STUDIES ON THE EFFECT OF HOST NUTRITION ON THE LARVAL PARASITE, *MICROBRACON BREVICORNIS* WESMAEL

(BRACONIDAE: HYMENOPTERA)

By

SUSAMMA MATHAI, B. Sc.

THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY) OF THE UNIVERSITY OF KERALA

DIVISION OF ENTOMOLOGY
AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE,
VELLAYANI

1965

C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Smt. Susamma Mathai under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

(Dr. C.K.N. NAIR)
Principal & Addl. Director
of Agriculture (Research).

(G. RENGA AYYAR)
Junior Professor of
Entomology.

Agricultural College &
Research Institute,
Vellayani, Kerala,
Date: -- --1965.

ACKNOWLEDGEMENT

The author records her deep sense of gratitude to Sri. G. Renga Ayyar, M.Sc.,Assoc.I.A.R.I.,M.S.(Tennesse), Junior Professor of Entomology, Agricultural College and Research Institute, Vellayani, for the valuable guidance and help rendered in the execution of this work and in the preparation of the thesis.

She is greatly indebted to Dr. M.R.Gopalakrishnan Nair, M.Sc.,Assoc.I.A.R.I.,Ph.D,F.E.S.I., Professor of Entomology, for the constant encouragement, valuable suggestions and constructive criticisms offered throughout the course of this investigation.

The author's thanks are due to Dr. C.K.N. Nair, M.Sc., Ph.D.(Cornell),D.R.I.P.(Oak Ridge), Principal & Additional Director of Agriculture (Research) for kindly providing the necessary facilities for the conduct of this work and for many other courtesies extended.

Helps rendered by Sri. Abraham Jacob, M.Sc.(Ag.), Lecturer in Entomology and Sri. N. Mohandas, M.Sc., Senior Lecturer in Entomology are gratefully acknowledged.

The author wishes to express her sincere thanks to the members of the staff of the Division of Entomology, for their co-operation and generous help.

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INTRODUCTION

There can be little doubt that a knowledge of the role of nutrition in insect parasites could be regarded as an important key to the successful introduction, multiplication and establishment of any parasitic species from one country to another where they are either scarce or altogether absent (Narayanan, 1957). Wolcott (1939) observes that the successful introduction and establishment into Peurto Rico from Brazil of a large wasp Larra americana Sauss., which is a parasite of the mole cricket, Scapteriscus vicinus Scud., depend on the presence in Peurto Rico of the two weeds Borreyia verticillata and Hyptis atrorubens from whose flowers the wasps obtain the nectar, the only source of their nutrition. When the weeds are not in flower the wasps are short lived, they decline in numbers and eventually perish. This feeding habit of the parasite and corresponding increase in longevity appears to have some influence on its power of prolificacy to lay greater number of eggs.

It is also recorded that many parasites belonging to the families Chalcidae, Braconidae and Ichneumonidae sting and feed on the body fluid of their host to

complete oogenesis. Metaphycus helvolus the Encyrtid parasite of black scale, Saissetia oleae (Bern.) feeds normally on the host and usually produces about 400 eggs. When host feeding is either prevented or interrupted the parasite lays only some 50 eggs (Doutt, 1960).

The food plant on which the host develops may also render it either suitable or unsuitable to a specific parasitic attack. Flanders (1939) has shown that Habrolepis rouxi Comp., developed readily on the Californian red scale Aonidiella aurantii (Mask) infesting citrus trees; but the parasite failed to complete its development on the same host found on Cycas revoluta. Since the food requirements of parasitic insects differ from species to species it is only reasonable to assume that such requirements determine the suitability of a host for parasites, in much the same way that the food requirements of the Mediterranean fruit fly determine the kinds of fruits in which it can develop.

The fact that the nutrition of the mother may affect not only her own fertility, but also the development of her offspring is strikingly illustrated by the work of Reynolds (1945).

These observations tend to suggest the presence of certain essential nutritional factors in suitable hosts which are either totally wanting or present in too low concentrations in unsuitable hosts. An intimate knowledge of these intriguing but nevertheless interesting phenomenon would greatly facilitate the mass multiplication and introduction of insect parasites to control noxious insect pests in any locality.

Though considerable amount of work on nutritional requirements of insects have been done in general as Sweetman (1958) had pointed out, little definite information exists relating to the feeding habits of many groups of parasitoids.

Therefore with view to studying the nutritional requirement of Microbracon brevicornis Wesm., an important larval parasite used to control the black headed coconut caterpillar, Nephantis serinopa Meyr., the present work was undertaken.

Microbracon brevicornis Wesm., is mass-multiplied in the biological control laboratories of Kerala state using the larvae of Corcyra cephalonica (Stainton) as the laboratory host and the parasites are periodically released

in large numbers throughout the coastal tracts of the state to keep the black headed coconut caterpillar under check. The studies envisaged here aims to find out the effect of various host nutrition on development, longevity, fecundity and sex-ratio of the adult parasitoid, Microbracon brevicornis using the larvae of Corcyra cephalonica as the laboratory host. Though work on this aspect of a parasitoid has received scanty attention, some work on this line has been initiated by Katiyar (1962) on Microbracon gelechiae and Trichogramma evanescens minutum.

A brief review of work done on the effect of nutrition on fecundity, development and longevity of insects with special reference to entomophagous forms is also presented.

REVIEW OF LITERATURE

EFFECT OF NUTRITION ON FECUNDITY, DEVELOPMENT AND LONGEVITY OF INSECTS WITH SPECIAL REFERENCE TO ENTOMOPHAGOUS FORMS

Insects can maintain life over relatively long periods of time on a diet of very limited nature or even without any food. In order to grow and reproduce, insects like other animals require in their food adequate quantities of water, minerals, organic compounds as a source of energy, carbon, nitrogen, sulphur, essential aminoacids and vitamins which are indispensable to the functioning of protoplasm and which they are unable to synthesise (Trager, 1953).

EFFECT OF NUTRITION ON FORM, DEVELOPMENT AND LONGEVITY

Limitation of the quantity of food available to growing insect ordinarily results in the formation of an adult of reduced size. Metalnikov (1908) and Titschack (1926) had shown that adult waxmoth and clothes moth of only one tenth normal weight can be obtained from partially starved larvae and partial starvation prolonged

the length of larval period and increased the number of moults. The small adult females obtained from the larvae reared on a quantitatively inadequate diet laid fewer eggs both absolutely and in proportion to their weight than female moths from adequately fed larvae. However, partial or complete starvation during the late larval periods seemed to accelerate metamorphosis in most holometabolous insects. The adaptive significance of an insect's ability to curtail its larval period if the food supply is suddenly exhausted is well illustrated by the investigation of Lafon et al (1939) on the larvae of meal worm Tenebrio molitor. Complete starvation of larger larvae produced premature but otherwise normal metamorphosis and the larval period was shortened by two months with elimination of at least two larval instars.

Bergman (1940) had observed that the quality of food profoundly influences the development of insects. He found that though the silkworm larvae could develop on a diet of lettuce leaves, their growth was far inferior to that obtained on mulberry leaves. The larvae of potato beetle Leptinotarsa decemlineata feed well on Solanum hendesonii and S. capsicastrum but they failed to complete the development on these plants

though the nature of substances responsible for such effect is not known (Trouvelot et al, 1933).

The entomophagous parasites present some interesting nutritional peculiarities. This is not surprising since most parasitoids are highly specialised and are restricted to few species of hosts (Trager, 1953). Since the food requirements of parasitic insects differ, it is reasonable to assume that such requirements determine the suitability of a host for parasite, in much the same way that the food requirements of the Mediterranean fruit fly determine the kinds of fruit in which it can develop (Flanders, 1938). The host of the parasitoid is not only its food but it is also the environment in which it lives, nourishes and completes its development (Doutt, 1960). Unlike others this environment is dynamic and complicated with all biological phenomena of life and therefore it exerts an unparalleled influence on the rate of development of the parasitoid in a remarkable manner. As Salt (1941) mentioned, the host is not a passive victim and it is often able to impress its mark upon the parasitoid that systematically destroys it. It may bequeath to its parasite important, sometimes striking legacy of morphological, physiological and behaviouristic characters.

Some interesting effects on form probably of a nutritional nature have been observed in Trichogramma semblids by Salt (1937 and 1938). When the egg parasites were reared in the eggs of the moths, Ephestia kuehniella, Sitotroga cerealella or Barathra brassicae or in two species of Chrysopa all the males were winged. When the parasites were allowed to develop in Sialis sp., (Neuroptera), 417 out of 419 males emerged were wingless and they possessed markedly different antennae from those of winged forms. He also observed that Trichogramma evanescens was unable to mature in Sialis lutaria, and a few that could complete development and emerge out were feeble, showed physogastry and soon died. T. evanescens larvae likewise failed to develop to adult stage in the eggs of the beetle, Tenebrio molitor although they reached prepupal or pupal stage. Again the parasitic larvae developing in the eggs of Bruchus sp. were colourless and transparent whereas those developing in normal host such as Ephestia were cream-coloured and opaque. All these observations suggest the presence of certain essential nutritional factors in suitable hosts which are either lacking or present in too low a concentration in unsuitable host (Trager, 1953).

In an unsuitable host the parasite succumbs while it is in a stage of rapid growth either as embryo or as a larva in suitable hosts (Flanders, 1938). Narayanan *et al* (1955) studied in detail the effect of different hosts on development of *Microbracon gelechiae*. The development of the parasite when bred on different hosts varied considerably; the parasite took nearly 15-18 days on *Dichocrocis* larvae as against the usual 10-11 days on *Corcyra* host to complete its development. Narayanan *et al* (1955) have studied the effect of nutrition on *Trichogramma evanescens minutum* and the following results were obtained. Freshly emerged unmated males lived for one day without food and water or on extract of *Corcyra* eggs. Supplied with water only they lived for two to three days. When fed on different sugars like glucose, fructose, sucrose and maltose, the parasites lived for four to six days. With glucose and proteins (like skimmed milk, yeast extract or *Corcyra* egg extract) they lived for three to four days. The corresponding figures for freshly emerged unmated females were two days, three days, nine to ten days, and three to eight days. The authors have noticed that out of the four sugars tried, fructose showed significant increase in longevity and addition of protein in nutrition had no effect.

EFFECT OF NUTRITION ON FECUNDITY

The fertility of an adult insect depends in whole or in part upon the adequacy of its nutrition during the pre-imaginal stages. Some insects, such as the saturnid moths take neither food nor water during adult stage, so that all the nutritional requirements for bodily activity during an adult life of a week or two and for the development of hundreds of eggs by the female must have been obtained from food stored during larval life (Trager, 1953).

Stober (1927) had stated that many Lepidoptera, Diptera and Hymenoptera require during their adult life only some carbohydrate as a source of energy. It is only among female insects that special nutritional requirements for reproduction in addition to a source of energy, have been observed. Grison (1947) found that the number of eggs laid by female potato beetles depend on the species of plant on which they feed and also on the age of the leaves they eat. Beetles fed on old potato leaves laid only 8-20 eggs whereas beetles fed on young potato leaves laid 30-50 eggs. He attributed this prolificity to the higher lecithin content of younger leaves since

beetles fed on potato leaves coated with lecithin emulsion laid more eggs than those fed on untreated leaves.

Glaser (1923) observed that Musca domestica laid a few eggs when fed on sucrose alone but they laid more eggs when fed on sucrose plus bouillon. He also mentioned that the biting fly, Stomoxys calcitrans laid no eggs if fed on serum alone or washed blood cells alone but feeding on a combination of these two blood fractions produced normal longevity and reproduction.

Hobson (1938) noted that the blowfly Lucilia sericata normally requires a meal of meat juice before it will lay eggs and that the meat could not be replaced by either milk, blood serum or other protein containing materials. However a combination feed of serum with autolyzed yeast induced prolificity as good as that obtained with meat juice.

The relation of blood meals to egg production by mosquitoes provides an especially interesting illustration of the effects of nutrition on fecundity (Hecht, 1933). Culex pipiens laid twice as many eggs per milligram of blood ingested after a meal of canary blood as after a

meal of human blood. Observations made by Roubaud et al (1934) showed that Aedes aegypti laid more eggs when fed on rabbit, guinea pig, canary or turtle or frog blood than when they are fed on human blood.

Buxton (1948) found that fleas, Xenopsylla cheopis fed well and lived normally on baby mice; but they laid only a small number of eggs. However if the fleas were first fed for a few hours on an adult mouse and thereafter on baby mice they laid larger number of eggs.

Evidently these observations as pointed out by Trager (1953) show that there is not only a requirement for an ample quantity of protein in the diet for normal fecundity but specific proteins or accessory substances or both are also required.

In the honey bee colony worker or neuter type female is apparently differentiated from the queen type by nutritional factors. It is well known that if newly hatched honey bee larvae are transferred from worker cells to queen cells before the third day of larval life they develop into queens (Grout, 1949). Despite the weight of the traditional view that honey bee queens are differentiated from workers through receiving "royal jelly", a nitrogenous glandular product after the 3rd day,

Haydak (1943) has pointed to the significant fact that the queen larvae are fed continuously throughout their development whereas after the third day worker larvae are fed only at intervals. Kuwabara (1948) has advanced evidence favouring the view that queens are differentiated developmentally from workers on a quantitative rather than a qualitative trophic basis. Wheeler (1923) considered the worker ant 'a hunger form' inadequately nourished to an incomplete development of the ovaries. It is significant to note that the production of annual sexual brood containing queens or female reproductive forms in social insects occurs when food is most plentiful (Wheeler, 1928, Cumber, 1949).

The fact that the nutrition of the mother may affect not only her own fertility but also the development of her offspring is strikingly illustrated by the flour beetle Tribolium destructor (Reynolds, 1945). The offspring of adults fed on less highly extracted wheat flour (85%) developed more rapidly than those of adults fed on more highly extracted flour (60%). The effect of parental diet was so strong that the larvae fed on the (60%) flour but descended from adults fed on (85%) flour, grew better than those which received the better diet but were descended from adults fed on inferior diet.

Though the immature parasitoid is completely entomophagous it may have a quite different nutritional requirement as an adult. Many feed on honey dew, nectar and other organic substances (Sweetman, 1958). According to Doutt (1960) honey dew is extremely valuable and naturally available food for many species. It has several essential aminoacids in free state, a high concentration of carbohydrates, vitamins and minerals. Experiments have shown that not only is honey dew required by many insects for egg production, but a synthetic substitute for honey dew can be formulated in a chemically defined diet (Hagen, 1950). Chrysopa fed on honey produced about 100 eggs. If fed on honey dew or chemically defined substitute the individual produced nearly 1000 eggs. Even the distribution of some parasites are entirely influenced by the location of the source of honey dew (Sweetman, 1958). The adults of Tiphia vernalis Roh., a parasite of the notorious Japanese beetle grub normally feed on aphid honey dew (Gardner, 1938). In Puerto Rico, Tiphia wasps never become abundant enough to be effective against white grubs where the availability of honey dew is quite scarce. However these wasps in Haiti depend on the nectar of the flowers of wild Parsley Pastinaca sativa L., which is prevalent throughout the year and the parasite population is adequate to keep the white grub

population at a much lower level than in Puerto Rico where neither the nectar from the weed nor the honey dew is available for the adult wasp (Wolcott, 1942).

Larra americana, a larval parasite of the mole cricket Scapteriscus vicinus Scud., depends on the nectar obtained from two weeds Borreria verticillata and Hyptis atrorubens. The distribution of the wasp entirely depends on the distribution of these two weeds in Puerto Rico (Wolcott, 1942).

On the other hand there are many parasitic hymenoptera that appear never to frequent flowers and probably they exist on organic materials available by preying on the fluids exuding from wounds of their insect hosts (Sweetman, 1958). A number of species feed quite commonly on the host body fluids that exude from the wounds produced by the insertion of the ovipositor, especially if the host is exposed. This phenomenon was first observed by Marchal (1905) in the chalcid genus Tetrastichus and Doten (1911) gave an excellent description of this habit. The feeding punctures may be made only on the particular stage of host which is attacked by the parasite. When feeding punctures are made for feeding purposes only oviposition often takes place in

another individual of the same host species. Frequently a number of individuals may be punctured in succession without any deposition of eggs taking place. Faure (1924) has described the process in some detail with respect to two chalcids of the genera Pteromalus and Eurytoma and he concludes that this habit is frequent as a method of extracting nutrient from the hosts. Flanders (1935) states that it is probable that nitrogenous food of this kind is necessary to secure complete maturation of eggs before oviposition and this habit is associated with the stage of development of ovarian follicles.

Flanders (1942 and 1953) had demonstrated that if Metaphycus helvolus, a parasite of black scale Saissetia oleae is withheld from its hosts for long periods ovigenesis ceases from lack of protein. When placed with its host, the female immediately starts feeding upon it and three days later begins to oviposit.

Narayanan et al (1955) in their studies found that addition of fructose in the nutrition of Trichogramma gave excellent results. They also noticed that addition of protein resulted in the lowering of the fecundity of the parasites. The authors are of opinion that the parasites cannot assimilate any more quantity of protein than that ooze out of the host eggs when punctured for oviposition.

Katiyar (1962) had studied the effect of nutrition on the fecundity and longevity of Bracon gelechiae and Trichogramma evanescens minutum using their host Corcyra cephalonica, reared on various synthetic diets. The parasites bred from Corcyra reared on crushed sorghum mixed with 8% yeast gave the best results.

MATERIALS AND METHODS

A. MATERIALS

a) Hosts.

Adult moths of Corcyra cephalonica were obtained from the Parasite Breeding Station attached to the Division of Entomology, Agricultural College, Vellayani. All these moths were those emerged from larvae reared only on coarsely ground whole wheat flour. The eggs collected from these moths were utilised for the production of host larvae used in these experiments.

b) Parasites.

Microbracon brevicornis used for rearing a stock culture of parasites for the experiments were also obtained from the Parasite Breeding Station attached to the Division of Entomology, Agricultural College, Vellayani. The parasites were those continuously bred on host larvae, Corcyra cephalonica, reared on wheat flour only.

c) Materials used for the preparation of nutrient media on which host larvae were reared during the experiments.

The following materials were utilised for preparation of nutrient media for rearing Corcyra larvae for the experiments.

1. Coarsely ground whole wheat flour, obtained from the local market.
2. Bengal gram powder, got from the local market.
3. Black gram powder, obtained from the local market.
4. Skimmed milk powder, obtained from the local market.
5. American flour, obtained from the local market.
6. Yeast extract, Manufactured by ALEMBIC CHEMICALS, BARODA.
7. Glucose, manufactured by BRITISH DRUG HOUSE, BOMBAY.
8. Fructose, manufactured by BRITISH DRUG HOUSE, BOMBAY.
9. Whole cream milk powder - Busck Jun and Co., A/S Copenhagen, Denmark.

10. Thiamin manufactured by ALEMBIC CHEMICALS, BARODA.

d) Egg laying chamber. (Fig. 1)

A wide mouthed 1 lb. bottle with thin wire gauze tied over its mouth was kept inverted over a deep petri-dish and this chamber was utilised for the collection of Corcyra eggs. The eggs laid by the moths were collected from the petri-dishes and were utilised for rearing host larvae on different nutrient media. By this method a continuous regular supply of eggs were obtained.

e) Rearing of host larvae. (Fig. 2)

Corcyra larvae were reared on the different nutrient media contained in rectangular glass troughs measuring 26 cm. x 17 cm. x 9 cm.

f) Rearing of parasites. (Fig. 3)

The parasites Microbracon brevicornis were reared in specimen tubes measuring 7.5 cm. x 2.5 cm.

g) Feeding of the adult parasites.

Adult parasites were fed on diluted honey streaked on narrow pieces of elongated coconut leaf bits.

B. METHODS

The following nutrient media were prepared for rearing the host, Corcyra cephalonica larvae.

Medium A. Coarsely ground wheat flour used as basic diet.

Medium B. Mixture of coarsely ground wheat flour fortified with Yeast extract (3% by weight).

Medium C. Mixture of coarsely ground wheat flour (75% by weight) + Bengal gram powder (25% by weight).

Medium D. Mixture of coarsely ground wheat flour (75% by weight) + Black gram powder (25% by weight).

Medium E. Mixture of coarsely ground wheat flour (75% by weight) + Glucose (25% by weight).

Medium F. Mixture of coarsely ground wheat flour (75% by weight) + Fructose (25% by weight).

Medium G. Mixture of coarsely ground wheat flour (50% by weight) + Black gram powder (25% by weight)++

Glucose (25% by weight), fortified with 3% Yeast by weight.

Medium H. Mixture of coarsely ground wheat flour (75% by weight) + Whole cream milk powder (25% by weight).

Medium I. Mixture of coarsely ground wheat flour (75% by weight) + Skimmed milk powder (25% by weight).

Medium J. Mixture of coarsely ground wheat flour fortified with Thiamin 25 µg./gm. by weight.

Medium K. American flour.

1. Preparation of nutrient media on which host larvae were reared during experiments.

Mixtures B, C, D, E, F, G, H and I were prepared as follows.

i) The required quantity of the component material was added on to a part of the basic diet first and thoroughly mixed up. This mixture was further mixed with the rest of the basic diet so that a uniform constituency was obtained.

ii) In the case of Thiamin (J) the required quantity was weighed out and was dissolved in water. The liquid was sprayed uniformly on a part of the basic diet. This was dried under shade (room temperature) and later mixed throughly and uniformly with the rest of the basic diet.

2. Rearing of the host.

The adult moths (both males and females) of Corcyra were kept in the egg laying chamber and the eggs were collected from the Petridish.

Lots of 500 gm. of the different nutrient media were taken in each rectangular glass trough and about 200-300 eggs collected as mentioned above were introduced into each. The troughs were then kept closed by covering their mouths with thin muslin cloth tied with rubber bands. Observations were made in each lot on the hatching of the eggs, the duration of development of the larvae, pupation and emergence of the adult. The last instar larvae collected from each medium were utilised for the various experiments.

3. Rearing a stockculture of Microbracon brevicornis.

A stockculture of the parasite reared on Corcyra larvae fed on coarse wheat flour alone, was maintained in the laboratory and utilised for different experiments. This standardised method of rearing the parasite minimised to a large extent the variation in size, vigour etc. of the parasites used for different experiments.

The female parasites were easily identified by the presence of the prominent ovipositor. Five Corcyra larvae reared from each medium were introduced into a specimen tube into which a mated pair of Microbracon brevicornis (male + female) had already been introduced. From each medium ten lots of caterpillars were exposed to ten different pairs of parasites. The specimen tubes were closed with cotton plugs and were arranged on a tube rack and kept under close observation.

The number of eggs laid, the duration of development of parasitic larvae, sex-ratio etc. were recorded. The parasites emerged from each lot was used for studies on their longevity and fecundity.

During the experiments the parasite Microbracon brevicornis was fed on honey diluted with water (1:3)

twice, first on the 2nd day after emergence and then on the 5th day after emergence.

4. (a) Determination of period of development of the host larvae (Corcyra)

The period of development of the host larvae in each food medium was calculated as the number of days from the date of hatching of eggs introduced till the pupation of the larvae.

(b) Determination of period of development of parasite Microbracon brevicornis

The period of development of the parasites was determined as the number of days from the date of oviposition of the parasites till the date of emergence of the adults from the hosts.

5. Determination of longevity, total number of parasites emerged and sex-ratio.

Ten pairs of parasites emerged from the host larvae fed on each nutrient medium were taken in ten separate tubes. Care was taken to see that the parasites thus collected in each tube were those emerged on the same

day. The parasites were fed on diluted honey. The longevity of the parasites emerged from each lot of caterpillars fed on different media was recorded.

The total number of parasites emerged from each lot of larvae reared on different nutrient media was found out by counting the number of adults emerging daily.

The sex-ratio of the parasites emerging was also recorded.

6. Measurements of parasites and host larvae.

Measurements of ten parasites selected at random from the host larvae reared from different food media were recorded. The parasites were mounted on a slide in glycerin with the dorsal side upwards. The measurements were made under a microscope with the help of micrometers. The measurements of the host larvae were made with the help of a pair of dividers against a millimeter scale.

EXPERIMENTS AND RESULTS

With a view to studying the effect of the host, Corcyra larva reared in different nutrient media on development, fecundity and longevity of Microbracon brevicornis, a larval parasite of the former, the following two series of experiments were carried out.

In the first series of experiments, eleven different nutrient media were utilised to ascertain their effect on the development and growth of Corcyra cephalonica larvae. Coarsely ground whole wheat flour was maintained as the basic diet throughout.

Different nutritive media used.

A. Coarsely ground whole wheat flour (basic diet).

B. Coarsely ground wheat flour fortified with Yeast extract (3%).

C. Mixture of coarsely ground wheat flour (75%) + Bengal gram powder (25%).

D. Mixture of coarsely ground wheat flour (75%) + Black gram powder (25%).

E. Mixture of coarsely ground wheat flour (75%) + Glucose (25%).

F. Mixture of coarsely ground wheat flour (75%) + Fructose (25%).

G. Mixture of coarsely ground wheat flour (50%) + Black gram powder (25%) + Glucose (25%), fortified with 3% Yeast.

H. Mixture of coarsely ground wheat flour (75%) + Whole cream milk powder (25%).

I. Mixture of coarsely ground wheat flour (75%) + Skimmed milk powder (25%).

J. Coarsely ground wheat flour fortified with Thiamin 25 mg./gm.

K. American flour.

Five hundred grams of each of the above media was utilised to rear about 200 caterpillars.

Period of experiment: 6-10-1964 - 22-12-1964.

Temperature during the period: Minimum: 74°F - 79°F.
Maximum: 80°F - 83°F.

R.H. during the period: 80% - 92%.

About 200-350 eggs were introduced into each medium and detailed observations were recorded on the nature and duration of development, size of the larvae etc.

Results of the experiment are presented in Table I. A minimum larval period of 28 days was observed on larvae fed on a medium containing coarsely ground whole wheat flour and fructose. A maximum of 42 days was observed in the larvae reared from the basic diet medium containing coarsely ground whole wheat flour. Addition of black gram powder and glucose to the basic diet fortified with yeast shortened the larval period nearly by ten days. All other media exerted more or less the same influence on the larval development of Corcyra. Regarding pupal duration a minimum period of eight days was seen in larvae fed on a basic diet mixed with bengal gram powder. However the longest pupal duration was noticed in medium containing the basic diet to which either skimmed milk powder or black gram powder was added. Addition of fructose to basic diet had not exerted any influence on the duration of pupal period. In all other media the pupal duration did not show much change.

Total developmental period was considerably reduced to the minimum of 44 days in the medium containing basic diet to which fructose was added. The longest duration of 54-56 days was noticed in the medium containing the basic diet only or the basic diet to which whole cream milk powder was added. The basic diet to which either skimmed milk powder or glucose was added also showed prolongation of total developmental period. All other media exerted only more or less similar influence on the total developmental period of Corcyra cephalonica. Largest sized larvae measuring 18.75 mm. x 1.46 mm. were reared on a medium of basic diet to which glucose, black gram powder and yeast were added. Smallest sized larvae measuring 10.50 mm. x 1.01 mm. were reared from media containing basic diet to which glucose was added. Similar results were noticed by addition of black gram powder to basic diet also. All the other media practically showed no great variations between them.

The second series of experiments (A to K) were carried out to ascertain the effect of varied host nutrition on the fecundity, longevity, sex-ratio, development and size of the parasite Microbracon brevicornis.

TABLE I

DURATION OF DEVELOPMENT AND SIZE OF CORCYRA LARVAE REARED ON VARIOUS NUTRITIVE MEDIA

Name of Nutritive medium	LIFE - CYCLE				Average length of 25 larvae (mm.)	Average width of 25 larvae (mm.)
	Average incubation period of 25 eggs	Average larval period of 25 larvae	Average pupal period of 25 pupae	Average Total duration (days)		
A. Coarsely ground wheat flour	4	42	10	56	16.50	1.34
B. do. fortified with yeast	5	36	12	53	16.00	1.29
C. do. + bengal gram powder	4	36	8	48	15.50	1.25
D. do. + black gram powder	3	33	13	49	10.75	1.03
E. do. + glucose	5	36	11	52	10.50	1.01
F. do. + fructose	6	28	10	44	15.60	1.26
G. do. + black gram powder + glucose, fortified with yeast	6	32	11	49	18.75	1.46
H. do. + whole cream milk powder	4	39	11	54	15.33	1.14
I. do. + skimmed milk powder	5	34	13	52	16.33	1.32
J. do. fortified with thiamin	3	34	11	48	15.50	1.22
K. American flour	4	34	11	49	15.56	1.26

EXPERIMENT A

Effect of Corcyra larvae as host reared on the medium containing coarsely ground wheat flour to its parasite Microbracon brevicornis.

Experimental details

No. of host larvae used in each lot for parasitisation:	5
No. of parasites exposed:	2 (1 male + 1 female) (a pair mated)
No. of pairs of parasites studied:	10
Stage of the host larvae exposed:	Early stages of last instar larvae
Period of the experiment:	22-10-1964 - 22-12-1964
Temperature during the period:	Maximum: 80°F - 83°F Minimum: 74°F - 78°F
R.H. during the period:	77% - 92%

Procedure: Five last instar Corcyra larvae were exposed to each pair of mated (male + female) parasites and

observations were recorded on their development, longevity, fecundity and sex-ratio. The observations were repeated on ten different pairs of parasites.

Results: Table II gives the results of the experiment showing the duration of life-cycle, sex-ratio, biometrical studies and mortality during egg, larval and pupal stages.

The life-cycle was completed on an average of 11.3 days, which consisted of 4.8 days as egg period, 2 days as larval period and 4.5 days as pupal period. The ratio of male to female parasites was 10:17. The average length of the parasite observed was 2.52 mm. The length of the antennae was 1.22 mm. and that of the wing span was 2.37 mm. The length of the ovipositor was 0.55 mm. Though 78 larvae hatched from eggs laid by 10 parasites, only 44 completed the larval period and pupated. The larval mortality as well as pupal mortality was fairly high reaching 56.4% and 56.8% respectively.

The parasites fed on diluted honey continued to live for 5 days. Of the 10 pairs of parasites exposed, all females laid eggs and their total number was 117. The eggs were laid in the course of 4.8 days.

TABLE II

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATTERPILLARS GROWN IN MEDIUM 'A' CONTAINING COARSELY GROUND WHEAT FLOUR ALONE

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
A_1	7	5	2	2	nil	2	3.5	2	5.0	10.5	0:2	2.51	1.20	2.38	0.55	28.57	60.00	-	4	18
A_2	2	1	nil	nil	nil	nil	6.0	2	-	-	-	-	-	-	-	50.00	100.00	-	-	10
A_3	12	9	6	4	2	2	5.5	2	4.5	12.0	2:2	2.61	1.22	2.42	0.57	25.00	33.33	33.33	6	5
A_4	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	9
A_5	18	13	6	2	nil	2	5.0	2	4.0	11.0	0:2	2.42	1.21	2.33	0.53	27.78	53.85	66.67	6	16
A_6	3	2	nil	nil	nil	nil	5.5	2	-	-	-	-	-	-	-	33.33	100.00	-	-	4
A_7	18	13	6	5	nil	5	5.0	2	4.0	11.0	0:5	2.62	1.25	2.43	0.55	27.78	53.85	16.67	5	10
A_8	16	12	7	3	2	1	5.0	2	4.0	11.0	2:1	2.41	1.18	2.37	0.54	25.00	41.67	85.56	4	8
A_9	8	6	5	2	nil	2	4.5	2	5.0	11.5	0:2	2.52	1.21	2.39	0.56	25.00	16.67	60.00	5	23
A_{10}	23	17	12	9	6	3	5.0	2	5.0	12.0	6:3	2.51	1.21	2.35	0.55	26.09	29.41	25.00	5	14
Total	107	78	44	27	10	17	.	.	.	.	10:17	.	.	.	.	.	.	.	.	117
Average	.	.	.	.	.	.	4.8	2	4.5	11.3	.	2.52	1.22	2.37	0.55	29.87	56.40	56.80	5	.

EXPERIMENT B

Medium. Coarsely ground wheat flour fortified with Yeast extract 3%.

Experimental details.

Period of experiment:	8-10-1964 - 15-12-1964
Temperature during the period:	Minimum: 74°F - 78°F
	Maximum: 80°F - 83°F
R.H. during the period:	77% - 92%

Other details are as described earlier.

Results. Table III shows the results of the experiment. On an average the life-cycle was completed in 10.9 days which consisted of 3.7 days as egg period, 2.3 days as larval period and 5 days as pupal period. The ratio of male to female parasites was 38:14. The average length of the parasite observed was 2.87 mm. The length of the antennae was 1.18 mm. and that of the wing span was 2.56 mm. and the ovipositor measured 0.55 mm. Though 149 larvae hatched from eggs laid by 8 parasites, only 52 completed the whole life-cycle. The mortality during incubation, the larval mortality and pupal mortality were 25.44%, 40.69% and 47.73% respectively.

TABLE III

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATTERPILLARS GROWN IN MEDIUM 'B' (COARSELY GROUND WHEAT FLOUR FORTIFIED WITH YEAST)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
B_1	37	28	18	10	10	nil	4.0	3	4	11.0	10:0	2.89	1.24	2.64	0.62	24.32	35.71	44.44	6	20
B_2	23	17	11	5	2	3	2.5	2	5	10.5	2:3	2.88	1.21	2.61	0.57	26.09	35.29	54.55	8	24
B_3	16	12	3	2	1	1	3.5	2	6	11.5	1:1	2.87	1.20	2.59	0.57	25.00	75.00	33.33	7	nil
B_4	32	24	20	13	10	3	4.0	2	5	11.0	10:3	2.86	1.15	2.55	0.53	25.00	16.67	35.00	6	11
B_5	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	23
B_6	16	12	12	3	2	1	4.0	2	5	11.0	2:1	2.85	1.13	2.53	0.53	25.00	nil	75.00	7	17
B_7	32	23	15	9	5	4	3.5	2	5	10.5	5:4	2.85	1.13	2.33	0.51	28.13	34.78	46.67	8	nil
B_8	20	15	7	8	6	2	3.5	3	5	11.5	6:2	2.86	1.18	2.58	0.53	25.00	46.67	42.87	6	21
B_9	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	8
B_{10}	24	18	16	2	2	nil	3.5	2	5	10.5	2:0	2.87	1.19	2.59	0.55	25.00	nil	50.00	8	nil
Total	200	149	102	52	38	14	.	.	.	.	38:14	.	.	.	.	.	.	.	.	124
Average	.	.	.	.	.	.	3.7	2.3	5	10.9	.	2.87	1.18	2.56	0.55	25.44	40.69	47.73	7	.

The parasites fed on diluted honey continued to live for 7 days. Of the 10 pairs of parasites exposed only 7 females laid eggs and the total number of eggs laid was 124 in the course of 4.6 days.

EXPERIMENT C

Medium. Coarsely ground wheat flour + Bengal gram powder.

Experimental details.

Period of the experiment:	9-10-1964 - 12-12-1964
Temperature during the period:	Minimum: 74°F - 78°F
	Maximum: 80°F - 83°F
R.H. during the period:	77% - 92%

Other details are as described earlier.

Results. Table IV gives the results of the experiment. The life-cycle was completed on an average of 12.5 days which consisted of 4.6 days as incubation period, 2 days as larval period and 6 days as pupal period. The ratio of male to female parasites was 4:1. The average length of the parasite observed was 2.87 mm. The length of the antennae was 1.12 mm. and that of the wing span was 2.53 mm. and the ovipositor measured 0.51 mm. Though 41 larvae hatched from eggs laid by 4 parasites only 5

TABLE IV

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'C' (COARSELY GROUND WHEAT FLOUR + BENGAL GRAM POWDER)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
C_1	16	12	8	nil	nil	nil	5.0	2	-	-	-	-	-	-	-	25.00	33.33	100.00	-	-
C_2	7	5	3	nil	nil	nil	4.3	2	-	-	-	-	-	-	-	28.57	40.00	100.00	-	-
C_3	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C_4	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C_5	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C_6	15	11	7	4	4	nil	4.5	2	6	12.5	4:0	2.87	1.12	2.53	0.51	26.67	36.36	42.85	7	-
C_7	17	13	1	1	nil	1	4.5	2	6	12.5	0:1	-	-	-	-	23.53	92.31	nil	5	-
C_8	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C_9	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C_{10}	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	55	41	19	5	4	1	.	.	.	.	4:1	.	.	.	.	.	.	.	.	.
Average	.	.	.	.	.	.	4.6	2	6	12.5	.	2.87	1.12	2.53	0.51	25.94	50.50	80.95	6	.

completed the life-cycle. The mortality during incubation, larval mortality and pupal mortality were 25.94%, 50.50% and 80.95% respectively.

There is an increasing trend in the mortality rate at larval and pupal stages especially in the latter. The parasites fed on diluted honey continued to live for 6 days. The single female emerged, did not lay eggs.

EXPERIMENT D

Medium. Coarsely ground wheat flour + Black gram powder.

Experimental details

Period of the experiment:	13-10-1964 - 15-12-1964
Temperature during the period:	Minimum: 74°F - 78°F
	Maximum: 80°F - 83°F
R.H. during the period:	77% - 92%

Other details are as described earlier.

Results. Table V gives the results of the experiment. The life-cycle was completed on an average of 11.65 days, of which incubation period was 4.9 days, larval period 2 days and the pupal period was 4.7 days. The ratio of males to females was 22:24. The average length of the

TABLE V

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'D' (COARSELY GROUND WHEAT FLOUR + BLACK GRAM POWDER)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
D_1	15	11	11	10	1	9	5.5	2	4.3	11.83	1:9	2.86	1.15	2.58	0.53	26.67	nil	9.09	6	23
D_2	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	17
D_3	4	3	3	nil	nil	nil	5.5	2	-	-	-	-	-	-	-	25.00	nil	100.00	-	19
D_4	9	7	7	4	4	nil	5.5	2	5.0	12.50	4:0	-	-	-	-	22.22	nil	44.44	5	8
D_5	24	18	18	10	5	5	4.0	2	5.0	11.00	5:5	2.88	1.21	2.61	0.57	25.00	nil	44.44	7	8
D_6	9	7	5	3	1	2	5.0	2	5.0	12.00	1:2	2.89	1.24	2.64	0.57	22.22	28.57	40.00	6	12
D_7	12	9	6	3	2	1	5.5	2	4.0	11.50	2:1	2.87	1.20	2.59	0.55	25.00	33.33	50.00	7	7
D_8	4	3	2	nil	nil	nil	4.0	2	-	-	-	-	-	-	-	25.00	33.33	100.00	-	nil
D_9	31	23	22	15	9	6	4.5	2	4.8	11.25	9:6	2.85	1.13	2.55	0.53	25.81	4.35	31.82	6	28
D_{10}	8	6	3	1	nil	1	4.5	2	5.0	11.50	0:1	2.85	1.13	2.53	0.51	25.00	50.00	66.67	5	4
Total	116	87	77	46	22	24	.	.	.	.	22:24	.	.	.	.	.	.	.	.	126
Average	.	.	.	.	.	.	4.9	2	4.7	11.65	.	2.87	1.18	2.59	0.54	24.66	27.92	54.05	6	.

parasite observed was 2.87 mm., the length of the antennae was 1.18 mm. and that of the wing span was 2.59 mm. The length of the ovipositor was 0.54 mm. Though 87 larvae hatched from eggs laid by 9 parasites only 46 completed the life-cycle. The egg mortality and larval mortality were 24.66% and 27.92% respectively while the pupal mortality was 54.05%.

The parasites fed on diluted honey continued to live for 6 days. Of the ten pairs exposed only 9 females laid eggs. They laid 126 eggs in the course of 4.3 days.

EXPERIMENT E

Medium. Coarsely ground wheat flour + Glucose.

Experimental details.

Period of the experiment:	7-10-1964 - 19-11-1964
Temperature during the period:	Minimum: 74°F - 78°F.
	Maximum: 80°F - 83°F
R.H. during the period:	77% - 90%

The rest of the details are as above.

Results. Table VI gives the results of the experiment. The life-cycle was completed on an average of 12 days

TABLE VI

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'E' (COARSELY GROUND WHEAT FLOUR + GLUCOSE)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
E_1	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E_2	10	7	5	3	3	nil	4	2	6	12	3:0	3.20	2.1	2.33	-	30.00	28.57	40	9	-
E_3	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E_4	6	4	nil	nil	nil	nil	4	2	-	-	-	-	-	-	-	33.33	10.00	-	-	-
E_5	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E_6	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E_7	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E_8	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E_9	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E_{10}	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	16	11	5	3	3	nil	.	.	.	.	3:0	.	.	.	.	.	.	.	.	.
Average	.	.	.	.	.	.	4	2	6	12	.	3.2	2.1	2.33	33.17	33.17	19.29	40	9	.

which consisted of 4 days as incubation period, 2 days as larval period and 6 days as pupal period. The ratio of male parasite to female parasite was 3:0. The average length of the parasite was 3.2 mm. The length of the antennae was 2.1 mm. and that of the wing span was 2.33 mm. Though 16 eggs were laid by two parasites, only 3 completed the life-cycle. The mortality during incubation, the larval mortality and pupal mortality were 33.17%, 19.29% and 40% respectively.

The parasites fed on diluted honey lived for 9 days. As the emerged parasites were all males observation on fecundity was not made.

EXPERIMENT F

Medium. Coarsely ground wheat flour + Fructose.

Experimental details.

Period of the experiment:	7-10-1964 - 22-11-1964
Temperature during the period:	Minimum: 74°F - 78°F
	Maximum: 80°F - 83°F
R.H. during the period:	77% - 90%

The rest of the details are as described above.

TABLE VII

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'F' (COARSELY GROUND WHEAT FLOUR + FRUCTOSE)

Sl.No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
F_1	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F_2	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F_3	43	32	32	18	6	12	4.00	1.0	5.5	10.50	6:12	2.97	1.28	2.36	0.69	25.58	nil	43.75	18	3
F_4	45	34	28	19	5	14	4.67	2.5	4.5	11.67	5:14	2.88	1.21	2.36	0.63	24.44	17.65	32.14	17	nil
F_5	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	25
F_6	13	10	2	1	nil	1	4.67	2.0	7.0	13.67	0:1	2.87	1.18	2.33	0.62	23.08	80.00	50.00	16	nil
F_7	7	5	5	nil	nil	nil	4.00	2.5	-	-	-	-	-	-	-	28.57	nil	100.00	-	3
F_8	37	28	16	8	5	3	4.67	2.3	5.0	12.0	5:3	3.23	1.17	2.31	0.61	24.32	42.86	50.00	17	12
F_9	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	2
F_{10}	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	11
Total	145	109	83	46	16	30	.	.	.	.	16:30	.	.	.	.	.	.	.	.	76
Average	.	.	.	.	.	.	4.40	2.07	5.5	12.0	.	2.99	1.21	2.34	0.64	25.20	46.84	55.18	17	.

Results. Table VII gives the results of the experiment. The life-cycle was completed on an average of 12 days which consisted of 4.4 days as egg period, 2.1 days as larval period and 5.5 days as pupal period. The ratio of males to females was 16:30. The average length of the parasite was 2.99 mm. The length of the antennae was 1.21 mm. The wing span measured 2.34 mm. The average measurement of ovipositor in females was 0.64 mm. Though 109 larvae hatched from eggs laid by 5 parasites only 46 completed the life-history. The egg mortality and larval mortality were 25.20% and 46.84% respectively. The pupal mortality was as high as 55.18%.

The parasites fed on honey continued to live for 17 days. Of the 10 pairs of parasites exposed, only 7 females laid eggs. They laid 76 eggs in the course of 5.1 days.

EXPERIMENT G

Medium. Coarsely ground wheat flour + Black gram powder + Glucose, fortified with Yeast extract.

Experimental details.

Period of the experiment:	6-10-1964 - 22-11-1964
Temperature during the period:	Minimum: 74°F - 79°F
	Maximum: 80°F - 83°F

TABLE VIII

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'G' (COARSELY GROUND WHEAT FLOUR + BLACK GRAM POWDER + GLUCOSE FORTIFIED WITH YEAST EXTRACT)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
G_1	3	2	nil	nil	nil	nil	5.0	2	-	-	-	-	-	-	-	33.33	100.00	-	-	nil
G_2	20	15	13	4	2	2	4.5	2	5	11.5	2:2	2.97	1.19	2.34	0.68	25.00	13.33	69.23	17	11
G_3	37	28	25	8	4	4	4.0	2	4	10.0	4:4	2.99	1.25	2.41	0.69	24.32	10.71	68.00	16	24
G_4	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	13
G_5	23	17	11	9	1	8	4.5	2	5	11.5	1:8	2.93	1.18	2.41	0.69	26.09	35.29	18.18	15	20
G_6	17	13	9	nil	nil	nil	4.5	2	-	-	-	-	-	-	-	23.53	30.77	100.00	-	nil
G_7	8	6	6	3	3	nil	4.5	2	5	11.5	3:0	-	-	-	-	25.00	100.00	50.00	16	nil
G_8	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	19
G_9	13	10	8	1	1	nil	4.5	2	5	11.5	1:0	-	-	-	-	23.08	20.00	87.50	16	17
G_{10}	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	nil
Total	121	91	72	25	11	14	.	.	.	.	11:14	.	.	.	.	.	.	.	.	104
Average	.	.	.	.	.	.	4.5	2	4.8	11.2	.	2.96	1.21	2.32	0.69	25.76	44.30	65.49	16	.

R.H. during the period: 77% - 90%

The rest of the details are as above.

Results. Table VIII gives the result of the experiment. The life-cycle was completed on an average of 11.2 days which consisted of 4.5 days as egg period, 2 days as larval period and 4.8 days as pupal period. The ratio of male to female parasites was 11:14. The average length of the parasite was 2.96 mm. The average length of antennae was 1.21 mm. The forewings measured on an average 2.32 mm. and the ovipositor measured 0.69 mm. Out of the 91 larvae hatched from eggs laid by 7 parasites only 25 completed the life-cycle. The egg mortality and larval mortality were 25.76% and 44.30% respectively. The pupal mortality was as high as 65.49%.

The parasites fed on diluted honey continued to live for nearly 16 days. Of the ten pairs of parasites exposed, only 6 females laid eggs. They laid 104 eggs in the course of 5 days.

EXPERIMENT H

Madium. Coarsely ground wheat flour + Whole cream milk powder.

TABLE IX

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'H' (COARSELY GROUND WHEAT FLOUR + WHOLE CREAM MILK POWDER)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
H_1	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H_2	8	6	6	nil	nil	nil	4.5	1.75	-	-	-	-	-	-	-	25	nil	100	-	-
H_3	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H_4	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H_5	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H_6	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H_7	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H_8	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H_9	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H_{10}	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	8	6	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Average	.	.	.	.	.	.	4.5	1.75	.	.	.	.	.	.	.	25	-	100	.	.

Experimental details.

Period of the experiment:	19-10-1964 - 15-11-1964
Temperature during the period:	Minimum: 74°F - 78°F
	Maximum: 80°F - 81°F
R.H. during the period:	83% - 90%

The rest of the details are as above.

Results. Table IX gives the results of the experiment. Of the ten pairs of parasites exposed, only one female laid eggs. The number of eggs laid was found to be 8, of which 6 larvae hatched and they reached only upto the pupal stage. Thus the life-cycle was not completed in the medium. The incubation period and larval period were observed as 4.5 and 1.75 days respectively. Mortality during incubation was 25% and the larval mortality was 0% while the pupal mortality reached 100%. The experiment was repeated twice and parasites failed to lay any eggs.

EXPERIMENT I

Medium. Coarsely ground wheat flour + Skimmed milk powder.

Experimental details.

period of the experiment:	21-10-1964 - 6-12-1964
Temperature during the period:	Minimum: 74°F - 78°F
	Maximum: 80°F - 82°F

TABLE X

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'I' (COARSELY GROUND WHEAT FLOUR + SKIMMED MILK POWDER)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average largal duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
I_1	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	19
I_2	3	2	nil	nil	nil	nil	4.5	-	-	-	-	-	-	-	-	33.33	100.00	nil	-	29
I_3	2	1	1	nil	nil	nil	4.0	3.00	-	-	-	-	-	-	-	50.00	nil	100.00	-	7
I_4	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	nil
I_5	6	4	4	4	4	nil	4.5	2.50	5.0	12.00	4:0	2.51	1.20	2.38	0.55	33.33	nil	nil	6	24
I_6	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	nil
I_7	25	17	10	10	5	5	4.0	2.67	5.0	11.67	5:5	2.53	1.22	2.40	0.56	32.00	41.18	nil	5	nil
I_8	17	13	10	5	5	nil	4.0	2.67	5.0	11.67	5:0	2.54	1.23	2.40	0.56	23.00	23.08	50.00	7	nil
I_9	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	nil
I_{10}	40	30	24	8	8	nil	4.0	3.00	5.0	12.00	8:0	2.59	1.23	2.42	0.57	25.00	20.00	66.67	6	nil
Total	93	67	49	27	22	5	.	.	.	.	22:5	.	.	.	.	.	.	.	.	79
Average	.	.	.	.	.	.	4.17	2.77	5.0	11.84	.	2.54	1.22	2.40	0.56	32.78	46.06	72.22	6	.

R.H. during the period: 80% - 91%

The rest of the details are as described earlier.

Results. Table X gives the results of the experiment. The life-cycle consisted on an average of 11.84 days of which 4.17 was the egg period, 2.77 the larval and 5 the pupal periods respectively. The ratio of male to female was 22.5. The average length of the parasite was 2.54 mm. and that of the antennae was 1.22 mm. The wing span measured 2.40 mm. and the measurement of the ovipositor was 0.56 mm. Of the 67 larvae hatched from eggs laid by 6 parasites only 27 completed the life-cycle. The mortality during incubation and that during the larval stages were 32.78% and 46.06% respectively. The pupal mortality was as high as 72.22%.

The parasites fed on diluted honey lived for six days. Of the ten pairs of parasites exposed only 4 females laid eggs. Total number of eggs laid was 79, in the course of 4 days.

EXPERIMENT J

Medium. Coarsely ground wheat flour fortified with Thiamin.

Experimental details.

Period of the experiment:	16-10-1964 - 31-11-1964
Temperature during the period:	Minimum: 74°F - 78°F
	Maximum: 80°F - 82°F
R.H. during the period:	77% - 91%

The rest of the details are as described earlier.

Results. Table XI gives the results of the experiment. The life-cycle was completed on an average of 10 days of which 4 days was the egg period, 2 days the larval period and 4 days the pupal period. The ratio of male parasites to female parasites was 18:16. The average length of the parasite was 2.96 mm. The antennae measured 1.18 mm. The wing span of the parasites was 2.33 mm. The ovipositor measured 0.66 mm. Of the 60 larvae hatched from eggs laid by 4 parasites, only 34 completed the life-cycle. The egg mortality, the larval mortality and the pupal mortality were 24.76%, 11.30% and 42.68% respectively.

The parasites fed on diluted honey lived for 9 days. Of the 10 pairs of parasites exposed, all the 10 females laid eggs. The total number of eggs was 250, laid in the course of 4 days.

TABLE XI

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'J' (COARSELY GROUND WHEAT FLOUR FORTIFIED WITH THIAMIN)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
J_1	27	20	20	15	9	6	4.0	2	3.5	9.5	9:6	2.81	1.16	2.29	0.63	25.93	nil	25.00	10	32
J_2	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	13
J_3	13	10	8	4	3	1	3.5	2	4.0	9.5	3:1	3.06	1.18	2.36	0.66	23.08	20.00	50.00	9	37
J_4	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	29
JJ_5	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	11
J_6	24	18	17	10	4	6	4.5	2	4.5	11.0	4:6	2.88	1.17	2.33	0.65	25.00	5.56	41.18	8	26
J_7	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	21
J_8	16	12	11	5	2	3	4.0	2	4.0	10.0	2:3	3.10	1.19	2.38	0.70	25.00	8.33	54.55	9	32
J_9	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	36
J_{10}	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	13
Total	80	60	56	34	18	16	.	.	.	.	18:16	.	.	.	.	.	.	.	.	250
Average	.	.	.	.	.	.	4.0	2	4.0	10.0	.	2.96	1.18	2.33	0.66	24.76	11.30	42.68	9	.

EXPERIMENT K

Medium. American flour.

Experimental details.

Period of the experiment:	21-10-1964 - 8-12-1964
Temperature during the period:	Minimum: 74°F - 78°F
	Maximum: 80°F - 82°F
R.H. during the period:	80% - 91%

The rest of the details are as described earlier.

Results. Table XII gives the results of the experiment. The life-cycle was completed on an average of 10 days which consisted of 4 days as the incubation period, 2 days as the larval period and 4 days as the pupal period. The ratio of males to females was 16:54. The parasites measured 2.87 mm. The length of antennae was only 1.18 mm. The wing span was 2.59 mm. The ovipositor on an average measured 0.54 mm. Of the 88 larvae hatched from eggs laid by 6 parasites, only 70 completed the life-cycle. The mortality during incubation and pupal mortality were 25.43% and 21.67% respectively while the larvae showed no mortality at all.

TABLE XII

DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN MEDIUM 'K' (AMERICAN FLOUR ALONE)

Sl. No. of parasites	No. of eggs laid	No. of larvae hatched	No. of larvae pupated	No. of adults emerged	No. of males	No. of females	Average incubation (days)	Average larval duration (days)	Average pupal duration (days)	Total duration (days)	Sex-ratio M:F	Maximum length of adult (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Longevity of adults	No. of eggs laid
K_1	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	10
K_2	13	10	10	7	1	6	4.0	2	3.5	9.5	1:6	2.86	1.15	2.58	0.53	23.08	nil	30.00	10	8
K_3	19	14	14	11	nil	11	4.0	2	4.5	10.5	0:11	2.87	1.20	2.61	0.56	26.32	nil	21.43	11	16
K_4	24	18	18	15	2	13	3.5	2	4.0	9.5	2:13	2.90	1.24	2.64	0.57	25.00	nil	16.67	12	15
K_5	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	18
K_6	27	20	20	17	7	10	4.5	2	4.0	10.5	7:10	2.87	1.20	2.59	0.55	25.93	nil	15.00	15	7
K_7	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	12
K_8	11	8	8	6	1	5	3.5	2	4.5	10.0	1:5	2.85	1.13	2.56	0.53	27.27	nil	25.00	13	18
K_9	24	18	18	14	5	9	4.5	2	3.5	10.0	5:9	2.86	1.12	2.53	0.51	25.00	nil	22.22	11	20
K_{10}	nil	nil	nil	nil	nil	nil	-	-	-	-	-	-	-	-	-	-	-	-	-	nil
Total	118	88	88	70	16	54	.	.	.	.	16:54	.	.	.	.	.	.	.	.	124
Average	.	.	.	.	.	.	4.0	2	4.0	10.0	.	2.87	1.18	2.59	0.54	25.43	.	21.67	12	.

The parasites fed on diluted honey lived for 12 days. Of the ten pairs of parasites exposed, only nine females laid eggs and the total number was 124, laid in the course of 3 days.

DISCUSSION

EFFECT OF DIFFERENT NUTRIENT MEDIA ON THE DEVELOPMENT AND SIZE OF THE LARVAE OF CORCYRA CEPHALONICA (STAINTON)

As seen in Table I the average duration of development of Corcyra larva in the basic diet, medium (A) containing coarsely ground wheat flour, extended for a period of 42 days. However the shortest larval duration viz., 28 days was noticed in the medium (F) containing the basic diet to which fructose was added. Addition of black gram powder and glucose fortified with yeast to the basic diet (medium G) exerted more or less the same influence and the larval life was shortened to 32 days. It was also seen that similar results were noticed in larvae developed in medium (D), consisting of basic diet to which black gram powder alone was added. However, all other media exerted more or less the same influence on the duration of larval development. It was also noticed that the larval duration was reduced in all media compared to the medium (A) containing coarsely ground wheat flour alone. The observations revealed that addition of either fructose (medium F), or black gram powder,

(medium D) or a combination of black gram powder + glucose fortified with yeast (medium G), to the basic diet shortened the larval duration considerably - nearly 10-14 days.

Krishnamoorthy and Rao (1945) had shown that addition of yeast to the cereal diet of Corcyra larvae improved the nutritional quality of the mixture. The present observations also confirmed that addition of yeast to basic diet (medium B) shortened the duration of larval development.

Though Rao (1954) had observed that Corcyra larvae thrives best in coarsely milled cereals and that the pulses are poor media for larval development, the present observations had shown that a mixture of black gram powder or bengal gram powder and coarsely ground wheat flour (medium D or C) improved the nutritional quality of the mixture and shortened the larval duration.

The average pupal duration was not much influenced by various nutritional media. However medium (C), containing basic diet to which bengal gram powder was added, shortened the pupal duration by two days compared to medium (A) containing basic diet alone. The medium (D) containing basic diet to which black gram powder was added

and the medium (I), containing basic diet to which skimmed milk powder was added, prolonged the pupal period by three days, compared to the medium containing basic diet only. However, the significance of this disparity in addition of different kinds of proteins to the basic diet is not properly understood.

It is also observed that the total duration of development of Corcyra varied with different nutrient media. The shortest duration of 44 days was noticed in the medium (F) containing basic diet to which fructose was added. The longest duration of development of 54-56 days was noticed in the medium containing basic diet only or basic diet to which whole cream milk powder was added. Addition of either yeast or glucose or skimmed milk powder showed that the total duration of development was not much affected. However, medium (C) containing bengal gram powder or medium (D) containing black gram powder; or medium (G) containing black gram powder and glucose, fortified with yeast or medium (J) containing thiamin to the basic diet, reduced the total duration of development by 7-8 days.

The observations showed that addition of a sugar, like fructose, or proteinaceous material like bengal gram

powder or black gram powder to the basic diet was capable of reducing the total duration of development of Corcyra cephalonica by 8-12 days.

Though observations made by Ayyar (1934) and Rao (1954)had shown that total duration of development of Corcyra cephalonica is prolonged in nutrient media of pulses, the present observations showed that a combination of either bengal gram powder or black gram powder to the basic cereal diet considerably reduced the total duration of development of Corcyra cephalonica.

It was also seen that the largest sized last instar larvae were harvested from medium (G) containing black gram powder and glucose fortified with yeast to the basic diet. However, the smallest sized larvae were harvested from media (D & E) containing basic diet to which either black gram powder alone or glucose alone were added. All other media exerted more or less the same influence on the size of the larvae.

EFFECT OF HOST (CORCYRA LARVA REARED ON DIFFERENT NUTRIENT MEDIA) ON THE DURATION OF DEVELOPMENT OF THE PARASITE, MICROBRACON BREVICORNIS WESM.

The shortest duration of development ie., 10 days was noticed in parasites reared on hosts fed with the

medium (K) containing American flour, and the medium (J) containing the basic diet fortified with thiamin. The longest duration of development ie., 12.5 days was noticed in parasites reared on hosts fed with the basic diet to which was added bengal gram powder. All other hosts fed on different media exerted more or less the same influence on the duration of development of the parasite. (Fig 9)

However, the development of the parasites on hosts reared in medium (H) containing the basic diet to which whole cream milk powder was added, was rather peculiar. Though ten pairs of parasites were exposed to fifty caterpillars, only one parasitised the hosts by laying eight eggs and these eggs completed development only upto the pupal stage and no adults emerged. Though the experiment was repeated twice no hosts were parasitised. Therefore the hosts reared on a basic diet to which whole cream milk powder was added appeared to be quite unsuitable for the development of the parasite. As pointed out by Trager (1953) these hosts possessed either too little essential nutritional factors for complete development of the parasite or lacked them altogether.

Though the mortality of the parasites during incubation period was more or less the same (25-30%) in

all the hosts reared on different nutrient media, mortality appeared to be slightly higher in the hosts reared on medium (I) containing the basic diet to which skimmed milk powder was added. As this difference in the rate of mortality was not much pronounced and as the mortality in all other cases were more or less similar during incubation period, it appeared that the hosts reared on different nutrient media did not exert any appreciable influence on the development of the egg stage.

However, the larval mortality of the parasite(Fig 4) reared on different hosts fed in various nutrient media differed considerably ie., from 0 to 56%. The lowest larval mortality ie., 0% was noticed in parasites reared from hosts fed with nutrient medium (K) containing american flour. Low percentages of larval mortality ranging from 11-19% were noticed in parasites reared from hosts fed on medium (J) containing the basic diet fortified with thiamin and medium (E) containing basic diet to which glucose was added respectively. However the hosts reared on basic diet alone produced the maximum mortality ie., 56.4% among parasitic larvae. The observation appeared to reveal that the hosts reared on basic diet was deficient in some essential nutritional factor(s) for completion of larval

development of the parasite. Hosts reared on medium I, G, F, C and B also produced fairly high mortality of parasitic larvae varying from 40-50%, though the percentages of mortality in all cases were low compared to the hosts reared on basic diet alone.

The pupal mortality of the parasite reared from various hosts fed in different nutrient media also showed considerable variations ranging from 21% to 100%. Hosts reared on American flour produced the lowest pupal mortality (21%). Hosts reared on medium (H) containing the basic diet to which full cream milk powder was added produced the maximum 100% mortality and showed that the parasitic pupae could not complete development. Pupal mortality of the parasite reared on hosts fed in medium (I) containing basic diet to which skimmed milk powder was added, and in medium (G) containing basic diet to which bengal gram powder was added, were also high ranging from 72% to 80%. All other hosts reared from different nutrient media produced mortality of the parasites ranging from 40% to 65%.(Fig.5)

EFFECT OF HOST (*CORCYRA* LARVAE REARED ON DIFFERENT NUTRIENT MEDIA) ON THE LONGEVITY OF THE PARASITE *MICROBRACON BREVICORNIS*

All the parasites emerged were fed on honey diluted with water (1:3) on the 2nd day after emergence and later on the 5th day. The parasites were also supplied with *Corcyra* larvae for oviposition. They were not found stinging the hosts for feeding on their body fluid. Present observations showed that the adult longevity of parasites reared from different hosts fed on various nutrient media, varied considerably ranging from 5 to 17 days. Parasites reared on hosts fed in medium (F) containing basic diet to which fructose was added and medium (G) containing basic diet to which black gram powder and glucose fortified with yeast were added, lived for 16-17 days, showing the maximum period of longevity under laboratory conditions. Parasites reared from hosts fed on (Medium K) American flour continued to live for nearly 12 days. The shortest duration of longevity was noticed of parasites reared from hosts fed on medium (A) containing the basic diet only. All other hosts reared on various media produced more or less the same effect on the longevity of the adult parasites.(Fig.6)

EFFECT OF HOSTS (CORCYRA LARVAE REARED ON DIFFERENT NUTRIENT MEDIA) ON THE FECUNDITY OF THE PARASITE MICROBRACON BREVICORNIS

The largest number of eggs (25) were laid by parasites reared on hosts fed on basic diet reinforced with thiamin. Hosts reared on medium (B) containing basic diet fortified with yeast, medium (I) containing basic diet to which was added skimmed milk powder and medium (G) containing the basic diet to which was added black gram powder and glucose fortified with yeast, also produced appreciable effect on the fecundity of the parasite which laid from 17 to 20 eggs. The smallest number of eggs were laid by the parasites reared from hosts fed on medium (A) containing the basic diet alone and in the medium (F) containing the basic diet to which was added fructose. Parasites reared on hosts fed on medium (K) containing American flour and medium (D) containing basic diet to which was added black gram powder, also produced greater number of eggs as compared to the parasites reared from hosts fed on basic diet only.(Fig.7)

The observations revealed that the fecundity of parasites was influenced by hosts reared on different media and addition of yeast or thiamin to the basic diet of the

host appeared to increase the fecundity of parasites. Results of a similar nature were obtained by Katiyar (1962) on Bracon gelechiae Ahmd., and Trichogramma evanescens minutum Riley, where hosts reared on a diet of crushed sorghum added with yeast produced best results.

EFFECT OF HOST (CORCYRA LARVAE REARED ON DIFFERENT NUTRIENT MEDIA) ON THE SEX-RATIO OF THE PARASITE MICROBRACON BREVICORNIS

Considerable variations of sex-ratio were noticed in parasites reared on different hosts. The largest number of female parasites, sex-ratio being (54 females to 16 males) was produced from hosts reared in medium (K) containing American flour. The hosts reared in medium (A) containing the basic diet and medium (F) containing fructose and basic diet, also produced male and female parasites in the ratio of nearly 1:(1.7 to 2). The hosts reared in medium (D) containing the basic diet to which black gram powder was added, medium (G) containing the basic diet to which black gram powder, glucose and yeast were added and medium (J) containing basic diet fortified with thiamin produced male and female parasites in the ratio of 1:1. Hosts reared from medium (E) containing glucose and basic diet produced

no female parasite; all the emerged adults were males. Largest number of male parasites were produced from hosts reared in medium (C) containing bengal gram powder and basic diet and in medium (I) containing basic diet to which was added skimmed milk powder; the ratio of male to female parasites being 4:1. Hosts reared on medium (B) containing basic diet to which yeast was added also produced larger number of male parasites. Ullyett (1936) had observed that parasites emerging from small sized hosts are usually males and those emerging from larger hosts are usually females.

Present observations revealed that the hosts reared in medium (E) were all the smallest sized larvae and the adult parasites emerged from these hosts were also all males and confirmed the observations made by Ullyett (1936). However similar small sized hosts reared from medium (D) produced male and female parasites in the normal ratio of 1:1. Though the size of the host larvae produced in media (D & E) were more or less identical, the wide disparity of influence of the hosts on the sex ratios of the parasites emerged appeared more due to a qualitative rather than quantitative trophic basis.

EFFECT OF HOSTS (*CORCYRA* LARVAE REARED ON DIFFERENT NUTRIENT MEDIA) ON THE BIOMETRY AND SIZE OF THE PARASITE *MICROBRACON BREVICORNIS*

Differences in the size of the parasites reared from different hosts fed on various nutrient media occurred to some extent. The female parasites reared on hosts, fed in media (F) containing coarsely ground wheat flour + fructose and (G) containing coarsely ground wheat flour + black gram powder + glucose, fortified with yeast, and (J) containing coarsely ground wheat flour fortified with thiamin were all larger than those reared on hosts fed in medium (A) and they measured nearly 2.96 mm. to 2.99 mm. Their ovipositors were also longer compared with the parasites reared from hosts fed on medium (A) containing the basic diet alone. The smallest sized parasites measuring 2.52 mm. to 2.54 mm. were reared from hosts fed on medium (A) containing basic diet alone and the medium (I) containing basic diet and skimmed milk powder. All other hosts reared on different media exerted more or less the same influence on the size of the parasite. As had been pointed out by Doutt (1960) these differences in size could be due to the variations in the quantity of food ingested during the larval stage of the parasites.

EFFECT OF HOST (CORCYRA LARVA REARED ON DIFFERENT NUTRIENT MEDIA) ON THE EMERGENCE OF TOTAL NUMBER OF PARASITES MICROBRACON BREVICORNIS

Total number of adults emerged from different hosts reared on various nutrient media showed considerable variations (Fig. 9). Largest number of parasites were reared from hosts fed on medium K containing American flour, and medium F, containing basic diet to which was added fructose. Hosts reared on medium J containing basic diet to which was added Thiamin also produced large number of parasites. Hosts reared on medium B containing basic diet to which was added yeast, medium D containing basic diet to which was added black gram powder and medium I containing basic diet to which was added skimmed milk powder showed no great variations. The smallest number of parasites emerged from hosts reared on medium C containing basic diet to which was added bengal gram powder and medium E containing basic diet to which glucose was added. However, no parasites emerged from hosts reared on medium H containing basic diet to which whole cream milk powder was added.

BAR DIAGRAM SHOWING LARVAL MORTALITY, PUPAL MORTALITY AND ADULT LONGEVITY OF MICROBRACON BREVICORNIS BRED FROM CORCYRA LARVAE REARED ON DIFFERENT NUTRIENT MEDIA

A. Coarsely ground wheat flour (basic diet)

B. ,, fortified with yeast

C. ,, + bengal gram powder

D. ,, + black gram powder

E. ,, + glucose

F. ,, + fructose

G. ,, + black gram powder + glucose fortified with yeast

H. ,, + whole cream milk powder

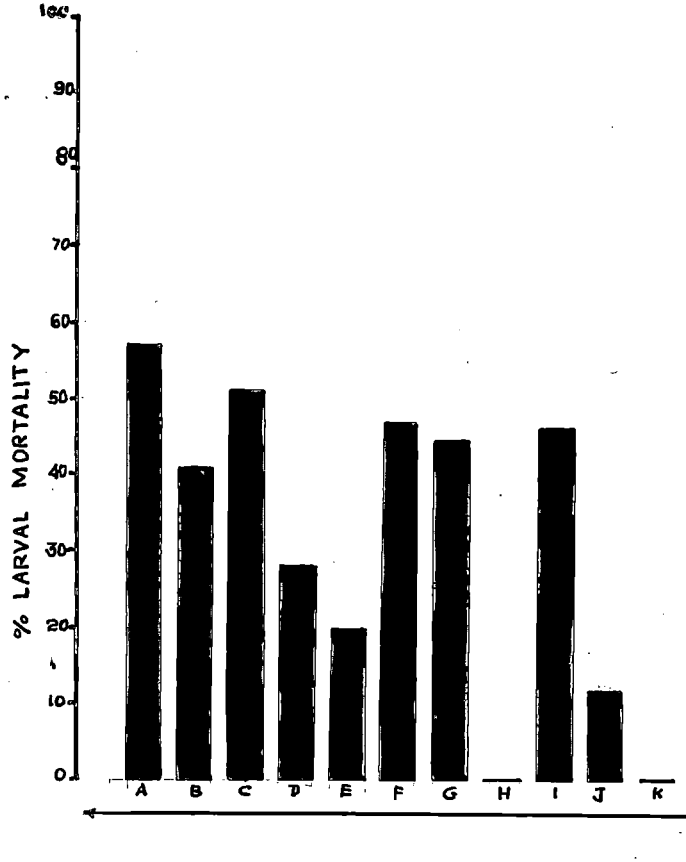
I. ,, + skimmed milk powder

J. ,, + fortified with Thiamin

K. American flour.

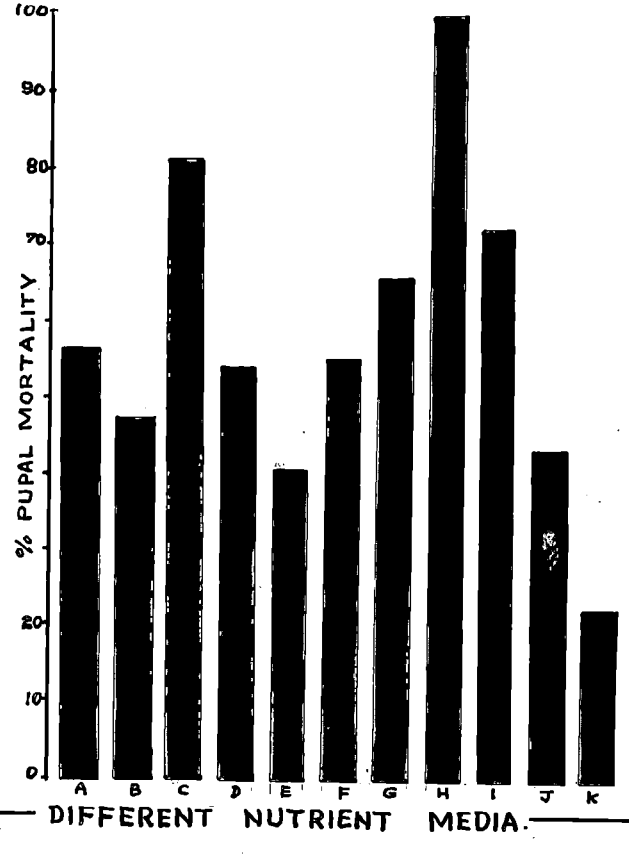
LARVAL MORTALITY

Fig. 4



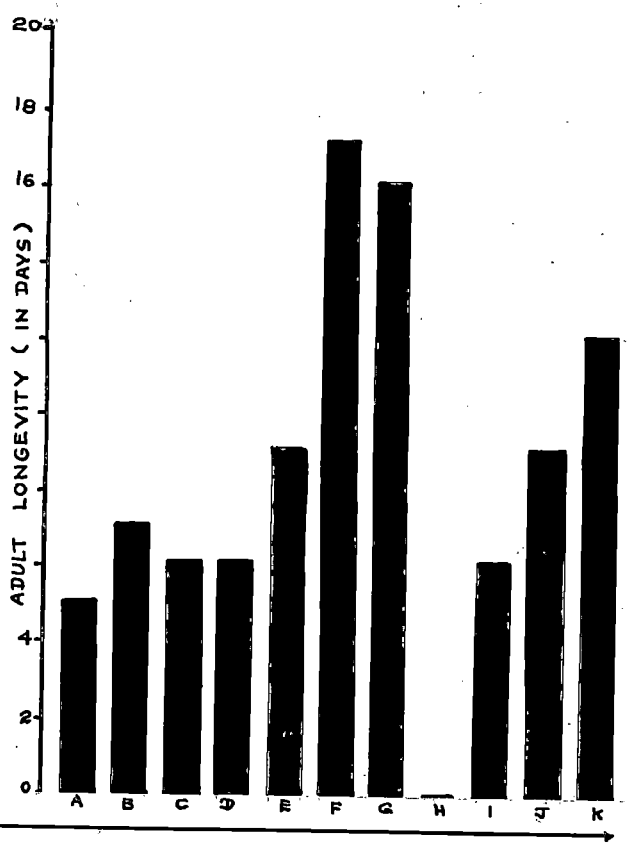
PUPAL MORTALITY

Fig. 5



ADULT LONGEVITY

Fig. 6



DIFFERENT NUTRIENT MEDIA.

BAR DIAGRAM SHOWING FECUNDITY, DURATION OF DEVELOPMENT AND NUMBER OF ADULTS EMERGED OF MICROBRACON BREVICORNIS BRED FROM CORCYRA LARVAE REARED ON DIFFERENT NUTRIENT MEDIA

A. Coarsely ground wheat flour (basic diet)

B. ,, + fortified with yeast

C. ,, + bengal gram powder

D. ,, + black gram powder

E. ,, + glucose

F. ,, + fructose

G. ,, + black gram powder + glucose fortified with yeast

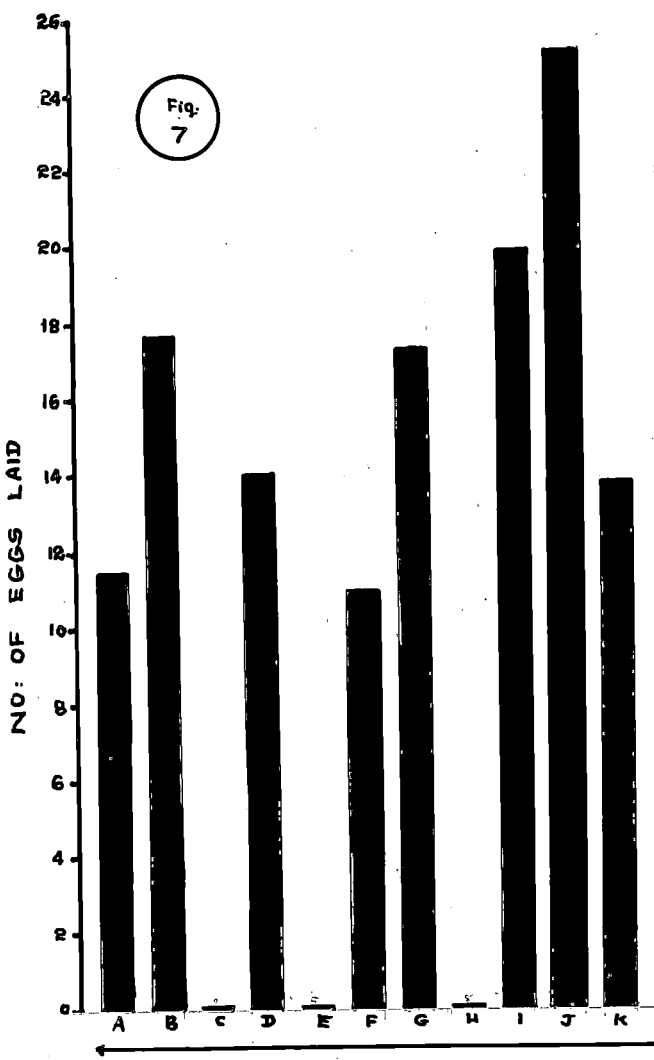
H. ,, + whole cream milk powder

I. ,, + skimmed milk powder

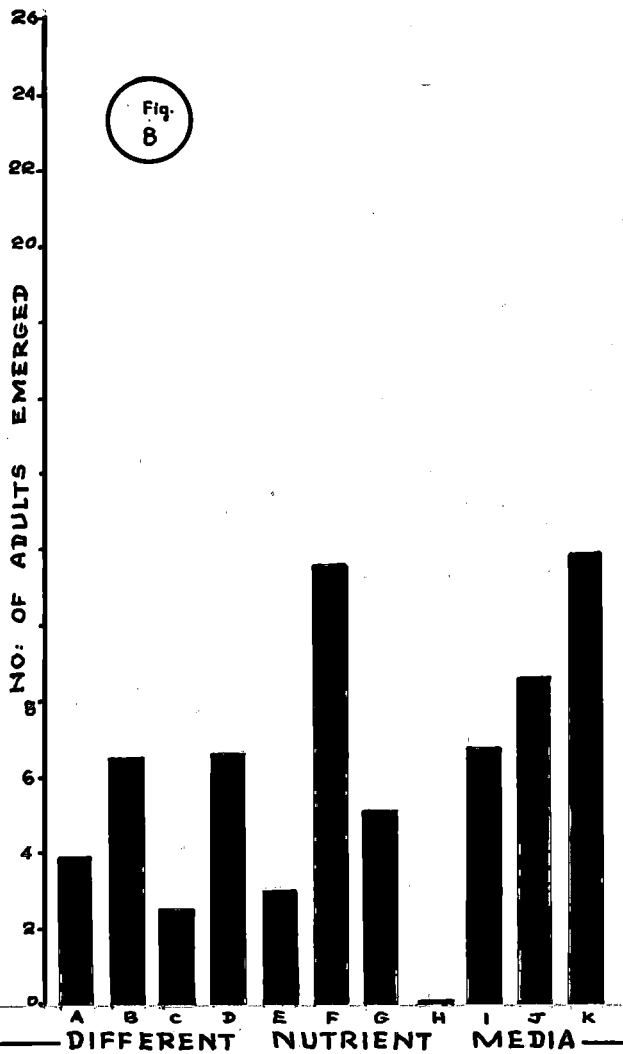
J. ,, fortified with Thiamin

K. American flour

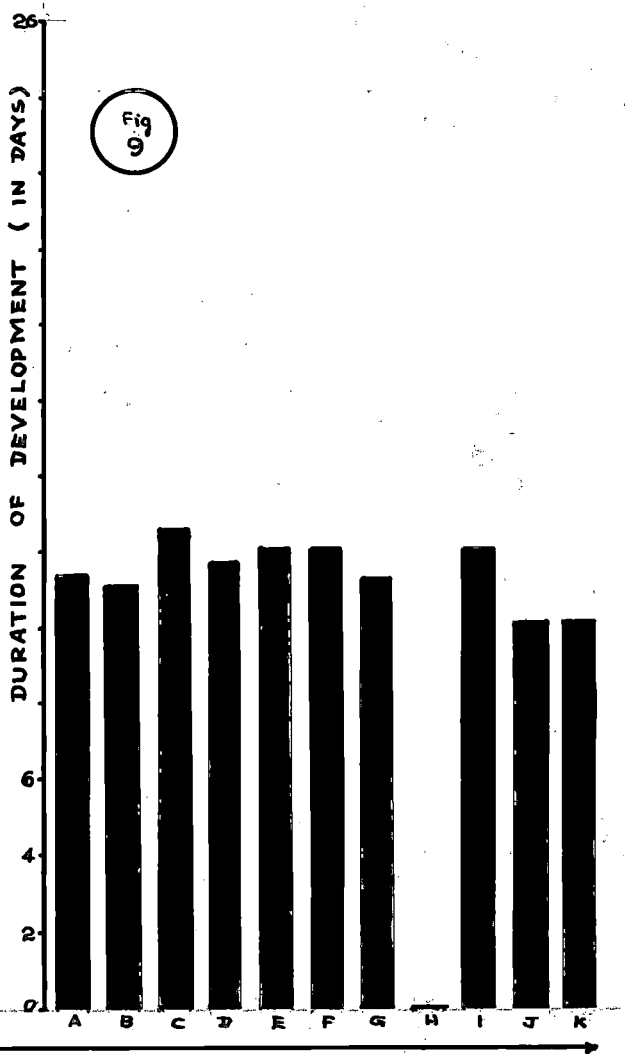
FECUNDITY



NO: OF ADULTS EMERGED



DURATION OF DEVELOPMENT (DAYS)



DIFFERENT NUTRIENT MEDIA

BAR DIAGRAM SHOWING PERCENTAGE OF FEMALE PARASITES EMERGED FROM CORCYRA LARVAE REARED ON DIFFERENT NUTRIENT MEDIA

A. Coarsely ground wheat flour (basic diet)
B. ,, fortified with yeast
C. ,, + bengal gram powder
D. ,, + black gram powder
E. ,, + glucose
F. ,, + fructose
G. ,, + black gram powder + glucose fortified with yeast
H. ,, + whole cream milk powder
I. ,, + skimmed milk powder
J. ,, fortified with Thiamin
K. American flour

Fig. 10

% FEMALE EMERGENCE

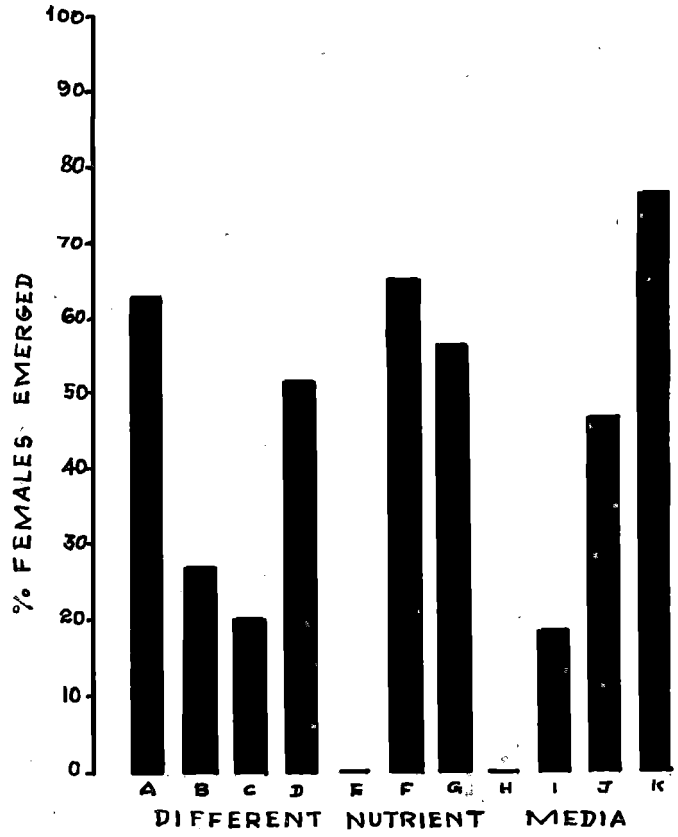


TABLE XIII

AVERAGES OF DURATION OF DEVELOPMENT, ADULT LONGEVITY, FECUNDITY, SEX-RATIO AND BIOMETRICAL OBSERVATIONS OF MICROBRACON BREVICORNIS REARED ON CORCYRA CATERPILLARS GROWN IN DIFFERENT MEDIA

Food media	Total duration of development	No. of adults	Sex ratio M:F	Fecundity	Longevity	Mortality during incubation (%)	Larval mortality (%)	Pupal mortality (%)	Maximum length of adults (mm.)	Length of antennae (mm.)	Length of forewing (mm.)	Length of ovipositor (mm.)
A	11.30	3.86	10:17	11.70	5	29.87	56.4	56.8	2.52	1.22	2.37	0.54
B	10.94	6.50	38:14	17.71	7	25.44	40.69	47.73	2.87	1.18	2.56	0.55
C	12.50	2.50	4:1	nil	6	25.94	50.50	80.95	2.86	1.12	2.53	0.51
D	11.65	6.57	22:24	14.00	6	24,66	27.92	54.05	2.87	1.18	2.59	0.54
E	12.00	3.00	3:0	-	9	30.00	19.29	40.00	only	males	emerged	
F	11.96	11.50	16:30	10.86	17	25.20	46.84	55.18	2.99	1.21	2.34	0.64
G	11.20	5.00	11:14	17.33	16	25.76	44.30	65.49	2.96	1.21	2.32	0.67
H	-	nil	-	-	-	25.00	nil	100.00	-	-	-	-
I	11.84	6.80	22:5	19.75	6	32.78	46.06	72.22	2.54	1.22	2.40	0.56
J	10.00	8.50	18:16	25.00	9	24.75	11.30	42.68	2.96	1.18	2.33	0.66
K	10.00	11.70	16:54	13.78	12	25.43	nil	21.61	2.87	1.18	2.59	0.54

SUMMARY

Literature on effect of nutrition on fecundity, development and longevity of insects with special reference to entomophagous forms has been reviewed.

Comparative studies of eleven different nutrient media were made to ascertain their effect on the development and growth of the larvae of Corcyra cephalonica (Stainton) using coarsely ground wheat flour as a medium of basic diet. The larval duration was considerably reduced, by 10-14 days when the larvae were reared in a medium of basic diet containing coarsely ground wheat flour to which either fructose, or a combination of black gram powder and glucose fortified with yeast were added.

The pupal duration of Corcyra cephalonica was not much affected by various nutrient media, though addition of bengal gram powder to basic diet in the larval nutrition shortened the pupal period by two days.

It was also noticed that the total duration of development of Corcyra cephalonica varied with different nutrient media. Addition of a sugar, like fructose or a proteinaceous material like bengal gram powder or black gram powder was capable of reducing the total duration of development.

Largest sized Corcyra larvae were harvested from a medium containing the basic diet to which was added black gram powder and glucose fortified with yeast. Smallest sized larvae were obtained from the medium containing the basic diet to which either black gram powder alone or glucose alone was added.

In a second series of experiments the effect of host Corcyra larvae reared in different nutrient media, on the development, fecundity, longevity, sex-ratio, total number of emergence and biometry of Microbracon brevicornis Wesmael., a larval parasite of the former was studied in some detail.

The shortest duration of larval development of the parasite was noticed in hosts reared on a medium containing American flour and the medium containing basic diet to which thiamin was added. Hosts reared on a medium of basic diet to which whole cream milk powder was added appeared to be quite unsuitable for the development of the parasite.

Hosts reared on various nutrient media did not exert any appreciable effect on the development of the eggs of the parasite.

Larval mortality of the parasite reared on different hosts fed with various nutrient media differed considerably. The lowest larval mortality of the parasite ie., 0% was noticed in hosts reared in the medium containing American flour. The highest larval mortality was noticed in hosts reared in the medium containing basic diet.

Pupal mortality of the parasite reared from various hosts fed in different nutrient media also varied considerably. Hosts reared on American flour produced the lowest pupal mortality (21%). Hosts reared on basic diet to which full cream milk powder was added produced the maximum (100% mortality) of the parasites during pupal stage.

Adult longevity of the parasites reared from different hosts fed on various nutrient media also differed considerably. Parasites reared from hosts fed on basic diet to which fructose was added and parasites reared from hosts fed on basic diet to which black gram powder and glucose fortified with yeast were added lived for the maximum number of days (16-17). The parasites reared on hosts fed with basic diet alone showed the shortest longevity (4-5 days).

Largest number of eggs were laid by parasites reared on hosts fed on basic diet to which thiamin was added. Hosts reared on basic diet to which yeast, glucose and black gram powder was added and hosts reared on basic diet to which skimmed milk powder was added, also showed increased fecundity of the parasites. Parasites reared from hosts fed with basic diet produced the smallest number of eggs.

Variations in the sex-ratio of the parasites reared from hosts fed with different nutrient media were prominent. The largest number of female parasites were produced by hosts reared in the medium containing American flour. Hosts reared on basic diet to which glucose was added produced no female parasites. All the parasites emerged were males. Present observations also revealed that the smallest sized hosts reared in a medium containing basic diet and glucose, produced only male parasites.

Differences in size of the parasites reared from different hosts fed on various nutrient media occurred to some extent. The female parasites reared on hosts fed in nutrient media containing fructose to basic diet or thiamin to basic diet or black gram powder and glucose fortified with yeast to basic diet, were the largest measuring nearly 2.96 mm. to 2.99 mm. Their ovipositors were also

longer than those of the parasites reared from hosts fed on the medium containing the basic diet. The smallest sized parasites were reared from hosts fed on the medium containing the basic diet.

Total number of adult parasites emerged also varied in different hosts. The largest number of parasites emerged from hosts fed on medium containing American flour and medium containing basic diet to which was added fructose. The smallest number of parasites emerged from hosts fed on the medium containing basic diet to which was added bengal gram powder and the medium containing basic diet to which glucose was added.

REFERENCES

Ayyar, P.N. Krishna.	1934	A very distructive pest of stored products in South India. Bull. Ent. Res., 24: 155-164.
Bergman, W.	1940	Relation of food to silk, silk worm. Textile Res., 10: 462-475.
Buxton, P.A.	1948	Mice and Fleas. Parasitology, 39: 119-124.
Cumber, R.	1949	Biology and castes, bumble bees. Trans. Roy. Ent. Soc. London, 100: 1-45.
Doten, S.B.	1911	Concerning the relation of food to reproduction, activity, and longevity in certain hymenopterous parasites. Nev. Agr. Expt. Sta. T. Bull., 78: 1-30.
Doutt, R.L.	1960	Biological control of Insect and weed pests. Department of Biological control, University of California (Mimeographed).
Faure, J.C.	1924	Etudes sur la ponte et mode de nutrition, chez chalcidiens parasites. Rev. Zool. Agr. et Appl. 23: 225-233.
Flanders, S.E.	1935	Host influence on the prolificy and size of Trichogramma. Pan Pac. Ent., 11: 175-177.

Flanders, S.E.	1938	Starvation of developing parasites as an explanation of immunity. Jour. Econ. Ent., 30: 970.
----------	1939	Environmental control of sex in hymenopterous insects. Ent. Soc. Amer. Ann., 32: 11-26.
----------	1942	Metaphycus helvolus an encyrtid parasite of the black scale. Jour. Econ. Ent., 35: 690-698.
Gardner, T.R.	1938	Influence of feeding habits of Tiphia vernalis on the parasitization of the Japanese beetle. Jour. Econ. Ent., 31: 204-207.
Glaser, R.W.	1923	Effect of food in longevity and reproduction, flies. Jour. Exptl. Zool., 38: 383-412.
Girison, P.	1947	Nutrition and fertility Leptinotarsa. Comp. Rend. Acad. Sci., 225: 1185-1186.
Grout, R.A.	1949	The hive and the honey bee. Hamilton, Ill., Dadant & Sons.
Hagen, K.S.	1950	A nutritive media for Chrysopa. Jour. Econ. Ent., 43: 101-104.
Haydak, M.H.	1943	Nutrition and caste development honey bee. Jour. Econ. Ent., 36: 778-792.
Hecht, S.	1933	Biology and Nutrition of female mosquito. Beihefte. Arch. Schitts-u. Tropenhyg., 37: 1-87.
Hobson, R.P.	1938	Oviposition and development, Lucila. Ann. Appl. Biol., 25: 573-792.

Katiyar	1962	Effect of nutrition on the fecundity, longevity and sex-ratio of Bracon gelechiae Ash., and Trichogramma evanescens minutum Riley, using Corcyra cephalonica Stainton, as their host reared on various synthetic diets. Agra Univ. J. Res. (Sci.) 2: 17-21.
Krishnamoorthy, B. and Seshagiri Rao, D.	1945	Alternate media for large scale rearing of rice moth (Corcyra cephalonica st.,) in the work of mass production of egg parasite, Trichogramma minutum. Curr. Sci., 14 (10)
Kuwabara, M.	1948	Relation of queen and colony honey bee. Jour. Faculty Sci. Hokkaido Univ., Ser. VI 9: 359-381.
Lafon, M. and Teissier, G.	1939	Nutrition, inaniation and metamorphosis, Tenebri., larva. Compt. Rent. Soc. Biol., 131: 75-77, 417-420.
Metalnikov, S.	1908	Experimental studies Galleria. Arch. Zool. Exptl. et Gen., 4th Ser. 8: 489-588.
Narayanan, E.S. and Mookherjii, P.M.	1955	Effect of nutrition on the longevity and role of reproduction in Trichogramma evaneceus minutum Riley. Indian J. Ent., 17: 376-382.
Narayanan, E.S.	1957	The phenomena of Insect Parasitism and their practical utilization in the biological control of Insect pests. Proc. Ind. Soc. Cong., (Presidential address) 1957.
Rao, D. Sesha giri.	1954	Notes on rice moth Corcyra cephalonica (Stainton). Indian J. Ent., 16: 95-114.

Reynolds, J.M.	1945	Inheritance of food effects, flour beetle. Proc. Roy. Soc. (London), B, 132: 438-451.
Roubaud, E. and Mezger, J.	1934	Action of birds blood on fertility of culex (Diptera). Bull. Soc. Path. Exotique., 27: 666-668.
Salt, G.	1937	Egg parasites of Sialis (Neuroptera). Parasitology 29: 539-553.
-------	1938	Notes, Trichogramma (Hymenoptera) Ibid. 30: 511-522.
-------	1941	The effects of hosts upon their insect parasites. Biol. Rev., 16: 239-264.
Sweetman, H.L.	1958	Principles of Biological Control. WM.C. Brown Company, Dubuque, Iowa. 560 pp.
Titschack, E.	1926	Growth, nutrition, reproduction, moulting, Tineola (Lepidoptera). Zeitschr. Wiss. Zool., 128: 509-569.
Trager, W.	1958	Nutrition, Insect Physiology, Edt. Roeder K.D., John Wiley and Sons, New York. 1: 350-386.
Trouvelot, B.H., Dussy, J. and Thenard, J.	1933	Trophic affinities, potatoe beetle larvae and food plants. Comp. Rend. Soc. Biol., 197: 273-275.
Ullyett, G.C.	1936	Host selection by Microplectron (Hymenoptera). Proc. Roy. Soc. (London), B. 120: 253-291.

Wheeler, W.M.	1923	Social life among Insects. New York, Harcourt Brace and Co.
----------	1928	The Social Insects. New York, Harcourt Brace and Co.
Wolcott, G.N.	1939	Univ. Peurto Rico. Agri. Expt. Stn. Ann. Rept., 30-31.
----------	1942	The requirements of parasites for more than hosts. Sci. 96: 317-318.

Fig. 1

Egg laying chamber used for collection of *Corcyra* eggs

Fig. 2

Glass troughs containing different nutrient media for rearing *Corcyra* larvae

Fig. 3

Tube rack containing specimen tubes used for rearing the parasite M. brevicornis