythrocephala and P.terranovae, the standard deviation from the mean duration of prepupal and pupal phases was never more than 2 days. From this it can be deduced that variations in duration of prepupal and pupal phases in the field were almost entirely due to the environment suffered after, and not before, deposition.

For L.illustris and L.caesar, the standard deviations from the mean were from 2 - 7 days and even this excluded those batches which had partially entered a long diapause. 7 out of 16 L.illustris batches and 6 out of 23 L.caesar batches entered such a diapause. There is therefore no justification for assuming that the rate of development of these two species in the field was entirely due to field conditions. Only if the behaviour of each field batch is studied in the light of the performance of the equivalent control batch will the field results for these two species be significant.

Length of Prepupal and Pupal Life of Blowflies at 22°C.

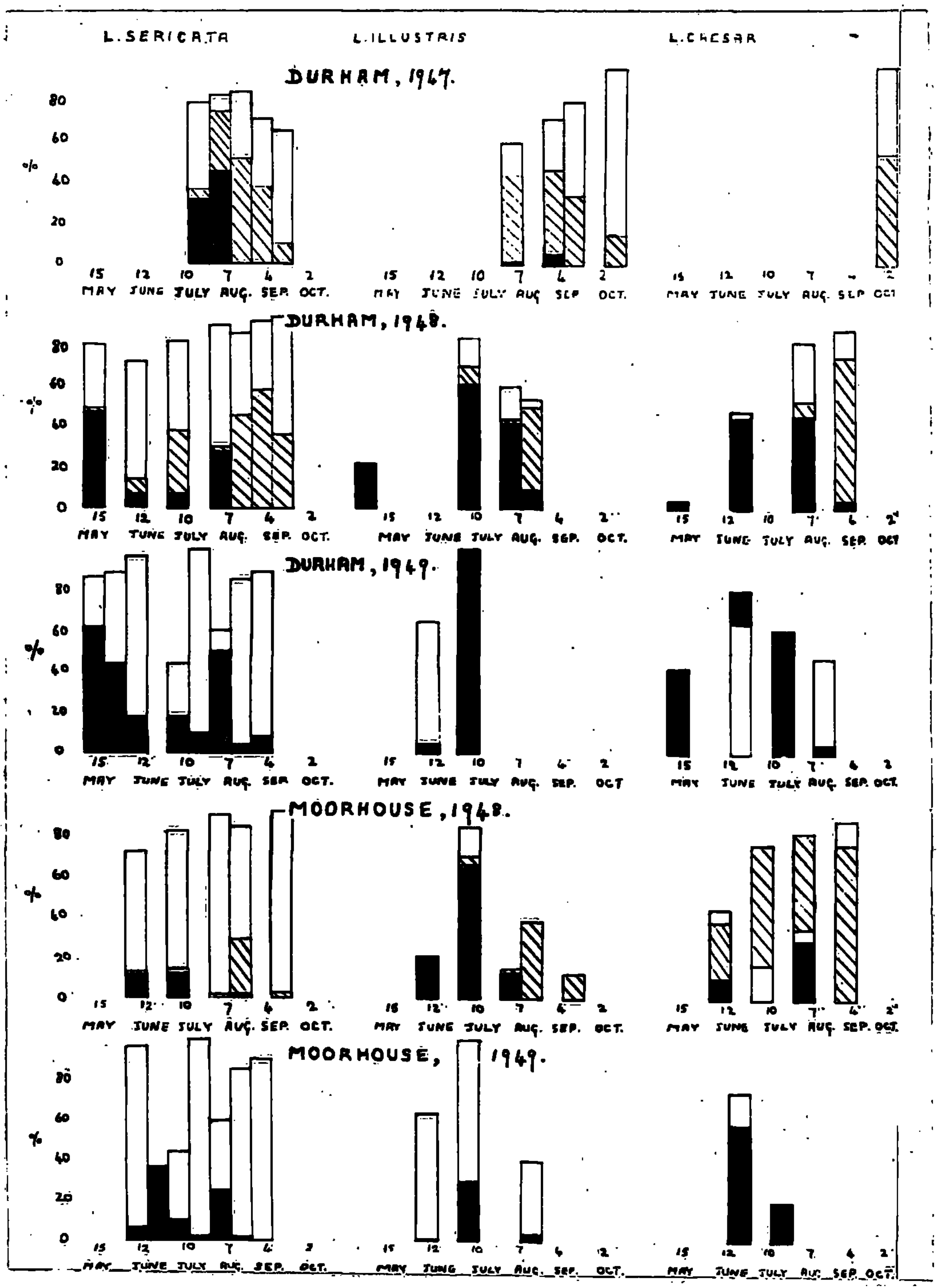
Table 6 shows the mean duration of prepupal and pupal life, taken from the 50% columns of Tables 3 and 5. In the case of L.sericata, C.vomitoria, C.erythrocephala and P.terranovae, there was little difference between the mean total development period derived as a whole from Table 4 and that obtained from summing the prepupal and pupal period shown in Tables 3 and 5. For L.illustris and L.caesar, the differences were considerable.

Development was most rapid in P.terranovae (10 days in all) and of about the same duration for L.sericata, C.vomitoria and C.erythrocephala (14 days in all). No definite conclusion could be reached as to the number of days L.caesar and L.illustris required for development, but it was usually from 13 to 19 days.

TABLE 6. MEAN LENGTH OF PREPUPAL AND PUPAL LIFE OF BLOWFLIES AT 22° C. (IN DAYS).

	L. SERICATA.	L. ILLUSTRIS.	L. CAESAR	C. VOMITORIA	C. ERYTHROCEPHALA	PROTOPHORMIA
Prepupae (Table 3)	3.9	8.3	7.1	3.6	2.3	1.9
Pupae (Table 5)	10.4	10.3	11.9	10.8	12.1	7.9
Sum.	14.3	18.6	19.0	14.4	14.4	9.8
Prepupae + Pupae (Table 4)	13.9	13.3	16.3	14.3	14.4	10.1

FIGURE 3. % EMERGENCE FROM BATCHES OF <u>LUCILIA</u> PREPUPAE DEPOSITED DURING THE NORMAL BLOWFLY SEASON



KEY TO FIGS. 1, 2, + 3

■ % emergence during year of deposition

▧ % emergence during the following year

□ % emergence from control batches

III VIABILITY OF BLOWFLY PREPUPAE DEPOSITED AT THE FIELD STATIONS DURING THE NORMAL BLOWFLY SEASON

The normal blowfly season for each species was taken as the period during which adults of that species were caught in meat traps situated in the vicinity of the soil tins. (See Table 7).

Since it was impossible to distinguish between the females of L.caesar and L.illustris, the normal blowfly season for these two species was taken as the period during which either males of the appropiate species or else females of the L.caesar type were caught.

Table 8 and figures 3, 4 and 5 show the percentage emergence from batches laid down throughout the normal blowfly season for each species and station.

L.sericata

(1) Viability was highest in batches deposited during early and late summer, reaching a maximum of 80% at Durham and 40% at Moorhouse. Batches put down at Durham during the most favourable time of year, therefore, survived just as well as the average batch brought up under control conditions.

(2) Viability was at a minimum in batches deposited at Durham in June and July and batches depposited at Moorhouse in July. Possible unfavourable factors acting against these batches include high temperatures, dryness and parasitism.

(3) A small proportion of all batches deposited at both Durham and Moorhouse entered diapause lasting throughout the succeeding winter, and practically all prepupae deposited from mid-August onwards entered diapause.

L.Illustris

(1) Records for this species were too incomplete to draw any conclusions as to the changes in viability during the season. However, July did not seem to be an

TABLE 7. THE FIRST AND LAST DATES ON WHICH BLOWFLIES WERE CAUGHT IN MEAT TRAPS DURING THE TWO SUMMER SEASONS 1948 AND 1949.

Species	DURHAM		MOORHOUSE	
	First Date	Last Date	First Date	Last Date
L. sericata	29 Apr.	18 Oct.	5 June	18 Sep.
L. illustris* } L. caesar* }	29 Apr.	25 Oct.	18 May	16 Oct.
C. vomitoria	15 Apr.	21 Nov.	18 May	16 Oct.
C. erythrocephala	5 Apr.	21 Nov.	18 May	16 Oct.
P. terranovae	15 Apr.	31 Oct.	15 June	24 Sept.

* These two species counted together, owing to impossibility of separating the females.

TABLE 8a.

% EMERGENCE FROM DURHAM AND
DURING BLOWFLY SEASONS

LUCILIA

Date of Deposition (Approx.)	LUCILIA SERICATA						LUCILIA		
	DURHAM			MOORHOUSE			DURHAM		
	1 May to 13 Oct.			5 June to 13 Sept.			29 Apr. to 25 Oct.		
	1947	1948	1949	1947	1948	1949	1947	1948	1949
1 May	-	-	-	-	-	-	-	22	-
15 May	-	47+ 2	62	-	-	-	-	-	-
29 May	-	-	44	-	-	-	-	-	-
12 June	-	7+ 7	17	-	12+ 1	6	-	-	5
26 June	-	-	-	-	-	37	-	-	-
10 July	-	7+31	17	-	13+ 1	9	-	61+ 8	100
24 July	32+ 6	-	10	-	-	2	-	-	-
7 Aug.	46+30	27+ 3	49	-	0+ 1	25	1+43	42+ 2	-
21 Aug.	1+51	0+46	3	-	1+29	1	-	9+42	-
4 Sept.	0+38	0+59	8	-	-	0	6+41	-	-
18 Sept.	0+10	0+36	0	-	0+ 3	0	0+34	-	-
2 Oct.	-	-	0	-	-	-	-	-	-
16 Oct.	-	-	-	-	-	-	0+15	-	-

NOTE: The first figure in each column denotes % emergence during the year of deposition and the second the % emergence during the following year.

MOORHOUSE BATCHES DEPOSITED
1947, 1948 AND 1949.

SPECIES.

ILLUSTRIS.			LUCILIA CAESAR.					
MOORHOUSE			DURHAM			MOORHOUSE		
28 May to 16 Oct.			29 Apr. to 25 Oct.			28 May to 16 Oct.		
1947	1948	1949	1947	1948	1949	1947	1948	1949
-	-	-	-	-	-	-	-	-
-	-	-	-	4+ 0	42	-	-	-
-	-	-	-	-	-	-	-	-
-	21+ 0	1	-	-	-	-	10+28	-
-	-	-	-	45+ 0	80	-	-	58
-	65+ 4	30	-	-	-	-	0+17	-
-	-	-	-	-	61	-	-	20
-	13+ 2	-	-	46+ 7	0	-	29+ 6	0
-	0+38	5	-	-	5	-	-	0
-	-	-	-	4+70	0	-	0+76	-
-	0+12	-	-	-	-	-	-	-
-	-	-	0+53	-	-	-	-	-
-	-	-	-	0+73	-	-	-	-

TABLE 8b.

% EMERGENCE FROM DURHAM AND MOORHOUSE BATCHES

(CALLIPHORA SPECIES AND

Date of Deposition (Approx)	CALLIPHORA VOMITORIA						CALLIPHORA		
	DURHAM			MOORHOUSE			DURHAM.		
	5 Apr. to 21 Nov.			18 May to 16 Oct.			5 April to 21 Nov.		
	1947	1948	1949	1947	1948	1949	1947	1948	1949
2 Apr.	-	-	80	-	-	-	-	-	56
17 Apr.	-	-	-	-	-	-	-	-	-
1 May	-	-	98	-	-	-	-	92+ 0	65
15 May	-	72	66	-	86+ 0	72	-	73+ 0	76
29 May	-	-	-	-	-	-	-	-	-
12 June	-	-	90	-	-	86	-	80+ 0	75
26 June	-	-	79	-	-	59	-	72+ 2	81
10 July	-	100	64	-	82+ 0	53	-	68+ 0	77
24 July	-	-	-	-	-	-	-	-	50
7 Aug.	-	84	-	-	50+ 0	-	-	64+ 0	91
21 Aug.	-	82+ 2	67	-	68+ 2	61	-	93+ 0	75
4 Sept.	-	47+12	34	-	20+ 6	2	-	93+ 0	70
18 Sept.	0+88	-	-	-	-	-	0+54	-	56
2 Oct.	0+67	-	63	0+22	-	-	-	-	18
16 Oct.	0+28	-	-	-	-	-	0+45	-	-
30 Oct.	0+50	0+83	-	-	-	-	-	0+20	-
15 Nov.	-	-	-	-	-	-	-	-	-

NOTE: The first figure in each column denotes % emergence during the year of deposition and the second the percentage emergence during the following year.

DEPOSITED DURING BLOWFLY SEASONS 1947, 1948 AND 1949.

PROTOPHORMIA TERRANOVAE).

ERYTHROCEPHALA.			PROTOPHORMIA TERRANOVAE.					
MOORHOUSE			DURHAM			MOORHOUSE		
18 May to 16 Oct.			15 Apr. to 31 Oct.			11 Jne. to 25 Sep.		
1947	1948	1949	1947	1948	1949	1947	1948	1949
-	-	-	-	-	-	-	-	-
-	-	-	-	42+ 0	40	-	-	-
-	-	-	-	-	66	-	-	-
-	55+ 0	54	-	81+ 0	-	-	-	-
-	-	-	-	-	-	-	-	-
-	82+ 0	91	-	76+ 0	-	-	42+ 0	-
-	56+ 0	31	-	36+ 0	96	-	-	76
-	58+ 0	39	-	81+ 0	49	-	64+ 0	58
-	-	67	-	64+ 0	-	-	-	-
-	48+ 2	98	-	-	92	-	18+ 0	87
-	79+ 0	80	-	81+ 0	68	-	-	42
-	56+ 6	76	-	1+ 0	-	-	0	0
-	-	33	-	-	76	-	0	-
-	-	-	-	0	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

FIG. 4. % EMERGENCE FROM BATCHES OF CALLIPHORA PREPUPAE DEPOSITED DURING THE NORMAL BLOWFLY SEASON

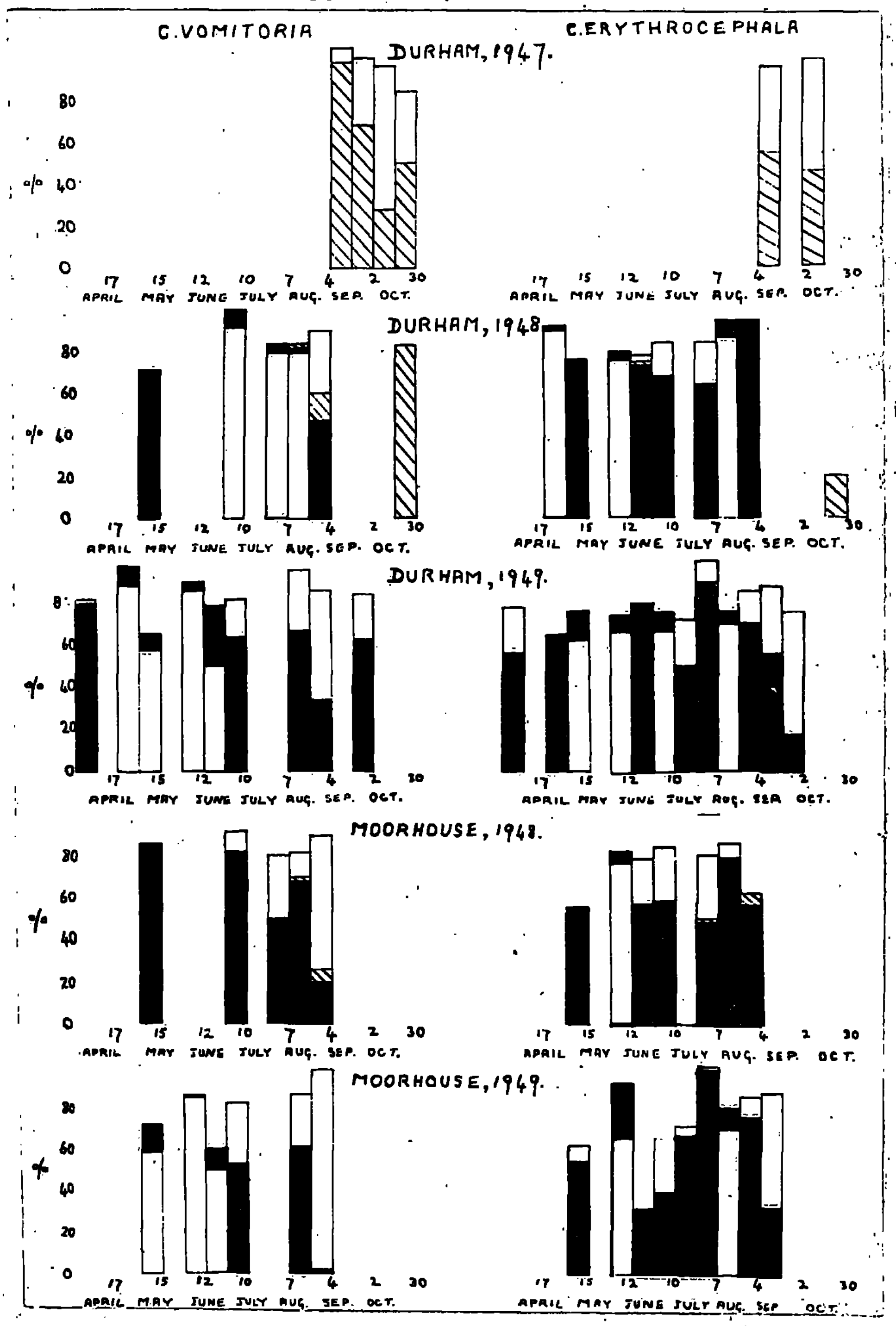
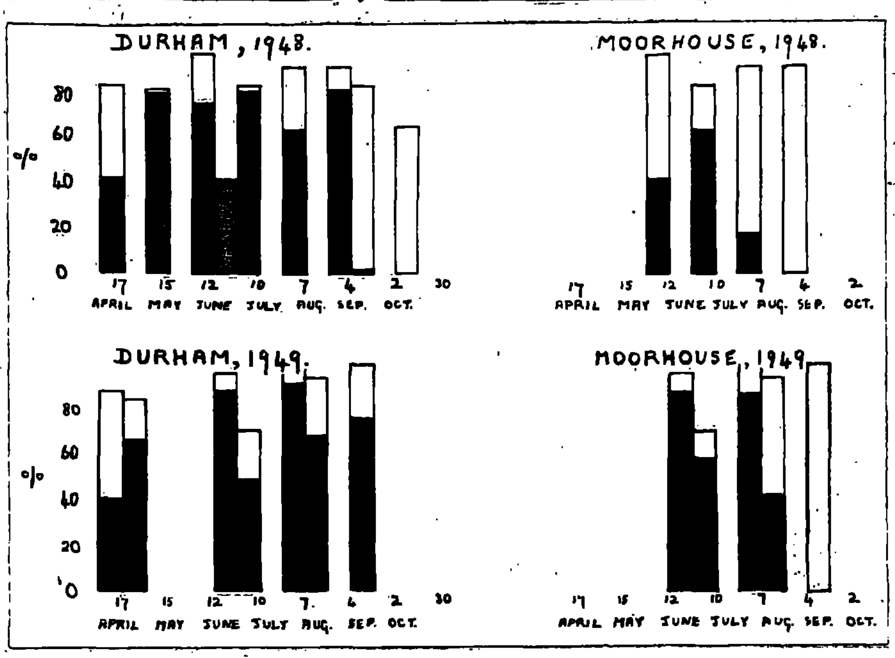


FIG. 5. % EMERGENCE FROM BATCHES OF P. TERRANOVAE PRE-PUPAE DEPOSITED DURING THE NORMAL BLOWFLY SEASON



Key as for Fig. 3

unfavourable month for deposition, as in the case of ~~L.sericata.~~ L.sericata

(2) A small proportion of nearly all batches entered diapause lasting throughout the winter, and practically all prepupae deposited from mid-August onwards entered diapause.

L.Caesar

(1) Records for this species were also incomplete, but most favourable times for deposition appeared to be June and September.

(2) A part of all the batches deposited at Moorhouse entered diapause lasting throughout the winter. Diapause was practically complete, at both stations from mid-August onwards.

C.vomitoria

(1) Percentage emergence was high and fairly constant throughout the season, except for September at Moorhouse, when the prepupae entered diapause and the adverse effect of overwintering at this field station became apparent.

(2) The batches were free from diapause except for those deposited from September onwards.

C.erythrocaphala

Similar results were obtained as for C.vomitoria, except that the percentage emergence of batches deposited in late June and early July was rather less than that for the rest of the summer.

P.terranovae

Percentage emergence from batches laid down at Durham from May to late September was high and constant. There was a decrease in viability before and after this period. Percentage emergence from batches laid down at Moorhouse from June until mid-August was high, but outside this period it was very low. No prepupae were found to overwinter successfully at either station.

Comparison between mortality at Durham and Moorhouse.

Summer Mortalities

All species showed a higher mortality at Moorhouse than at Durham, but the differences between the two mortalities varied with the species, being greatest in *L. sericata*, less in *L. caesar* and *L. illustris* and least in the *Calliphora* species. Midsummer mortality in *Protophormia terranovae* at Moorhouse was quite low, but rose steeply in early June and late August.

Overwintering Mortalities.

All species showed a higher overwintering mortality at Moorhouse than at Durham. The differences were again greatest with *L. sericata* and less with *L. caesar* and *L. illustris*. The *Calliphora* species deposited at Durham in 1947 successfully overwinter there, but a gap in deposition of batches in late 1948 resulted in no information on the overwintering ability of these species at Moorhouse. There were no cases at either Durham or Moorhouse of any individuals of the species *Protophormia terra-novae* overwintering successfully.

The Soil Factor

In order to discover how much of the higher mortality at Moorhouse was due to the type of soil, a tin of Moorhouse soil was brought to Durham and prepupae deposited in Durham soil. 200 *L. sericata*, 200 *C. vomitoria* and 200 *C. erythrocephala* were deposited in each tin in March 1949.

The percentage emergence were as follows:-

	L. sericata	C. vomitoria	C. erythrocephala
Durham soil	31%	76.5%	64%
Moorhouse soil	42%	77%	62%

In this case at any rate, the use of Moorhouse soil did not have any appreciable effect on the prepupal or pupal mortality.

<u>The Container Factor</u> The fact that the prepupae were confined in a tin may have had various effects on the mortality (e.g. partial shelter from wind, rain sun, inefficient drainage, crowding) No systematic experiments have yet been carried out on this point.

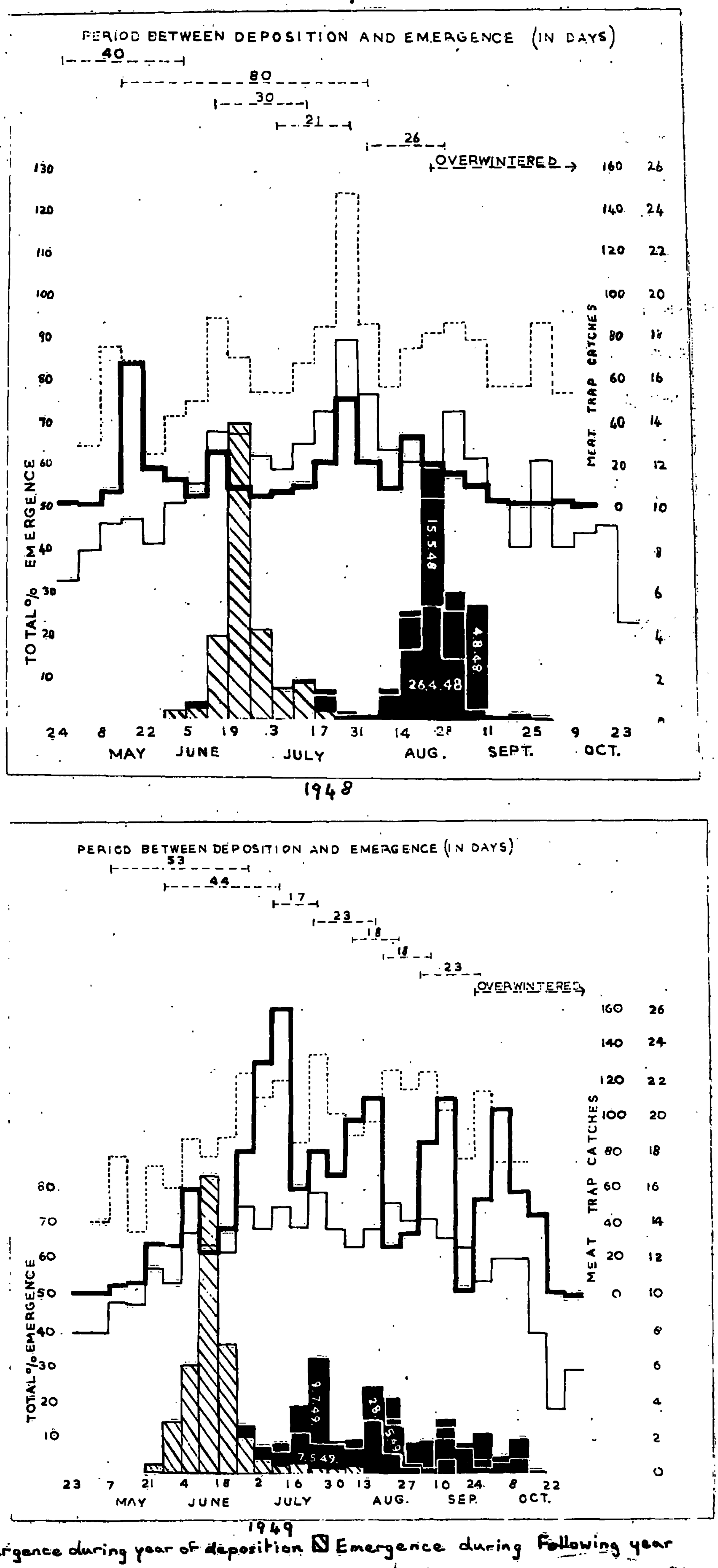
<u>Conclusions</u>

(1) Summer mortalities were always higher at Moorhouse than at Durham, but Moorhouse conditions were most suitable for the Calliphora species and least suitable for <u>Lucilia sericata</u>.

(2) Overwintering mortalities were higher at Moorhouse than at Durham. <u>Lucilia caesar</u> and <u>Lucilia illustris</u> overwintered more successfully than <u>Lucilia sericata</u> and <u>Protophormia terranovae</u> failed to overwinter at either station. <u>Calliphora species</u> overwintered well at Durham, but there is no data on the overwintering of <u>Calliphora sp</u>. at Moorhouse.

(3) As far as could be seen from the one experiment carried out at this point, type of soil had no effect on percentage emergence.

FIG. 6. WEEKLY % EMERGENCE FROM L. SERICATA BATCHES DEPOSITED AT DURHAM DURING THE NORMAL BLOWFLY SEASONS



KEY:-
■ Emergence during year of deposition ▧ Emergence during following year
— 1" soil temperatures - - - - Maximum temperatures
▬ Meat trap catches

1V THE EMERGENCE PATTERN OF BATCHES DEPOSITED DURING THE NORMAL BLOWFLY SEASON

(i) *Lucilia sericata* (Mg.)

Durham Batches

Emergence tables were constructed showing weekly percentage emergence from each batch of prepupae put down during the period 29th. April to 18th. October in 1948 and 1949 and from 23rd. July to 18th. October in 1947 (See Appendix Pages 91-4). From this data histograms were drawn showing total weekly emergence from these batches (Figure 6)

1948 Emergence The histograms showed that emergence lasted from 29th. May to 9th. October. There were two well-defined peaks with a period of very little emergence in between. The first peak covered the period 12th. June - 3rd July and was due to prepupae deposited during the previous late summer and autumn. The second peak covered the period 14th. August to 11th. September and was due to prepupae deposited during May to early August of the same summer. Batches deposited from late August onwards entered complete diapause.

1949 Emergence. The histograms show that emergence lasted from 21st. May to 15th. October. There was a well defined spring peak as before, covering the period 4th - 25th. June, and this was again mainly due to prepupae deposited in the preceding late summer and autumn, although partly due to prepupae put down in the preceding early summer. (No prepupae were deposited in the early summer of 1947) There was, however, no well-defined late August peak as in the preceding year but a small emergence peak from 16th. - 30th. July, followed by 2 weeks of low emergence, and then another peak from 13th. to 27th. August, and then a sustained emergence until 1st. October. Batches deposited from late August on wards entered practically complete diapause.

Temperature Data

The following were plotted above the emergence histograms:-

(1) Average weekly maximum temperatures as recorded in the Stevenson screen.

(2) Average weekly 1" soil temperature, recorded daily between 9a.m. and 10a.m.

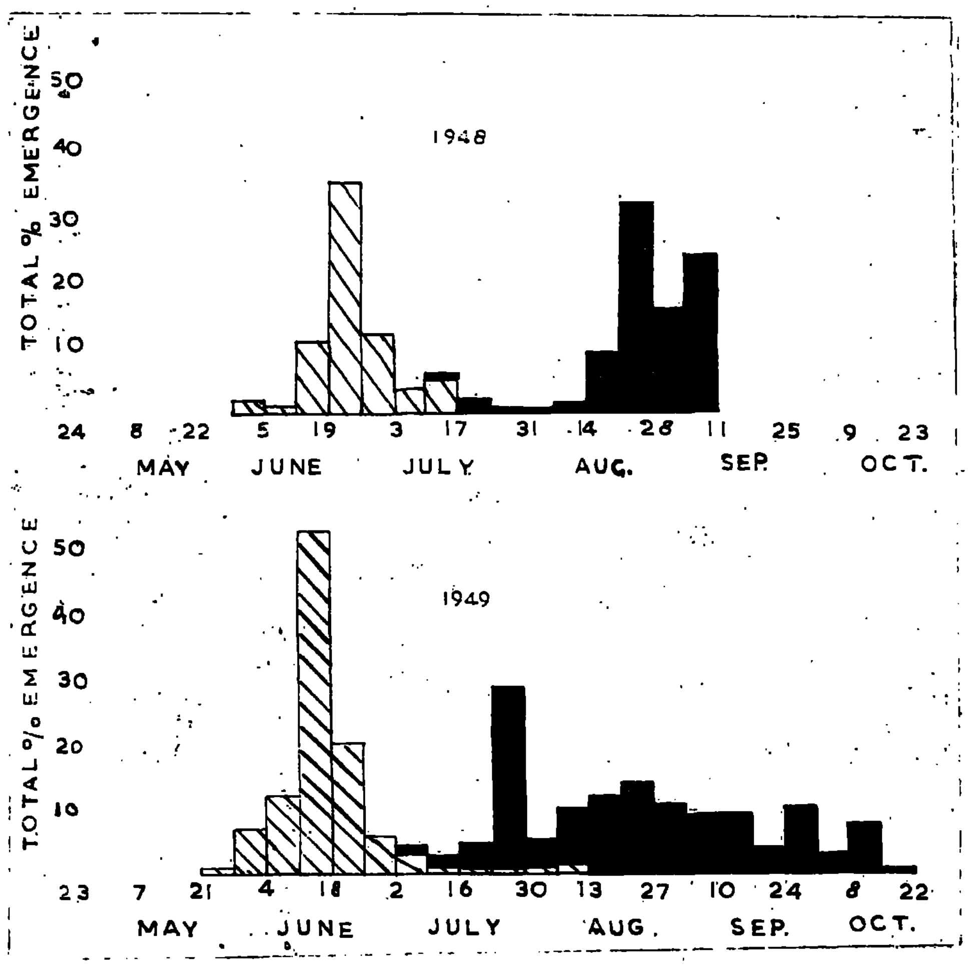
In both 1948 and 1949 emergence occurred when 1" soil temperatures were greater than 10°C and the maximum air temperatures were greater than 14°C. The spring emergence peaks followed increases in soil temperatures to 13°C, but the decrease in emergence in July was not due a decrease in temperature.

Meat Trap Catch Data

The weekly catches of L. sericata in two meat traps were added to the graphs. The correlation between catch data and emergence data was not obvious. There was a spring 'catch' peak from 15th - 29th. May, but this was earlier, and not later, than the emergence peak as would have been expected. There was also a peak from 17th. July to 13th. August, when emergence figures were very low. This may, however, have been caused by flies emerging during the spring emergence peak. There was a third 'catch' peak from 14th. - 28th. August which just preceded the late summer emergence peak.

In 1949, the meat trap catches were much higher. There was a meat trap peak from 25th. June to 16th. July, which may have corresponded to the spring emergence peak from 4th. - 25th. June. Catches for the remainder of the summer were very variable. There were 3 peaks, each of which seemed to occur immediately after a period of hot weather.

FIG. 7. WEEKLY % EMERGENCE FROM ONE L. SERICATA BATCH PER MONTH DEPOSITED AT DURHAM DURING THE NORMAL BLOWFLY SEASONS



Key as for Fig. 6.

Discussion

It was thought that the difference in the emergence pattern for the two years might be partly due to a difference in experimental technique, namely that more batches were put down in 1949 than in 1948. Consequently a pair of histograms were constructed for these years showing emergence resulting from the deposition of 1 batch per month for the five'blowfly'months of each year (May - September). The resulting histograms (Figure 7) resembled the first series.

Examination of the weekly emergence table (See Appendix pages 93-4) gave the following information:-

(1) The late July peak 1949 was entirely due to one batch of prepupae, namely the batch put down on 9th July 1949.

(2) The late August peak 1949 was due to batches put down in May, June and late July 1949.

The duration of that part of the life-cycle of the blowfly which is spent in the soil and the viability during that period both have a direct effect on the emergence pattern. The period between deposition and commencement of emergence is also represented in Figure 6. The prepupal plus pupal period was of long duration during the early part of the season (7 weeks) and then it progressively decreased until August (2 - 3 weeks) and then increased again. One 1948 batch and two 1949 batches did not fit in with this pattern:-

15th May batch 1948 This batch took 11 weeks to commence emergence as compared with 6 weeks for the preceding batch and 4 weeks for the succeeding batch. An examination of readings obtained from the minimum thermometer showed cold temperatures and ground frosts during the period 18th - 28th May, which may have killed off the first pupae or caused the organisms still in prepupal stage to enter diapause. There were no subsequent frosts during the summer.

11th June batch 1949 This batch took 9 weeks to commence emergence as compared with 6 weeks of the preceding batch and 4 weeks of the equivalent batch in 1948. Emergence from this batch could have been expected in late July instead of mid August. The hot weather of 10th - 14th July may have killed off pupae near the soil surface. Prepupae which had not pupated could have escaped such a fate by migrating downwards. Thus, the emergence from this batch would result from late-pupating pupae.

9th July batch 1949 This batch took only 16 days to emerge as compared with 3 weeks for the succeeding batch and 3 weeks for the equivalent batch in 1948. During the hot weather of 10th - 14th July, the batch was no doubt still in the prepupal stage and able to move downwards and escape the fate of the 11th June batch. The prepupae could thus select optimum conditions and rapidly complete development. These exceptionally advantageous conditions thus resulted in a July peak and the consequent diminution of the late August peak.

Conclusions

(1) *L. sericata* emerged under field conditions at Durham from late May until early October.

(2) Emergence was not even and regular throughout the summer, but was concentrated into two emergence peaks, one in June and one in late August.

(3) The June peak was caused by those batches laid during the autumn of the previous year.

(4) The late August peak was the result of two Factors:-

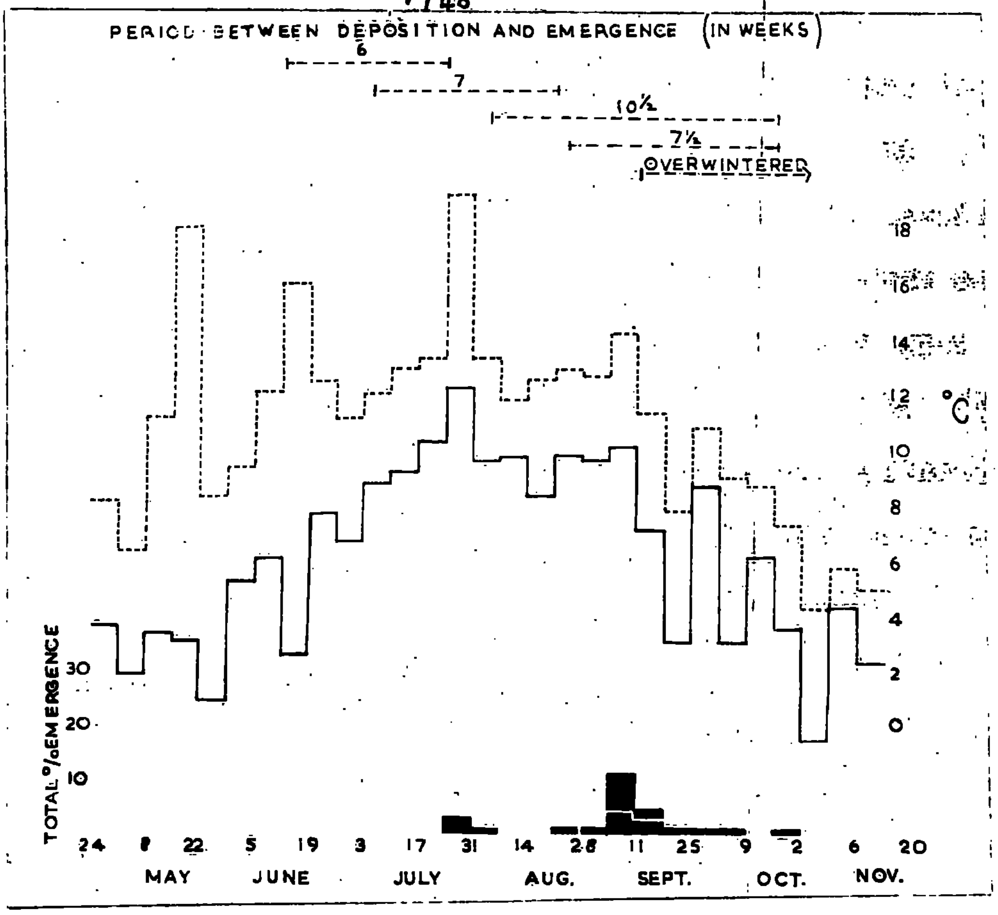
a) The higher viability of batches deposited in early August, as compared with June and July batches.

b) The successive decrease in development period until early August, resulting in an accumulation of flies about to emerge at this time.

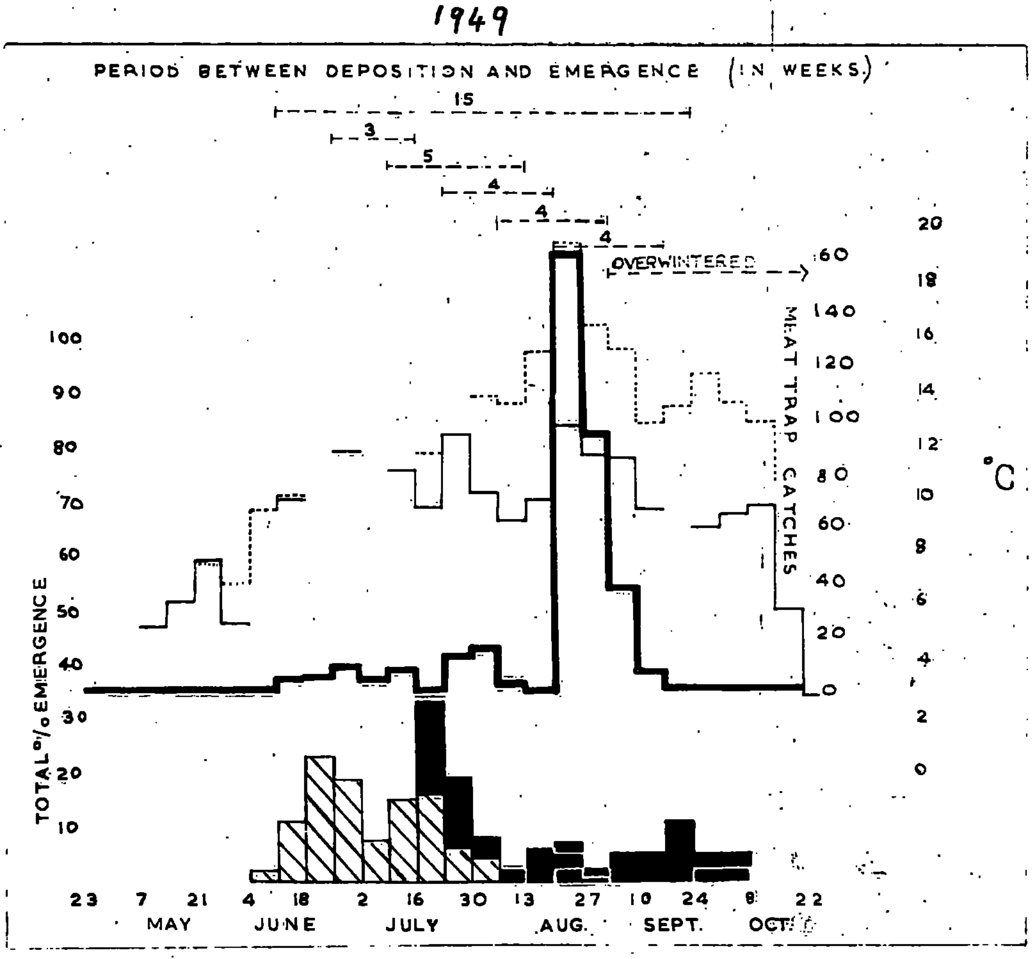
This would suggest that the late August/September strike wave may be in part related to the population density of the flies.

FIG. 8. WEEKLY % EMERGENCE FROM *L. SERICATA* BATCHES DEPOSITED AT MOORHOUSE DURING THE NORMAL BLOWFLY SEASONS

1948



1949



Key as for Fig. 6.

(5) In no case was it obvious that summer temperatures had caused the prepupae to aestevate. The prepupae laid down on 9th July 1949 suffered high temperatures (max. air temp. 33.8°C, and max. no. hours sunshine per day, 14.4) but developed very rapidly.

(6) In one case, there was a possibility of high temperatures having killed pupae, which, unlike prepupae, would be unable to migrate from the surface layers of soil during very hot weather.

(7) Although the rainfall for the summer 1949 was exceptionally low (total for April - September was 7.97 inches, average value 13.2 inches), there were no signs of any batch entering a summer diapause, with the possible exception of the batch laid down 11th June, 1949.

(8) Meat trap catches did not show the form that might have been expected from emergence data, namely a high density in late June and early September with a low density in between. The 1949 records showed a high June density, but there was no early September peak.

(9) Batches deposited from late August onward entered practically complete diapause.

Moorhouse Batches

Weekly emergence tables (See Appendix Pages 95-6) and total weekly emergence histograms (Figure 8) were constructed for ...epupae deposited during the period 5th June to 13th September ...949. No *L. Sericata* prepupae were put down at

...mergen... ...1947 batches, there were no ...e during the earl... ...49, but emergence began in ... in early October. There was a peak emergence in early Se... ...osited from early August onwards entered comple...

1949 Emergence Emergence began in mid-June and continued until early October. The spring emergence peak lasted from 11th

June until 23rd. July, a longer period than for Durham. Also, whereas the Durham spring peak was mainly produced by the emergence from prepupae laid down in the latter half of the blowfly season of 1948, the Moorhouse spring peak was produced by prepupae laid down throughout the summer of 1948. August/September emergence was due to prepupae put down earlier the same year, but there was no well-defined peak, although emergence increased in early September.

Temperature Data

The following were graphed above the histograms:-

1948:- Weekly average maximum air temperatures recorded by thermograph in a Stevenson screen. Weekly average minimum air temperatures similarly recorded.

1949:- Weekly average maximum air temperatures as for 1948. Weekly average minimum 2" soil temperatures recorded by Cambridge recorder.

Emergence occurred at soil temperatures above about 9°C and at maximum air temperatures above 10 - 11°C.

Meat Trap Data

The meat trap data for 1948 was too incomplete to graph, but in 1949, one meat trap was continuously maintained at Moorhouse. There was a well-defined catch peak in late August/early September.

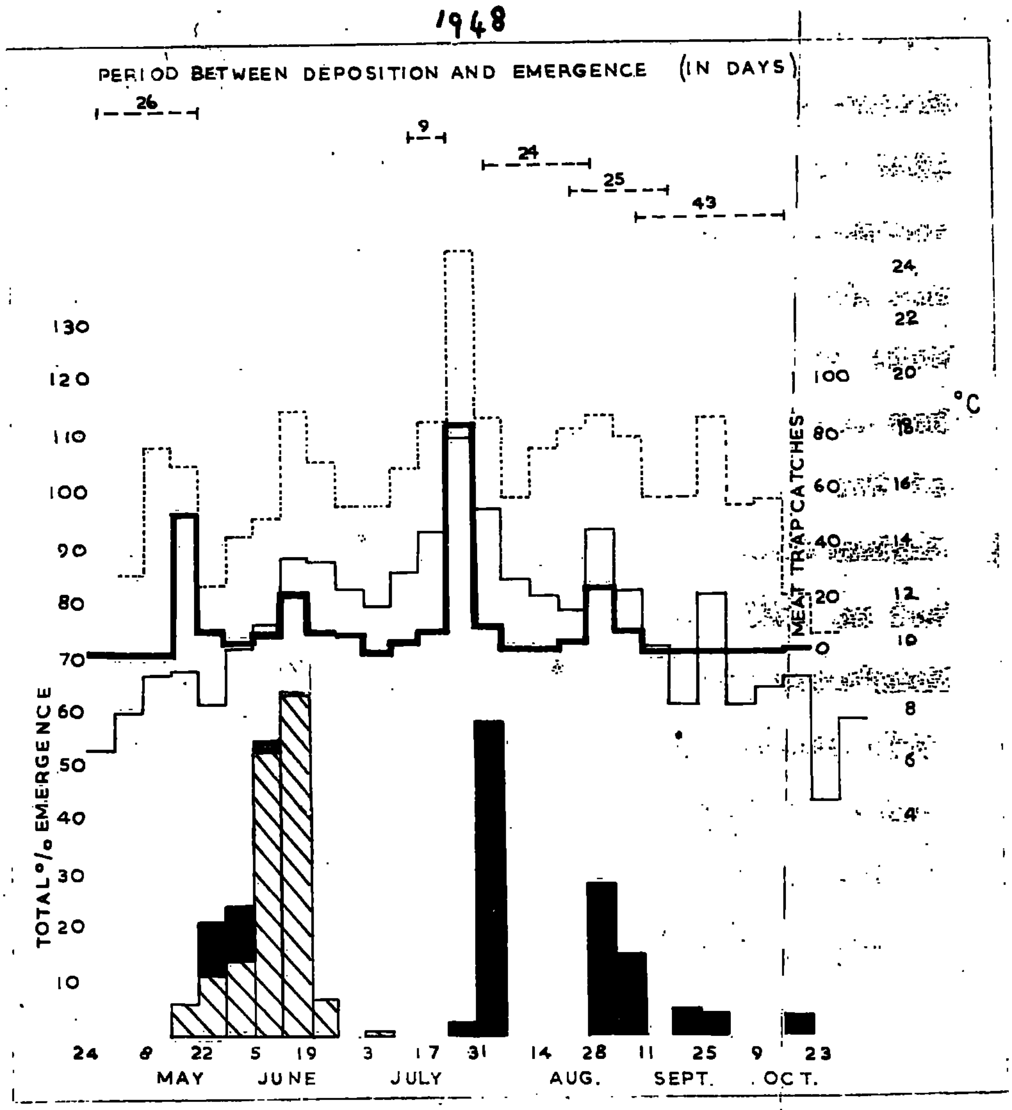
General Conclusions.

(1) Emergence commenced about a fortnight earlier at Durham than at Moorhouse and ended at about the same time (early October).

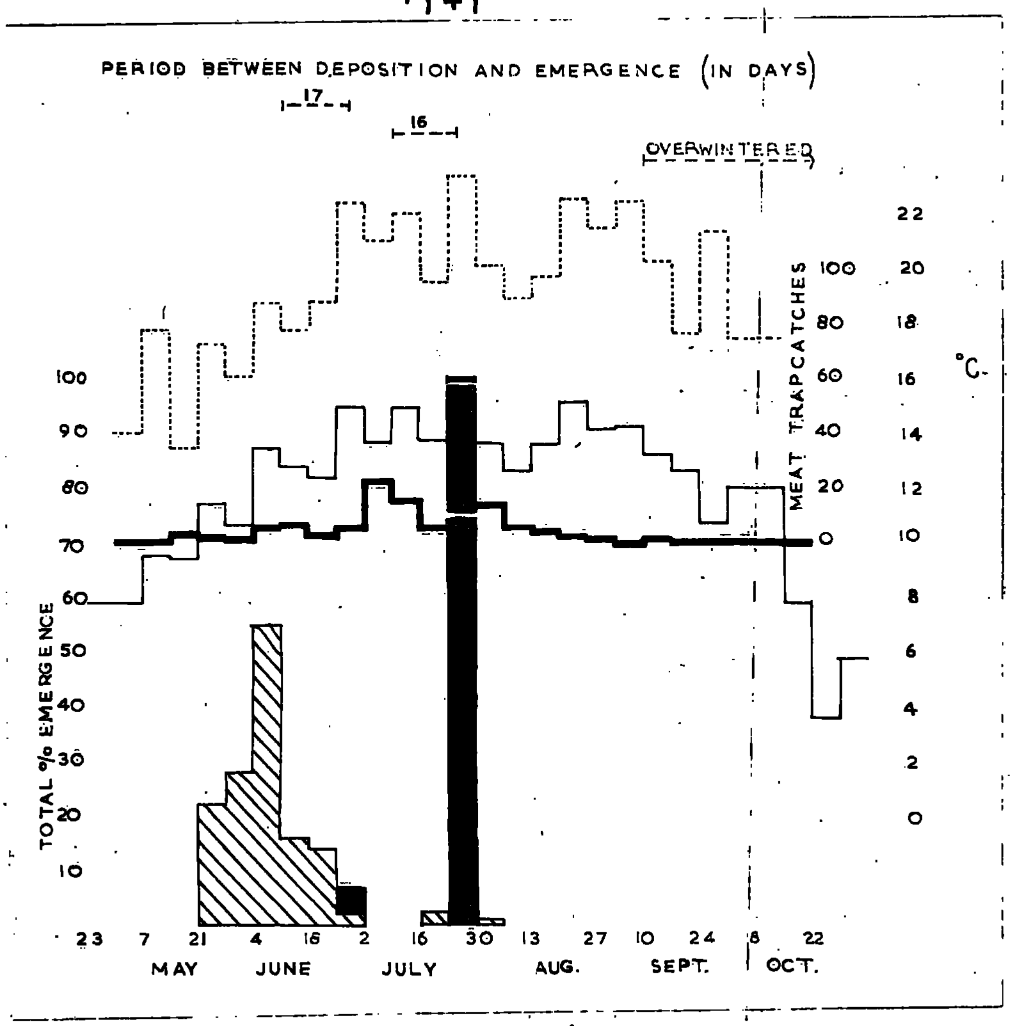
(2) Spring peak emergences occurred during June both at Moorhouse and Durham, that at Moorhouse occurring about a week later than that at Durham. The Durham one was caused by prepupae deposited during the second half of the previous summer, whereas the Moorhouse one was caused by prepupae deposited

FIG. 9. WEEKLY % EMERGENCE FROM L. ILLUSTRIS BATCHES DEPOSITED AT DURHAM DURING THE NORMAL BLOWFLY SEASONS

1948



1949



Key as for Fig. 6.

throughout the previous summer.

(3) Late summer emergence peaks occurred during late August at Durham and during the first half of September at Moorhouse. Both at Durham and Moorhouse, these peaks were less well defined in 1949 than in 1948. Possibly the sustained hot weather of 1949 caused rapid pupation which did not allow the emergences to accumulate as in 1948.

(4) Both at Durham and Moorhouse, there was no sign of hot or dry weather causing aestevation or diapause of the prepupae.

(5) Durham meat trap records showed a high June density but no well-defined late summer peak. 1948 Moorhouse records were too incomplete to graph, but 1949 records gave a Spring and an early September peak. The latter preceded the late summer emergence peak and might therefore have been due to migrations of flies from lowland areas. The very large numbers of flies caught also suggested this.

(6) Batches deposited from early August at Moorhouse and late August at Durham entered complete diapause.

ii) Lucilia illustris (Mg.)

Durham Batches

The season for L. illustris was taken as 29th April to 25th October. An attempt was made to deposit batches at monthly intervals, but difficulties were encountered in rearing this species satisfactorily throughout the winter. The data is therefore somewhat incomplete. Weekly emergence tables are given (see Appendix, page 98) and total weekly histograms are shown in Figure 9.

1948 Emergence

Emergence lasted from mid-May until late October. The spring emergence peak caused by flies deposited during July-

September 1947 lasted until mid-June. No batches were deposited in May and June, but later batches emerged discreetly and within 1 to 2 weeks; the duration of the period spent in the soil was at a minimum in July (1½ weeks). The last batch to emerge was deposited in mid-September.

<u>1949 Emergence</u>

Emergence began about the same time as in 1948, and the spring emergence peak lasted until mid-June as before. No batch was deposited in May, but the June and July batches emerged rapidly and discreetly, each taking 2½ weeks to develop. A large proportion of the June batch, however, entered diapause. There was no August batch and the September batch entered complete diapause.

<u>Temperature Data</u>

Emergence proceeded at soil temperatures above 8°C and maximum air temperatures above 12°C. The Spring emergence peaks occurred at soil temperatures from 10-13°C. The very rapid development of the early July batch, 1948, coincided with a period of high temperatures.

<u>Meat trap Records.</u>

The number of <u>L. illustris</u> males taken was so small that the trapping records for this species are of little significance. Appearance of <u>L.illustris</u> in the meat traps coincided with the beginning of emergence. In 1948, there was an apparent early June meat trap peak corresponding with the spring Emergence Peak, but this did not occur in 1949. No <u>L.illustris</u> males were caught after mid-September. There seemed to be some direct relationship between meat trap catches and temperature, but catches in the summer of 1949 were very low despite the warm weather.

<u>Discussion</u>

In neither year did the histograms give any indication of a late summer peak. This was not surprising owing to the following facts:-

a) Much fewer L.illustris batches were deposited than L.sericata batches and it would therefore be unlikely that emergence from two or more batches would have coincided.

b) L.illustris batches emerged over a shorter period (i.e. 1-2 weeks). It would therefore have been necessary to deposit L.illustris batches weekly, or at the most, fortnightly, in order to obtain any overlapping of the emergence from one batch with that from another. Assuming that this had been possible, and assuming for the moment that the viability of all batches had been the same, an emergence peak would be obtained during the emergence of flies having the shortest development period (i.e. early August).

Examination of the viability data for L.illustris batches revealed a lower percentage emergence for batches deposited in August than in early July i.e. the batches which developed most rapidly had the highest viability. This would enhance the effect of any early August peak. Thus, although such a peak was not apparent in Figure 9, it is possible that one occurs.

Conclusions

(1) L.illustris emerged at Durham from mid-May until late October.

(2) Emergence began with a spring emergence peak lasting from mid-May until mid-June.

(3) There were no signs of aestavation or diapause due to dryness of soil.

(4) Batches deposited from September onwards entered complete diapause.

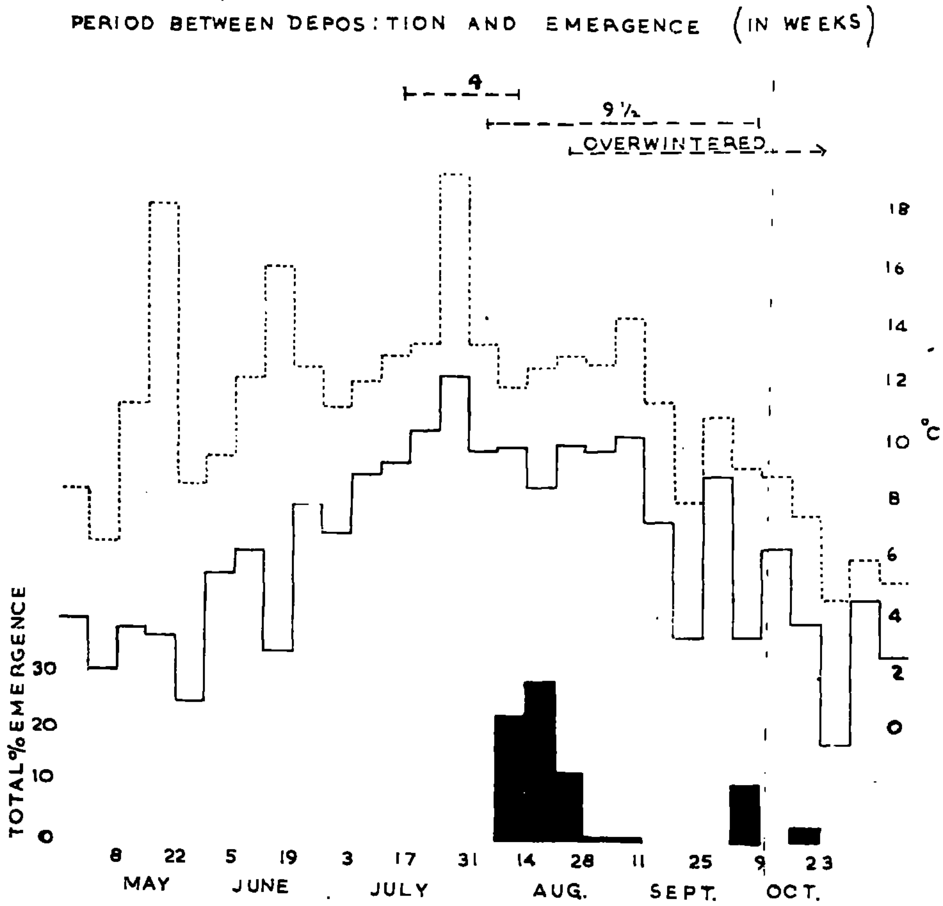
(5) Owing to some unknown reason, the species was found to be difficult to rear under laboratory conditions and therefore field data is very incomplete.

Moorhouse Batches

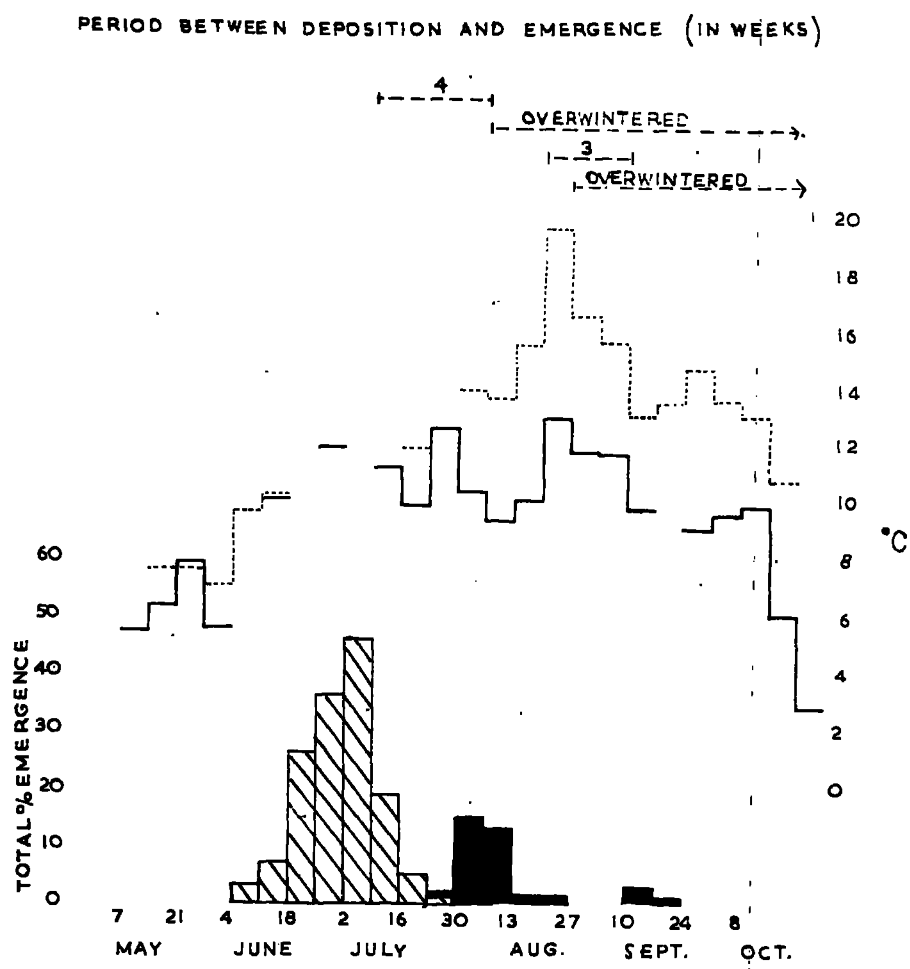
The season during which L.illustris adults were likely to

FIG. 10. WEEKLY % EMERGENCE FROM *L. ILLUSTRIS* BATCHES DEPOSITED AT MOORHOUSE DURING THE NORMAL BLOWFLY SEASONS

1948



1949



Key as for Fig. 6.

be active at Moorhouse was taken as 18th May to 16th October. The Appendix pages 100-1 gives the weekly emergence figures and Figure 10 shows the total emergence histograms.

1948 Emergence

There was no spring emergence peak because no L.illustris prepupae were deposited at Moorhouse during 1947. No June 1948 batch was deposited. The July and August batches emerged discretely and rapidly (within 3 weeks). The time between deposition and commencement of emergence was 3 weeks for the July batch and 8 weeks for the August batch. The September batch entered complete diapause.

1949. The spring emergence peak lasted from 18th June until 16th July, and was caused by prepupae deposited throughout the preceding year. The June batch entered practically complete diapause, and the July and August batches emerged discretely and rapidly, each taking three weeks to develop. The September batch entered complete diapause.

Temperature Data.

Emergence took place at minimum 2" soil temperatures above 8°C and at air temperatures above 9°C. The rapid development of the August 1949 batch coincided with a period of high temperatures.

Meat traps. Only 1 male L.illustris was caught in the Moorhouse meat trap in 1948 and 1 male in 1949.

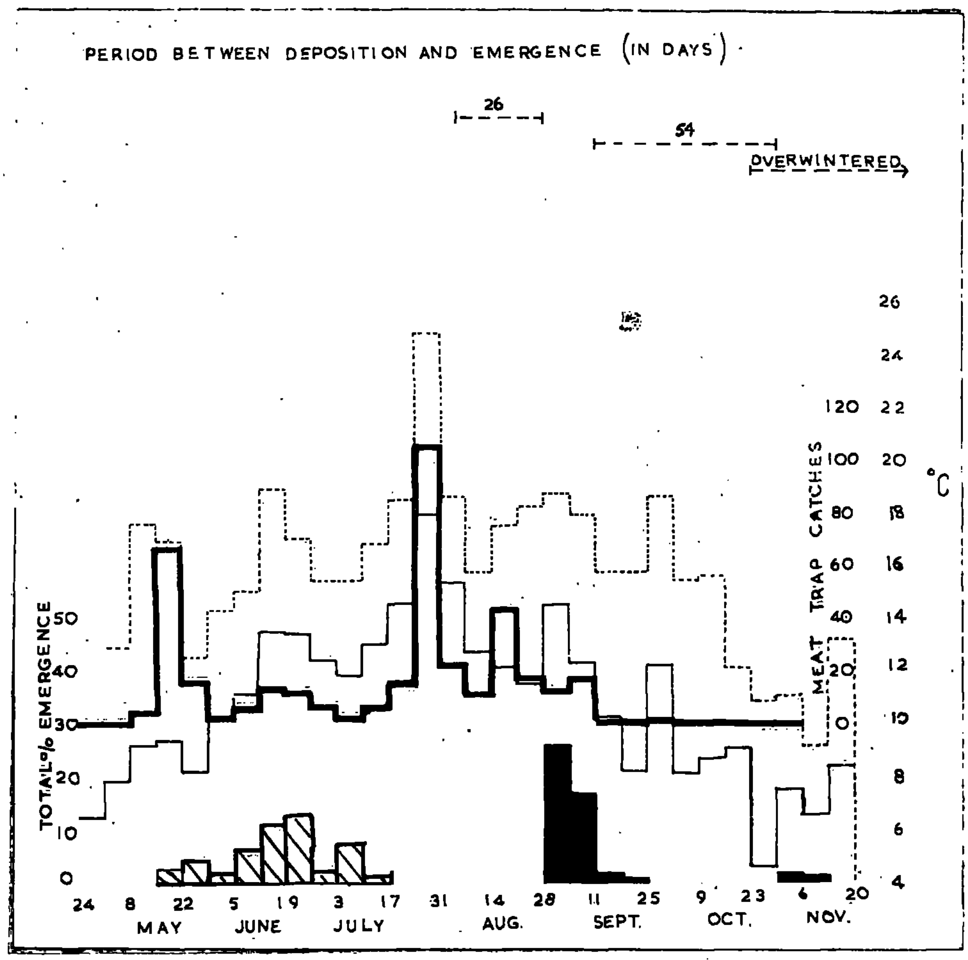
Discussion The fact that the 1949 June batches entered diapause both at Moorhouse and Durham is of interest. An examination of control data showed that it took 73 days in the incubator for 50% of the prepupae to pupate. It seems probable, therefore, that some factor acting upon the larvae before deposition caused diapause in the field batches. There were no signs of a late summer peak probably for the same reasons as given in the discussion on the behaviour of L.illustris at Durham.

Conclusions

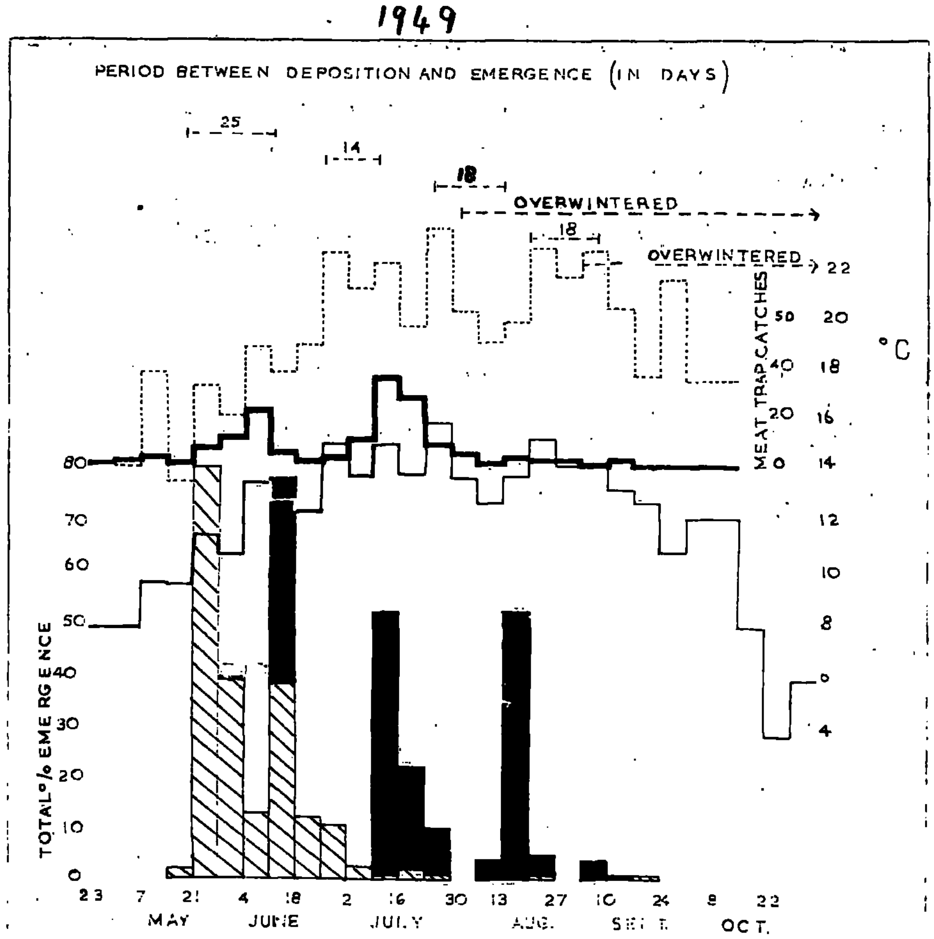
(1) L.illustris emerged at Moorhouse from mid-June until late September.

FIG II. WEEKLY % EMERGENCE FROM L. CAESAR BATCHES DEPOSITED AT DURHAM DURING THE NORMAL BLOWFLY SEASONS

1948



1949



Key as for Fig. 6.

(2) Spring emergence peak lasted from mid June until mid July.

(3) Each batch took only 2-3 weeks to emerge.

(4) For reasons given in the Durham section, it is possible that under natural conditions there would be an emergence peak in late summer, July/early August.

(5) There were no signs of aestevation or diapause due to dryness in the soil, but an examination of data on control batches showed a high susceptibility for this species to enter diapause. This phenomenon, unexpectedly observed in some field batches (e.g. June 1949) could therefore be put down to conditions suffered before and not after deposition.

(6) Batches deposited from late August onwards entered practically complete diapause.

(iii) Lucilia Caesar (L)

Durham Batches

The normal blowfly season for L. caesar at Durham was taken as 29th April to 25th October, the same as that for L. illustris, since the females of these two species could not be distinguished.

One batch was laid down inOctober 1947 and batches were laid down in 1948 and 1949 at approximately monthly intervals. Weekly emergence tables (Appendix, pages 103-4) and histograms (Figure 11)were constructed as for the other species.

1948 Emergence began in mid-May with the appearance of flies from the October 1947 batch. No June batch was deposited, but the May and July batches entered complete diapause. There was no further emergence until 28th August, this being from the 4th August batch. A slight emergence occurred in November from the September-batch.

1949 The spring emergence peak caused by batches deposited in the previous year began in mid-May and continued until the end of June. Batches laid down in 1949 emerged rapidly and discretely, with the exception of the early August batch which entered diapause. The development period was at a minimum in early July (2 weeks). No late August peak was apparent.

Temperature Records

Emergence proceeded at 1" soil temperatures of 8-9°C and above. The spring emergence peak of 1949 occurred at soil temperatures of about 10-13°C. The rapid development of prepupae during early July 1949 coincided with a period of high temperatures. The early August 1949 batch, on the other hand, was deposited during a period of relatively low temperatures.

Meat trap records.

Weekly catches of L. caesar males were added to the weekly emergence histograms. It is doubtful whether these catches are an indication of the L. caesar density, as the field results showed that the males formed only a small proportion of the meat trap catches. However the following points were shown:-

1) High meat trap catches coincided with periods of high temperature.
2) The 1948 Spring emergence peak was not traced, but the 1949 one was followed by a small meat trap catch peak.
3) There was another meat trap peak in July, coincident with a period of hot weather.
4) Few L. caesar males were taken in September and October.

Discussion

The difference between the behaviour of batches deposited in 1948 and 1949 is striking. The 1948 May and July batches (there was no June batch) entered complete diapause, whereas the equivalent 1949 batches emerged normally. There are two possible reasons for this:-

1) Cool summer weather of 1948 induced these batches to

enter diapause. This is unlikely in view of the fact that the May 1949 batch emerged satisfactorily within 4 weeks.

2) The batches had a predisposition to diapause at the time they were deposited (L. caesar was found to enter diapause readily if fed in dry or otherwise unsatisfactory conditions). This possibility is substantiated by the fact that the controls of these two batches entered a long diapause and suffered a high ultimate mortality.

As in the case of L. illustris, the short period during which the emergence of a single batch took place, together with the scarcity of batches deposited, prevented the possibility of a summer peak being observed. The batches which exhibited a minimum period of development and produced the largest percentage of flies were those deposited in early July, and consequently a peak emergence might have been expected in late July/early August.

Conclusions

1) L. caesar emerged under field conditions at Durham from mid-May until early November.

2) Emergence began with a spring emergence peak lasting from late May to early June. The spring emergence peak was due to prepupae deposited during the preceding summer. Even without the emergence from the May and July 1948 batches, which were suspected of abnormal behaviour, there would have been a spring peak.

3) There were no signs of aestavation or diapause due to dryness of the soil.

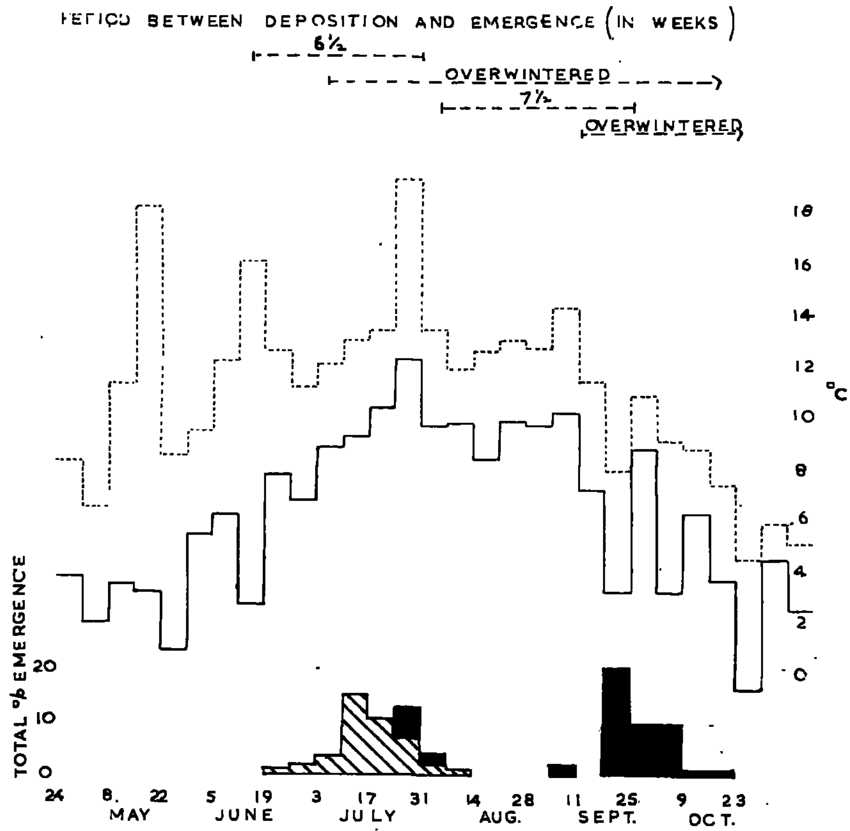
4) No later peak was observed, although it is possible that under natural conditions one occurs in late July/early August.

5) All 1948 batches entered partial diapause, flies emerging from them during the next summer.

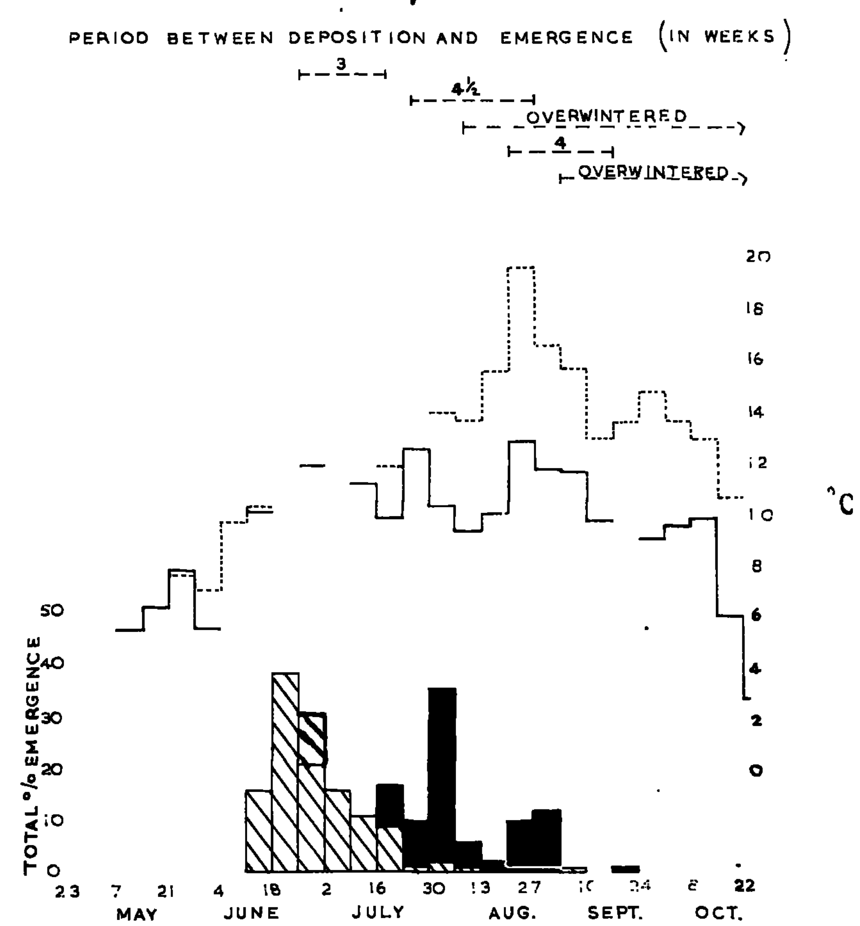
6) Batches deposited from September onwards entered practically complete diapause.

FIG. 12. WEEKLY % EMERGENCE FROM L. CAESAR BATCHES DEPOSITED AT MOORHOUSE DURING THE NORMAL BLOWFLY SEASONS

1948



1949



Key as for Fig. 6

Moorhouse Batches

The season during which L. caesar was likely to be active at Moorhouse was taken as 28th May to 16th September. Weekly emergence tables (Appendix, pages 105-6) and histograms (Figure 12) were constructed as before. Batches were deposited at the rate of approximately one per month during 1948 and 1949.

1948 Emergence

Only one batch of L. caesar was deposited during 1947 and this produced a small spring emergence peak in early July 1948 The 15th June batch did not emerge at all in 1948, and the 4th August batch took 6½ weeks to emerge. There was no July batch. The September batch entered complete diapause. Emergence finished in late October.

1949 Emergence

The spring emergence peak, caused by emergences from all batches laid down in 1948 occurred from mid June until early July, about three weeks later than at Durham. The batches deposited in 1949 emerged discreetly and in order within 2-3 weeks, with no accumulation into a late summer peak. The development period reached a minimum of three weeks in early July. The early July batch also had the highest viability.

Temperature Data

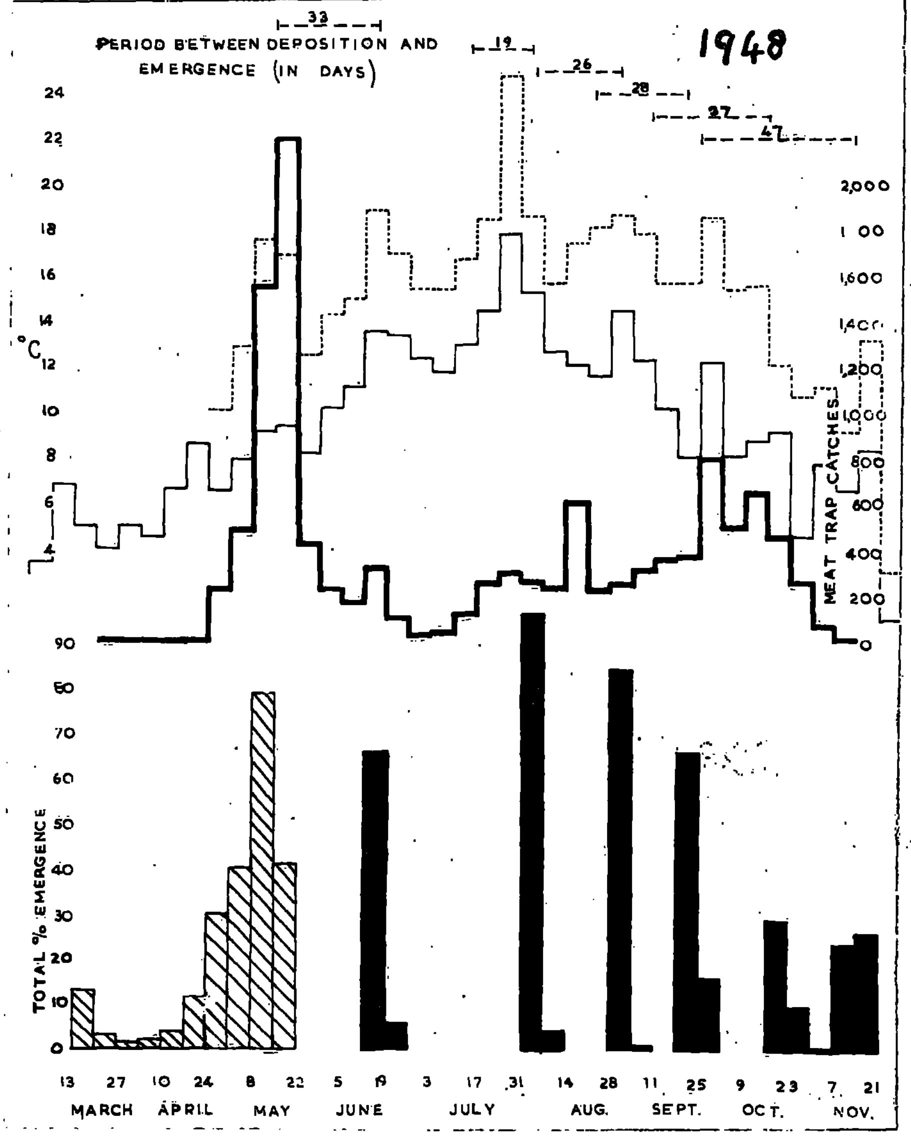
Emergence occurred at average minimum 2" soil temperature of 8°C and above and maximum air temperatures of 9°C and above The 1949 spring emergence peak took place at 2" soil temperatures of 10 - 12°C. The two batches which entered diapause in 1949, namely the early August and early September batches were deposited during cooler weather than the July and late August batches, both of which commenced emergence after a few weeks.

Meat Trap Data The number of L. caesar males caught in the meat trap was so small that no conclusions could be drawn on this point.

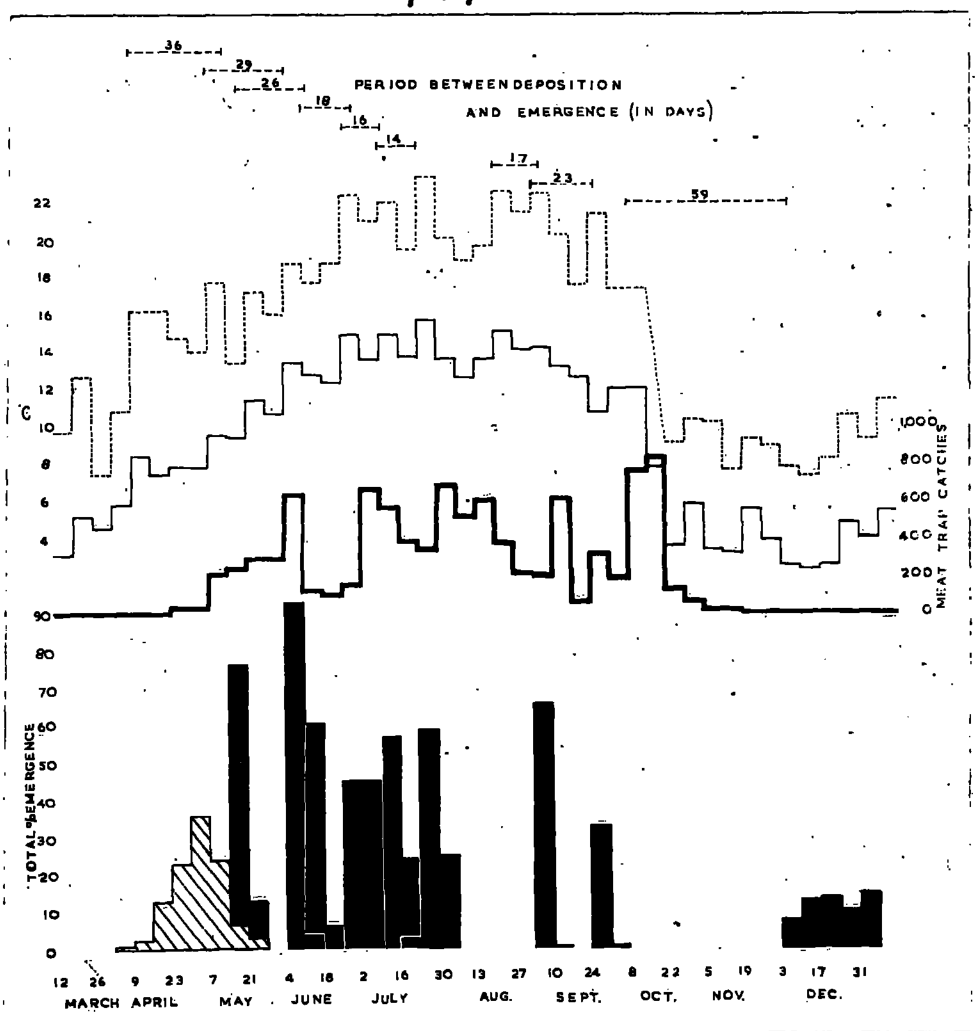
Conclusions

1) L. caesar emerged under field conditions at Moorhouse from mid-June until late September/early October.
2) Emergence began with a spring emergence peak lasting from mid-June to mid-July. The peak was due to prepupae deposited throughout the preceding summer.
3) Most batches emerged rapidly and discreetly.
4) No late summer peak was observed, although it is possible that one occurs during late July.
5) There were no signs of aestavation or diapause due to dryness of the soil.
6) All batches entered partial diapause, flies emerging from them during the following summer.

FIG. 13. WEEKLY % EMERGENCE FROM C. VOMITORIA BATCHES DEPOSITED AT DURHAM DURING THE NORMAL BLOWFLY SEASONS



1949



Key as for Fig. 6.

(iv) CALLIPHORA VOMITORIA (L.)

DURHAM BATCHES.

The season during which *C. vomitoria* was active at Durham lasted from 15 April to 21 November. Batches were deposited during the latter part of this season in 1947 and during the whole of this season in 1948 and 1949. The emergence is shown in Figure 13 ~~and in the Appendix pages.~~

1948.

Emergence started in mid-March and ended in late November. A spring emergence peak, produced by prepupae deposited in autumn 1947, covered the period 24 April - 22 May. There were no other emergence peaks, each batch emerging discretely and in order, over a period of not more than two weeks. The development period reached a minimum of 3 weeks in late July.

1949.

Emergence started in early April and a batch deposited in early October emerged in December, making a total of nine months during which emergence was possible. The spring emergence peak covered the period 16 April to 14 May, a week earlier than in 1948. Batches emerged discretely and in order as before, the development period reaching a minimum of 2 weeks in mid-July.

Temperature Records.

Emergence started in the spring when 1" soil temperatures rose above 5° C., but the October 1949 batch emerged in December at temperatures between 2° C. and 5° C. The minimum development period coincided with a period of high soil temperatures (14° - 16° C.).

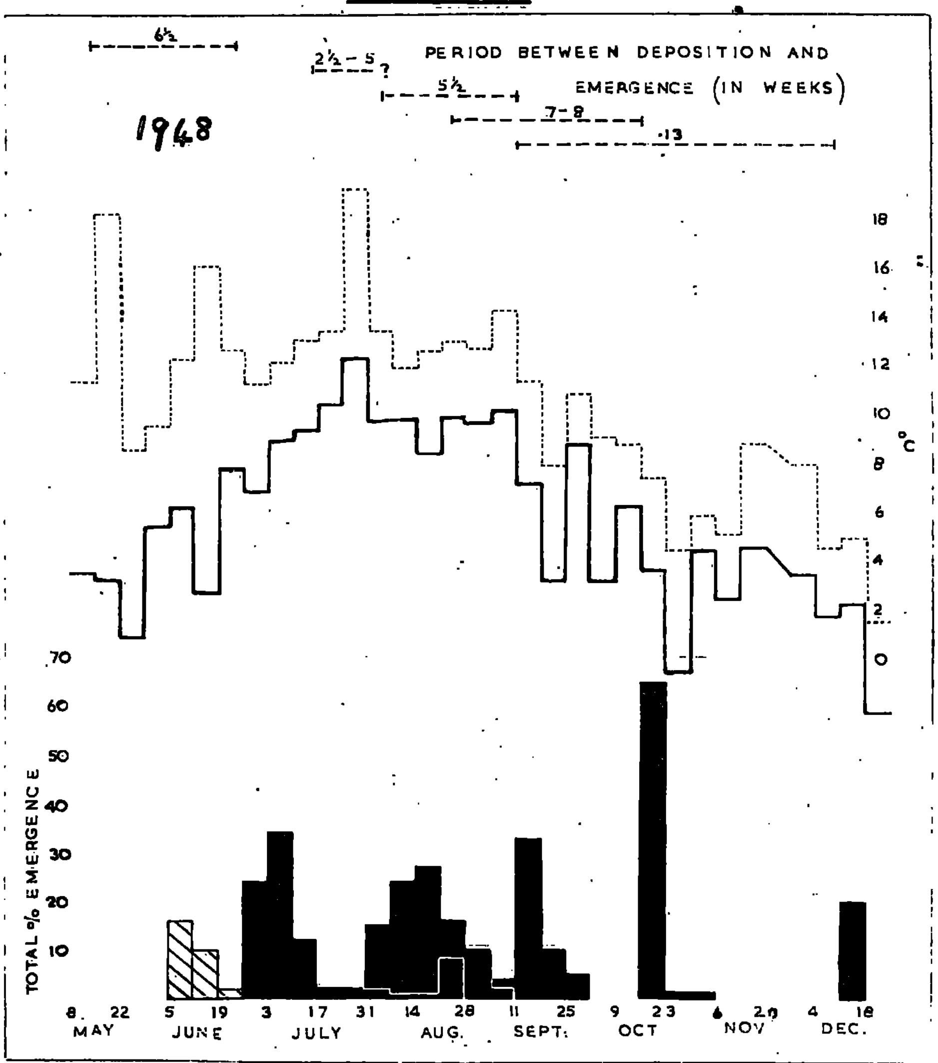
Meat Trap Records.

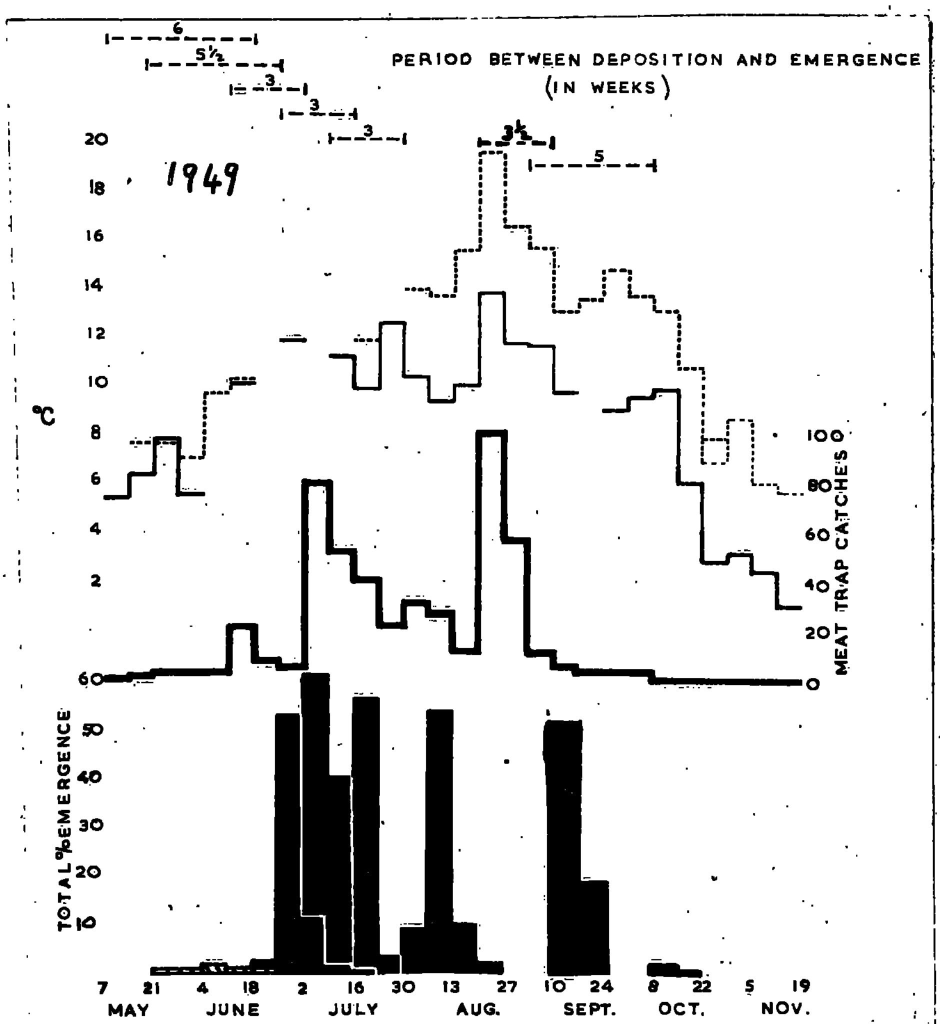
There was a large spring "catch" peak in 1948 and a smaller one in 1949 coinciding with the spring emergence peak. In 1948 there was then a period of very low density followed by a rise in "catch" figures in late August to late October. Low densities seemed to be partly associated with highest temperatures. The lowest density occurred during late June/early July. In 1949 the catches were more variable, but again there was a period of lowest density in the last 3 weeks of June. This period was associated with neither very high nor very low temperatures. By this time, all flies produced from over-wintered pupae would have died. Graham Smith (1915) found that C. vomitoria was most abundant in September and October and least abundant in May. The 1948 and, to a certain extent the 1949 records, showed high catches of C. vomitoria in September and October. The density of C. vomitoria in May would largely depend on the mortality of over-wintered pupae and hence on the weather conditions, etc. of the preceding winter.

DISCUSSION.

C. vomitoria could develop slowly and even emerge at very low temperatures (2°- 5° C.) and successful development and emergence also occurred at mid-summer temperatures. Maximum air temperatures recorded were 20°-25° C., but 1" soil temperatures were considerably lower. Since breeding for culture purposes was successfully carried out at $26\frac{1}{2}^{\circ}$ C., it is not surprising that no ill-effects were caused by this hot weather. The development period was at a minimum in late July, suggesting a possible peak emergence in early August which would give rise to an increased density of flies in late August. Since the percentage viability of this species remained high and

FIG. 14. WEEKLY % EMERGENCE FROM C. VOMITORIA BATCHES DEPOSITED AT MOORHOUSE DURING THE NORMAL BLOWFLY SEASONS.





fairly constant, except at the very end of the season, this factor would not affect the peak in any way.

CONCLUSIONS.

(1) C. vomitoria could emerge under field conditions from mid-March to the end of December.

(2) The spring emergence peak occurred in late April/ early May.

(3) No later peak was apparent from the histograms, although such a peak might have occurred in early August if more batches had been deposited. This may partly explain the larger meat trap catches in late August and September.

(4) C. vomitoria prepupae and pupae were not adversely affected either in viability or in speed of development by midsummer temperatures and they could also develop and emerge at very low temperatures (2^{o}-5^{o} C.).

(5) Batches laid down from November onwards entered complete diapause.

MOORHOUSE BATCHES.

The season during which C. vomitoria was active at Moorhouse lasted from 18 May to 16 October. Histograms record emergence from one batch deposited in October 1947 and from batches deposited throughout the active seasons of 1948 and 1949 (see Figure 14 ~~and Appendix pages~~).

1948.

Emergence started in early June with individuals from the October 1947 batch. This emergence was smaller than that from the equivalent Durham batch, showing that over-wintering had been less successfully accomplished at Moorhouse. The 1948 batches emerged discretely and in order as at Durham, but emergence from each batch lasted about 4 weeks instead of 2 as at Durham. This difference was probably exaggerated by the fact that weekly examination of the emergence tubes at Moorhouse was not always possible. The development period was at a minimum in late July.

1949.

Emergence from overwintered batches began in late May, but there was no true emergence peak. This was probably due to the fact that part of the September batch emerged in December and to the high overwintering mortality at Moorhouse. The summer batches emerged discretely and in order as before, taking less time to complete emergence than in 1948. The development period remained at about 3 weeks during June and July.

Temperature records.

Emergence started in the spring when minimum 2" soil temperatures reached $4^{\circ} - 6^{\circ}$ C., but one batch emerged in December 1948 when minimum 2" soil temperatures were only 2° C. Minimum development period coincided with maximum soil temperatures.

Meat Trap Records.

Peak catch periods for 1949 occurred in early July and late August, the latter coinciding with a period of warm weather. The early July catches probably consisted of individuals which had overwintered and emerged during June (i.e. during the spring emergence peak).

DISCUSSION.

The wide range of temperatures over which C. vomitoria could successfully develop and emerge is emphasized by the above results. This species did not overwinter very successfully at Moorhouse. As at Durham, the development period was at a minimum in late July, the viability being fairly constant throughout the summer. This suggests the presence of an emergence peak in early August, as at Durham. There is some evidence for this in the large meat trap catches which occurred during late August.

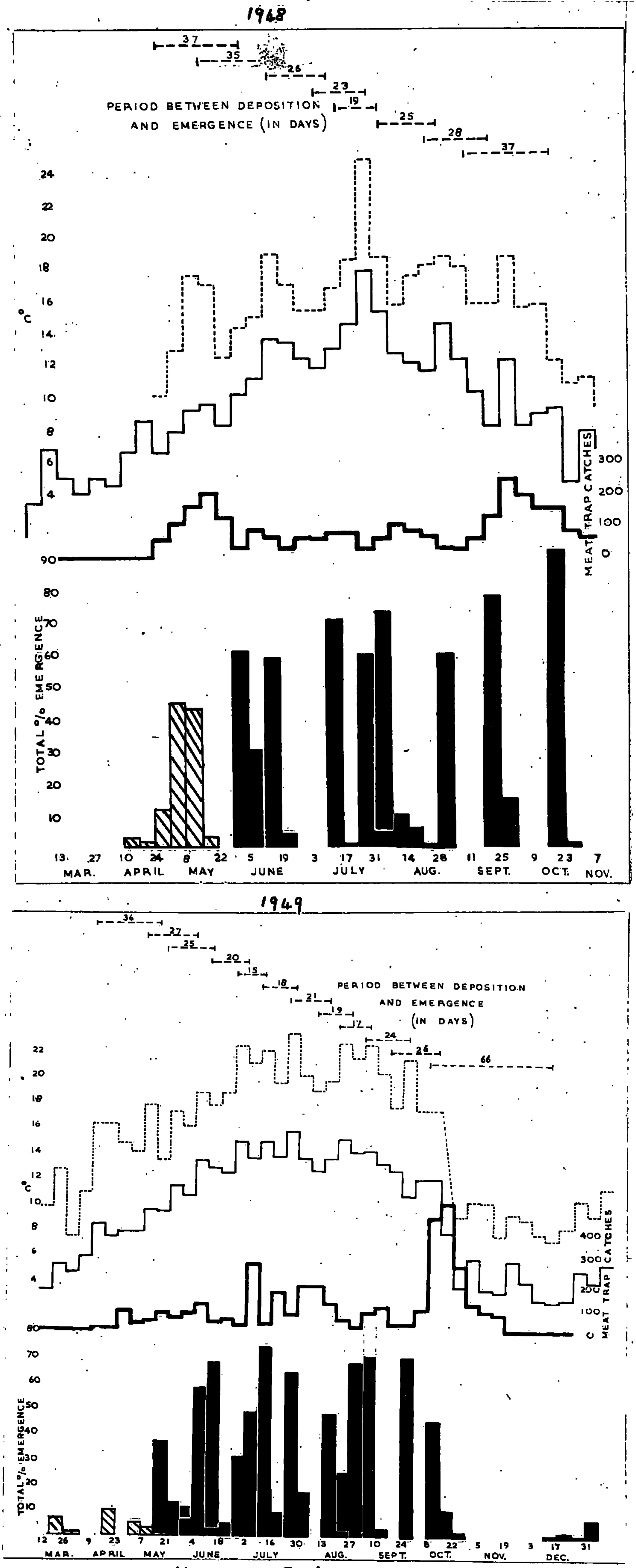
CONCLUSIONS.

(1) C. vomitoria could develop and emerge under field conditions whenever the minimum 2" soil temperature was above 2^{o} - 4^{o} C.

(2) Spring emergence peaks were larger at Durham than at Moorhouse owing to the high overwintering mortality at the latter station.

(3) A further emergence peak may occur in early August. This would fit in with the increased meat trap catches of late August.

FIG. 15. WEEKLY % EMERGENCE FROM C. ERYTHROCEPHALA BATCHES DEPOSITED AT DURHAM DURING THE NORMAL BLOWFLY SEASONS



Key as for Fig. 6.

(v) CALLIPHORA ERYTHROCEPHALA (Mg.)

DURHAM BATCHES.

The season during which *C. erythrocephala* entered meat traps at Durham lasted from 5 April to 21 November - the longest season of all. Histograms were constructed for batches laid down during this part of 1948 and 1949 and for two batches deposited in autumn 1947 (See Figure 15) ~~and Appendix pages~~).

1948.

Emergence started in mid-April and ended in late October, the spring emergence peak occurring in early May. The batches emerged discretely (within 1 - 2 weeks) and in order, as for *C. vomitoria*. Development period graded from 5½ weeks to slightly less than three weeks and then back to 5½ weeks, the minimum occurring in late July.

1949.

Emergence started in mid-March and ended in early January. There was very little evidence of a spring emergence peak, but this may have been partly due to lack of batches deposited in late September and early October 1948. The 1949 batches emerged discretely (1 - 2 weeks) and in order as before, the development period fluctuating between 2 and 3 weeks during June, July and August and then increasing in September.

Temperature Records.

Emergence began when the average 1" soil temperature rose above 4^{o} C., but the October 1949 batch emerged in December at temperatures between 2^{o} C. and 5^{o} C. The shortest development periods coincided with periods of highest temperature.

Meat Trap Records.

1948 meat trap data showed two peak periods, one in May and one in late September/early October. The first peak may well have been the result of a spring emergence peak.

1949 meat trap data did not show a spring "catch" peak, which is interesting in view of the fact that there was no spring emergence peak in 1949 either. There was a well marked October peak and some suggestion of higher catches during July and early August.

DISCUSSION.

C. erythrocephala developed and emerged over a slightly larger range of temperature than *C. vomitoria*. Development was most rapid at highest temperatures. In 1948, highest temperatures occurred in late July and development was most rapid at this time. In 1949, there was one period of high temperatures in July and another in late August, both of these causing rapid development. Emergence peaks might, therefore, have been expected in early August 1948 and in late July and early September 1949. The corresponding meat trap "catch" peaks occurred in late September (1948) and in October (1949), rather later than might have been expected. The relationship between emergence and meat trap "catches" has not been fully studied. There may be a mortality factor acting on the newly-emerged adult which varies with the time of year (e.g. predators).

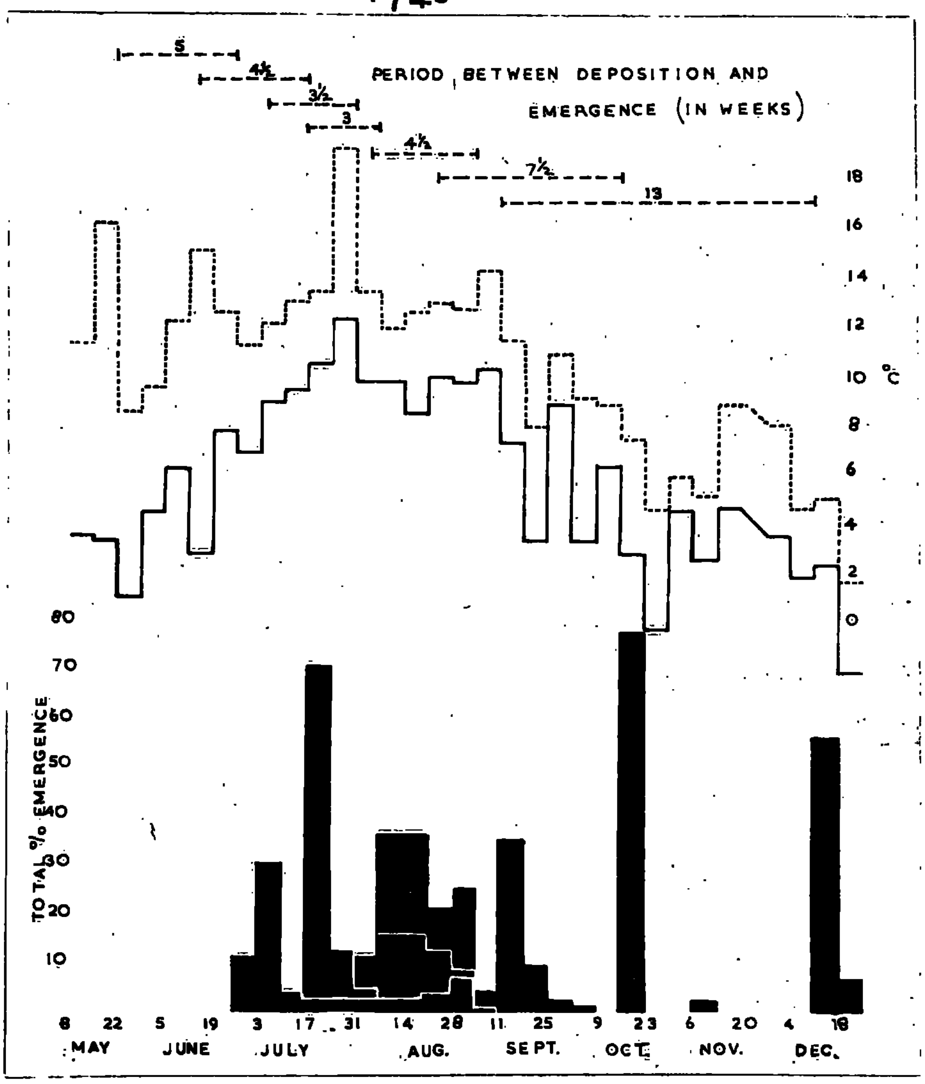
CONCLUSIONS.

(1) Emergence could occur from late March until early January.

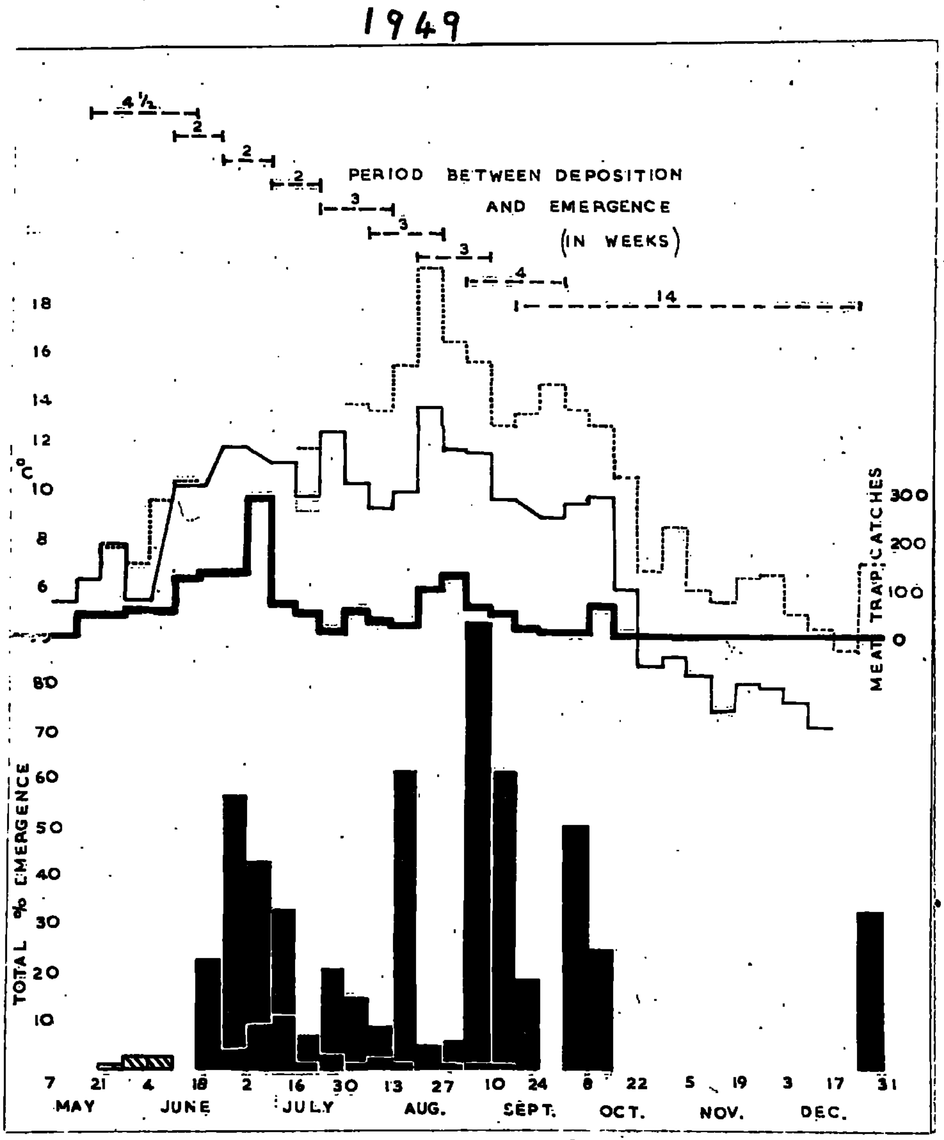
(2) The spring emergence peak lasted from late April until mid-May. There was no well-defined peak in 1949.

FIG. 16. WEEKLY % EMERGENCE FROM C. ERYTHROCEPHALA BATCHES DEPOSITED AT MOORHOUSE DURING THE NORMAL BLOWFLY SEASONS

1948



1949



Key as for Fig. 6.

(3) Spring and summer batches emerged discretely and in order, taking only 1 - 2 weeks to complete emergence.

(4) Development was usually rapid at high temperatures and emergence peaks could be expected after periods of warm weather.

(5) The delay of 4 - 5 weeks between the commencement of predicted emergence peaks and the corresponding meat trap "catch" peaks made it doubtful whether the two were in fact related.

(6) In only one case (late July 1949 batch) were there signs of high temperatures causing an increased mortality and a slight lengthening of development period. There was no equivalent C. vomitoria batch, but the P. terranovae batch suffered similarly.

MOORHOUSE BATCHES.

Figure 16 ~~and Appendix pages~~ shows the weekly emergence from batches deposited during the period 18 May to 16 October in 1948 and 1949.

1948.

No C. erythrocephala prepupae were deposited at Moorhouse during 1947, so that there was no likelihood of a spring emergence peak in 1948. The 1948 batches emerged in order, but, in the case of the earlier ones especially, emergence was continued for a considerable time (3 - 10 weeks), a striking contrast to the behaviour at Durham. Time from deposition to onset of emergence reached a minimum of 3 weeks in late July. The development periods were from 1 - 2 weeks longer than at Durham. Emergence finished in December.

1949.

No. C. erythrocephala prepupae were deposited in late September and early October, and the early September batch emerged in December. Consequently there was again no possibility of a spring emergence peak. The development period was at a minimum of 2 weeks in late June and throughout July. Emergence ended in late December.

Temperature Records.

As there were no overwintering pupae, the necessary temperature for onset of spring emergence could not be determined. Emergence occurred, however, during December 1948 and 1949, at average minimum 2" soil temperatures of $2^{o} - 4^{o}$ C.

Meat Trap Records.

The meat trap "catch" showed a peak in early July and another in late August/early September. The small catches obtained in late July and early August support the emergence results - namely, that there is a higher mortality in batches emerging at this time than either earlier or later in the year.

DISCUSSION.

The elongated period of emergence for each batch and the fact that development periods did not decrease regularly as the summer of 1949 wore on, makes it difficult to estimate the presence of a summer emergence peak. For 1948, there appears to have been a peak emergence in mid-August. The emergence histograms show an apparent hiatus in late July/early August. This proved entirely due to a decreased viability of the July batches. Since the equivalent Durham batches were not similarly affected, this does not seem to be a result of high temperatures but of some other factor.

CONCLUSIONS.

(1) Emergence lasted from 21st May to 31 December.

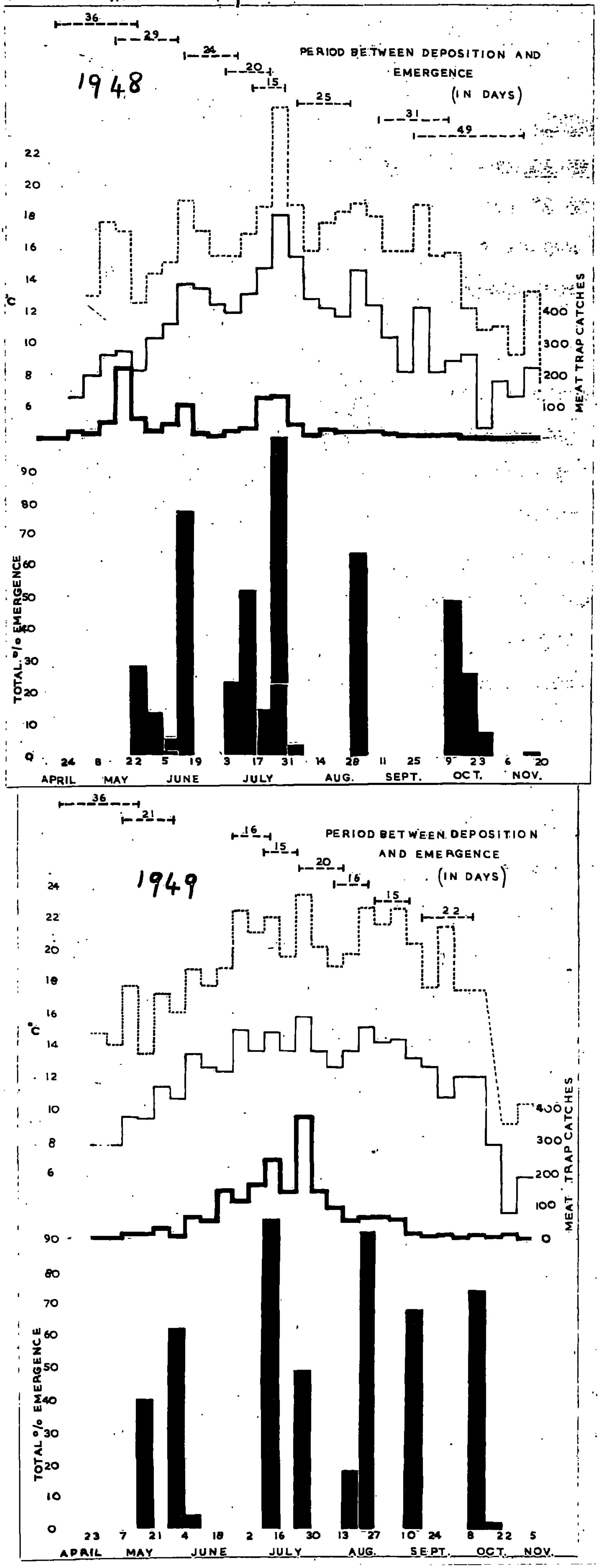
(2) No spring emergence peak was observed, partly owing to the fact that the September and October batches

emerged during the same year.

(3) There were no subsequent emergence peaks, but in 1949 there was a period of low emergence during early August. This was due entirely to a decrease in viability of July and early August batches, this factor over-riding the factor of more rapid development of these batches.

(4) Meat trap catches followed the 1949 emergence pattern closely.

FIG.17. WEEKLY % EMERGENCE FROM P. TERRANOVAE BATCHES DEPOSITED AT DURHAM DURING THE NORMAL BLOWFLY SEASONS



(vi) PROTOPHORMIA TERRANOVAE (R - D).

DURHAM BATCHES.

P. terranovae were caught in the meat traps from 15 April to 31 October. Weekly emergence of batches deposited during this part of 1948 and 1949 is shown in Figure 17 ~~and Appendix pages~~

1948.

Emergence occurred from late May until the end of October, each batch emerging discretely and in order, within 1 - 2 weeks. No batches of this species were deposited in 1947, so there was no possibility of a spring emergence peak. The period required for development reached a minimum of 2 weeks in late July. Since the preceding batch had taken 3 weeks to develop, there was a certain amount of overlap in the emergence of these two batches.

1949.

Emergence took place from mid-May until late October. Again, all batches emerged discretely and within 1 - 2 weeks. Although batches were deposited in September and October of 1948, there was no emergence from these batches in 1949. Batches developed most rapidly in late July, late August and early September, the early August batch taking rather longer. There was no overlap of emergence in 1949, although two batches emerged within a week of each other in August, a phenomenon which would be likely to cause a high density of flies just afterwards.

Temperature Records.

Emergence of this species did not occur until 1" soil temperatures rose above 8° C., about the same temperature as for L. caesar and L. illustris. The shortest development periods coincided with periods of highest temperature.

Meat Trap Catches.

Peak catches occurred during the warmest weather. There was some evidence of a high spring population in 1948, although this was not the case in 1949.

DISCUSSION.

The results indicate that P. terranovae has a very high winter mortality and consequently no spring emergence peak. In the course of breeding this species it was found that, unlike the other five species studied, the prepupae tended to remain on the meat on which they had been feeding and to pupate there. The batches used for the present experiments, however, had been removed from the meat before deposition. It is possible that the presence of carcase remains are indispensible for the protection of overwintering pupae.

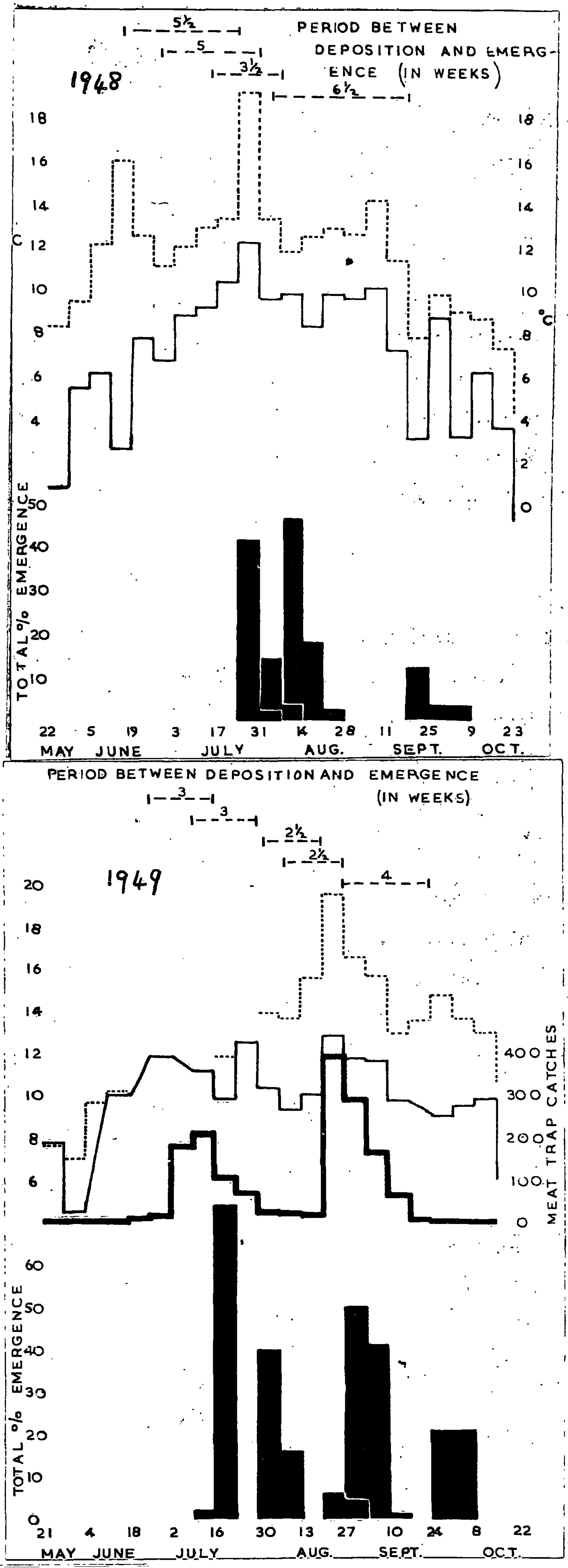
CONCLUSIONS.

(1) P. terranovae could develop and emerge under field conditions whenever the average soil temperature was above 8° C. approximately.

(2) The species appeared to have poor over-wintering abilities, although this might have been partly due to the unnatural mode of deposition. Meat trap records indicated a possible spring emergence peak under natural conditions.

(3) Batches developed uniformly, the whole batch taking only 1 - 2 weeks to complete emergence. There were no indications of part of the batch entering diapause.

(4) Development was most rapid during periods of warm weather and the viability of the species did not appear to be adversely affected by high temperatures. An increased density of flies might, therefore, be expected after such a period (e.g. in late July 1948).



PERIOD BETWEEN DEPOSITION AND EMERGENCE (IN WEEKS)
5½
5
3½
6½
1948
°C
°C
TOTAL % EMERGENCE
22 5 19 3 17 31 14 28 11 25 9 23
MAY JUNE JULY AUG. SEPT. OCT.
PERIOD BETWEEN DEPOSITION AND EMERGENCE (IN WEEKS)
3
3
2½
2½
4
1949
MEAT TRAP CATCHES
TOTAL % EMERGENCE
21 4 18 2 16 30 13 27 10 24 8 22
MAY JUNE JULY AUG. SEPT. OCT.

FIG. 18.

MOORHOUSE BATCHES.

Adult *P. terrenovae* were caught in the meat traps from mid-June until late September. Emergence is shown in Figure 18 ~~and Appendix pages~~ .

1948.

Emergence began in mid-July and ended in early October. There was no possibility of a spring emergence peak, since no prepupae were deposited in 1947. The batches emerged discretely within 2 - 3 weeks and the development period was at a minimum of 3½ weeks in late July.

1949.

Emergence occurred from early July until early October. There was no spring emergence peak since all the prepupae deposited during the preceding autumn had died during the winter. The batches emerged discretely within 1 - 2 weeks and development period reached a minimum of 2½ weeks in early August.

Temperature Records.

Normally this species only emerged when the minimum 2" soil temperatures were above 8° C. There was, however, a small emergence from one batch in late September when the minimum 2" soil temperatures were between 3° C. and 8° C. The prepupal and pupal development of this batch had occurred mainly at temperatures above 8° C. Most rapid development occurred during the warmer weather.

Meat Trap Records.

Two peak catches could be observed - one in early July and the other in late August/early September. A period of very small catches occurred in early August.

DISCUSSION.

The early July "catch" peak suggests the presence of a spring emergence peak. This may have occurred in the Moorhouse area, or, alternatively, there may have been a migration of flies from the lowland areas. If the former explanation is accepted, it must be assumed that there must be some unnatural and unfavourable factor acting on the experimental prepupae (e.g. method of deposition, or undue water-logging). As at Durham, periods of warm weather induced rapid development and the possibility of a high density of flies soon afterwards during late August/early September 1949.

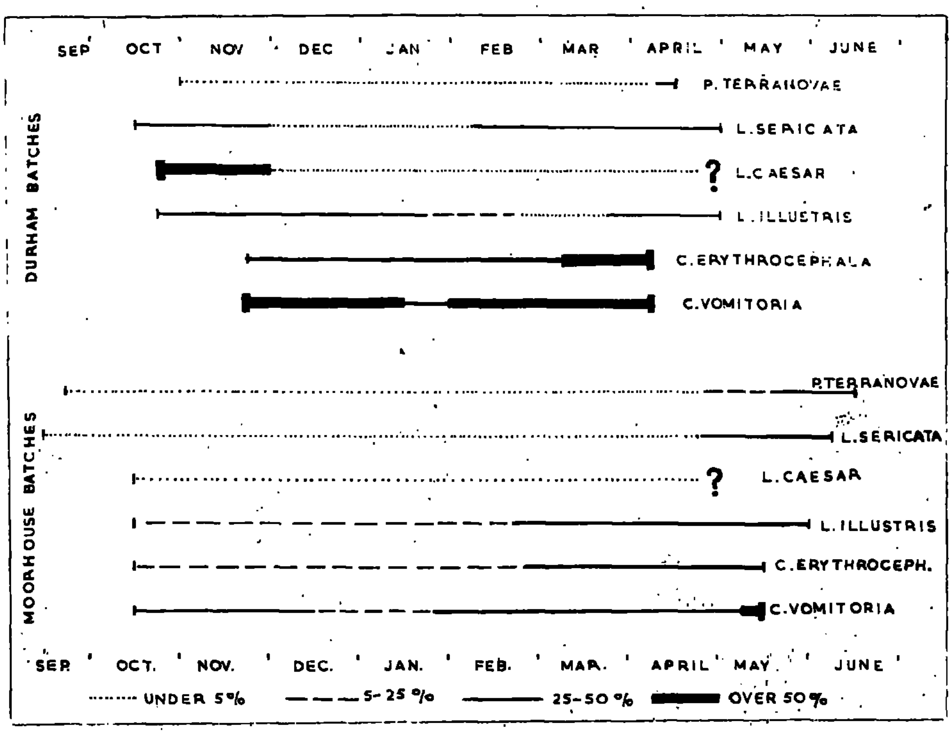
CONCLUSIONS.

(1) P. terranovae developed and emerged at temperatures above 8° C. and had very poor overwintering abilities.

(2) Batches developed fairly uniformly, especially during warm weather, and development was most rapid at high temperatures.

(3) A high density of flies might be expected just after a period of warm weather.

FIG.19. VIABILITY OF BLOWFLY PREPUPAE DEPOSITED AFTER THE TERMINATION OF THE NORMAL BLOWFLY SEASON



V. THE VIABILITY OF BLOWFLY PREPUPAE DEPOSITED AFTER THE TERMINATION OF THE NORMAL BLOWFLY SEASON.

Table gives the total percentage emergence from batches deposited after the termination of the normal blowfly season. Figure 19 shows graphically the viability of each species in relation to the date of deposition.

RESULTS.

(1) All species suffered higher mortalities at Moorhouse than at Durham. No Moorhouse batch of L. illustris suffered total mortality, but a mortality of over 75% was suffered over a longer period at Moorhouse than at Durham.

(2) The viability of the six species when deposited during the winter months decreased in the following order:- C. vomitoria, C. erythrocephala, L. illustris, L. caesar, L. sericata, P. terranovae. The data for L. caesar is inadequate and the results therefore unreliable, but from existing data it appears that this species had a viability slightly less than that of L. illustris.

CONCLUSIONS.

Whereas deposition of P. terranovae and L. sericata prepupae during the winter months was unlikely to give rise to an appreciable emergence, deposition of the Calliphora species, and, to a lesser extent, Lucilia illustris, caused an appreciable spring emergence, especially at Durham.

TABLE 9 .

THE VIABILITY OF BLOWFLY
THE TERMINATION OF THE

Date of Deposition (Approx)	L. SERICATA				L. ILLUSTRIS				L. CAESAR			
	(18 Oct. -29 Apr.)		(18 Sept. -5 June)		(25 Oct. -29 Apr)		(16 Oct. -28 May)		(25 Oct. -29 Apr.)		(16 Oct. -28 May)	
	DURHAM		MOORHOUSE		DURHAM		MOORHOUSE		DURHAM		MOORHOUSE	
	1947 -8	1948 -9	1947 -8	1948 -9	1947 -8	1948 -9	1947 -8	1948 -9	1947 -8	1948 -9	1947 -8	1948 -9
18 Sep.	-	-	-	2.5	-	-	-	-	-	-	-	-
2 Oct.	-	-	-	0	-	-	-	-	-	-	-	-
16 Oct.	-	-	-	-	-	-	-	-	-	-	-	-
30 Oct.	18	39	0	0	-	-	20	-	-	-	-	4
15 Nov.	-	38.5	-	0	-	-	-	-	-	63	-	4
30 Nov.	0	-	0	-	24	-	-	-	2	-	0	-
14 Dec.	-	2.5	-	0	-	-	-	-	-	6	-	0
28 Dec.	2	-	0	-	26.5	-	5	-	-	-	-	-
11 Jan.	-	-	-	-	-	-	-	-	-	-	-	-
25 Jan.	2	-	1	-	7	-	12	-	2	-	1	-
8 Feb.	-	74	-	4	-	-	-	-	-	-	-	-
22 Feb.	2	-	16	-	3	-	27	-	-	-	-	-
8 Mar.	-	31	-	0	-	-	-	-	-	-	-	-
22 Mar.	27	-	7	-	26	-	7	-	-	-	-	-
5 Apr.	-	-	-	0	-	-	-	-	-	-	-	-
19 Apr.	76	60.5	25	35.5	-	-	45	-	-	2	42	0
3 May	-	-	-	34	-	-	-	-	-	-	-	93
17 May	-	-	34.5	-	-	-	-	-	-	-	10	34
31 May	-	-	-	37.5	-	-	-	-	-	-	-	-

PREPUPAE DEPOSITED AFTER NORMAL BLOWFLY SEASON.

C. VOMITORIA				C. ERYTHROCEPHALA				P. TERRANOVAE			
(21 Nov. -24 Apr)		(16 Oct. -18 May)		(21 Nov. -5 Apr.)		(16 Oct. -18 May)		(31 Oct. -15 Apr)		(25 Sep. -11 Jne)	
DURHAM		MOORHOUSE		DURHAM		MOORHOUSE		DURHAM		MOORHOUSE	
1947-8	1948-9	1947-8	1948-9	1947-8	1948-9	1947-8	1948-9	1947-8	1948-9	1947-8	1948-9
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	0
-	-	-	-	-	-	-	-	-	-	-	-
-	-	6	-	-	-	0	2	0	-	0	0
-	-	-	47	-	-	-	0	-	-	-	0
-	-	-	-	33	-	-	-	0	-	0	-
-	69	-	7.5	-	-	-	-	-	0	-	0
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
30	-	21	-	29	-	10	-	0	-	0	-
-	74	-	39	-	82	-	10	-	-	-	0
50	-	40	-	41	-	33	-	0	-	0	-
-	77	-	27	-	64	-	10.5	-	-	-	-
-	-	-	-	42	-	40	-	0	-	0	-
-	80	-	15	-	58	-	57	-	40	-	-
-	-	-	-	-	-	-	-	-	-	25	2
-	-	-	80	-	-	86	58	-	-	-	-
-	-	-	-	-	-	-	-	-	-	45	8
-	-	-	-	-	-	-	-	-	-	-	-

VI. THE EMERGENCE PATTERN OF BATCHES DEPOSITED AFTER THE TERMINATION OF THE NORMAL BLOWFLY SEASON.

The Appendix pages 108-18 give the total weekly emergence from batches deposited during that part of the year when the species under consideration was not caught in the meat traps.

(i) LUCILIA SPECIES.

LUCILIA SERICATA (Mg.)

Durham. The survivors of batches deposited during the winter mainly emerged in the following June, coinciding with the spring emergence peak caused by batches deposited during the previous autumn. The April batches emerged later than the others, behaving in that and other respects more like the batches deposited during the blowfly season.

Moorhouse. No data is available for the November-January batches, since there was a 100% mortality during this period. The survivors of other batches started to emerge in late June, but there was no well-defined peak emergence time. The main part of the April and May batches of 1948 did not emerge until late August/early September, whereas the equivalent 1949 batches emerged in late July.

L. CAESAR (L.)

Durham. No records are available for February and March, but the other winter batches started to emerge in mid-June in 1948 and in late May in 1949, the latter coinciding with the spring emergence peak caused by batches deposited during the preceding autumn. The April batch contributed to this peak.

<u>Moorhouse</u>. The prepupae deposited during the winter of 1947-8 did not emerge until September 1948 and some not even until 1949. Those deposited during the winter of 1948-9 emerged in late June/early July, coinciding with the spring emergence peak. The late May batch contributed to this peak.

<u>L. ILLUSTRIS (Mg.)</u>

<u>Durham</u>. No prepupae were deposited during the winter 1948-9, but the 1947-8 winter batches started emerging in late May. Their emergence tended to be spread out over a rather longer period than <u>L. caesar</u> and some individuals remained in diapause until 1949. The main bulk, however, emerged in early June, coinciding with the spring emergence peak.

<u>Moorhouse</u>. No prepupae were deposited during the winter of 1948-9, but those deposited in the winter of 1947-8, unlike the equivalent <u>L. caesar</u> batches, emerged in late June and July, each batch taking 3 - 9 weeks to complete emergence. The April batch commenced emergence at the same time as the winter batches.

<u>CONCLUSIONS</u>.

(1) Batches of <u>Lucilia</u> prepupae deposited at Durham throughout the winter tended to emerge simultaneously, and at a time when emergence from batches deposited during the preceding Autumn was also occurring, i.e. about a fortnight later for <u>L. sericata</u> than for <u>L. caesar</u> and <u>L. illustris</u>.

(2) The April batch of <u>L. caesar</u> deposited at Durham contributed to the spring peak, whereas the equivalent <u>L. sericata</u> batch emerged later. No data is available on this point for <u>L. illustris</u>.

(3) Batches of Lucilia prepupae deposited at Moorhouse throughout the winter tended to emerge in a more scattered manner, some prepupae emerging in late June, remaining in diapause until late Summer or even until the following year.

(4) The April and May batches of L. caesar and L. illustris deposited at Moorhouse tended to emerge at the same time as the winter batches, whereas the main part of the April and May batches of L. sericata emerged later.

(ii) CALLIPHORA SPECIES.

CALLIPHORA VOMITORIA (L.)

Durham. In both years the winter batches emerged in May, thus coinciding with the spring emergence peak caused by batches deposited during the previous Autumn.

Moorhouse. In both years, the winter batches emerged in June, thus coinciding with the spring emergence peak. The latter, however, was very small, owing to shortage of batches deposited in the Autumn. The May batches behaved more like "summer" batches, emerging later than the others.

CALLIPHORA ERYTHROCEPHALA (Mg.)

Durham. The batches showed a similar behaviour to the C. vomitoria batches, except that emergence was spread over a longer period and was not completed until mid-July.

Moorhouse. As for C. vomitoria, batches started emerging in early June, but emergence was scattered over a longer period. Peak emergence occurred in late June.

The May batches emerged later than the others, thus resembling "summer" batches.

CONCLUSIONS.

(1) Batches of prepupae deposited throughout the winter tended to emerge simultaneously, during May at Durham and June at Moorhouse, i.e. about a fortnight earlier than L. caesar and L. illustris and a month earlier than L. sericata.

(2) Where there was a spring emergence peak caused by batches deposited during the preceding autumn, the emergence from winter batches coincided with it.

(3) The May batches deposited at Moorhouse emerged later than the other batches, behaving more like "summer" batches.

(4) C. erythrocephala larvae emerged in a more scattered manner than C. vomitoria.

(iii) PROTOPHORMIA TERRANOVAE (R - D).

Durham. Batches deposited from November to February inclusive suffered a 100% mortality. Late March and early April batches emerged during late May.

Moorhouse. Batches deposited from October to March inclusive suffered 100% mortality. April and May batches emerged in late June.

CONCLUSIONS.

There was a complete mortality of all batches deposited before March at Durham and April at Moorhouse.

GENERAL CONCLUSIONS.

(1) Winter batches emerged as follows:- (peak emergence)

	Durham.	Moorhouse.
C. vomitoria.........	7 - 28 May	12 - 26 June
C. erythrocephala...	15 May - 5 June.	19 June - 2 July
P. terranovae	15 - 21 May	18 June - 2 July
L. caesar	22 May - 11 June	3 - 11 July
L. illustris	29 May - 19 June	3 - 17 July
L. sericata	11 - 25 June	16 July - 7 Aug.

(2) Where spring emergence peaks from Autumn-deposited prepupae were present, the emergence from winter batches coincided with them.

(3) Emergence tended to be more scattered at Moorhouse than at Durham.

VII. EXAMINATION OF CONTENTS OF SOIL TINS FOR PUPARIA.

DURHAM BATCHES.

Twelve to eighteen months after deposition, the contents of the tins were removed to the laboratory and sieved in order to recover any remaining prepupae or pupae. It was possible to distinguish between Lucilia, Calliphora and Protophormia pupae, and also to estimate the fate of each individual. They could be roughly classified as follows:-

(1) Normal Emergence - anterior "cap" of puparium missing, but remainder quite whole and empty.

(2) Incomplete pupation - Puparia uncontracted, usually complete, with no apparent contents. Laboratory experiments have shown that these "long" pupae were often the result of subjection to cold temperatures and that development rarely proceeded to the production of an imago. If, however, this did occur, the imago frequently died in an attempt to emerge from the abnormally narrow opening of the puparium.

(3) Decayed Pupae - complete puparia with no contents or merely a small quantity of fliud. It could be assumed that these individuals died during metamorphosis.

(4) Full Pupae - complete puparia containing the remains of fully-developed flies. These probably died in an attempt to break open the puparium - possibly owing to the lack of water.

(5) Parasitised Pupae - complete puparia except for one or more small holes at anterior or posterior ends or at the side.

RESULTS.

Table 10 shows the number and type of puparia recovered. From these records, certain deductions can be made. If the total number of puparia was small, then it could be assumed that there was a high mortality during the prepupal stage. From the type of puparium, the pupal mortality, the stage at which mortality occurred, and, in the case of parasitised pupae, the reason for the mortality could all be estimated. (See Table 10).

CONCLUSIONS.

The fact that the number of empty pupae obtained approximated to the number of emergences recorded, indicated that a high percentage of pupae were recovered. At all times of the year, most of the mortality occurred in the prepupal stage. This could be deduced from the fact that the number of complete pupae was small. The one exception to this was the species *Protophormia terranovae* during spring (March-April) and autumn (October). Conditions at these times permitted some of the prepupae to pupate but not to emerge. Large numbers of complete pupae containing larval or imago remains were recovered at these times.

The hardiness of the three genera, as exhibited by the number of empty and, to a lesser extent, complete puparia produced during unfavourable parts of the year, followed the general pattern found in the preceding work. *Calliphora* species were the most hardy, followed by the *Lucilia* species, and then by *Protophormia*. It must be remembered that for this analysis the three *Lucilia* species had to be considered together.

There was some indication of parasitism during the summer months, but this never exceeded 6%

Moorhouse Batches. Owing to the type of soil, it was found impossible to recover a significant proportion of the puparia without destroying them in the process.

VIII. THE CORRELATION BETWEEN THE MEAN WEIGHT OF L. SERICATA PREPUPAE AND THEIR WATER CONTENT AND THEIR VIABILITY.

METHOD.

When the prepupae were being counted out for deposition at the field stations, fifty of each species were selected at random, and after having been subjected to the same treatment as the remainder of the batch (usually one night in a jar containing sawdust and kept at 5° C.) they were killed in a cyanide killing bottle. They were then dried for one hour over phosphorous pentoxide at room temperature and weighed individually on an appropriate torsion balance. Arranged on a perspex rack, they were then dried in an oven at approximately 70° C. Further weighings were made after two days and then at intervals of one day until they became constant.

RESULTS.

Table 11 gives the mean fresh weight and the mean dry weight of each batch of L. sericata prepupae. The percentage water content has been calculated from this data.

A 2-way Frequency Table was constructed for fresh weight and percentage water content ~~(Table)~~. The correlation coefficient was found to be 0.17 (Snedecor, Table 8.7) which gave a probability greater than 0.1 (Simpson and Roe, Table IX). The correlation was not, therefore, significant.

A similar 2-way Frequency Table was constructed for fresh weight and percentage emergence from the equivalent control batch ~~(Table)~~. The correlation coefficient was found to be -0.61, which again gave a probability greater than 0.1. The correlation was not, therefore, significant.

IX. THE CHANGES IN FRESH WEIGHT AND IN WATER CONTENT UNDERGONE BY L. SERICATA PREPUPAE DURING THE SPRING.

METHOD.

500 fully-fed L. sericata prepupae were deposited in a soil tin at Durham on 20 November 1949. Groups of 25 prepupae were removed at intervals throughout the Spring and the fresh and dry weight of each batch was determined. The drying temperature for this experiment was 110° C. and the prepupae were weighed at intervals of 24 hours. Mean fresh and dry weights and percentage dry matter were determined for each group.

RESULTS.

Date of Removal from Soil.	No. of Weeks in Soil.	Mean Fresh Wt. (in mgms.)	Mean Dry Wt. (in mgms.)	% Dry Matter.	% Water.
1950 23 Jan.	9	38.4 ± 5.8	12.0 ± 2.0	33.7 ± 1.3	66.3 ± 1.3
6 Mar.	15	35.7 ± 3.5	11.3 ± 1.4	31.7 ± 2.1	68.3 ± 2.1
4 Apr.	19	36.1 ± 2.9	11.04± 1.6	30.8 ± 2.1	69.2 ± 2.1
15 May*	25	35.8 ± 4.7	10.2 ± 1.4	28.2 ± 1.0	71.8 ± 1.0

* 1 pupa found on this date. Emergence started on 10 June

Each pair of consecutive figures for percentage dry matter were subjected to a test for the hypothesis that the two samples were drawn from one population (Simpson and Roe, Example 54). Then the first and last figures were compared in the same way.

CONCLUSIONS.

While there was no significant difference between the % water content of consecutive batches, the result obtained when the first (23 Jan.) and last (15 May) batches were compared was over 3 and therefore just significant. It may therefore be concluded that L. sericata prepupae probably increase their percentage water content during the spring.

X. GENERAL DISCUSSION ON FIELD DATA.

The two factors which determine the magnitude of emergence at any given time are as follows:-

(1) The time taken for the insects to pass through the prepupal and pupal stages. This may vary from about ten days to a whole winter, or in some cases, a whole year or more.

(2) The percentage viability of the batches. This may vary from 0% in winter to 100% in summer.

In nearly all cases, prepupae deposited during the autumn months were the first to emerge in the following spring. They normally did this within the same period of a few weeks, irrespective of the date of deposition. If the overwintering mortality was low, then a large spring peak was obtained (e.g. <u>L. sericata</u> at Durham). If the overwintering mortality was high then there was little or no spring peak (e.g. <u>P. terranovae</u>). For the batches which emerged during the season of their deposition it was clear that the development rate was dependent on temperature. Usually increase of temperature accelerated development, but in one case at least there were signs of mortality as a result of high temperatures. The development period reached a certain minimum sometime during mid-summer. Clearly, provided the viability of all batches was the same, there would be a maximum number of flies emerging at a time when the development period was at a minimum, since the later batches would tend to emerge simultaneously with the earlier ones.

There were, however, in some species, marked differences in the viability of the batches, depending on the time of year at which the prepupae were deposited. In some cases (e.g. <u>L. sericata</u>) those batches which had the highest rate of development had the greatest viability.

This enhanced the summer emergence peak. In other cases (e.g. *C. erythrocephala*) summer conditions, whilst accelerating development, also apparently caused a higher death rate. In such cases, the summer emergence peak would be partly or wholly nullified. Other species were intermediate in their reactions.

The late August/September strike wave may be in part related to the August/September emergence peak characteristic of *L. sericata*, but if this is so, *L. caesar* and *L. illustris* would not play an important part in this strike wave since their emergence peak appeared to occur somewhat earlier. This conclusion was also reached by MacLeod (1943) who examined the incidence of *L. caesar* and *L. sericata* on *caesar*-infested farms throughout the summer. The greatest number of *L. caesar* strikes were found in late June and early July. The incidence then declined to a low level and remained so throughout the rest of the season. The greatest number of *L. sericata* strikes was also found in late June and early July, but there was a second peak in late August.

That part of the year during which emergence occurred also varied in length with the species. For the main part, those species which appeared first, disappeared last. It seemed that development and emergence could proceed at a lower temperature for some species than for others. Thus, *C. erythrocephala* and *C. vomitoria* emerged at 2" soil temperatures above 4^{o} - 5^{o} C., *L. illustris* and *L. caesar* and *P. terranovae* at 8^{o} C, and *L. sericata* at 9^{o} - 10^{o} C. Part of the variation in development time was due to diapause.

In all three *Lucilia* species, the percentage of prepupae in each batch entering diapause increased as autumn approached, until, in later batches, all prepupae entered diapause. Apart from this seasonal diapause, part or whole of some L. caesar and L. illustris batches entered diapause regardless of the time of year. This diapause sometimes lasted a few weeks, sometimes over a year. In these cases, a similar phenomenon occurred in the "control" batches, kept at 22° C. It seemed, therefore, that this type of diapause was due to factors suffered before, and not after, deposition. It has been found difficult to culture these two species throughout the year, as they sometimes tend to enter diapause.

The spring emergence peaks of the Calliphora species were almost entirely the result of batches deposited during October and November at Durham, and September and October at Moorhouse. Earlier batches emerged during the same year as deposition, and, except in the case of batches which emerged under really wintry conditions (December), all the viable part of the batch emerged within 1 - 2 weeks. Unlike the Lucilia species, the Calliphora species passed the winter in the pupal stage and readily emerged during spells of warm weather.

P. terranovae prepupae deposited after August at Moorhouse and after September at Durham completely failed to emerge. It has already been suggested that the 100% overwintering mortality may be due to the unnatural method of deposition for this species (i.e. removal from meat). Alternatively, it may be possible that this species normally survives the winter by hibernation in the adult stage.

Batches of P. terranovae and the Calliphora species tended to emerge over a shorter period than the Lucilia species - i.e. the individuals of any one batch behaved in a more uniform manner. This was no doubt associated with the tendency to diapause inherent in the Lucilia species.

On the whole, meat trap records appeared to follow the emergence patterns fairly closely, but there were some discrepancies. In most cases there was evidence of a spring meat trap peak following the spring emergence peak, and of a summer meat trap peak following the summer emergence peak. The Calliphora species, however, did not appear to conform to this plan. The present work has given an indication of differential mortality during the prepupal and pupal stages only, whereas the populations caught in meat traps mainly consisted of gravid females, probably 1 - 3 weeks old. There must be a considerable mortality due to predators and unfavourable climatic conditions during the "hopper" stage before the wings have expanded and the cuticle hardened. Graham-Smith (1915) found that oppressive sultry weather caused a high mortality in adult flies.

The decrease in viability during late June and the whole of July observed in the L. sericata batches and in certain of the Calliphora batches did not generally appear to be caused by too hot or dry conditions, although there were signs of this occurring on at least one occasion at Durham.

Examination of the contents of the soil tins after all emergence had finished indicated a parasitism of only up to 6% in summer batches and also indicated that the main mortality occurred in the prepupal stage. Some of this mortality may have been caused by predators, e.g. beetle and dipterous larvae.

A statistical analysis of the correlation between the mean weight of L. sericata prepupae and their water content and their viability indicated that the batches of prepupae had, up to the time of deposition, an approximately equal chance of survival. This conclusion had already been reached for L. sericata, C. vomitoria, C. erythrocephala and P. terranovae from an analysis of the behaviour of control batches. It had also been found that the variability in the behaviour of control batches of L. illustris and L. caesar was such that field results of these two species were only significant if compared with the behaviour of the equivalent control batch.

Experiments on the changes in fresh weight and in water content undergone by L. sericata prepupae during the spring gave some indication that the prepupae increase their percentage of water at this time. In January, the mean percentage dry matter was 33.7 ± 1.3. In May, this had decreased to 28.2 ± 1.0. Total fresh weight remained approximately constant. Cousin (1932) found that pupation of L. sericata was impossible when the proportion of dry matter was above 29%. She found that such prepupae must first lose some of their fat reserves and then drink water until they had reached the necessary proportions for pupation. Mellanby (1938) also suggested that prepupae drink water in the spring before they are able to pupate.

XI. SUMMARY OF FIELD DATA.

1. Batches of larvae of _L. sericata_, _L. caesar_, _L. illustris_, _C. vomitoria_, _C. erythrocephala_ and _P. terranovae_ were laid down at Durham and Moorhouse throughout 1948 and 1949 and the latter half of 1947.

2. The active season of the various species was assumed to be the period during which the species occurred in meat trap catches. These were as follows:-

	DURHAM.* (1948 and 1949).	MOORHOUSE. (1949).
L. sericata.	29 April to 18 Oct.	5 June to 18 Sept.
L. caesar.	29 April to 25 Oct.	18 May to 16 Oct.
L. illustris.	29 April to 25 Oct.	18 May to 16 Oct.
C. vomitoria.	15 April to 21 Nov.	18 May to 16 Oct.
C. erythrocephala.	5 April to 21 Nov.	18 May to 16 Oct.
P. terranovae.	15 April to 31 Oct.	15 June to 24 Sept.

* The earliest and latest dates on which individuals of the species were caught in either 1948 or 1949.

3. The periods during which emergence occurred were as follows:-

	DURHAM.	MOORHOUSE.
L. sericata.	Late May to Early Oct.	Mid June to Early Oct.
L. caesar.	Mid May to Early Nov.	Mid June to Late Oct.
L. illustris.	Mid May to Late Oct.	Mid June to Late Oct.
C. vomitoria.	Early Apr. to Early Jan.	Mid May to Early Dec.
E. erythrocephala.	Late Mar. to Early Jan.	Mid May to Late Dec.
P. terranovae.	Mid May to Late Oct.	Mid July to Early Oct.

At Moorhouse all emergences started about a month later and ended slightly earlier than at Durham.

4. Spring emergence peaks occurred as follows:-

	DURHAM.	MOORHOUSE.
L. sericata.	June.	Late June.
L. caesar.	Late May/Early June.	Mid June/Mid July.
L. illustris.	Mid May/Mid June.	Mid June/Mid July.
C. vomitoria.	Early May.	Early June.
C. erythrocephala.	Early May.	No Peak.
P. terranovae.	No Peak.	No Peak.

5. Summer peaks, due either to an increase in viability or to a successive decrease in development period, or both, were only obvious from the histograms in the case of L. sericata.. L. illustris and L. caesar batches were deposited too irregularly to present any peak emergence and C. vomitoria, C. erythrocephala and P. terranovae batches emerged within such a short period that there was little or no possibility of accumulation into a peak. From an examination of the relative development periods and viability of the batches, it was, however, usually possible to identify a period during which peak emergence was likely to occur. One would expect an increase in the mature fly population 1 - 2 weeks after this period. The probable peak emergence periods and the peak meat trap catch periods were as follows:-

SUMMER EMERGENCE AND "CATCH" PEAKS.

DURHAM.

Species.	Peak Emergence.	Peak "Catch".
L. sericata.	late Aug.	None.
L. illustris.	late July.	late July.
L. caesar.	late July.	late July.
C. vomitoria.	early Aug.	late Aug./Oct.
C. erythrocephala.	Aug./early Sept.	late Sept./Oct.
P. terranovae.	late July (?)	None.

MOORHOUSE.

Species.	Peak Emergence.	Peak "Catch".
L. sericata.	early Sept.	early Sept.
L. illustris.	*	*
L. caesar.	*	*
C. vomitoria.	early Aug.	late Aug.
C. erythrocephala.	mid Aug. (?)	None.
P. terranovae.	late Aug.	late Aug.

* Insufficient data.

6. From meat trap and emergence records it appears that L. caesar and L. illustris are more fitted for development under cool conditions than L. sericata. In a cool summer such as 1948, the slow development of early batches of L. sericata produced a late summer peak, whereas a warm summer (1949) caused more scatter. A more detailed study into the history of each batch lead one to the conclusion that the extreme temperature conditions prevailing at Durham in 1949 caused abnormal behaviour.

7. In no case was it shown that summer temperatures or dry soil conditions caused the prepupae to aestevate or enter diapause due to dryness, although in one or two cases it was possible that viability was decreased by high temperatures.

PART TWO - LABORATORY STUDIES ON BLOWFLIES.

XII. EXPERIMENTS ON THE LARVAL STAGE.

(i) Determination of The Duration of The Feeding Period of *L. sericata* Larvae at 26½° C.

METHOD.

Large batches of *L. sericata* eggs were obtained from the cultures and hatched in the usual way. On hatching, the larvae were placed, together with some sheeps' "lights" on a layer of sawdust in a maggot-proof tin, and the whole was put into the breeding cupboard, running at a temperature of 26½° C.

When the larvae were 1 - 2 days old, a standard number was counted out (using a camel-hair paint brush), placed on a larger piece of "lights" contained in a large petridish. In the 1949 experiments, a thin layer of sawdust was placed on the bottom of the petridish in order to prevent the larvae from being drowned in the meat juices. The petridish was placed on an inverted jar over a maggot tin containing a thin layer of sawdust. The maggot tins were searched twice a day for prepupae and their numbers recorded.

RESULTS.

Table 12 shows the number of hours each batch required to finish feeding. There was considerable variability in the results, especially in the case of a batch in which the eggs were hatched overnight. Also, there seemed to be considerably more larvae leaving the meat during the night than during the day, even allowing for the fact that the "night" period was 5 p.m. to 10 a.m.

Table 12 **The Duration of Feeding Period of L. sericata At $26\frac{1}{2}$°C**

Date	10% Finished Feeding	50% Finished Feeding	90% Finished Feeding
1948	hours	hours	hours
2 Dec.	93 - 111	115 - 119	160 - 166
6 Dec.*	78 - 96	127 - 144	127 - 144
1949			
26 Jan.(A)	96 - 111	96 - 111	119 - 135
26 Jan.(B)	119 - 135	119 - 135	143 - 159
11 Feb.**	100 - 112	123 - 134	124 - 136

Table 13 **The Numbers of Larvae Migrating from their Food per Hour of the Day and Night**

Date 1949	4th Day	4th Night	5th Day	5th Night	6th Day	6th Night	7th Day
2 Dec.	0	2.0	0.4	1.3	0.2	0.3	0.1
6 Dec.	0	1.0	0.0	1.5	0.5	5.0	0.0
26 Jan. (A)	0	3.5	0.4	1.6	0.1	0.2	0.0
26 Jan. (B)	0	0.1	0.1	4.8	0.0	2.6	0.0
11 Feb.	0	1.3	0.1	1.5	0.0	0.3	0.0

Table 14 **The Numbers of Larvae Migrating from their Food per Hour During Day and Night, the Larvae being kept Continuously in Electric Light.**

Date 1949	3rd Night	4th Day	4th Night	5th Day	5th Night	6th Day	6th Night
11 Mar.	15	13	0	62	2	6	6
30 Mar.	0	70	5	12	0	2	5

* Eggs were hatched overnight

** Examined at 12 - hourly intervals

(ii) The Effect of Diurnal Rhythm on The Duration of The Feeding Period of *L. sericata* Larvae.

METHOD.

Experiments were continued on similar lines as before, but the maggot tins were examined at 12-hourly intervals (10 a.m. and 10 p.m.).

RESULTS.

Table 13 shows the average number of larvae migrating from the meat per hour of the day and of the night. Considerable more larvae left the meat at night than during the day.

~~(iii)~~ The Effect of Constant Light on Fully-Fed *L. sericata* Larvae.

METHOD.

Similar experiments were carried out under conditions of constant light produced by an electric light bulb suspended over the feeding larvae.

RESULTS.

Table 14 shows the number of larvae leaving the meat during each day and night. There was no tendency for the larvae to leave the meat during the night rather than during the day.

(iii) DISCUSSION.

The average feeding time of *L. sericata* larvae at $26\frac{1}{2}^{\circ}$ C. appeared to be from four to four and a half days. This period was slightly longer than the normal feeding period required by *L. sericata* larvae, probably due to the fact that the fully-fed larvae spent some time escaping from the petri dish into the surrounding sawdust.

Cousin (1932) found the feeding period of <u>L. sericata</u> to be 55 hours at 25.5° C. and 38 hours 45 min. at 33° C. She did not, however, use the time at which the larvae left their food as the end-point of the feeding period. Instead, she used the following technique. First, she took 1,000 larvae brought up at various temperatures and, by weighing them 100 at a time, she established a mean full-fed weight. She does not describe the stage at which she weighed these larvae, but does describe larvae with full crops as "first stage prepupae". Having established a mean full-fed weight, she then removed batches of 100 larvae at intervals from her feeding experiments and weighed them. When these had reached the established "full-fed weight" she considered the batch to be fully fed. It therefore seems probable that she considered her larvae to be fully-fed at an earlier stage than in the present experiments. She also found that all 3rd instar larvae were capable of pupation.

The present experiments also showed that the larvae did not leave their food at a constant rate, but preferred to migrate during the night rather than during the day. This preference could have been due to an inherent diurnal rhythm in the larvae, or, alternatively, due to a photophobic response. Further experiments proved it to be the latter.

XIII. EXPERIMENTS ON THE PREPUPAL AND PUPAL STAGES.

(1) THE EFFECT OF LOW TEMPERATURES ON L. SERICATA PREPUPAE

Over the period during which the following low temperature experiments were performed, breeding was being carried out at a slightly lower temperature (approximately 24° C.) than normally. This meant that larvae were not fully-fed and prepared to leave the meat until 5 days had elapsed from the time of egg-laying. By that time they were shiny and pinkish in colour and had digested all or nearly all of their gut contents. Larvae removed after only 4 days were slightly smaller, whitish, with their crops full of food.

The experiments were carried out using two temperatures, namely -4° C. and +5° C., prepupae of various ages, and dry, "normal"* or well-damped sawdust.

GROUP ONE - THE EFFECT OF -4° ON FULLY-FED (5-DAY) LARVAE.

METHOD.

Fully-fed larvae (5-day) were counted out in batches of 100 and placed in "normal" sawdust in honey jars. The honey jars were then placed on the ice-box in the refrigerator (-4° C.); these were removed at intervals and placed in the control incubator (22° C.). The contents of the jars were examined daily for deaths, pupation and emergence.

RESULTS.

Table 15 shows the percentage pupation and emergence. There appeared to be a double mortality effect:-

(1) A mortality during the prepupal stage of up to about 50%

(2) A mortality during the pupal stage of up to a further 40-70%.

* i.e. just slightly damp, as used for control batches.

Table 17 % pupation and % emergence from prepupae of various ages kept in damp and dry sawdust at -4°C for 18 hours

a) % pupation

Date of Experiment	Damp Sawdust			Dry Sawdust		
1948	4 Day	5 Day	6 Day	4 Day	5 Day	6 Day
19th Feb.	-	2L*	-	-	2L+57N**	
26th Feb.	4N	42L+4N	46L+2N	24N	4L+78N	82N
27th Feb.	0	42L+4N	86L+2N	28N	76N	6L+78N

b) %emergence

	Damp Sawdust			Dry Sawdust		
1948	4 Day	5 Day	6 Day	4 Day	5 Day	6 Day
19th Feb.	-	0	-	-	45	-
26th Feb.	4	0	2	18	74	72
27th Feb.	0	6	0	24	70	70

* Uncontracted pupa ** normal pupa.

Exposures of up to 6 hours duration had little effect. The low temperatures sometimes caused pupation and emergence to be delayed for a few days, but there was no true diapause effect.

GROUP TWO - THE EFFECT OF EXPOSURE TO -4° C. on *L. SERICATA* LARVAE OF DIFFERENT AGES.

METHOD.

Large batches of larvae were reared as before and groups of 100 larvae were removed from the feeding tin 4, 5, 6 and 7 days after oviposition. The larvae were placed in "normal" sawdust in honey jars as before, and subjected to -4° C. for 18 hours. Pupation was recorded as before (Table 16). Emergence records were spoiled owing to overheating which occurred when the incubator capsule broke.

CONCLUSIONS.

Resistance to cold appeared to increase with age.

GROUP THREE - COMPARISON OF THE MORTALITY OF PREPUPAE OF VARIOUS AGES KEPT IN DAMP AND IN DRY SAWDUST AT -4° C. FOR 18 HOURS.

METHOD.

Groups of 50 prepupae, 4, 5 and 6 days old, were placed in damp and in dry sawdust in honey jars and subjected to -4° C. for 18 hours. Table 17 shows % pupation after transferring the prepupae to the control incubator. This time a differentiation was made between normal pupae and pupae which had failed to contract, remaining larva-like in shape.

CONCLUSIONS.

Mortality was much higher amongst those prepupae which were kept in damp sawdust than in dry. Not only was there a greater mortality in the prepupal stage, but

Table 18 Rate of Pupation and Emergence of L. Sericata Prepupae at 22°C after subjection to 4-5.5°C.

Experiments started on 21st December, 1947.

Days at 4.0° 5.5°C

	0	1	3	5	7	12	23	40
50% Pupation	1-2	2-3	4-5	6-7	8	13	25	42
	1-2	1-2	1-2	1-2	1	1	2	2
90% Pupation	3	4	6	8	9-10	15	26	44
	3	3	3	2	2-3	3	3	4
1st Emergence	8	9	11	13	14	20	33	-
	8	8	8	8	7	8	10	-
50% Emergence	10	11	12	14	16	22	-	-
	10	10	9	9	9	10	-	-
75% Emergence	11	12	13	16	17	-	-	-
	11	11	10	11	10	-	-	-
90% Emergence	11	13-14	14	-	-	-	-	-
	11	12-13	11	-	-	-	-	-
% Mortality (Prepupal)	1	0	0	2	0	0	11	14
% Pupation on removal from 'fridge	0	3	15	26	23	31	29	31

Table 19 Rate of Pupation and Emergence of P. terranovae Prepupae at 22°C after subjection to 4-5.5°C.
Experiments started on 21st December, 1947.

Days at 4.0 - 5.5° C.

	0	1	3	5	7
50% Pupation	1	2	3	5	7
	1	1	0		0
90% Pupation	2	2	4	6	8
	2	1	1	1	1
1st Emergence	7	8	10	12	14
	7	7	7	7	7
50% Emergence	8	9	11	12	14
	8	8	8	7	7
75% Emergence	8	9	-	13	15
	8	8	-	8	8
90% Emergence	-	9	-	13	-
	-	8	-	8	-
% Mortality (Prepupal)	6	2	2	4	2
% Pupation on removal from fridge.	0	16	74	30	56
% Emergence from original Prepupae.	78	94	68	86	76

many of the pupae formed were of the uncontracted type from which there was little or no emergence.

GROUP FOUR - SUBJECTION OF L. SERICATA AND P. TERRANOVAE PREPUPAE TO 4 - 5.5° C. FOR 1 - 40 DAYS.

METHOD.

Batches of 50 fully-fed larvae were put into honey jars with some "normal" sawdust and the jars were placed on the floor of the refrigerator. The temperature in this region fluctuated between 4° C. and 5.5° C. Jars were removed to the control incubator (22° C.) at intervals of several days and the contents examined daily for pupation and emergence. Results are shown in Tables 18. + 19.

CONCLUSIONS.

(1) No diapause effect was produced by subjecting either *L. sericata* or *P. terranovae* to 4 - 5.5° C. Subjection to this temperature merely retarded development for the period of subjection. *P. terranovae* prepupae readily pupated at this temperature and even 30% of the *L. sericata* prepupae had pupated after 12 days.

(2) In all cases more than 90% of the prepupae achieved normal pupation, but the longer periods at 4 - 5° C. did cause a decrease in the percentage emergence of *L. sericata*. No uncontracted pupae were formed.

GROUP FIVE - SUBJECTION OF L. SERICATA, L. ILLUSTRIS AND C. ERYTHROCEPHALA to 4 - 5.5° C. FOR VERY LONG PERIODS.

METHOD.

Groups of fully-fed larvae and "normal" sawdust were placed in honey jars and deposited at the bottom of the refrigerator. They were periodically examined for pupation and emergence. Some jars were removed to the incubator (22° C.) after long periods, others were kept in the refrigerator until the insects had either emerged or died.

RESULTS.

(1) A jar of L. sericata prepupae were removed after 50 days at 4 - 5.5° C. 25% had died, none had pupated, but 50% completed pupation within 5 days of being put into the 22° C. and emergence began after 11 days.

(2) Four jars of L. sericata prepupae, kept in the refrigerator indefinitely, failed to pupate. After 9 months about 10 - 20% were alive.

(3) Three batches of L. illustris prepupae, kept in the refrigerator indefinitely, produced 15 - 50% pupae and 5 - 10% imagos. The remaining larvae died. Examination of the dead pupae showed that a high proportion of fully-formed flies died in emergence.

(4) One large batch of C. erythrocephala prepupae, kept in the refrigerator, all pupated within 2 weeks. There was 20% emergence within 12 weeks. The majority of the imagos, however, although fully formed, failed to emerge.

(ii) THE EFFECT OF LIGATURES ON EARLY AND LATE STAGE L. SERICATA PREPUPAE.

METHOD.

Larvae which had fed for four, five and six days were ligatured in either of two positions:-

(1) "Head" - i.e. just in front of the region of the corpus allatum.

(2) "Middle" region.

The larvae were then placed in jars with normal sawdust and deposited in the 22° C. incubator. They were examined daily for pupation and deaths.

Table 20 The Effect of Ligatures on Early and Late Stage L. sericata Prepupae.

Age of Prepupae in Days	"Head" Region		"Middle" Region	
	Group One (25 prepupae)	Group Two (25 prepupae)	Group One (25 prepupae)	Group Two (25 prepupae)
4	1C + 18P	6P	all died	all died
5	12P	2C+17P+5A	1A	4C + 1A
6	15P+8A	5C+3P+9A	3C+1P+3A	8C + 4A

KEY: A = portion anterior to ligature pupated only.

P = portion posterior to litature pupated only.

C = complete pupation.

RESULTS.

The younger prepupae tended to pupate only on the side of the ligature which contained the corpus allatum. In some cases the "head" ligature had obviously been made behind instead of in front of this organ. The older prepupae tended to complete pupation. (See Table 20)

The Effect of Ligatures on Prepupae Which Had Been Subjected to 4 - 5.5° C. for 50 Days.

METHOD.

Two groups of prepupae were used - one group had been submitted to the cold temperature after four days feeding time, the other after five days. The prepupae were ligatured with cotton around the middle.

RESULTS.

All of the 5-day larvae died. Of the 4-day larvae, seven died and the anterior halves only of the other three pupated.

(iii) DISCUSSION.

The fore-going experiments showed that L. sericata prepupae increased in resistance to cold with age and dryness of their environment. Cousin (1932) submitted prepupae of three different ages to -10° C. and found that the eldest survived best. Hodson (1937) found that Cynomya cadavennia (?) prepupae survived best in moist soil at temperatures just above freezing point, but dry soil favoured survival below freezing point. From experiments on L. sericata prepupae, he concluded that soil moisture does not affect resistance to low temperatures until it is present in quantities greater than that which can be absorbed by the soil. He suggested that ice crystals pierce the body wall and actually inoculate the body fluid causing partial hydration of the tissues.

It seems probable that, in the case of young prepupae, the crop contents might also freeze, with serious consequences.

The production of uncontracted pupae from which there was little or no emergence was characteristic of subjection to sub-zero temperatures combined with a damp environment. Cousin (1932) also produced abnormal pupae in this manner.

Exposure of prepupae to temperatures round about the threshold of development (4 - 5.5° C.) merely suspended or greatly retarded development. No permanent diapause effect was produced, the prepupae resuming development soon after their return to control conditions. Normal pupation occurred, but there was a decrease in the percentage emergence. Cousin (1932) found that there was sometimes even a slight acceleration in rate of development after a period at 5° C.

When kept permanently at 4 - 5.5° C, C. erythrocephala readily pupated, L. illustris less readily and L. sericata, in one experiment, failed to pupate at all. The fact that 30% of the L. sericata prepupae pupated at 4 - 5.5° C. in another experiment, suggests that the physiological age of the prepupae at the time of subjection to a low temperature may be important. If subjection occurs prior to the circulation of the "pupation hormone", then the action of the latter may be retarded or completely arrested.

Emergence from pupae kept at 4 - 5.5° C. was very poor. The fact that development proceeded until the imagos were fully developed and terminated with death before emergence, indicated that there was some vital lack at this time. The water required for the process of emergence may well have been used up during the greatly elongated development period, with fatal results.

The readier pupation and emergence of C. erythrocephala at 4 - 5.5^{o} C. fits in with the data from field experiments on the temperatures necessary for pupation and emergence. Graham-Smith (1915) postulated a critical temperature of emergence for each species, with a slightly lower critical point for pupation.

LIGATURE EXPERIMENTS.

A detailed discussion of the physiology of pupation is not relevant to the present work. Suffice it to say that Dennel (1949) suggested the development of a "pupation hormone" during the prepupal stage which destroys Weissmann's ring and the action of a "juvenile hormone". This activity would commence in the region of Weissmann's ring and the effect would travel backwards and forwards from this region. Mellanby (1938) ligatured early and late stage C. erythrocephala prepupae in the mid-region and found that whereas only the anterior half of early stage prepupae pupated, both halves of late stage prepupae pupated.

The present experiments on L. sericata prepupae have yielded similar results. Namely, the older pupae pupated completely, whereas the younger ones pupated only in that region which contained Weissmann's ring. Early stage L. sericata prepupae which had been kept at 4-5.5^{o} C. for 50 days, when ligatured around the middle, only pupated at the anterior half. This indicated that the movement "pupation hormone" had been inhibited by the low temperature.

XIV. EXPERIMENTS ON THE IMAGO.

(i) THE EFFECT OF CLIMATIC CONDITIONS ON L. SERICATA FEMALES.

Wild *L. sericata* females were obtained from meat traps and placed in cages under normal culture conditions. The following day, and then at approximately weekly intervals, eggs were obtained from them and from culture flies. The batches were brought up under identical conditions (i.e. normal culture conditions in the breeding cupboard which was running at 26.5° C.). When the larvae had finished feeding, batches of 40, 50 or 100 larvae were counted out and placed in damp sawdust in jars in an incubator running at 22° C.. The jars were aerated daily by tipping the contents out on to a large piece of paper. The sides of the jars were dampened weekly. Pupation and emergence were recorded daily.

RESULTS.

Tables 21 + 22 shows the number of days each batch required for pupation and emergence. Specimens of *L. sericata* females caught in the field from the middle of September onwards gave rise to prepupae with a tendency to enter diapause, but this characteristic could be obliterated by a period of about a fortnight under culture conditions.

(ii) DISCUSSION.

The above results indicate that the abnormal behaviour of *L. sericata* females during the autumn was a direct result of climatic conditions on the parent and not an inherent characteristic. Cousin (1932) found that badly-fed females gave rise to prepupae which tended to enter diapause: or possibly the cooler Autumn weather had an effect on the developing ova. Dickson (1949) found that diapause in *Grapholitha molesta* (Busck) larvae was controlled by the daily photoperiod, provided that the temperature was medium. Maximum diapause was produced by a 12-hour photoperiod. He also found that the photoperiod had no effect on L. sericata larvae. No experiments have been carried on these lines for L. sericata imagos.

REFERENCES.

Bodenheimer, F.S. (1938). "Problems of Animal Ecology," P.39-41.

Bruce, W.G. (1939). Journ. Kansas Ent. Soc. Vol. 12, No. 3.

Burtt, E.T. (1937-38). Proc. Roy. Soc. B. Vol. 124, P.13-22.

Buxton, P.A. (1933). Trans. Roy. Soc. Trop. Med. Vol. XXVI, No. 4.

Cousin, G. (1932). Suppl. au Bull. Biol. de France et de Belgique, Vol. XV.

Cragg, J.B. and Ramage, G.R. (1945). Parasitology, Vol. 36, P.168-175.

Dennel, R. (1949). Proc. Roy. Soc. B. Vol. 136, P.94-109

Deonier, C.C. (1945). Journ. Ecol. Ent. Vol. 38 (1), P. 90-98.

Dickson, R. (1949). Ann. Ent. Soc. America. Vol. XLII.

Evans, A.C. (1935). Parasitology. Vol. 27, P.291-298.

Fraenkel, G. (1935). Proc. Roy. Soc. B. Vol. 118, P.1-12.

Graham-Smith, G.S. (1915). Parasitology, Vol. 8.

Hodson, A.C. (1937). Ecological Monographs No. 7.

Lindquist, A, and Barrett, W.L. (1945). Journ. Ecol. Ent. 38(1), P.77-82.

MacLeod, J. (1943). Bull Ent. Res. Vol. 34 Part 1.

Mannley, G. (1942). Q.J. Roy. Met. Soc. Vol. LXVIII No. 295.

Mellanby, K. (1933). Proc. Roy. Ent. Soc. Vol. VIII, P.22-4.

Mellanby, K. (1937). Proc. Roy. Soc. (B), Vol. 127, P.473-486.

Mellanby, K. (1938). Parasitology, Vol. 30, No. 3, P.392-402.

Mellanby, K. (1940). Journ. An. Ecol. Vol. 9, No. 2, P.296-301.

Nicholson, A.J. (1933). Journ. An. Ecol. Vol. 2, P.132-178.

Nicholson, A.J. and Bailey, V.A. (1935). Proc. Zoo. Soc. London, P.551-98.

Parman, D.C. (1945). Journ. Ecol. Ent. 38 (1), P. 66-76.

Payne, N.M. (1927). Journ. Morph. t.XLIII, P.521.

Peairs, L.M. (1914). Journ. Ecol. Ent. Vol. 7.

Peairs, L.M. (1927). Agr. Expt. Station, W. Virginia, Bull. 208.

Pfadt, T.E. (1947). Journ. Ecol. Ent. 40, No. 3, P.293.

Pradhan, S. (1945). Proc. Nat. Inst. Science, India, Vol. XI, No. 2, P.74-80.

Sacharov, N.L. (1930). Ecology, Vol. XI, No. 4.

Uvarov, B.P. (1931). Trans. Ent. Soc. Vol. 79, P.1-247.

Varley, G. (1947). Journ. An. Ecol. P.139-187.

Wardle, R.A. (1930). Ann. App. Biol. 17, P.554-74.

Wigglesworth, V.B.(1934). Q.J. Micr. Science. Vol. 77, Pt.II, P.191-222.

WEEKLY % EMERGENCE OF L. SERICATA

(From batches deposited during the

Date of Deposition	29 May - 4 June.	5-11 June.	12-18 June.	19-25 June	26 June - 2 July	3-9 July	10-16 July	17-23 July
1947								
28 July	1.6	0.5	1.5	1.0				
15 August	0.5	2.0	5.5	14.5	2.0	3.5	1.5	
30 August			8.0	29.0	6.0	3.0	3.0	1.5
6 Sept.			4.0	20.0	10.0	0	4.0	
20 Sept.			0.5	5.0	3.0	1.0	0	0.5
1948								
26 April		1.5	0	0.5	0	0	0.5	3.5
14 May								
15 June							0.4	1.6
5 July								
4 August								
TOTALS:	2.1	4.0	19.5	69.5	21.0	7.5	9.4	7.1

AT DURHAM DURING 1948.

blowfly seasons of 1947 and 1948).

24-30 July	31 July - 6 Aug.	7-13 Aug.	14-20 Aug.	21-27 Aug.	28 Aug. - 3 Sept.	4-10 Sept.	11-17 Sept.	18-24 Sept.	25 Sept. - 1 Oct.
1.0	0.5	5.5	16.0	26.5	14.5	2.5	0.5	1.0	0.5
	0.5	1.0	8.0	25.5	11.0				
0.6	0.2	0	0	1.8	2.6	0.2			
0.3	0.3	0.3	1.3	5.0					
					2.3	24.0	0.3	0.3	
1.9	1.5	6.9	25.3	58.8	30.4	26.7	0.8	1.3	0.5

WEEKLY % EMERGENCE OF L. SERICATA

(From batches deposited during the

Date of Deposition	21-27 May	28 May - 3 June	4-10 June	11-17 June	18-24 June	25 June - 1 July	2-8 July	9-15 July	16-22 July	23-29 July
1948										
26 Apr.						1.5				
14 May				1.0	0.5					
15 June			0.4	3.6	2.4	0.6	0.4	0	0.2	
5 July	0.7	6.3	8.0	13.3	1.3	0.3	0.3	0	0	0
4 Aug.		0.3	1.0	3.0	1.3	1.0	0.3	0.7	0.3	0
24 Aug.		0.3	4.0	22.3	14.0	1.0	1.7	1.3	1.3	
10 Sept.		0.5	2.5	30.3	14.3	4.0	1.8	0.5	0.3	1.0
24 Sept.	0.5	6.8	14.3	10.5	2.3	1.5				
22 Oct.										
1949										
7 May						3.0	3.0	3.5	8.5	6.5
29 May								0.5	0	0.5
11 June										
9 July										24.0
25 July								2.0	8.0	
8 Aug.										
20 Aug.										
3 Sept.										
TOTALS:	1.2	13.5	30.2	84.0	36.1	12.9	7.5	6.5	18.6	32.0

AT DURHAM DURING 1949.

blowfly seasons of 1948 and 1949).

30 July - 5 Aug.	6-12 Aug.	13-19 Aug.	20-26 Aug.	27 Aug. - 2 Sept	3- 9 Sept	10-16 Sept.	17-23 Sept.	24-30 Sept.	1- 7 Oct.	8-14 Oct.	15-21 Oct.
0.7	0	0.3									
0.3	0.7										
0	0.8										
6.5	5.0	14.5	5.0	2.0	0	4.0	0.5				
0	2.0	9.0	8.5	1.0	1.5	5.5	7.0	1.5	3.0	4.0	0
	0.5	0	2.0	0.5	0	3.5	0.5	2.5	1.0	5.5	0.5
1.0	0	0	1.0								
	2	6	2								
			2.0	4.5	4.0	1.5					
					3.0						
								7.0	0.5		
8.5	9.0	23.8	18.5	8.0	8.5	14.5	8.0	11.0	4.5	9.5	0.5

WEEKLY % EMERGENCE OF L. SERICATA

(From batches deposited
(No L. sericata batches were deposited

Date of Deposition	24-30 July	31 July - 6 Aug.	7-13 Aug.	14-20 Aug.	21-27 Aug.
1948.					
15 June	3	0.2	0	0	0.2
5 July		0.3	0	0	0.6
4 Aug.					
24 Aug.					
TOTALS:	3	0.5	0	0	0.8

WEEKLY % EMERGENCE OF L. SERICATA

(From batches deposited

Date of Deposition	4-10 June	11-17 June	18-24 June	25 June - 1 July	2-8 July	9-15 July	16-22 July	23-29 July
1948.								
15 June		2.0	2.0	8.0	4.0	6.0	3.0	1.0
5 July			1.3	0.7	1.0	0	0.3	0
4 Aug.		0.7						
24 Aug.	2.3	6.7	7.0	2.7	0.7	1.0	5.0	2.7
10 Sept.	0.3	2.3	11.5	6.5	1.5	8.0	8.0	2.0
1949.								
11 June								
25 June							17.0	13.0
9 July								
25 July								
8 Aug.								
20 Aug.								
TOTALS:	2.6	11.7	21.8	17.9	7.2	15.0	33.3	18.7

AT MOORHOUSE DURING 1948.

during 1948 only).
at Moorhouse during 1947.

28 Aug. - 3 Sept	4-10 Sept	11-17 Sept.	18-24 Sept.	25 Sept - 1 Oct.	2-8 Oct.	9-15 Oct.	16-22 Oct.
0.8	3.8	2.4	0.4	0.4	0.4		
0	6.7	2.0	0.7	0.3	0.3		
							0.3
	0.3	0	0	0	0	0	0.6
0.8	10.8	4.4	1.1	0.7	0.7	0	0.9

AT MOORHOUSE DURING 1949.

during 1948 and 1949.

30 July - 5 Aug.	6-12 Aug.	13-19 Aug.	20-26 Aug.	27 Aug. - 2 Sept.	3-9 Sept	10-16 Sept	17-23 Sept.	24-30 Sept.	1-7 Oct.	8-14 Oct.
2.0										
0	0	0	0	0	0.3					
0.7	0	0	0.3							
								2.5	2.5	0.5
4.0	1.5	0	2.0	0.5						
		6.0	3.0							
			2.0	2.0						
					5.0	5.0	10.0	2.0	2.0	
							0.5			
6.7	1.5	6.0	7.3	2.5	5.3	5.0	10.5	4.5	4.5	0.5

Appendix.

CATCHES OF L. SERICATA IN MEAT TRAPS DURING 1948 AND 1949.

Week Ending	Durham						Moorhouse	
	1948			1949			1948	19
	Trap I	Trap II	Total	Trap I	Trap II	Total	(Incomplete Records)	
29/30 Apr.	0	4	4	0	0	0	-	
6/ 7 May	2	0	2	0	0	0	-	
13/14 May	8	5	13	10	0	10	-	
20/21 May	49	87	136	9	3	12	-	
27/28 May	17	20	37	43	12	55	-	
3/ 4 June	16	9	25	21	(31+ (1 r.*	(52+ (1r.*	-	
10/11 June	7	3	10	86	72	158	-	
17/18 June	23	29	52	24	22	46	-	
24/25 June	3	15	18	57	16	73	2	
1/ 2 July	9	1	10	103	76	179	4	
8/ 9 July	13	1	14	170	89	259	-	
15/16 July	12	8	20	145	174	319	-	
22/23 July	25	16	41	81	37	118	1	
29/30 July	77	25	102	103	55	158	1	1
5/ 6 Aug.	30	12	42	94	40	134	1	1
12/13 Aug.	13	5	18	92	106	198	0	
19/20 Aug.	46	19	65	115	106	221	0	
26/27 Aug.	31	8	39	5	47	52	-	16
2/ 3 Sept.	22	10	32	26	8	34	-	9
9/10 Sept.	11	9	20	85	0	85	-	3
16/17 Sept.	3	3	6	108	2	110	-	
23/24 Sept.	2	3	5	2	0	2	-	
30 Sept./ 1 Oct.	3	2	5	52	1	53	-	
7/ 8 Oct.	4	3	7	104	0	104	-	
14/15 Oct.	0	1	1	50	8	58	-	
21/22 Oct.	0	0	0	43	1	44	-	
28/29 Oct.	0	0	0	1	0	1	-	

* L. richardsi.

APPENDIX.

WEEKLY % EMERGENCE OF L. ILLUSTRIS

(From batches deposited

Date of Deposition	15 -21 May	22 -28 May	29 May -4 June	5-11 June	12 -18 June	19 -25 June	26 June -2 July	3-9 July	10 -16 July	17 -23 July
1947.										
15 Aug.	3.0	7.0	6.0	23.0	4.0					
6 Sept.			2.5	12.5	41.0					
20 Sept.			2.0	14.0	12.0	6.0				
18 Oct.	3.0	4.0	3.0	2.0	3.0	0.5	0	1.0		
1948.										
26 Apr.		10.0	10.0	2.0	0.5					
15 July										
3 Aug.										
24 Aug.										
10 Sept.										
TOTALS:	6.0	21.0	23.5	52.5	60.5	6.5	0	1.0	0	0

WEEKLY % EMERGENCE OF L. ILLUSTRIS

(From batches deposited

Date of Deposition	14-20 May	21-27 May	28 May -3 June	4-10 June	11 -17 June
1948.					
15 July				2.5	2.5
3 Aug.					2.0
24 Aug.			0.5	27.0	7.0
10 Sept.		22.0	28.0	26.0	4.0
1949.					
11 June.					
9 July					
10 Sept	Nil				
TOTALS:		22.0	28.5	55.5	15.5

AT DURHAM DURING 1948.

during 1947 and 1948).

24 -30 July	31 July -6 Aug.	7-13 Aug.	14 -20 Aug.	21 -27 Aug.	28 Aug. -3 Sep.	4-10 Sep.	11 -17 Sep.	18 -24 Sep.	25 Sep. - 1 Oct.	2-8 Oct.	9-15 Oct.	16 -22 Oct.
2.5	58.0											
					28.0	15.0						
								5.0	4.0			
												4.0
2.5	58.0	0	0	0	28.0	15.0	0	5.0	4.0	0	0	4.0

AT DURHAM DURING 1949.

during 1948 and 1949).

18 -24 June	25 June -1 July	2-8 July	9-15 July	16 -22 July	23 -29 July	30 July -5 Aug.
1.0	0	0	0	0.5	0	0.5
2.0						
5.0	2.0					
6.0	0	0	0	2.0		
	5.0					
					100	
14.0	7.0	0	0	2.5	100	0.5

WEEKLY % EMERGENCE OF L. ILLUSTRIS

(From batches deposited
(No L. illustris batches were

Date of Deposition	15-21 May	22-28 May	29-May -4 June	5-11 Jne	12-18 Jne	19-25 Jne	26-Jne -2 Jly	3-9 Jly	10-16 Jly	17-23 Jly	24-30 Jly	31 Jly -6 Aug.
1948.												
15 June												
16 July												
4 Aug.												
24 Aug.												

WEEKLY % EMERGENCE OF L. ILLUSTRIS

(From batches deposited

Date of Deposition	14-20 May	21-27 May	28 May -3 June	4-10 June	11-17 June	18-24 June	25 June -1 July	2-8 July	9-15 July
1948									
15 June				1.0	4.0	3.0	5.0	3.0	5.0
16 July						2.0	2.0		
4 Aug.						2.5			
24 Aug.					3.0	9.0	5.0	7.0	8.0
11 Sept.						8.0	20.0	34.0	4.0
25 Sept.				2.0		4.0	4.0	2.0	2.0
1949									
11 June									
9 July									
20 Aug.									
TOTALS:				3.0	7.0	28.5	36.0	46.0	19.0

AT MOORHOUSE DURING 1948.

During 1948 only).
deposited at Moorhouse during 1947.)

7-13 Aug.	14-20 Aug.	21-27 Aug.	28 Aug.-3 Sep.	4-10 Sep.	11-17 Sep.	18-24 Sep.	25 Sep.-1 Oct.	2-8 Oct.	9-15 Oct.	16-23 Oct.
22.0	28.0	12.0	1.0	1.0						
								10.0		2.5

AT MOORHOUSE DURING 1949.

During 1948 and 1949).

15-22 July	23-29 July	30 July-5 Aug.	6-12 Aug.	13-19 Aug.	20-26 Aug.	27 Aug.-2 Sep.	3-9 Sep	10-16 Sep.	17-23 Sep.
	0.5								
5.0	0	0	0.3	0.3		0.3	0.3		
	1.0								
		15.0	13.0	1.0	1.0				
								3.0	1.5
5.0	1.5	15.0	13.3	1.3	1.0	0.3	0.3	3.0	1.5

Appendix.

CATCHES OF L. ILLUSTRIS MALES IN MEAT TRAPS AT DURHAM DURING 1948 AND 1949.

Week Ending	1948			1949		
	Trap I	Trap II	Total	Trap I	Trap II	Total
13/14 May	2	1	3	0	0	0
20/21 May	24	33	57	2	0	2
27/28 May	2	7	9	1	1	2
3/ 4 June	1	3	4	1	0	1
10/11 June	6	1	7	3	2	5
17/18 June	11	11	22	1	5	6
24/25 June	0	8	8	2	0	2
1/ 2 July	6	1	7	3	2	5
8/ 9 July	0	0	0	18	4	22
15/16 July	1	3	4	3	12	15
22/23 July	6	2	8	3	2	5
29/30 July	60	24	84	4	6	10
5/ 6 Aug.	7	3	10	6	8	14
12/13 Aug.	0	1	1	1	4	5
19/20 Aug.	1	0	1	1	3	4
26/27 Aug.	1	2	3	0	2	2
2/ 3 Sept.	15	9	24	1	0	1
9/10 Sept.	4	4	8	0	0	0
16/17 Sept.	0	0	0	1	0	1
23/24 Sept.	0	0	0	0	0	0
30 Sept./1 Oct.	2	0	2	0	0	0
7/ 8 Oct.	0	0	0	0	0	0
14/15 Oct.	0	0	0	0	0	0
21/22 Oct.	0	1	1	0	0	0
28/29 Oct.	0	0	0	0	0	0

WEEKLY % EMERGENCE OF L. CAESAR

(From batches deposited

Date of Deposition	15 -21 May	22 -28 May	29 May -4 June	5-11 June	12 -18 June	19 -25 June	26 June -2 July	3-9 July	10-16 July	17 -23 July	24 -30 Jly
1947											
6 Oct.	2.7	5.0	2.0	7.0	11.0	12.0	4.0	7.0	1.0	-	-
1948											
14 May											
5 July											
4 Aug.											
10 Sept.											
TOTALS:	2.7	5.0	2.0	7.0	11.0	12.0	4.0	7.0	1.0	0	0

WEEKLY % EMERGENCE OF L. CAESAR

(From batches deposited

Date of Deposition	14 -20 May	21 -27 May	28 May -3 June	4 -10 June	11 -17 June	18 -24 June	25 June -1 July	2-8 July	9 -15 July
1948									
14 May					8		2		
5 July		8	9	4	19	4	1		
4 Aug.		1	2	1	2	1			
10 Sept.		32	18	4	11	2.5	1.5	0.5	0.5
23 Oct.	2	39	9	4	4	4	6	2	0
1949									
18 May					40				
25 June									51
25 July									
8 Aug.									
20 Aug.									
	2	80	38	13	78	11.5	10.5	2.5	51.5

AT DURHAM DURING 1948.

during 1947 and 1948).

	31 Jly -6 Aug	7 -13 Aug	14 -20 Aug	21 -27 Aug	28 Aug. -3 Sep.	4-10 Sep.	11 -17 Sep.	18 -24 Sep.	25 Sep. -1 Oct	2-8 Oct	9 -15 Oct	16 -23 Oct	24 -30 Oct	31 Oct. -6 Nov.	7-13 Nov.
					26.0	17.0	2.0	1.0							
														2.0	1.5
	0	0	0	0	26.0	17.0	2.0	1.0	0	0	0	0	0	2.0	1.5

AT DURHAM DURING 1949.

during 1948 and 1949).

	16 -22 July	23 -29 July	30 July -5 Aug.	6-12 Aug.	13 -19 Aug.	20 -26 Aug.	27 Aug. -2 Sep.	3-9 Sep.	10 -16 Sep.	17 -23 Sep.
	0.5									
	2	1				1				1
	20	9								
				4	52	5				
								4	0.5	
	22.5	10	0	4	52	6	0	4	0.5	1

WEEKLY % EMERGENCE OF L. CAESAR

(From batches deposited

Batch Laid Down Approx.	15 -21 May	22 -28 May	29 May -4 June	5-11 June	12 -18 June	19 -25 June	26 June -2 July	3-9 July	10 -16 July	17 -23 July	24 -30 July
1947											
6 Oct.						0.5	1.5	3.5	15.5	11	7
1948											
15 June											6
5 July											
4 Aug.											
11 Sept.											
TOTALS:						0.5	1.5	3.5	15.5	11	13

WEEKLY % EMERGENCE OF L. CAESAR

(From batches deposited

1948	14-20 May	21-27 May	28 May -3 Jne	4-10 Jne	11-17 Jne	18-24 Jne	25 Jne -1 Jly	2-8 Jly	9-15 Jly	16-22 Jly	23-29 Jly
15 June					2	2	8	4	6	4	
5 July						7	3	2	1	1	1
4 Aug.						1	1	3			
11 Sept.					13.5	29	20	7	4	4	
1949											
25 June										7.5	9
25 July											
8 Aug.											
20 Aug.											
TOTALS:					15.5	39	32	16	11	16.5	10

AT MOORHOUSE DURING 1948.

during 1947 and 1948).

31 July -6 Aug.	7-13 Aug.	14 -20 Aug.	21 -27 Aug.	28 Aug. -3 Sep.	4-10 Sep.	11 -17 Sep.	18 -24 Sep.	25 Sep. -1 Oct.	2-8 Oct.	9-15 Oct.	16 -23 Oct.
2	1.5										
2					2						
							21	10	10	1	1
4	1.5				2		21	10	10	1	1

AT MOORHOUSE DURING 1949.

during 1948 and 1949.

30 July - 5 Aug.	6-12 Aug.	13-19 Aug	20-26 Aug.	27 Aug -2 Sep.	3 - 9 Sep.	10-16 Sep.	17-23 Sep.	
2								
	1				1			
34	5	2	1	1				
			9	12				
							1	
36	6	2	10	13	1	0	1	

Appendix.

CATCHES OF L. CAESAR MALES IN MEAT TRAPS AT DURHAM DURING 1948 AND 1949.

Week Ending	1948			1949		
	Trap I	Trap II	Total	Trap I	Trap II	Total
29/30 April	0	0	0	0	1	1
6/ 7 May	0	0	0	1	1	2
13/14 May	1	3	4	3	1	4
20/21 May	18	48	66	1	0	1
27/28 May	6	9	15	1	6	7
3/ 4 June	1	1	2	0	11	11
10/11 June	1	4	5	1	21	22
17/18 June	7	6	13	1	4	5
24/25 June	0	11	11	2	0	2
1/ 2 July	5	1	6	1	3	4
8/ 9 July	0	2	2	3	8	11
15/16 July	2	4	6	16	19	35
22/23 July	9	6	15	4	23	27
29/30 July	83	21	104	1	7	8
5/ 6 Aug.	16	6	22	2	3	5
12/13 Aug.	5	6	11	0	1	1
19/20 Aug.	18	25	43	0	4	4
26/27 Aug.	9	8	17	0	3	3
2/ 3 Sept.	4	8	12	2	1	3
9/10 Sept.	1	16	17	0	0	0
16/17 Sept.	0	0	0	3	0	3
23/24 Sept.	0	0	0	0	0	0
30 Sept./1 Oct.	1	0	1	0	0	0

WEEKLY % EMERGENCE FROM LUCILIA BATCHES DEPOSITED AT DURHAM DURING WINTER 1947-8.

(i.e. after the termination of the 1947 blowfly season and before the beginning of the 1948 one).

Date of Deposition	Week Ending: 21 May	28 May	4 June	11 June	18 June	25 June	2 July	9 July	16 July	23 July	30 July
L. SERICATA											
1947.											
20 Oct.			1	2.5	8	6.5	0	0.5			
30 Nov.	Nil.										
27 Dec.				0.75	0.5	0.75					
1948.											
23 Jan.					1	1					
20 Feb.						0.4	0.8	0.4			
24 Mar.					2.0	6.0	5.5	3.0	5.5	4.5	0.5
TOTALS			1	3.25	11.5	14.6	6.3	3.9	5.5	4.5	0.5
L. ILLUSTRIS											
1947.											
30 Nov.		2	2	12	6	2					
27 Dec.	1.5	0.75	3	2	3	6	2	3	1	1	
		(Plus 1% in August 1948 and 2.5% in 1949).									
1948.											
23 Jan.						1	0	0	1	1	
		(Plus 4% in 1949)									
20 Feb.					1.6					1.6	
		(Plus 1% in 1949)									
24 Mar.	4	12	4	2	0	0	0	0	0	4	
TOTALS	5.5	14.7	9	16	10.6	9	2	3	2	7.6	
L. CAESAR											
1947											
30 Nov.					2						
1948											
23 Jan.						0.4	0.4	0.8			
TOTALS					2	0.4	0.4	0.8			

Date Of Deposition	20 May	27 May	3 June
L. SERICATA			
1948			
23 Oct.		5	3
20 Nov.	1.5	28	3
18 Dec.			0.5
1949			
12 Feb.		8	26
11 Mar.	0.5	0	0
16 Apr.			
TOTALS:	2	41	32.5

L. ILLUSTRIS

L. CAESAR.			
1948			
20 Nov.	10	37	8
18 Dec.	2	1.5	1.5
1949.			
16 Apr.			4
TOTALS:	12	38.5	13.5

WEEKLY % EMERGENCE FROM LUCILIA BATCHES DEPOSITED AT DURHAM DURING WINTER 1948-9.

Week Ending:

10 June	17 June	24 June	1 July	8 July	15 July	22 July	29 July	5 Aug.	12 Aug.	19 Aug.	26 Aug.
4	15	5	4	1							
3.5	0.5	0	0.5	0.5	0.5	0	0	0.5			
1.5	0.5										
18	18	4									
2.5	6.5	10.5	2.5	6.5	1	1					
	0.5	0	2	16	16	15	13	2	1.5	1.5	1
29.5	41	19.5	9	24	17.5	16	13	2.5	1.5	1.5	1

No prepupae deposited.

5	0	1	1
1	1		
6	1	1	1

WEEKLY % EMERGENCE FROM LUCILIA

DURING THE

Date of Deposition	11 June	18 June	25 June	2 July	9 July	16 July	23 July
L. SERICATA.							
1947.							
Nov.-Jan.	No emergence.						
1948.							
28 Feb.				1	1	2	3
27 Mar.		1.5	1.5	1	1	0.5	0.5
20 Apr.	2	0.5	0.5	0	0.5	0.5	1
15 May.					0.5	0.5	0.5
TOTALS:	2	2	2	2	3	3.5	5
L. ILLUSTRIS.							
1947.							
2 Nov.				5	10	5	
28 Dec.			0.3	0.3	0	0	1
1948.							
24 Jan.						1	2
28 Feb.							
20 Apr.		2	9	10	12	11	1
TOTALS:		2	9.3	15.3	22	17	4
L. CAESAR.							
1947.							
1 Dec.	No emergence.						
1948.							
24 Jan.							
20 Apr.							
15 May							
TOTALS:							

BATCHES DEPOSITED AT MOORHOUSE

WINTER 1947-8.

Week Ending:									
30 July	6 Aug.	13 Aug.	20 Aug.	27 Aug.	3 Sep.	10 Sep.	17 Sep.	24 Sep.	1 Oct.
3	3	1	1	1					
0.5	0.5								
1	2	0.5	0.5	5	5	4	2		
0.5	0	0	0	3	3.5	13.5	9.5	2.5	1
5	5.5	1.5	1.5	9	8.5	17.5	11.5	2.5	1
1	3	1	1						
2	2	5							
	3	3	1	(Plus 5% in 1949)					
3	8	9	2						
				1					
					1	18	3	1	
				2	(Plus 8% in 1949)				
				3	1	18	3	1	

WEEKLY % EMERGENCE FROM LUCILIA BATCHES

Date of Deposition	24 June	1 July	8 July	15 July	22 July	29 July
L. SERICATA.						
1948.						
25 Sep.	2	0.5				
Oct.-Jan.	No emergence.					
1949						
12 Feb.				2	2	
12 Mar.	No emergence.					
9 Apr.	No emergence.					
16 Apr.				16	15.5	2
7 May					0.5	8.5
28 May					2.5	2.0
TOTALS:	2	0.5		18	20.5	12.5
L. ILLUSTRIS.	No prepupae deposited.					
L. CAESAR.						
1948.						
23 Oct.	2	1	2			
20 Nov.	2	2	1			
18 Dec.	No emergence.					
1949.						
16 Apr.	No emergence.					
7 May.					55	14
18 May	3	20	10	1		
TOTALS:	7	23	13	1	55	14

DEPOSITED AT MOORHOUSE DURING THE WINTER 1948-9.

Week Ending:								
5 Aug.	12 Aug.	19 Aug.	26 Aug.	2 Sep.	9 Sep.	16 Sep.	23 Sep.	30 Sep.
1	0.5							
7.5	1	1.5	6.5	4				
1.0	1.5	1	6	5	0	1	2.5	13.5
9.5	3.0	2.5	12.5	9	0	1	2.5	13.5

24
24

APPENDIX.

WEEKLY % EMERGENCE FROM

AT DURHAM DURING

AND

Date of Deposition	29 -30 Apr.	6-7 May	13 -14 May	20 -21 May	27 -28 May	3-4 June
C. VOMITORIA.						
1948.						
23 Jan.	0.7	7.0	16.7	4.7	0.3	0.3
20 Feb.			16.0	9.0	4	10
TOTALS:	0.7	7.0	32.7	13.7	4.3	10.3
C. ERYTHROCEPHALA.						
1947.						
30 Nov.			33			
1948.						
23 Jan.		0.3	15	6	4	2
20 Feb.					1	22
24 Mar.					4	0
TOTALS:		0.3	48	6	9	24
C. VOMITORIA.						
1948.						
18 Dec.		13.5	29	21	6	1
1949.						
12 Feb.			7	34	36	2
11 Mar.		3	70	1.5	0.5	
9 Apr.				70	10	
TOTALS:		16.5	106	126.5	52.5	3
C. ERYTHROCEPHALA.						
1949.						
12 Feb.		4	4	16	32	10
11 Mar.		1.5	10	4.5	19.5	1.5
TOTALS:		5.5	14	20.5	51.5	11.5

CALLIPHORA BATCHES DEPOSITED

THE WINTERS 1947-8
AND 1948-9.

Week Ending:							
10-11 June	17-18 June	24-25 June	1-2 July	8-9 July	15-16 July	22-23 July	29-30 July
5	4	1	0	1	1		
5	4	1	0	1	1		
1							
11	6	0.5					
0	0	16	2	10	8	2	
12	6	16.5	2	10	8	2	
4							
4							
3	12.5	3.5	0	4.5	0.5	2	0.5
3	12.5	3.5	0	4.5	0.5	2	0.5

WEEKLY % EMERGENCE FROM MOORHOUSE DURING THE

Date of Deposition	20-21 May	27-28 May	3- 4 June	10-11 June	17-18 June
C. VOMITORIA					
1947: 2 Nov.				5	1
1948: 24 Jan.	0.5	1.5	4	7.5	4
28 Feb.			4.5	6.5	13
14 May					
TOTALS:	0.5	1.5	8.5	19	18
C. ERYTHRO-CEPHALA.					
1947: 2 Nov.	No emergence.				
1948: 24 Jan.	1	1.5	2	3	2
28 Feb.				1	11
27 Mar.					2
27 Apr.					10
15 May.					
TOTALS:	1	1.5	2	4	25
C. VOMITORIA.					
1948: 20 Nov.				41	4.5
18 Dec.				6	1.5
1949 12 Feb.				3	14
12 Mar.				11.5	15
9 Apr.				12	11.5
7 May.					
TOTALS:				73.5	46.5
C. ERYTHRO-CEPHALA.					
1948: 23 Oct.				1	
1949: 12 Feb.					4
12 Mar.				0.5	7.5
9 Apr.				0.5	32
7 May.					1
18 May					
TOTALS:				2	44.5

CALLIPHORA BATCHES DEPOSITED AT WINTERS 1947-8 AND 1948-9.

Week Ending:

24-25 June	1- 2 July	8- 9 July	15-16 July	22-23 July	29-30 July	5- 6 Aug.	11-12 Aug.	18-19 Aug.	25-26 Aug.
2	1	0.5							
12.5	2.5	1	0.5						
	24	34	12	2	2	2	1	1	8
14.5	27.5	35.5	12.5	2	2	2	1	1	8
1	0.3								
14	7								
4	12	4	4	5	5	4			
46	22	6.5	1						
	11	19	11	3	3	3	5	4	
65	52.3	29	16	8	8	7	5	4	
1									
20	1								
65.5	14								
86.5	15								
2	4								
1.5	1								
7.5	0	2	9	5					
29	17.5	1	3.5	4	1.5				
	23	4	9	11	1	0	1	2	1
40	45.5	7	21.5	20	2.5	0	1	2	1

Table 10

Examination of Contents Of Durham Soil Tins deposited during 1947 and 1948

DATE OF DEPOSITION	PREPUPAE DEPOSITED			PUPARIA RECOVERED			TOTAL	EMERGENCE		COMMENTS
1947	LUCILIA	CALLIPHORA	PROTOPHORMIA	LUCILIA	CALLIPHORIA	PROTOPHORMIA	LUCILIA	LUCILIA	PROTOPHORMIA	
15 Aug.	300			90E+4D			195			A considerable proportion of all species were able to pupate and metamorphose successfully. Some evidence of slight parasitism
31 Aug.	210			110E+6D+6P			113			
6 Sept.	250			101E+11D			101			
20 Sep.	221	50		45E	21E		34	27		
6 Oct.	150	200		150E	46E		79	134		
18 Oct.	400	400		293E+18F+2P	73E+20F		66	146		
4 Nov.		200	200		42E+11D	NIL		99	NIL	Some Calliphora prepupae pupated, but no Protophormia.
30 Nov.	200	34		4E+2L	13E		1	11		All species failed to pupate
30 Nov.	50		200	8E+1L		NIL	12		NIL	
27 Dec.	800			107E+1F+6D+5L			104			Calliphora pupated successfully, Lucilia less successfully, Protophormia not at all.
1948										
23 Jan.	500	300		5E	85E+1F+1L		4	86		
23 Jan.	100	300	150	15E+2D	109E+7D	NIL	7	89	NIL	
20 Feb	560	700	85	8E+1D+1L	341E+4L+6D	NIL	10	334	NIL	
24 Mar.	250	50	500	74E+6L+3D+4F	28E+1D+1F	110E+215D+26F+8L	67	21	13	Fairly successfull pupation of all species, but a large number of Protophormia died in pupal stage.
26 Apr.	525	100	400	205E+10D+7F	96E+1D+3F	244E+82D	?	92	152	
15 May	250	500	400	116E+10D+4L+5F+6P	394E+6D+3F+6P	343E+31D+15F+1L	98	366	324	Over 50% pupation of all species. Some evidence of slight pupation.
15 June	500	150	500	345E+15D+15F+3L+5P	133E+2D	399E+10D+14F+2L+2P	75	120	379	
3 July	400	50	50	205E+2D	32E&3D	18E+11D	206	36	18	
15 July	200	100	300	173E+5F+5P	55E+3P	243E+12D+1P	151	84	242	
4Aug.	40	250	400		164E+4F+1L	86E+9D+1F+2L	17	160	255	
4 Aug.	600	250		120E+2F	90E+7D+1F		265	212		
24 Aug.	650	300		334E+1D+12P	272+6D+10P		286	261		
10 Sep.	50	400	200	44E+1D+1F+3P	177E+3D+20F+7P	185E+1D+11F	47	233	162	
10 Sep.	600	100		396E+11D+7F+3P	90E+3D+1F		380	93		
23 Oct.	290	90	70	131E+1D	66E+2D+19F	17E+47F	160	18	NIL	Less successful pupation in Lucilia and Protophormia than in Calliphora. Many died in pupal stage

KEY:- E = Normal emergence. D = decayed or dried out pupa (death in early pupal stage)

F = Pupa containing remains of a ølly. P = Parasitised pupa.

Table 21 The Duration (in Days) of the Prepupal and Pupal Periods (at 22°C) of the Offspring from Wild Culture *L. sericata* females

DATE ON WHICH EGGS WERE LAID	EXPT.	ONSET OF PUPATION		50% PUPATION		90% PUPATION		1st EMERGENCE		50% EMERGENCE		90% EMERGENCE	
1948		Culture	Field	Culture	Field	Culture	Field	Culture	Field	Culture	Field	Culture	Field
23 August	(18)	3	4	3	5	30	10	12	14	14	17	-	-
10 September	(39)	3	22	5	101	7	107	13	77	16	117	-	-
1949													
29 August	-	2	4	3	5	5	7	12	14	14	17	-	-
5 September	-	3	3	4	11	14	-	13	13	17	-	-	-
12 September	A	3	3	5	6	7	-	13	13	15	16	-	-
12 September	B	3	3	4	6	7	-	13	13	14	18	-	-
28th September	J	2	6	2	47	14	79	11	13	13	58	-	81
28 September	K	2	5	2	45	14	90	11	13	13	68	-	98
7 October	T	3	6	4	66	9	104	12	16	14	95	15	-
7 October	U	-	5	-	81	-	98	-	16	-	115	-	-
14 October	V	1	7	3	73	6	96	12	16	12	82	-	-
14 October	W	1	8	2	73	6	96	11	17	12	82	15	-

Table 22 The Duration (in Days) of the Prepupal Period (at 22°C) of the Offspring from Wild *L. sericata* Females Which Had Been Kept Under Culture Conditions For Various Periods.

DATE ON WHICH FLIES WERE CAUGHT	ONSET OF PUPATION			50% PUPATION			90% PUPATION		
No of Days under culture conditions	1-2	8-11	15-19	1	8-11	15-19	1-2	8-11	15-19
1949									
11 September	3	3	5	6	5	6	-	86	8
11 September	3	-	4	6	-	7	-	-	9
27 September	5	6	3	46	24	10	90	98	17
5 October	6	7	3	66	74	7	104	97	5
5 October	5	8	3	81	74	4	93	97	5
13 October	7	6	-	74	72	-	96	112	-
13 October	8	4	-	74	73	-	96	98	-