STUDIES ON THE REGULATION OF PROGENY PRODUCTION AND SEX-RATIO OF *BRACON BREVICORNIS* WESMAEL

(HYMENOPTERA : BRACONIDAE)

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Studies on the regulation of progeny production and sex-ratio of *Bracon brevicornis* Wesmael (Hymenoptera: Braconidae)" is a bonafide record of research work done by me during the course of research work and the thesis had not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
2 -7-1979.

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CERTIFICATE

Certified that this thesis entitled "Studies on the regulation of progeny production and sex-ratio of *Bracon brevicornis* Wesmael (Hymenoptera : Braconidae)" is a record of research work done independently by Kumari. Sosamma Jacob under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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CERTIFICATE

We, the undersigned members of the Advisory Committee of Kumari Soosamma Jacob, a candidate for the degree of Master of Science in Agriculture with major in Agricultural Entomology agree that the thesis entitled "Studies on the regulation of progeny production and sex-ratio of *Bracon brevicornis* Wesmael (Hymenoptera : Braconidae)" may be submitted by Kumari Soosamma Jacob in partial fulfilment of the requirements for the degree.

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INTRODUCTION

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The black headed caterpillar *Nephantis serinopa* Meyrick (Lepidoptera:Xyloryctidae) is a major pest of coconut in India occurring more commonly along the West and East-coast regions. Sporadic outbreaks of the pest occurs during the dry months from January to May in the West-coast and from April to June in the East-coast. In Kerala, the pest is widely distributed throughout the coastal belt and in pockets around lakes and lagoons.

Along the West-coast, the population of *N. serinopa* is found to be minimum during South-West monsoon period from June to August. There is a progressive increase in pest population after abatement of the South-West monsoon and the peak population levels are attained in the summer season. The black headed caterpillar, *N. serinopa* supports a wide spectrum of natural enemies and the parasites are relatively more important among the key biotic agents. Periodic inoculative releases of suitable parasites after cessation of the South-West monsoon is considered to be adequate in maintaining the pest populations below the economic threshold.

Serious pest outbreaks are often experienced during the summer months in areas where parasite releases are not carried out on a regular basis. Severe pest outbreaks are to be brought under control by the application of a suitable contact toxicant. Frequent application of insecticides in coconut plantations will lead to pest resurgence due to progressive elimination of the parasites which form the major component of the natural enemy complex associated with the pest in Kerala. It is, therefore, essential that the insecticidal applications are to be followed by parasite releases with a view to compensate for the populations that are eliminated due to insecticidal application.

The important natural enemies of H. serinopa which are mass multiplied and released against the pest in Kerala are the parasites Bracon brevicornis Wesmael and Trichospilus pupivora Ferriere. The pupal parasite T. pupivora lacks tolerance to high temperature conditions experienced in the summer months and these parasites are, therefore, not quite promising for inoculative or inundative releases during the hot season. B. brevicornis is relatively tolerant to high temperature conditions in the summer months, but a major handicap of this parasite is the production of progeny dominated by the males. The laboratory

stock of this parasite often dwindles substantially due to progressive dominance of males among the offsprings. This is a major obstacle to the adoption of inundative release techniques involving B.brevicornis. In order to build up and maintain large stocks of B. brevicornis in the insectary, a satisfactory level of progeny production consistent with suitable sex-ratio levels in the succeeding generations will have to be ensured.

Ayyar and Ananthanarayanan (1935) reported that B. brevicornis produces greater percentage of males in the hot seasons. Ramachandra Rao et al. (1940) had also recorded the dominance of males in the laboratory cultures of B. brevicornis and suggested that this might be due to the defective fertilisation at pairing caused by adverse climate and nutritional factors. That short exposures to high temperature conditions brings about considerable variations in the sex-ratio of the offsprings of Dahlbominus fuliginosus (Nees)(Hymenoptera : Eulophidae) has been reported by Wilkes (1959 and 1963).

Mathew and Nair (1977) and Abraham and Mathew (1978) have indicated that the sex-ratio of the parent parasite populations and the host larval density are

relatively more important in the sex-ratio regulation of B. brevicornis. The importance of host size as a sex-ratio regulating mechanism in parasitic Hymenoptera has been indicated by a few workers (Clausen, 1939; Flanders, 1939; Ullyett, 1943 and 1945).

In order to explore the feasibility of manipulating the sex-ratio and progeny production in laboratory cultures of B. brevicornis, information on the precise influence of different levels of host larval density, weight of host larvae and sex-ratio of the parent parasite population at different temperature-humidity combination is considered to be vital. The present studies were carried out to meet the above desideratum.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Bracon brevicornis Wesmael is an important component of the natural enemy complex associated with the black headed caterpillar *Nephantis serinopa* Meyrick in Kerala.

Cherian (1929) worked out the biology of this parasite under Coimbatore conditions. The female wasps are yellowish-brown, with dark-brown dorsal bands on the abdomen and with fairly long ovipositor. Males are relatively smaller and duskier. The wasps mate on the day of emergence and egg laying commences the next day. Under confinement, the wasp freely oviposits on several species of noctuid and pyralid caterpillars. The female lays 8 to 12 eggs on the ventral surface of each larva, the mean fecundity being 200 per female. The incubation period is 28 to 36 hours and the larval and pupal periods are 3 to 4 days and 2 to 4 days respectively. The life-cycle is about 7 to 9 days.

B. brevicornis was first recorded in the South Malabar and areas around Cochin as an important parasite on *Nephantis serinopa* (Venkatasubban, 1932). This parasite was later introduced to North Malabar and

Coimbatore areas, but failed to keep down H. serinopa populations in those regions, perhaps due to the presence of alternative hosts (Ramachandra Rao et al. 1940). The alternate hosts of the parasite in India include Noorda porinnae Tams and Adisura atkinsoni Moore (Krishnamurthy and Appanna, 1944). It also attacks the larvae of Natrachedra amydraula Meyr., Ephestia cautella W., Earias insulana Bois., Phycita infuscella Meyr. and Sesamia cretica Led., (Cherian and Margabandhu, 1942).

A major handicap of the parasite is the tendency to produce offsprings dominated by males. Quite often, the laboratory stock of the parasite progressively declines due to this handicap.

Work carried out on the factors influencing the regulation of the sex-ratio and progeny production in parasitic Hymenoptera in general and B. brevicornis in particular is briefly reviewed here.

I GENETIC FACTORS

As in most species of parasitic Hymenoptera, Bracon brevicornis exhibits the phenomenon of arrhenotoky, characterised by the production of females from fertilised diploid eggs and of males from unfertilised haploid eggs.

Speicher and Speicher (1938) observed that the occasional uniparental females of Bracon hebetor Say originated from patches of tetraploid tissue in a normal diploid ovary.

Whiting (1945) stated that sex determination in Bracon is regulated by a series of multiple alleles of which nine have thus far been identified. The females conform to the xa/xb, xa/xc, xc/xd allelic genetic configuration while azygotes of the xa, xb, xc types or any diploid homozygote of the types xa/xa, xb/xb etc., will be males.

Genetic improvement of sex-ratios of some parasitic insects was obtained by Wilkes (1947) and Simmonds (1947). Wilkes (1947) showed that in the case of Dahlbominus fuliginosus (Nees)(Hymenoptera: Eulophidae), a continuous decrease in the number of sterile males from 35 to 2 per cent was brought about by selective breeding. It was shown that continued inbreeding in the laboratory stock was actually responsible for the prevalence of male sterility which resulted in the progressive reduction of female progeny in successive generations.

Simmonds (1947) found that in Mantrus carpocapsae (Lush), a higher percentage of females was obtained by breeding from males and females selected from high sex-ratio families and he suggested that the sex-ratio in this case is genetically determined.

The absence of fruitful fertilisation of eggs at pairing, possibly as a result of the defective climatic or nutritional factors has been implicated as a factor for male dominance in B. brevicornis (Ramachandra Rao et al. 1948).

According to White (1954), arrhenotoky is a method of sex determination as well as a form of reproduction, the frequency of occurrence of males in the population being determined on the basis of the frequency of production of unfertilised eggs.

In the arrhenotokous parasitic wasp Dahlbominus fuliginosus, a sex-ratio controlling factor of genetic origin was reported by Wilkes (1964). This factor is sex limited and transmitted by females to their male progeny, its effect on sex-ratio being constant and not influenced by the female parent.

Lee and Wilkes (1965) detected five different types of spermatozoa in Pahlbominus fuscipennis Zett. (Hymenoptera: Eulophidae) on the basis of length and the pattern of spiralling of the helical coil in the head region of the spermatozoa. The spiralling may be of dextral or sinistral types and this dimorphism in the spermatozoa may determine whether fertilization occurs or not.

II HOST AND HOST NUTRITION

According to Salt (1941), the host is often able to impress its mark upon the parasitoid that systematically destroys it and may bequeath to its parasite striking legacy of morphological, physiological and behaviouristic characters.

Narayanan and Chaudhuri (1955) reported that the sex-ratio of Stenobracon deesae (Cam.) (Hymenoptera: Braconidae) varies according to the host and among the adults reared on Chilo zonellus, 28.0% were females, while among those reared on Corcyra larvae only 6.2% were females. It was suggested that the ovipositor enabled the parasite to recognise the host and the stimuli thus received influence the functioning of the spermatheca, which in turn controls fertilisation and sex of the offspring.

Narayanan and Subba Rao (1955) observed that when Bracon celechiae Ashmead was reared on Platyedra gossypiella, Corcyra cephalonica and Sitotroga cerealella, the proportion of females produced among the progeny were 55, 74 and 44 per cent respectively. The size of the host had little relation to the sex-ratio of the parasite and the higher incidence of males in some hosts was attributed in part to a lack of external stimulation of the spermatheca in the ovipositing female due to host unsuitability.

House and Barlow (1961) studied the influence of different diets of a host, Agria affinis (Fall.) (Diptera: Sarcophaginae) on the development of a parasitoid, Aphaereta pallipes (Say.) (Hymenoptera: Braconidae). The diet containing of 3 per cent of amino acids and 0.5 per cent of dextrose caused greater host mortality and unsuccessful emergence of the parasites.

Louis (1961) recorded that when the females of Bombus hypnorum (Ltg.) (Hymenoptera: Ichneumonidae) were fed on host larvae and pollen in sucrose solution, greatest number of eggs per female was obtained, while females supplied with host larvae alone deposited only fewer eggs.

Katiyar (1962) studied the parasitisation by Trichogramma minutum (Hymenoptera: Trichogrammatidae) and Bracon kolechina of eggs and larvae of Corcyra cephalonica respectively. It was found that C. cephalonica reared on crushed sorghum mixed with 8 per cent yeast was more suitable for parasite development.

Doutt (1960), stated that the host of the parasitoid exerts considerable influence on the rate of development of the parasitoid in a remarkable manner.

Wylie (1966) indicated that females of Nasonia vitripennis (Walk.) (Hymenoptera: Pteromalidae) parasitising housefly pupae (Musca domestica L.) gave rise to a smaller percentage of female progeny at high parasite - host ratios than at lower ones due to failure in fertilisation and because more female than male larvae die on superparasitised hosts. The adult females fertilise relatively fewer eggs at high parasite-host ratios since they encounter relatively more previously attacked hosts, on which a smaller percentage of fertilised eggs are laid. The reduction in the percentage of fertilised eggs under high parasite: host ratios is also due to mutual interference by the female parasites which inhibits fertilisation.

Nathai (1971) observed that the fecundity of B. brevicornis was significantly influenced by nutrition of its laboratory host Corcyra cephalonica. The host larvae bred on a media containing wheat flour fortified with skimmed milk powder (25% of the basic diet) or on wheat flower enriched with thiamine at 2 mg per gram was found to increase parasite fecundity. Variations in the nutrition of C. cephalonica did not significantly affect the duration of development of the parasite. A preponderance of males was found among the adult parasites reared on larvae bred on a media containing yeast, bengalgram or skimmed milk powder while the females were dominated in progeny reared out on larvae bred on maize flour diet.

Songwan (1973) reported that when Stenobracon deesae, a parasite of Chilo partellus Swinhoe, was reared in the laboratory on a single fictitious host Corcyra cephalonica, 34.7 per cent of the eggs developed into adults and 65.46 per cent of these were males, as compared with 67.3 per cent and 31.98 per cent respectively obtained from the natural host. However, when additional food in the form of further larvae of C. cephalonica that had been paralysed by B. brevicornis were provided, the survival ratio and the sex-ratio were restored. It was thus concluded that a single larva of C. cephalonica

did not provide sufficient nutrition for females of *B. dorsone* to complete their normal development.

Reporting the results of laboratory studies, David *et al.* (1977) stated that the parasite-host interaction between *Bracon hebetor* and *Ephestia cautella* was influenced by migration of host larvae prior to pupation and also by the feeding of the parasite females. Wandering host larvae were attacked more often than confined hosts. Survival and fecundity of adult female parasites were directly related to the frequency of host finding. Host feeding prolonged adult female parasite's survival, but the adult male parasites did not feed on the hosts. The long reproductive life, short life-cycle and reliance on hosts for adult and offspring nutrition should render *B. hebetor* quite responsive to manipulation of host availability.

Nadarajan and Jayaraj (1977) observed that the sex-ratio of the parasite *Tetrastichus israeli* Moni and Kurian (Hymenoptera: Eulophidae) was highly influenced by the host species and superparasitism. In *Nephantis serinopa* at the density level of 30 parasites, the number of males were slightly more than females. There were more males at the density of 30 parasites per host in *Haroramia indica* S. The sex-ratio was as high as 2.06

in *Corcyra cephalonica* even at a level of 10 parasites indicating male preponderance. The male preponderance could be attributed to the differential mortality of sexes during development.

III HOST DENSITY

Flanders (1935) studied the influence of hosts on progeny production in *Trichogramma evanescens*. According to him, with increasing host densities, the number of progeny per parasite increased until a maximum was reached. The number of progeny per parent becomes stable beyond a stage when the number of hosts within the sphere of action of the parasite exceeds the total reproductive potential of the parasite. Under laboratory conditions, progeny per female decreased with the increase in the number of parasites beyond a critical level. This is perhaps due to the phenomenon of superparasitism and the consequential intraspecific competition.

Ullyett (1951) reported that *Bracon hebetor* tended to deposit a fixed number of eggs during a period of 24 hours regardless of the number of hosts.

Dharmaraju (1952) observed that the maximum fecundity of *Perisierola nephantidis* Muesebeck (Hymenoptera: Bethylidae) was obtained with one larva of

Corcyra cephalonica, while in the case of Trichospilus pupivora Ferriere (Hymenoptera: Eulophidae), the fecundity did not show any increase with increase in the host pupal number.

Puttarudriah and Usman (1957) found that the decline in the field parasitisation of eggs of Chilo zonellus by Trichogramma evanescens minutum Riley in the Mysore State was mainly due to low host density levels.

Doutt (1959) concluded from observations on a species of Hieroboroon that the number of eggs per female per day was dependent on the number of hosts available up to the fourth day. Thereafter, host density was not observed as influencing egg production rate.

According to Flanders (1962), the proportion of host individual which stimulate the spermatheeal gland increases as the density of host population decreases.

King (1962) recorded that at low host densities, the females of Exeristes vitripennis produced a smaller percentage of female progeny than at higher levels.

Jayaratnam (1963) established a highly significant positive linear correlation between the weight of host pupa and the progeny production in Trichospilus pupivora.

The progeny production in Bracon brevicornis according to Seshagiri Rao et al. (1967), increased progressively with the number of hosts available but the progeny production decreased in Perisierola nephantidis at high host density levels. Host density had no influence on the sex-ratios of both the parasites.

Viktorov and Azizov (1972) reported that the number of progeny produced in Muscidifurax raptor (Hymenoptera: Pteromalidae) increased with increase in number of host puparia of Musca domestica Vicina (Diptera: Muscidae) which were available.

Fusco and Hower (1974) indicated that reproduction of the arrhenotokous parasite Microctonus aethiops (Nees) (Hymenoptera: Braconidae) produced the maximum number of progeny (average 25.8 per female) when fifty hosts were made available to each mated female. When fifty hosts were exposed to parasite, the progeny production declined and the percentage mortality of the hosts increased substantially. The percentage of females

in the progeny was higher when hosts were supplied discontinuously than when these were offered continuously.

According to Subba Rao et al., (1974), maximum fecundity in Bracon hebetor was obtained when two Corcyra larvae of six weeks old were exposed to a single pair of parasites.

Yeargan et al., (1976) tested the effect of density of Hypera postica (Gyllenhal) (Coleoptera : Curculionidae) on parasitism by Bathyplectes curculionis (Hymenoptera: Ichenumonidae). It was observed that host density had no significant effect on the proportion of hosts parasitised. Host mortality was not attributable to normal parasite development but this was positively corrolated with parasite density, suggesting some form of injury inflicted by the parasite.

Lathoef et al., (1977) studied the effect of density on host-parasite interactions between Hypera postica and Bathyplectes anurus (Thomson). There was no significant relationship between proportion of hosts parasitised and host density. The frequency distribution of the parasite's eggs approximated the poisson distribution in eighty three per cent of the cases. There was

a quadratic relationship between number of super parasitised hosts and parasite density. However, no significant correlation between proportions of hosts parasitised and host density was detected.

Chandurwar (1977) observed that parasitism by Orgilus parcus Turner (Hymenoptera: Braconidae) on the host Ephthorimaea operculella (Lepidoptera: Gelechiidae) was higher when the number of hosts per case was increased. However, the increase in parasite density resulted in reduced searching efficiency per individual parasite.

Abraham and Mathew (1978) reported that among the factors regulating the progeny production in Bracon brevicornis, the number of exposed Corcyra larvae was relatively more important. The number of host larvae exposed exerts significant influence on the sex-ratio of the offspring, the contribution of this factor being 20.7 per cent.

Cameron and Rodfern (1978) recorded that the densities of the Hymenopteran parasite Torymus nigriturcus Dalman and Mesopolobus diffinis were determined mainly by the density of available host, Taxomyia taxi (Inhbald) (Diptera: Cecidomyiidae).

Haggaipodoler et al., (1978) studied the ovipositional responses of Aphytis holoxanthus (Hymenoptera: Aphelinidae) to increasing density levels of its host, the Florida red scale Chrysomphalus aonidum (Homoptera: Diaspididae). As the host density increased, the number of eggs laid by the female parasite also increased, but at a retarded rate. This type of functional response resulted in reduced parasitism at higher host densities.

Chewyreuv (1913) found that the great majority of individuals of Pimpla reared on large hosts were females, whereas those from small hosts were predominantly males.

Holdaway and Smith (1932), studying the sex-ratio of Alysia manducator (Panz.) (Hymenoptera: Braconidae) bred on hosts of different sizes indicated that the quantity of available food determined by the size of the host played an important role in determining the sex of the parasite.

The influence of host size on progeny production has been studied extensively in Trichogramma spp. Salt (1934) stated that the number of eggs laid by

Trichogramma in a single host egg increased with host size, being one in Sitotroga cerealella Olivier, two in Corcyra cephalonica, two to three in Diatraea saccharalis three to four in Chilo sacchariphagus and eight to ten in Papilio demoleus Sp. (Metcalf, 1959; Arenière, 1965).

According to Clausen (1939) and Flanders (1939), in parasitic Hymenoptera, generally large hosts favour the production of female parasites while the smaller hosts tend to produce males.

Ullyett (1943, 1945) observed that the number of Bracon eggs laid on or near a given host is related to the size of the host and ultimately to its potential as food.

Fusco and Hover (1973) studied the effect of size, sex and age of Hyper postica on the productivity of Microctonus aethiops in the laboratory. According to him, host size had no significant effect on the mean number of progeny or mean percentage of females produced per parasitoid. However, host mortality was significantly higher among the smaller hosts. Host sex had no effect on host selection by M. aethiops nor was any differential mortality observed between male or female hosts.

Gurjanova (1974) reported that the sex-ratio of Exenterus abruptorius (Hymenoptera: Ichneumonidae) was determined by the size of the host Neodiprion sertifer and differential infestation rates on its males and females. The parasite lays most of the fertilised eggs on large female larvae and unfertilised eggs on male larvae.

IV. SEX OF THE HOST

Hodgson (1955) found that the males of Apechthis ontario (Cresson) emerged mainly from male host pupae and females from female pupae, apparently the result of selective oviposition.

Sithanantham and Subramoniam (1977) reported the influence of sex of the larvae of Chilo partellus on the sex-ratio of the associated parasite Stenobracon deesae Cam. The sex-ratio of the parasite was in favour of males in the male hosts while it shifted significantly in favour of females in the female hosts.

V AGE OF THE HOST

Ransom (1937) stated that females of many hymenopterous species can distinguish between parasitised and unparasitised hosts and fertilise a smaller percentage

of eggs they lay on unsuitable hosts.

Wylie (1962) observed that the age of pupae of the housefly Musca domestica (L.) affect the longevity and fecundity of Nasonia vitripennis that fed on them mainly due to variations in the nutritional status of hosts of different ages. At 24.5°C, both longevity and fecundity of females were greatest when it fed on pupae of less than 48 hours age.

According to Wylie (1963), mortality of N. vitripennis was least an young housefly pupae but increased with increasing host age.

VI PARASITE DENSITY AND SUPERPARASITISM

According to Narayanan and Subba Rao (1955) superparasitism affected the sex-ratio of the progenies of Dragon geloechiae through selective elimination of females due to intra-specific competition. As the parasite larvae increased from three to thirty, the proportion of females declined drastically from 73.6 to 9.8%.

Narayanan and Mukerji (1956) studied the phenomenon of superparasitism in Trichogramma evanescens minutum and have observed that superparasitism occur at both high and

low host densities.

Narayanan and Chacko (1957) stated that in Trichogramma spp. the occurrence of superparasitism in laboratory breeding led to the production of progeny with impaired vitality, fecundity and longevity.

Iyatomi (1958) concluded that in the case of T. japonicum, superparasitism caused decrease of the percentage of female progeny and fecundity besides the impairment of vitality.

Chacko (1964) demonstrated that in Bracon gelechiae, superparasitism led to a lower proportion of females. He concluded that under crowded conditions, many members of both sexes fails to obtain sufficient food and that the females were the more seriously affected.

Wylie (1965) reported that superparasitism created food shortage and thereby reduced survival and size of adults of Nasonia vitripennis reared on pupae of Musca domestica. Super parasitism also reduced the percentage of females in the adult progeny.

Reinert and King (1971) found that Bracon hebetor preferred female larvae of Plodia interpunctella (Hubner) (Lepidoptera: Pyralidae) for parasitization. The sex-ratio

of *B. hebetor* in the F_1 generation appeared to vary with host: parasite density ratio.

Benson (1973) observed that *B. hebetor* being gregarious in the larval stage, the developing eggs and larvae were subjected to intraspecific competition which leads to direct mortality, size variation and changes in sex-ratio. The size of the surviving progeny and the sex-ratio decreases as parasite density/host-*Ephestia cautella* increases. It is shown that this change is caused by differential mortality which acts more strongly against the female.

Carpenter (1943) observed that single fertilised females of *Bracon mellitor* yielded on an average of 7.5 adult offsprings with 20 host larvae maintained at 85°F for 72 hours. But the individual productivity was decreased when batches of 5, 10, 15, 30 and 60 larvae were kept under the same conditions. This decrease was partly due to competition among the parasites and because they had to spend more time in searching for unparasitised hosts.

Dharmaraju (1952) found that the maximum number of fecundity was obtained with one pair of *Perisierola nephantidis* and the same trend was also noticed in the case of *Trichospilus pupivora*.

Sharma (1956) concluded that the fecundity of B. brevicornis declined with increase in the density of parasite population.

Subba Rao et al. (1974) stated that maximum fecundity was recorded in B. hebetor when one pair of parasites were exposed to two host caterpillars.

VII SEX-RATIO OF THE PARENT PARASITE POPULATION

Mathew and Nair (1977) stated that the proportion of females in the progeny of B. brevicornis can be improved to a great extent by adjusting the sex-ratio of the parent parasite population.

Abraham and Mathew (1978) observed that the number of males in the parental population of B. brevicornis significantly influenced the progeny production. The number of females in the parental population exerted significant influence on the sex-ratio of the offspring.

VIII MATING AND FERTILISATION

Whiting (1921) observed that the unmated females of Microbracon hebetor produced occasional females.

Flanders (1946) reported that in Macrocentrus angulivorus (Hymenoptera: Braconidae) male offsprings

predominated when multiple mating occurred. According to him, the sex-ratios are determined extrinsically by the effect of the density of oviposition sites on differential mortality during development, pre-ovipositional period, excessive mating, the difference in oviposition response before and after mating, the rate of oviposition etc. Sex-ratios are determined intrinsically by the number of eggs deposited at one insertion of the ovipositor, the number of ovarian eggs ready for deposition and the differential in the polyembryonic tendency.

The fecundity of unmated females was reduced according to Moutia and Courtois (1952) in Trichogramma australiense.

Hoelscher and Vinson (1971) observed that offsprings from unmated females of Campoletis perdistinctus (Viereck) (Hymenoptera: Ichneumonidae) were all males and females might not be produced after copulation. The exposure of older females to males for fertilisation yielded offspring with a greater percentage of females.

IX ADULT PARASITE NUTRITION

According to Dharmaraju (1952), ten per cent sugar solution was the best among the food materials tried for improving the fecundity of Perisierola nephantidis and Trichospilus pupivora.

Sharma (1956) indicated that in Bracon brevicornis maximum fecundity was obtained when the parasitics were fed with sucrose solution.

Subba Rao et al. (1974) reported that sucrose ten per cent was found to be the best among the different diets tried to increase fecundity of B.hebetor.

X LIGHT AND PHOTOPERIOD

Martin and Finney (1946) improved the sex-ratio of Macrocentrus ancylivorus by decreasing the light intensity in the mating room.

Ramachandra Rao et al.(1948) reported that when sets of pairing adults of B. brevicornis were placed in special cages and kept exposed to diffused light in the open, equal proportions of both sexes of progeny were obtained.

According to Hoelscher and Vinson (1971), a 12:12 (L:D) photoperiod produced offsprings with the greatest percentage of females in Campoletis perdistinctus (Viereck) (Hymenoptera: Ichneumonidae).

XI TEMPERATURE-HUMIDITY CONDITIONS

Hase (1922)observed that oviposition in Habrobracon brevicornis was inhibited at temperatures below 15°C.

Payne (1931) reported that both the period of development and the duration of adult life of Microbracon hebetor were affected by temperature.

Payne subsequently (1933) studied the differential effect of environmental factors upon M. hebetor. It was showed that at high temperature, the parasite had a decided advantage over the host, but at lower temperatures there was no possibility of the parasite overtaking the host.

Knowles (1933) working on the influence of temperature and air humidity on the embryonic development of M. hebetor, observed that the duration of development depended chiefly on temperature and only slightly on humidity. He noted that under the combined influence of optimum temperature and humidity, all the larvae hatched out simultaneously while under other conditions some larvae hatched first and were then followed by the majority. The effect of low humidities was more than that of high levels and the effect of humidity was more marked at low temperatures than at high ones. High temperatures produced mortality more quickly than lower levels.

Thrond and Garman (1933) reported that temperature affects the sex-ratio of Trichogramma through adverse

effects on the viability of the sperms . They have noticed that an excess of males appeared in the progeny of *Trichogramma* kept for two weeks at 3° to 8°C.

Payne (1934) found that the proportion of males was higher under low temperature and this was attributed to the suppression of mating activities.

Hanna (1935) indicated that pupae of *Euchalcidia caryobori* Hanna. (Hymenoptera: Chalcididae) held at 16°C produced some sterile males, the proportion increasing with the duration of exposure and the females similarly treated produced increasingly fewer eggs.

Ayyar and Ananthanarayanan (1935) reported that *B. brevicornis* produced greater percentage of males in the hot season.

Iijima (1940) recorded that both males and females of *Lucosma schistaceana* Snellen. which were held at 32°C during the pupal stage were all found to be sterile.

Ahmad and Ghulamullah (1941) studied the influence of temperature on *Earias fabia* (Stoll) and its parasite *Bracon greeni* Lefroi Dudgeon and Gough. At low temperatures, the parasite developed more rapidly than the host, while at high temperatures the host population increased at a faster rate.

Mourai (1946) found that when Nasonia vitripennis were held at temperatures from -1°C to 16°C for increasing periods of time, there was a gradual decrease in the proportion of females in the progeny.

Georgiana (1949) observed that haploid males in Habrobracon juglandis Ashmead were more vulnerable to environmental adversities.

The sex of the parasite and consequently the sex-ratio in most Hymenoptera is largely a function of the environment (Flanders, 1962). According to him, the remarkable variability in sex-ratios in many species of parasitic Hymenoptera under natural conditions results from the fact that in the progeny of the mated female, the sex of any particular individual is a maternal effect, this being a response to environmental stimuli acting through the spermatheeal gland. The control of sex is accomplished by the facultative response of the spermatheeal gland to environmental stimuli associated with the process of oviposition. Certain environmental temperatures and humidities and certain species of host may inhibit the stimulation of the spermatheeal gland without affecting the number of eggs deposited.

Shalla and Venkataraman (1963) observed an accelerative effect on the rate of egg development with the rise of temperature from 20°C to 40°C in Vipion deonae (Cam.) (Hymenoptera: Braconidae), a parasite of Chilo zonellus. At 20°C, the larval period was completed on an average in 9.42 days. The developmental period decreased significantly with the rise of temperature till a minimum of 4.03 days was attained at 34°C. At 20°C and 90% RH there was a complete arrest of development in the pre-pupal stage, while at the same temperature and at lower humidities, a smaller percentage pupated and emerged as adults.

Wilkes (1963) reported that in the arrhenotokous insect Bethylobinus fulicinosus, variation in the sex-ratio occurred when unfavourable environmental conditions prevailed before, during and immediately after mating. Temperatures above 27°C during post-embryonic development, sterilised otherwise functional males, but had much less effect on females. Mating was successful only within the normal range for optimum adult activity. Although females were inseminated by more than one male, the sex-ratio of their progeny was not affected. Larval mortality from superparasitism above sixtyfive larvae per host differentially favoured survival of males.

The percentage of females was significantly reduced when oviposition was interrupted or delayed by low temperature.

Pilon (1966) stated that temperature and relative humidity significantly influenced the life span of both sexes in the adults of Heeldimion guainai Middleton. The influence of temperature varied with relative humidity in the case of males but not in the case of females.

Rotary and Gerling (1973) studied the influence of some external factors upon the sex-ratio of Bracon hebetor and found that numerous females produced male progeny only, perhaps due to internal factors. Cannibalism and mortality due to superparasitism favour male survival. The percentage of females increased significantly when females were allowed to feed only on hosts inside their webbing and also when mating and oviposition were delayed.

Barfield et al. (1977) observed the influence of temperature on the development of immature stages of Bracon mellitor a braconid parasite of the cotton boll weevil Anthonomus grandis Boheman (Coleoptera: Curculionidae) at a series of constant and variable

temperatures. Mean developmental periods were in close agreement with predictions based on a developmental model. They have stated that the adult longevity decreased with increasing temperature.

Madrajan and Channa Basavanna (1970) studied the effect of different levels of temperature and humidity on the biology and the development of the parasites, Parisierola nephantidis and Tetrastichus israeli. They have observed that the incubation period for eggs of P. Nephantidis was not influenced by temperature and humidity variations, while the larval period was highly influenced. There was no effect due to humidities alone but they interacted with temperature in influencing the larval period. There was no effect due to interaction of temperature and humidity and also by humidity alone on the pupal period. The humidity had no influence on the male longevity either alone or with temperature. Male preponderance was noted as the temperature increased, indicating that the sex-ratio is adversely affected at higher temperature.

MATERIALS AND METHODS

MATERIALS AND METHODS

I. Maintenance of *Bracon brevicornis* Wesmael stock cultures

The nucleus culture of *Bracon brevicornis* Wesmael required for the present investigations were obtained from the Parasite Breeding Laboratory of the Kerala Department of Agriculture at Irinjalakuda, Trichur District. The parasites were reared on twenty five days old fourth instar larvae of *Corcyra cephalonica* Stainton, maintained at 28 ± 1.5°C. Stock cultures of the parasite were maintained in small specimen tubes of size 10 x 2.5 cm. The tubes were thoroughly washed and sterilised in hot air oven at 50°C for one hour and after cooling, were stored in sterilised desiccators. As and when required, the tubes were drawn out from the desiccators. The parasites with adequate number of females were introduced into the specimen tubes and six to ten *Corcyra* larvae of required age were then introduced into these tubes with a camel hair brush. A mixture of equal volumes of honey and 10 per cent glucose solution in water was used for feeding the adult parasites. The mixture was provided on bits of coconut leaflet of size 6.0 cm x 0.5 cm in the form of fine droplets by means of a coconut midrib piece of about 10 cm long with bluntly

pointed ends. The leaflet bits with food droplets were introduced into the specimen tubes which were then closed with cotton plugs. Fresh honey-glucose solution was provided immediately on exhaustion of the solution previously supplied. About five to six days after confinement of the parasites and host larvae, the tubes were cleaned by removing the unparasitised Corcyra larvae and the dead parasites. The stock cultures were maintained at 28 ± 1°C and 75 per cent relative humidity.

The adult parasites of the succeeding generation emerged in eight to ten days and the culture was continuously maintained to ensure availability of adequate populations for experimental purposes.

II. Maintenance of stock culture of Corcyra cephalonica Staint.

Stock cultures of Corcyra cephalonica Staint. were established from eggs obtained from the Parasite Breeding Laboratory of M/S EID Parry & Co. LTD., at Nellikuppam, S. Arcot District of the Tamil Nadu State. Adequate cultures were maintained throughout the course of the studies in museum jars of size 13.0 cm x 12.5 cm x 5.0 cm using crushed "jowar" (Sorghum vulgare Pers.) as the food medium. About 0.2 c.c. of freshly laid Corcyra eggs containing about 3500 eggs were initially mixed with 25 gms of jowar meal

and the mixture was then transferred to cylindrical glass bottles of size 26 cm x 21 cm. The bottles were closed with muslin cloth and tightly held in position by rubber bands. Four to five days later the jowar meal containing freshly emerged Corcyra larvae were taken out of the bottles and this was mixed with 350 gms of crushed jowar fortified with 50 gms of split black gram (Phaseolus mungo Linn.). The 'jowar' meal and crushed material as also split blackgram were sterilised at 50°C for one hour in a hot air oven before offering these as food for Corcyra larvae. The high temperature sterilisation was carried out to destroy any latent infestations of Corcyra or of other storage pests. Further rearings were carried out in rectangular museum jars. The moths emerging from these cultures were collected daily and these were confined in oviposition cages. The oviposition cage consisted of a cylindrical glass tube of size 19 cm x 12 cm, both ends of which were open. The two open ends of the glass tube were closed with suitably sized poly-meshes which were very tightly held by rubber bands. The moths were released inside the cage and the eggs collected inside glass dishes of the same diameter held on the bottom of the cylindrical glass tube. The eggs deposited on the poly-meshes were collected by brushing with a painting brush of

size 2.5 cm. The glass dish and the cylindrical glass tube were held together by winding adhesive bandage around. The oviposition cage was kept protected from predatory spiders by enclosing it in an ant-proof wire net cage.

III. Studies on parasite development under different conditions

The influence of host larval density, weight of the host larvae and sex-ratio of the parent parasite population on the number of eggs laid, duration of development, progeny production and female-male composition of the F_1 progeny at different temperature-humidity combinations were studied inside BOD incubators. The parasites under all treatment combinations were fed with honey-glucose mixture and exposed to semi-dark conditions obtaining inside the incubators.

The fecundity, duration of development, progeny production and female-male composition of the F_1 progeny were studied as follows:-

a) Fecundity

The fecundity was recorded by examining the host larvae on successive days after confinement, under Stereo-microscope and directly counting the eggs adhering to the

host cuticle.

b) Duration of development

The duration of development was found out by calculating the weighted means of the number of days taken by the parasites of both sexes emerging on successive days. For this, the parasites emerging on successive days were isolated, killed and the female-male composition in relation to the durations of development recorded.

c) Progeny production

The total number of males and females which emerged out from each replicate was recorded as the F_1 progeny production under different treatment combinations.

d) Female-male composition of the F_1 progeny

The female-male composition of the F_1 progeny produced under each treatment combination was recorded by pooling the data on the parasites of both sexes emerging on successive days.

IV. Experimental details

a) Treatment combinations

The influence of host larval density (A), weight of host larvae (B) and sex-ratio of the parent parasite

population (C) on the number of eggs laid, duration of development, progeny production and female-male composition of the F_1 progeny, were studied in the present experiments. The levels at which each of these three factor was studied are indicated below.

Factor 1 - A - Host larval density

Levels a_0 = 1 host larva per female parasite

a_1 = 2 host larvae per female parasite

a_2 = 3 host larvae per female parasite

Factor 2 - B - Weight of host larvae

Levels b_0 = Larval weight 30 - 35 mg

b_1 = Larval weight 8 - 10 mg

b_2 = 50 per cent of larvae of the b_0 type + 50 per cent of larvae of the b_1 type.

Factor 3 - C - Sex-ratio of parent parasite population

Levels c_0 = 1:1 (Female : Male)

c_1 = 2:1 (")

c_2 = 3:1 (")

c_3 = 1:2 (")

c_4 = 1:3 (")

There were altogether forty five treatment combinations involving the three main factors and these were

replicated thrice. The treatment combinations are furnished in Table M-1. The statistical design employed was Factorial C.R.D.

b) Maintenance of temperature-humidity levels

The experiments were conducted at the following temperature-humidity combinations which represented near optimum conditions i.e., 28°C and 75% RH and the two progressively adverse conditions viz., 30°C and 60% RH and 32°C and 50% RH.

The different levels of constant temperatures were maintained in electric B.O.D. incubators while constant levels of humidity were obtained in desiccators (30 cm diameter) by keeping calculated quantities of pure saturated potassium hydroxide pellets dissolved in distilled water according to Burton (1951).

c) Selection of Corcyra larvae of the required weight group

Considerable size variations were observed among Corcyra larvae of the same age group. The larvae were classified according to their weight by quickly weighing live individual larvae in physical balances. In order to ensure that the larvae do not wriggle out from the pan, they were taken on coarse emery paper cards of size 4 x 4 cm

Table M-1

Treatment combinations involving host larval density (A), host larval weight categories (B) and sex-ratio of the parent parasite population (C).

Sl. No.	Treatment codes	Host larval density(A)	Host larval weight categories (B)		Sex-ratio of parent parasite population(C)	
			30-35 mg	8-10 mg	Number of females	Number of males
1.	$a_o b_o c_o$	6	6	-	6	6
2.	$a_o b_o c_1$	6	6	-	8	4
3.	$a_o b_o c_2$	6	6	-	9	3
4.	$a_o b_o c_3$	6	6	-	4	8
5.	$a_o b_o c_4$	6	6	-	3	9
6.	$a_o b_1 c_o$	6	-	6	6	6
7.	$a_o b_1 c_1$	6	-	6	8	4
8.	$a_o b_1 c_2$	6	-	6	9	3
9.	$a_o b_1 c_3$	6	-	6	4	8
10.	$a_o b_1 c_4$	6	-	6	3	9
11.	$a_o b_2 c_o$	6	3	3	6	6
12.	$a_o b_2 c_1$	6	3	3	8	4
13.	$a_o b_2 c_2$	6	3	3	9	3
14.	$a_o b_2 c_3$	6	3	3	4	8
15.	$a_o b_2 c_4$	6	3	3	3	9
16.	$a_1 b_o c_o$	12	12	-	6	6
17.	$a_1 b_o c_1$	12	12	-	8	4
18.	$a_1 b_o c_2$	12	12	-	9	3
19.	$a_1 b_o c_3$	12	12	-	4	8
20.	$a_1 b_o c_4$	12	12	-	3	9
21.				12		6
22.	$a_1 b_1 c_1$	12	-	12		4
23.	$a_1 b_1 c_2$	12	-	12	9	3
24.	$a_1 b_1 c_3$	12	-	12	4	8
25.	$a_1 b_1 c_4$	12	-	12	3	9
26.	$a_1 b_2 c_o$	12	6	6	6	6
27.	$a_1 b_2 c_1$	12	6	6	8	4
28.	$a_1 b_2 c_2$	12	6	6	9	3
29.	$a_1 b_2 c_3$	12	6	6	4	8
30.	$a_1 b_2 c_4$	12	6	6	3	9
31.	$a_2 b_o c_o$	18	18	-	6	6
32.	$a_2 b_o c_1$	18	18	-	8	4
33.	$a_2 b_o c_2$	18	18	-	9	3
34.	$a_2 b_o c_3$	18	18	-	4	8
35.	$a_2 b_o c_4$	18	18	-	3	9
36.	$a_2 b_1 c_o$	18	-	18	6	6
37.	$a_2 b_1 c_1$	18	-	18	8	4
38.	$a_2 b_1 c_2$	18	-	18	9	3
39.	$a_2 b_1 c_3$	18	-	18	4	8
40.	$a_2 b_1 c_4$	18	-	18	3	9
41.	$a_2 b_2 c_o$	18	9	9	6	6
42.	$a_2 b_2 c_1$	18	9	9	8	4
43.	$a_2 b_2 c_2$	18	9	9	9	3
44.	$a_2 b_2 c_3$	18	9	9	4	8
45.	$a_2 b_2 c_4$				3	9

with uprightly folded edges. The larvae were then classified on the basis of their weights into the two categories viz., those with a weight range of 30 mg to 35 mg and those with a range of 8 mg to 10 mg.

d) Obtaining the required female-male composition of the parent parasite population

In order to obtain the required number of females and males for the different treatment combinations, freshly emerged parasites were drawn from the nucleus culture and counted immediately after anaesthetisation. For anaesthetisation, sterilised absorbent cotton pads were pressed on to the bottom of the specimen tubes of size 10 cm x 2.5 cm and then 2 to 3 drops of chloroform were poured on to the cotton pad. The specimen tube was kept tightly closed with dark and was opened just prior to anaesthetisation. The parasites were anaesthetised by inverting the tube containing chloroform-soaked cotton pad over the open tube containing parasites for a split second. The parasites which were thus immobilised were immediately transferred to glass plates and sexed. The parasites were observed till they recovered from anaesthetisation. Those which did not recover were removed and fresh parasites were introduced to compensate for the loss.

V. Statistical methods

The analysis of the data on fecundity, progeny production and number of female progeny was carried out by using the chi-square method. The total variability in the data as measured by chi-square assuming equal distribution of counts, has been partitioned into the components reckoning the variation due to levels of the factors and their interactions. Thus the total χ^2 was computed by summing up χ^2_A, χ^2_B, χ^2_{AxB}, χ^2_C, χ^2_{AxC}, χ^2_{BxC} and χ^2_{AxBxC}. The chi-squares for the factors were used to test the null hypothesis of equal distribution of counts over the levels. The chi-squares for interactions measure the heterogenity among the levels of one factor. For example, χ^2_{AxB} measures the heterogenity of distribution of counts according to the levels of A over the levels of B. Here the chi-square for the combination of A x B are partitioned into $\chi^2_A + \chi^2_B + \chi^2_{AxB}$. Here the chi-square for a set of observations a_1, a_2 ..... a_n was obtained by the formula $\frac{\sum ai^2 - n\bar{a}^2}{\bar{a}}$ where $\bar{a}$ is the arithmetic mean of the frequencies.

The analysis of variance technique which is applicable in the case of observations following the normal

law has not been used here, since the observations were in the form of counts. Even after square root transformation normality could not be achieved in such cases and hence chi-square test which is a distribution-free test has been adopted. However, in the case of duration of development the usual method of analysis of variance has been adopted since normality was evident.

The sex-wise counts of the parasites under different treatment combinations have been analysed for the following aspects employing the techniques outlined below.

(a) Testing the significance of the difference between the levels of the main factors in the expression of the female-male composition of the F_1 offspring by transforming the ratio $\frac{\text{Number of females}}{\text{Total}}$ as angles and by testing the differences between these angles in pairs by applying the formula $\frac{\theta_1 - \theta_2}{\sqrt{820.7\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$ where $\frac{820.7}{n1}$ is the variance of θ_1.

(b) Testing the association between the main factors and sex-wise classification of the F_1 progeny, the chi-square values were computed on the basis of the formula $\frac{(an_2 - a'n_1)}{a + a'}$ where a and a' denote the sex-wise frequencies corresponding to the levels and n_1 and n_2 represent the corresponding total counts in each case.

RESULTS

RESULTS

The fecundity, progeny production and the female-male composition of the F_1 progeny of Bracon brevicornis Wesm. as influenced by number and weight of host larvae of Corcyra cephalonica Stainton and sex-ratio of the parent populations of B. brevicornis were studied at three temperature-humidity combinations which represented near optimum conditions of 28°C and 75% RH and near adverse conditions of 30°C and 60% RH and 32°C and 50% RH. The effects of the three factors on the duration of development were also studied in the present experiments.

The following were the levels at which the effect of the three factors were studied.

Factor 1:- Host larval density (A)

Levels - a_0 = 1 host larva per female parasite
a_1 = 2 host larvae per female parasite
a_2 = 3 host larvae per female parasite

Factor 2:- Weight of the host larvae (B)

Levels - b_0 = larval weight: 30-35 mg
b_1 = larval weight: 8-10 mg
b_2 = half of the hosts of the 'b_0' category and the other half of the 'b_1' type.

Factor 3:- Sex-ratio of parent parasite population (♀).

Levels - c_0 = 1:1 (Female : Male)

c_1 = 2:1 (")

c_2 = 3:1 (")

c_3 = 1:2 (")

c_4 = 1:3 (")

There were altogether forty five treatment combinations and these were replicated thrice as outlined in materials and methods.

FECUNDITY

1. Fecundity of *B. brevicornis* at 28°C and 75% RH

The fecundity was recorded by examining the host larvae on successive days after confinement under Stereo-microscope and directly counting the eggs adhering to the host cuticle. The data on the mean number of eggs laid by the parasite females in the different treatment combinations at the above temperature-humidity level are furnished in column 3 of Table 1-a and the raw data in Appendix-I. The fecundity was too low (6.67) under the treatment combination involving one host larva weighing 3-10 mg per female parasite and a composition of one female: one male in the parent population (a_0 b_1 c_0).

Fecundity of *B. brevicornis* in different temperature and humidity combinations

Sl. No.	Treatments	Mean number of eggs laid		
		28°C and 75% RH	30°C and 60% RH	32°C and 50% RH
1.	a_o b_o c_o*	60.67	29.33	61.33
2.	a_o b_o c_1	45.67	50.67	110.00
3.	a_o b_o c_2	32.00	47.00	122.33
4.	a_o b_o c_3	55.00	81.00	49.67
5.	a_o b_o c_4	12.67	29.00	58.67
6.	a_o b_1 c_o	6.67	34.33	27.33
7.	a_o b_1 c_1	22.67	58.33	24.67
8.	a_o b_1 c_2	78.33	65.33	20.67
9.	a_o b_1 c_3	52.33	14.00	25.33
10.	a_o b_1 c_4	53.00	39.33	16.33
11.	a_o b_2 c_o	57.67	50.00	78.00
12.	a_o b_2 c_1	54.00	73.33	80.00
13.	a_o b_2 c_2	93.33	71.67	61.00
14.	a_o b_2 c_3	64.00	46.33	35.00
15.	a_o b_2 c_4	82.00	25.33	43.67
16.	a_1 b_o c_o	88.33	38.33	67.33
17.	a_1 b_o c_1	66.33	80.33	118.00
18.	a_1 b_o c_2	96.00	54.33	119.33
19.	a_1 b_o c_3	45.00	71.00	87.67
20.	a_1 b_o c_4	51.33	22.67	75.33
21.	a_1 b_1 c_o	69.33	35.00	27.33
22.	a_1 b_1 c_1	88.33	61.67	33.33
23.	a_1 b_1 c_2	39.67	43.33	38.00
24.	a_1 b_1 c_3	45.00	30.00	46.67
25.	a_1 b_1 c_4	36.67	39.33	35.67
26.	a_1 b_2 c_o	68.33	115.00	75.67
27.	a_1 b_2 c_1	[illegible]	[illegible]	[illegible]
28.	a_1 b_2 c_2	107.33	98.33	54.33
29.	a_1 b_2 c_3	28.00	55.00	34.00
30.	a_1 b_2 c_4	43.00	30.00	105.00
31.	a_2 b_o c_o	33.00	91.00	59.67
32.	a_2 b_o c_1	54.33	85.67	86.67
33.	a_2 b_o c_2	66.00	56.67	112.67
34.	a_2 b_o c_3	25.33	21.00	68.67
35.	a_2 b_o c_4	33.00	44.00	35.67
36.	a_2 b_1 c_o	20.67	62.00	30.67
37.	a_2 b_1 c_1	77.67	36.67	38.33
38.	a_2 b_1 c_2	45.33	53.67	53.00
39.	a_2 b_1 c_3	27.67	50.00	17.00
40.	a_2 b_1 c_4	32.67	15.33	33.00
41.	a_2 b_2 c_o	64.00	23.00	70.67
42.	a_2 b_2 c_1	154.00	37.00	69.00
43.	a_2 b_2 c_2	33.00	36.67	90.33
44.	a_2 b_2 c_3	45.00	38.33	68.67
45.	a_2 b_2 c_4	31.00	32.33	31.00

*a_o - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_o - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the larvae of the 'b_o' type and the other half of the 'b_1' type

c_o - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_o - " " " " 2:1 (")
c_1 - " " " " 3:1 (")
c_2 - " " " " 1:2 (")
c_3 - " " " " 1:3 (")
c_4

Table 1-b

Chi-square values for the effect of the main factors A, B and C on fecundity of B. brevicornis at different temperature and humidity combinations

Source	df	Chi-square values		
		28°C and 75% RH	30°C and 60% RH	32°C and 50% RH
A	2	90.94**	65.44**	81.74**
B	2	185.94**	77.25**	1009.03**
A x B	4	90.76**	220.97**	40.04**
C	4	343.35**	337.78**	332.33**
A x C	8	463.72**	79.98**	138.02**
B x C	8	132.29**	84.77**	275.66**
A x B x C	16	554.23**	531.45**	185.67**

** Significant at 1% level

A - host density

B - weight of host larvae

C - sex-ratio of parent parasite population

Table 1-c

Number of eggs laid by *H. bowringia* at different levels of the main factors at different temperature and humidity combinations

	28°C and 75% RH		30°C and 60% RH		32°C and 50% RH	
	Total	Mean	Total	Mean	Total	Mean
a_0*	2310	51.33	2139	47.53	2442	54.27
a_1	2844	63.20	2558	56.84	3068	68.18
a_2	2228	49.50	2050	45.56	2565	57.00
b_0*	2294	50.98	2406	53.47	3659	81.31
b_1	2088	46.40	1909	42.42	1402	31.61
b_2	3000	66.67	2432	54.04	3004	66.76
c_0*	1406	31.24	1434	31.87	1494	33.20
c_1	1915	42.56	1686	37.47	1995	44.33
c_2	1773	39.40	1575	35.00	2015	44.78
c_3	1162	25.82	1220	27.11	1268	28.18
c_4	1126	25.02	832	18.49	1303	28.96

a_0* - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

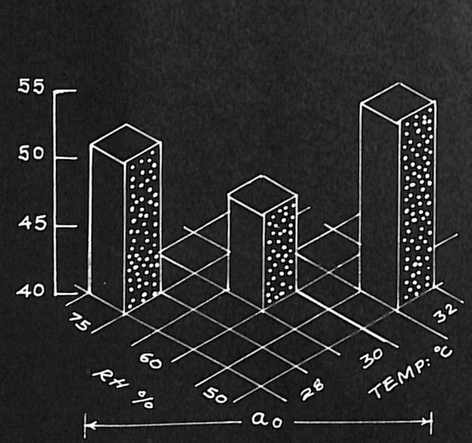
b_0* - larval weight 30 - 35 mg.
b_0 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and other half of the 'b_1' type.

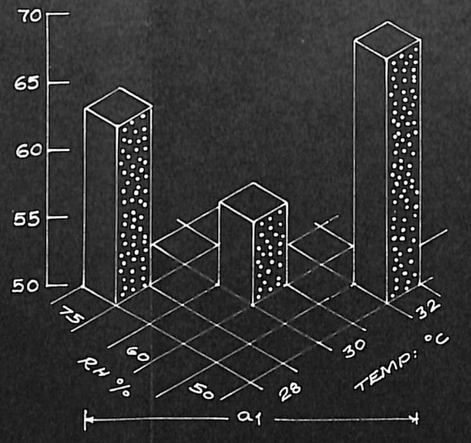
c_0* - Sex ratio of parent parasite population - 1:1 (Female: Male)
c_0 - " " " " - 2:1 (" ")
c_1 - " " " " - 3:1 (" ")
c_2 - " " " " - 1:2 (" ")
c_3 - " " " " - 1:3 (" ")
c_4

Fig. 1 A - Fecundity of Bracon brevicornis at different temperature-humidity combinations as influenced by the host larval density

Fig. 1 B - Fecundity of Bracon brevicornis at different temperature-humidity combinations as influenced by the weight (size) of host larvae

Fig. 1 C - Fecundity of Bracon brevicornis at different temperature-humidity combinations as influenced by the sex-ratio of the parent parasite population





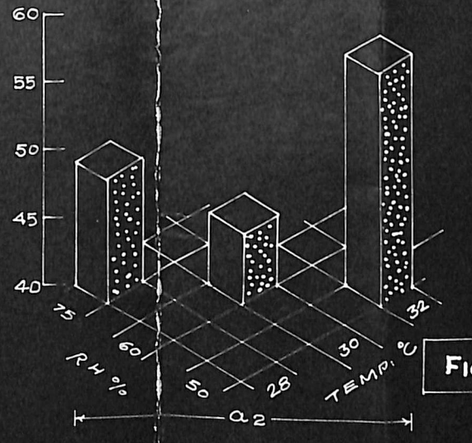
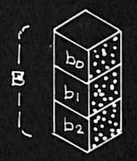
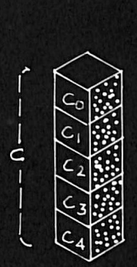


FIG: 1 A

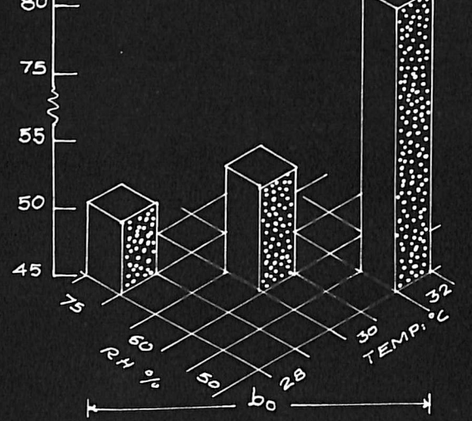
1 HOST LARVA PER FEMALE PARASITE
2 " " " " "
3 " " " " "

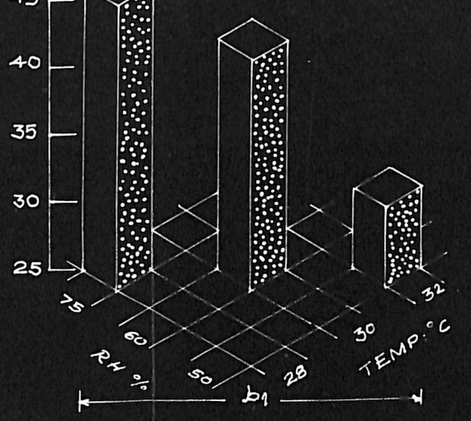


LARVAL WEIGHT 30–35 mg.
" " 8–10 "
HALF OF THE LARVAE OF THE 'b₀' TYPE AND THE OTHER HALF OF THE 'b₁' CATEGORY



1 FEMALE : 1 MALE
2 " 1 "
3 " 1 "
1 " 2 "
1 " 3 "





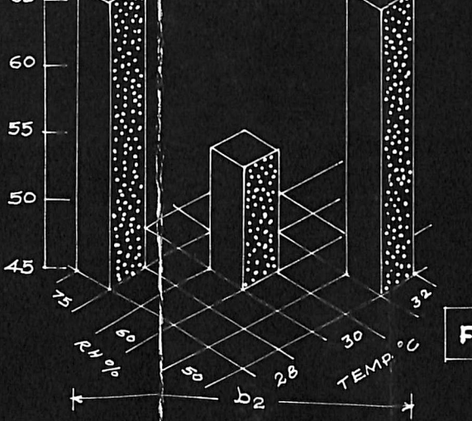
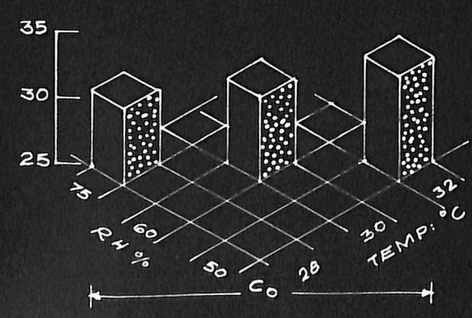
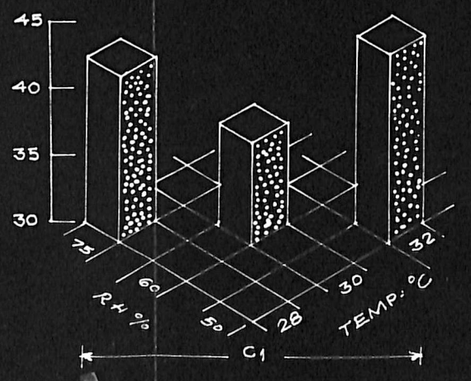
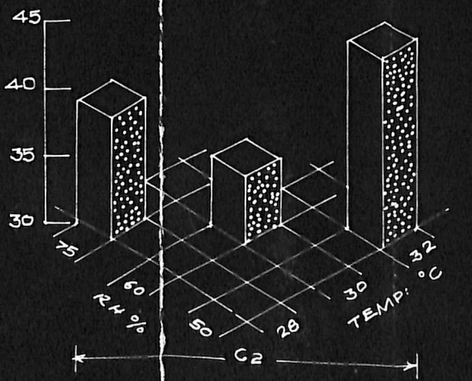
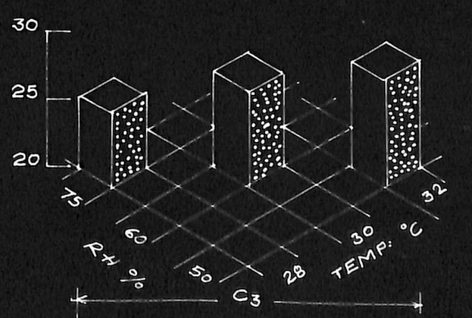


FIG: 1 B









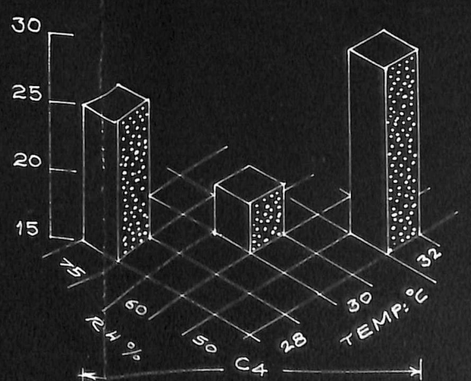


FIG: 1

Table 1-d

Chi-square values for comparing the effects of different levels of the main factors A, B and C at different temperature and humidity combinations on fecundity of *B. brevicornis*

	Chi-square values					
	28°C and 75% RH	Ranking	30°C and 60% RH	Ranking	32°C and 50% RH	Ranking
a_0 Vs a_1	55.33**	a_2	37.38**	a_2	71.1?**	a_2
a_1 Vs a_2	74.81**	a_0	55.64**	a_0	44.92**	a_1
a_0 Vs a_2	1.48 NS	a_1	1.89 NS	a_1	3.0? NS	a_0
b_0 Vs b_1	9.68**	b_1	57.?4**	b_1	1006.53**	b_2
b_1 Vs b_2	163.47**	b_0	63.01**	b_0	58?.48**	b_1
b_0 Vs b_2	94.15**	b_2	0.14 NS	b_2	64.39**	b_0
c_0 Vs c_1	78.01**		20.35**		100.84**	
c_0 Vs c_2	4?.37**		6.61*		77.36**	
c_0 Vs c_3	?3.18**		17.?6**		18.49**	
c_0 Vs c_4	30.96**	c_4	159.93**	c_4	13.04**	c_3
c_1 Vs c_2	5.47*	c_3	3.78 NS	c_3	0.10 NS	c_4
c_1 Vs c_3	184.?7**	c_0	74.73**	c_0	161.98**	c_0
c_1 Vs c_4	204.71**	c_2	?89.64**		145.?0**	
c_2 Vs c_3	1?7.?0**		45.09**	c_2	169.97**	c_1
c_2 Vs c_4	144.40**	c_1	?29.35**	c_1	15?.79**	c_2
c_3 Vs c_4	0.57 NS		73.36**		0.4? NS	

* Significant at 5% level
** Significant at 1% level
NS Not significant

a_0 - 1 host larva per female parasite
a_1 - ? " " " "
a_2 - 3 " " " "

b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

c_0 - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " - ?:1 (")
c_2 - " " " " - 3:1 (")
c_3 - " " " " - 1:? (")
c_4 - " " " " - 1:3 (")

Table 1-c

Chi-square values for comparison of effects of the three main factors A, B and C on fecundity of *B. brevicornis* at different temperature and humidity combinations

	Chi-square for levels of B			Chi-square for levels of C				
	b_0	b_1	b_2	c_0	c_1	c_2	c_3	c_4
TH_1 Vs TH_2	2.67 NS	8.01**	59.39**	0.28 NS	14.56**	11.71**	1.41 NS	44.15**
TH_2 Vs TH_3	257.63**	27.63**	60.19**	1.23 NS	25.94**	53.93**	0.93 NS	103.91**
TH_1 Vs TH_3	312.99**	134.84**	0.002NS	2.67 NS	1.64NS	15.46**	4.82*	12.90**

Analysing

TH_1 TH_2 TH_3 | TH_1 TH_3 TH_2 | TH_2 TH_3 TH_1 | TH_1 TH_2 TH_3 | TH_1 TH_3 TH_2 | TH_2 TH_3 TH_1 | TH_1 TH_2 TH_3 | TH_1 TH_3 TH_2 | TH_2 TH_3 TH_1

Chi-square due to heterogenity

Host larval density (A)	6.51 NS
Weight of host larvae (B)	461.60**
Sex-ratio of parent parasite population (C)	64.66**

^0B - Weight of host larvae
b_0 - larval weight 30 - 35 mg
b_0^1 - " " 8 - 10 mg
b_2^1 - half of the hosts of the 'b_1' type and the other half of the 'b_1^0' type

^0C - Sex-ratio of parent population
c_0 - 1 female : 1 male
c_1 - 2 " : 1 "
c_2 - 3 " : 1 "
c_3 - 1 " : 2 "
c_4 - 1 " : 3 "

* Significant at 5% level
** Significant at 1% level
NS Not significant

TH_1 - 28°C and 75% RH
TH_2 - 30°C and 60% RH
TH_3 - 32°C and 50% RH

while under three host larvae per female parasite which is a mixture of heavier and lighter types and a ratio of two females : one male in the parent population ($a_1 b_2 c_1$), the egg production was 154.00.

The data being in the form of counts of eggs, the analysis of variance table was not found applicable even after square root transformation since normality could not be achieved even by transformation. Therefore, chi-square test which is a distribution free test, has been adopted as outlined in the materials and methods and the results of testing of the three main factors A, B and C and their interactions are presented in Table 1-b. It will be seen that all the main effects, viz., host larval density (A), weight of the host larvae (B), sex-ratio of parent parasite population (C) as well as the interactions AxB, AxC, BxC and AxBxC are highly significant at 1 per cent level indicating the importance of these factors operating individually and jointly in the realisation of oviposition potential of the female parasites.

The data pertaining to the total number of eggs laid at different levels of the three main factors host larval density (A), weight of host larvae (B) and sex-ratio of parent parasite population (C) are summarised and

presented in Table 1-c and these are graphically depicted in Fig.1A, 1B and 1C. A maximum number of 63.20 eggs were obtained when two host larvae were offered per female parasite (a_1 level). The chi-square values for the comparison between the different levels of the factors are given in Table 1-d. At the a_1 level (two hosts per female parasite) of host density, which gave maximum number of eggs, the fecundity was significantly higher than those recorded at the a_0 level of one host larva per female parasite and at the a_2 level of three host larvae per female parasite, the mean fecundity values for the two latter cases being 51.33 and 49.50 respectively. Significant differences were not detected between the a_0 and a_2 levels.

Among the levels of the weight of host larvae (B), (Table 1-c) the maximum fecundity of 66.67 was registered when the host larvae comprised of heavier and lighter ones in equal proportions (b_2). This was followed by the b_0 level (host larvae with a weight of 30-35 mg) with mean 50.98 and the b_1 level (host larvae with a weight of 8-10 mg) with mean 46.40. All the three levels of the weight of host larvae (B) were significantly different. It will be seen that the weight of the host larvae considerably influences the egg production in B. brevicornis

and that the maximum egg production is registered when relatively heavier and lighter larvae of the same age were offered for parasitisation.

Among the different levels of the sex-ratios of the parent parasite population (C), the ratio of 2 females: 1 male (c_1) gave the maximum number of eggs, mean being 4[illegible].56 (Table 1-d). Under the levels 3 females: 1 male (c_2) and 1 female:1 male (c_0), the mean fecundity were 39.40 and 31.[illegible]4 respectively. When the sex-ratio of the parental population was 1 female: 2 males (c_3) and 1 female: 3 males (c_4), there was a drastic decline in the number of eggs laid, the mean values under these two levels being 25.02 and 25.02 respectively. Significant differences were not detected between the two levels c_3 and c_4.

Fecundity of B. brevicornis at 30°C and 60% RH

The mean fecundity of the parasites at 30°C and 60% RH are furnished in column 4 of Table 1-a. The range of fecundity was quite wide being 14.00 under a_0 b_1 c_3 treatment combination (one host larva per female parasite; larval weight 8-10 mg; sex-ratio of the parent parasite population 1:3). The fecundity was the maximum (115) for the treatment combination a_1 b_2 c_0 (two host larvae per female parasite; half of the host larvae of 30-35 mg type

and the other half of 8-10 mg type; sex-ratio of the parent parasite population 1:1).

Analysis of the data was carried out by employing chi-square test and the results are furnished in Table 1-b. It is indicated that all the main effects (host larval density, weight of host larvae, sex-ratio of parent parasite population) as well as their interactions are highly significant. The data showing the mean fecundity at different levels of the three main factors are summarised in Table 1-c and these are illustrated in Fig. 1A, 1B and 1C. The maximum number of eggs (56.84) were recorded when two host larvae (a_1 level) were offered per female parasite and this was followed by the fecundity registered with one host per female parasite (a_0) and three hosts per female parasite (a_2). The chi-square values to compare between levels of the three factors are presented in column 3 Table 1-d. It will be noted that the fecundity registered at two hosts larvae per female parasite (a_1) is superior (56.84) to those at one host larva per female parasite (a_0) and three host larvae per female parasite (a_2). Significant differences were, however, not detected between one host larva per female parasite (a_0) and three host larvae per female parasite (a_2) levels.

As regards the weight of the host larvae of the

same age, it was found that the maximum number of eggs was recorded with a mixture of relatively heavier and lighter larvae in equal proportions (b_2) the mean fecundity being 54.04. This was followed by the values corresponding to b_1 (relatively lighter larvae) and b_0 (relatively heavier larvae), the means being 53.47 and 42.43 respectively. No significant difference was evident between b_0 (host larvae with 30-35 mg weight) and b_2 levels (a mixture of heavier and lighter larvae in equal proportions) indicating that heavier host larvae and a mixture of heavier and lighter ones in equal proportions are equally effective for the better realisation of oviposition potential of A. brevicornis. The host larval weight level b_1 (0-10 mg) gave significantly lower fecundity.

The maximum fecundity of 37.47 at 30°C and 50% RH was registered when the sex-ratio of the parent population (c_1) was maintained at 2:1 (female:male). At the c_2 (3:1) and c_3 (1:2) levels, mean fecundity levels were 35.00 and 27.11 respectively. The number of eggs laid were quite low under the levels c_3 (1:2) and c_4 (1:3) characterised by the dominance of the males, the mean values being respectively 27.11 and 13.49. The fecundity at the c_1 and c_2 levels were on par while c_0, c_3 and c_4 gave

significantly different fecundity.

Fecundity of B. brevicornis at 32°C and 50% RH

The data on the fecundity of B. brevicornis at 32°C and 50% RH are presented in column 5 of Table 1-a. The number of eggs laid by the parasites was the lowest (16.33) under the treatment a_0 b_1 c_4 (one host larva per female parasite, weight of host larva 8-10 mg; sex-ratio of parent parasite population 1:3) to 122.33 under the treatment a_0 b_0 c_2 (one host larva per female parasite, weight of host larvae 30-35 mg, sex-ratio of parent parasite population 3:1). The results of chi-square test are given in Table 1-b. It is seen that all the main effects A, B and C (host larval density, weight of host larvae and sex-ratio of parent parasite population) as well as their interactions are highly significant.

The data representing the total and mean number of eggs laid at different levels of the main factors are summarized in Table 1-c and these are depicted in Fig.1A, 1B and 1C. Among the levels of host larval density (A), maximum eggs (68.18) were obtained at two hosts per female parasite (a_1). The same trend was also revealed for the other temperature and humidity conditions viz., 28°C and 75% RH and 30°C and 60% RH. The chi-square values

for the treatment comparisons between the different levels of the factors are indicated in Table 1-d. The fecundity registered under the level a_1 (two hosts per female parasite) was superior to those obtained at the levels a_2 (three hosts per female parasite) and a_0 (one host per female parasite) there being no significant difference between the levels a_2 and a_0.

Among the levels of the host weight categories, the b_0 level (host larvae weighing 30-35 mg) produced the maximum number of eggs (81.31), followed by the b_2 level (a mixture of larvae with 30-35 mg and 8-10 mg in equal proportions) giving 66.76 eggs and under the level b_1, when the hosts were all relatively lighter, the number of eggs was quite low, the mean being 31.16. Significant differences were detected among all the three levels of B (weight of host larvae).

Among the levels of the sex-ratio of the parent parasite population (C), the maximum number of eggs were obtained at c_2 (3 female:1 male), the mean being 44.73 (Table 1-c). At the c_1 level (2:1) the fecundity was 44.33 and the two levels c_2 and c_1 were on par. When the sex-ratio was maintained at 1 female: 1 male (c_0), the mean fecundity was 33.20. Under the two levels c_3 (1 female: 2 males) and c_4 (1 female: 3 males) a sharp

reduction in the fecundity was recorded, the mean values being respectively 20.18 and 23.96 and these two levels were on par. The low levels of fecundity for the two levels c_3 and c_4 were also recorded for the other two temperature and humidity combinations as well i.e., 28°C and 75% RH and 30°C and 60% RH.

Whether the effects of the different levels of the three main factors viz., host larval density (A), weight of host larvae (B) and sex-ratio of parent parasite population (C) were significantly different at different temperature and humidity conditions has been tested employing the chi-square method and the results of testing are furnished in Table 1-e. The chi-square due to heterogeneity of host larval density (A) being non-significant, it is evident that there is no heterogeneity in response to host larval density over the different temperature and humidity levels. The heterogeneity chi-square for the weight of host larvae (B) and sex-ratio of parent parasite population (C) are significant indicating that the responses vary between temperature and humidity combinations.

The b_0 level (host larvae having a weight range 30-35 mg) produced the maximum number of eggs(81.31)

at 32°C and 50% RH (TH_3). This is significantly higher than those at 30°C and 60% RH (TH_2) and 28°C and 75% RH (TH_1). But no significant difference was detected between the fecundity at 28°C and 75% RH (TH_1) and 30°C and 60% RH (TH_2).

At the b_1 level of host larval weight (larval weight 8–10 mg) maximum fecundity (46.40) was produced at 28°C and 75% RH (TH_1). This is significantly higher than those at 30°C and 60% RH (TH_2) and 32°C and 50% RH (TH_3).

At the b_2 level (mixture of heavier and lighter larvae in equal proportions) maximum number of eggs were produced at 30°C and 50% RH (66.76). But no significant difference was detected between the fecundities at 30°C and 50% RH (TH_3) and 28°C and 75% RH (TH_1), while the fecundity at 28°C and 75% RH (TH_1) is found to be significantly higher than that at 30°C and 60% RH (TH_2).

When the sex-ratio of parent parasite population was kept at the e_0 level i.e., 1:1 (Female: male), no significant difference was observed in the egg production between the three temperature and humidity combinations (28°C and 75% RH; 30°C and 60% RH and 32°C and 50% RH) though the maximum fecundity (33.20) was obtained at 32°C and 50% RH (TH_3).

At the e_1 level of the sex-ratio of parent parasite population (1:2), maximum fecundity was (44.33) obtained at 32°C and 50% RH (TH_3). But no significant difference was detected between fecundities at 32°C and 50% RH (TH_3) and 28°C and 75% RH (TH_1). At the e_2 level (1:3) highest egg production was found to be at (TH_3) 32°C and 50% RH (44.78). This is found significantly higher than those at 28°C and 75% RH (TH_1) and 30°C and 60% RH (TH_2). At the e_3 level (1 female: 2 males) also maximum fecundity was found to be at (TH_3) 32°C and 50% RH (28.18) which is significantly higher than those at 28°C and 75% RH (TH_1). When the sex-ratio of parent parasite population was maintained at the e_4 level also (1 female: 3 males), maximum egg production was obtained at 32°C and 50% RH (20.96). Significant differences were detected between the three temperature and humidity combinations (32°C and 50% RH, 28°C and 75% RH and 30°C and 60% RH).

II. DURATION OF DEVELOPMENT

The duration of development was found out by calculating the weighted means of the number of days taken by the parasites of both sexes emerging on successive days. For this, the parasites emerging on successive days were isolated, killed and the male-female

composition in relation to the durations of development recorded.

Duration of development of B. brevicornis at 28°C and 75% RH.

Data on the mean duration of development of the parasites under different treatments at the above temperature and humidity combination are furnished in column 3 of Table 2-a and the raw data in Appendix II. The range in the duration of development was from 8.47 days under the treatment combination a_1 b_0 c_4 (two host larvae per female parasite; larval weight 30-35 mg; sex-ratio of parent parasite population 1:3) to 11.73 days under the treatment combination a_0 b_0 c_1 (one host larvae per female parasite; larval weight 30-35 mg; sex-ratio of parent parasite population 2:1).

Analysis of the data using the method of analysis of variance has been carried out and the results of the analysis of variance table is given in Table 2-b. It will be seen that the factors A (host larval density) and C (sex-ratio of parent parasite population) have significant influence on the duration of development of the parasites. The weight of host larvae (B) did not show any influence on the duration of development of the parasite. The interactions AxC and AxBxC were also found to be significant.

The mean values of the duration of development at different levels of the three factors host larval density (A); weight of host larvae (B) and sex-ratio of parent parasite population (C) are furnished in Table 2-c and these are depicted in Fig. 2 A, 2B and 2C. The duration of development was shortest at the a_2 level (three host larvae per female parasite) the mean being 9.607 days. With regard to the duration of development under a_1 (two host larvae per female parasite) and a_2 (three host larvae per female parasite) significant difference was not detected and the mean values were 9.764 and 9.607 days respectively.

The duration of development was found to be longest (10.104 days) under the level c_3 i.e., when the parent parasite population was kept at one female : two males. The shortest duration of development of the parasite was recorded at c_2 level (3females: 1 male) the mean duration of development being 9.574 days. The duration of development at the level c_2 (3 females: 1 male) was found significantly superior to that at c_3 level (1:2). The duration of development at the levels c_{-1}, c_0, c_1 and c_4 were on par.

Duration of development of *B. hyalinosoma* in different temperature and humidity combinations

Sl. No.	Treatments	Mean duration of development in days		
		28°C and 75% RH	30°C and 60% RH	32°C and 50% RH
1.	$a_o b_o c_o$*	9.37	9.88	8.80
2.	$a_o b_o c_1$	11.73	8.63	8.73
3.	$a_o b_o c_2$	10.63	9.90	9.67
4.	$a_o b_o c_3$	9.47	8.63	8.53
5.	$a_o b_o c_4$	10.77	88.33	9.27
6.	$a_o b_1 c_o$	10.03	11.40	8.07
7.	$a_o b_1 c_1$	9.00	9.60	8.00
8.	$a_o b_1 c_2$	10.13	8.63	8.00
9.	$a_o b_1 c_3$	10.37	8.00	8.43
10.	$a_o b_1 c_4$	10.13	9.73	8.00
11.	$a_o b_2 c_o$	9.73	8.80	8.00
12.	$a_o b_2 c_1$	10.50	9.03	8.30
13.	$a_o b_2 c_2$	9.97	8.67	8.30
14.	$a_o b_2 c_3$	9.70	8.47	8.00
15.	$a_o b_2 c_4$	9.70	9.13	8.37
16.	$a_1 b_o c_o$	9.87	10.43	9.57
17.	$a_1 b_o c_1$	10.03	8.97	8.83
18.	$a_1 b_o c_2$	7.00	8.60	8.70
19.	$a_1 b_o c_3$	9.97	8.70	8.47
20.	$a_1 b_o c_4$	8.67	9.10	9.23
21.	$a_1 b_1 c_o$	9.53	8.47	9.13
22.	$a_1 b_1 c_1$	9.70	8.70	8.20
23.	$a_1 b_1 c_2$	8.47	8.10	8.10
24.	$a_1 b_1 c_3$	9.67	8.97	7.93
25.	$a_1 b_1 c_4$	9.67	8.77	8.47
26.	[illegible] c_o	9.97	[illegible]	[illegible]
27.	$a_1 b_2 c_1$	9.57	8.67	8.40
28.	$a_1 b_2 c_2$	9.33	8.00	8.37
29.	$a_1 b_2 c_3$	10.47	8.00	9.57
30.	$a_1 b_2 c_4$	10.13	9.57	9.70
31.	$a_2 b_o c_o$	9.90	9.07	8.53
32.	$a_2 b_o c_1$	8.80	8.00	8.17
33.	$a_2 b_o c_2$	9.20	8.17	8.13
34.	$a_2 b_o c_3$	10.40	8.97	8.23
35.	$a_2 b_o c_4$	9.80	8.30	8.33
36.	$a_2 b_1 c_o$	9.43	8.57	8.30
37.	$a_2 b_1 c_1$	9.07	8.30	8.17
38.	$a_2 b_1 c_2$	9.00	8.37	8.07
39.	$a_2 b_1 c_3$	11.03	8.33	8.83
40.	$a_2 b_1 c_4$	9.70	8.60	8.27
41.	$a_2 b_2 c_o$	9.60	8.40	8.43
42.	$a_2 b_2 c_1$	9.60	8.57	8.60
43.	$a_2 b_2 c_2$	9.43	8.93	8.50
44.	$a_2 b_2 c_3$	9.80	8.30	9.67
45.	$a_2 b_2 c_4$	9.40	8.40	9.97

*a_o - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_o - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_o' type and the other half of the 'b_1' type

c_o - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " 2:1 (Female:Male)
c_2 - " " " " 3:1 (Female:Male)
c_3 - " " " " 1:2 (Female:Male)
c_4 - " " " " 1:3 (Female:Male)

Table 2-b

Duration of development of *B. brevicornis* at different temperature and humidity combinations

Analysis of variance table

Source	df	Mean squares		
		28°C and 75% RH	30°C and 60% RH	32°C and 50% RH
● A	2	2.640**	4.594**	1.063**
● B	2	1.342 N.S.	0.661 N.S	3.196**
A x B	4	0.626 N.S.	1.425**	2.352**
● C	4	1.136*	3.351**	0.922**
A x C	8	1.398**	1.009**	0.589**
B x C	8	0.747 N.S.	1.030**	0.988**
A x B x C	16	0.878*	0.922**	0.337**
Error	90	0.479	0.251	0.152

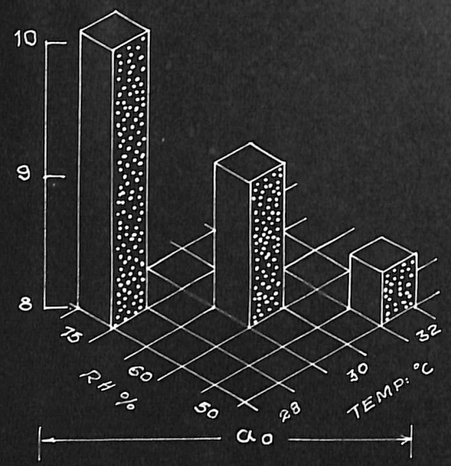
* Significant at 5% level
** Significant at 1% level
N.S Not significant

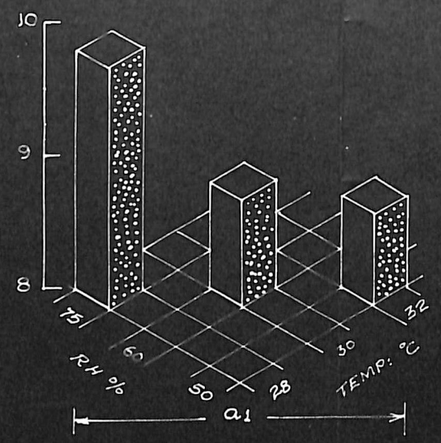
● A - host larval density
● B - weight of host larvae
● C - sex-ratio of parent parasite population

Fig. 2 A - Duration of development of Bracon brevicornis at different temperature-humidity combinations as influenced by the host larval density

Fig. 2 B - Duration of development of Bracon brevicornis at different temperature-humidity combinations as influenced by the weight (size) of host larvae

Fig. 2 C - Duration of development of Bracon brevicornis at different temperature-humidity combinations as influenced by the sex-ratio of the parent parasite population





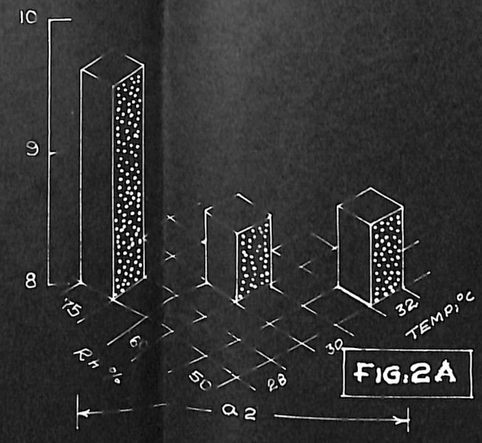
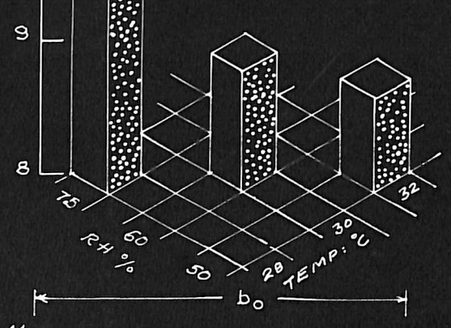


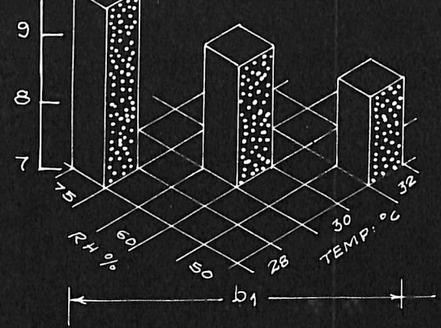
FIG.2A

A
- a_0 1 HOST LARVA PER FEMALE PARASITE
- a_1 2 " " " " "
- a_2 3 " " " " "

B
- b_0 LARVAL WEIGHT 30 – 35 mg
- b_1 " " 8 – 10 "
- b_2 HALF OF THE LARVAE OF THE 'b0' TYPE AND THE OTHER HALF OF THE 'b1' CATEGORY

C
- C_0 1 FEMALE : 1 MALE
- C_1 2 " : 1 "
- C_2 3 " : 1 "
- C_3 1 " : 2 "
- C_4 1 " : 3 "





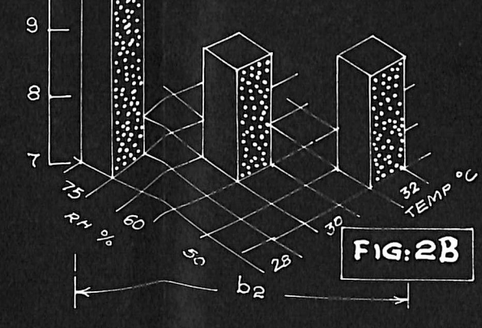
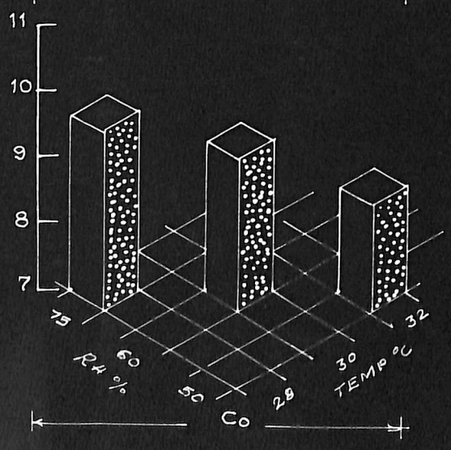
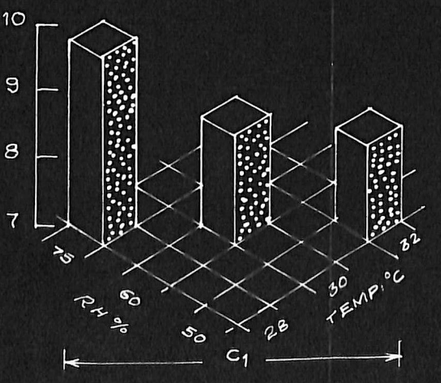
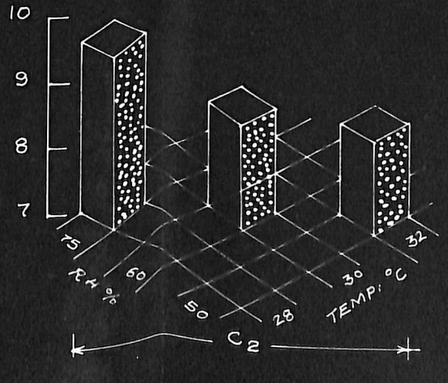
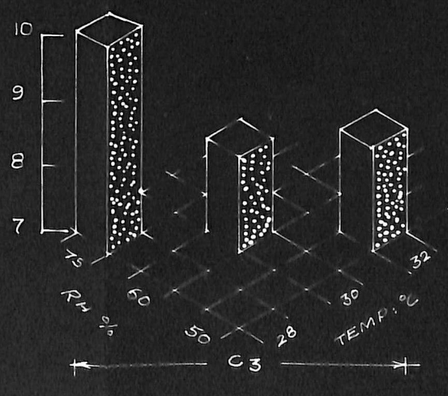


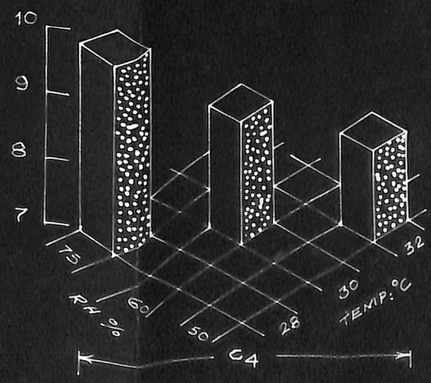
FIG:2B











FIG

Table 2-c

Duration of development of B.brevicornis at 28°C and 75% RH

(Mean table)

		* A levels a_0	a_1	a_2	Mean	Ranking
	b_0	10.393	9.993	9.620	10.002	
* B levels	b_1	9.993	9.407	9.640	9.660	
	b_2	9.920	9.893	9.560	9.791	
	c_0	9.711	9.789	9.611	9.704	
	c_1	10.411	9.767	9.156	9.778	
* C levels	c_2	10.244	9.267	9.211	9.574	$\overline{c_2 c_0 c_1 c_4 c_3}$
	c_3	9.844	10.033	10.433	10.104	
	c_4	10.200	9.967	9.622	9.930	
Mean		10.082	9.764	9.607	9.818	$\overline{a_2 a_1} a_0$

		B levels b_0	b_1	b_2	Mean
	c_0	9.711	9.667	9.733	9.704
	c_1	10.189	9.256	9.889	9.778
C levels	c_2	9.944	9.200	9.578	9.574
	c_3	9.944	10.356	10.011	10.104
	c_4	10.224	9.822	9.744	9.930
Mean		10.002	9.660	9.791	9.818

CD for comparing levels of A = 0.282
" " B = 0.282
" " C = 0.364
" combinations of AB = 0.489
" " AC = 0.631
" " BC = 0.631

* a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

*b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

* c_0 - sex-ratio of parent parasite population -1 : 1 (Female:Male)
c_1 - " " " " 2 : 1 " "
c_2 - " " " " 3 : 1 " "
c_3 - " " " " 1 : 2 " "
c_4 - " " " " 1 : 3 " "

Table 2-d

Duration of development of B. brevicornis at 30°C and 60% RH

(Mean table)

		* A levels a_0	a_1	a_2	Mean	Ranking
* B levels	b_0	9.073	9.160	8.500	8.911	
	b_1	9.473	8.480	8.433	8.800	
	b_2	8.820	8.667	8.520	8.669	
* C levels	c_0	10.022	9.333	8.678	9.344	
	c_1	9.089	8.778	8.289	8.719	
	c_2	9.067	8.233	8.489	8.596	$\overline{c_3 c_2} \overline{c_1 c_4} c_0$
	c_3	8.367	8.356	8.533	8.419	
	c_4	9.067	9.144	8.433	8.881	
Mean		9.122	8.769	8.484	8.792	$a_2\ a_1\ a_0$

		B levels b_0	b_1	b_2	Mean
C levels	c_0	9.789	9.478	8.767	9.344
	c_1	8.533	8.867	8.756	8.719
	c_2	8.889	8.367	8.533	8.596
	c_3	8.767	8.233	8.256	8.419
	c_4	8.578	9.033	9.033	8.881
Mean		8.911	8.800	8.669	8.792

CD for comparing levels of A = 0.211

" " " B = 0.211

" " " C = 0.273

" " combinations of AB = 0.366

" " " AC = 0.473

" " " BC = 0.473

* a_0 - 1 host larva per female parasite
  a_1 - 2 " " " "
  a_2 - 3 " " " "

* b_0 - larval weight 30 - 35 mg
  b_1 - " " 8 - 10 mg
  b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

* c_0 - sex-ratio of parent parasite population - 1:1 (Female:Male)
  c_1 - " " " " 2:1 (")
  c_2 - " " " " 3:1 (")
  c_3 - " " " " 1:2 (")
  c_4 - " " " " 1:3 (")

Table 2-c

Duration of development of B. brevicornis at 32°C and 50% RH

(Mean table)

		* A levels a_0	a_1	a_2	Mean	Ranking
* B levels	b_0	9.000	8.960	8.280	8.747	
	b_1	8.100	8.367	8.327	8.264	b_1 $\overline{b_2\ b_0}$
	b_2	8.193	8.880	9.033	8.702	
* C levels	c_0	8.289	9.022	8.422	8.578	
	c_1	8.344	8.478	8.311	8.378	
	c_2	8.656	8.389	8.233	8.426	$\overline{c_1 c_2 c_4 c_0 c_3}$
	c_3	8.322	8.656	8.911	8.630	
	c_4	8.544	9.133	8.855	8.440	
Mean		8.431	8.736	8.547	8.571	$\overline{a_0\ a_2\ a_1}$

		B levels b_0	b_1	b_2	Mean
C levels	c_0	8.967	8.500	8.267	8.578
	c_1	8.578	8.122	8.433	8.378
	c_2	8.833	8.056	8.389	8.426
	c_3	8.411	8.400	9.078	8.630
	c_4	8.944	8.244	9.344	8.440
Mean		8.747	8.264	8.702	8.571

CD for comparing levels of A = 0.165

" " " B = 0.165

" " " C = 0.212

" " combinations of AB = 0.285

" " " AC = 0.368

" " " BC = 0.368

* a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

* b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

* c_0 - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " 2:1 (")
c_2 - " " " " 3:1 (")
c_3 - " " " " 1:2 (")
c_4 - " " " " 1:3 (")

Duration of development of B. brevicornis at 30°C and 60% RH.

Data on the mean duration of development under various treatments are given in column 4 of Table 2-a. Minimum duration of development was registered for the combination of one host larva per female parasite which was of lighter type and with one female : three males ratio for the parent parasite population (a_0 b_1 c_3) being eight days. The levels a_1 b_2 c_3, a_1 b_2 c_3 and a_2 b_0 c_1 also indicated relatively short durations of development. Maximum duration of development was 11.4 days for the treatment combination of one host larva per female parasite, host larvae of lighter type (8-10 mg) and one female: one male ratio of the parent parasite population (a_0 b_1 c_1).

The abstract of the analysis of variance table is given in Table 2-b. The effects of host larval density(A) and sex-ratio of parent parasite population (C) were significant while weight of host larvae (B) had no significant effect on the duration of development of the parasite at 30°C and 60% RH. The interactions AxB, AxC, BxC and AxBxC are also found to be significant.

The mean values of the duration of development at different levels of the factors are furnished in

Table 2-d and these are represented in Fig. 2A, 2B and 2C. The longest duration of development (9.122 days) was observed at the a_0 level (one host larva per female parasite). At the a_2 level (two host larvae per female parasite) the duration of development was 8.484 days. The mean duration of development at the a_0 level (one host larva per female parasite) is significantly longer than the durations for a_1 (two host larvae per female parasite) and a_2 (three host larvae per female parasite) levels. The durations of development at the a_1 and a_2 levels were also found to be significantly different.

In relation to the sex-ratio of the parent parasite population, the e_0 level (1 female: 1 male in the parent population) recorded the longest duration of development of 9.344 days. Under e_3 level i.e., when the sex-ratio of parent population was maintained at one female: three males, the developmental period was the lowest being 8.419 days. The mean duration of development for e_0 level (1 female: 1 male) is significantly higher than for the other levels e_1, e_2, e_3 and e_4.

Duration of development at 32°C and 50% RH

Data on the mean duration of development under various treatments are furnished in column 5 of Table 2-a.

The duration of development ranged from 7.93 days under the treatment a_1 b_1 c_3 (two host larvae per female parasite; weight of host larvae 8-10 mg sex-ratio of parent population one female: two males) to 9.97 days under the treatment a_2 b_2 c_4 (three host larvae per female parasite; a mixture of host larvae with 30-35 mg weight and 8-10 mg in equal proportions; sex-ratio of parent parasite population - one female: three males).

The results of the analysis of variance is furnished in Table 2-b. It is indicated that the effects of host larval density (A), weight of host larvae (B) and sex-ratio of parent parasite population (C) are significant. The mean duration of development at different levels of the factors are given in Table 2-c and are illustrated in Fig. 2A, 2B and 2C.

It will be seen from the Table 2-c that the parasites produced at the a_0 level (1 host larva per female parasite) recorded the shortest duration of development (8.431 days). But no significant difference was detected in the duration of development between the a_0 and a_2 levels.

Among the levels of B, the b_1 level (larval weight 8-10 mg) recorded the shortest duration of

development 8.264 which was significantly superior to that recorded at b_2 and b_0 levels.

The shortest duration of development (8.378 days) was recorded for the a_1 level (2 females : 1 male for the parent population) the duration of development at the a_1 level was significantly superior to those recorded at a_4 (1 female: 3 males) and a_3 (1 female: 2 males) levels.

III. PROGENY PRODUCTION

Progeny production at 28°C and 75% RH

The total number of males and females which emerged out from each replicate was recorded as the F_1 progeny production under different treatment combinations. The data on the mean number of progenies produced under various treatments at 28°C and 75% RH are furnished in column 3 of Table 3-a and the raw data is given in Appendix III. The mean progeny production varied widely from 2.00 for the treatment a_0 b_1 c_1 (one host larva per female parasite; weight of host larvae 8-10 mg; two females: one male in the parent parasite population) to 26.67 under the treatment a_0 b_0 c_3 (one host larva per female parasite; weight of the host larva 30-35 mg, a ratio of one female: two males in the parent parasite

population). The data being in the form of counts, the analysis of variance technique was not found applicable in this case even after square root transformation. Therefore, the chi-square test, which is a distribution free test has been adopted as indicated in materials and methods and the results of testing are furnished in Table 3-b. All the main effects viz., host larval density (A), weight of the host larvae (B) and sex-ratio of the parent parasite population (C) as well as their interactions were found to be significant.

The data on the total number of progenies produced and their mean values are presented in Table 3-c and these are graphically depicted in Fig. 3A, 3B and 3C. The different levels of the three factors viz., host larval density (A), weight of the host larvae (B) and sex-ratio of the parent parasite population (C) are compared using the chi-square test and the results are given in table 3-d. Maximum number of progeny production was registered with two host larvae per female parasite (a_1) the mean being 12.31 and the minimum (9.20) was recorded with three host larvae per female parasite of a_2 level and the difference between the two levels was significant. No significant difference was detected between the a_0 (one host larva per female parasite)

Table 3-a

Progeny production of B. brevicornis in different temperature and humidity combinations

Sl. No.	Treatments	Mean number of progenies		
		28°C and 75% RH	30°C and 60% RH	32°C and 50% RH
1.	$a_0 b_0 c_0$*	18.00	19.33	22.00
2.	$a_0 b_0 c_1$	13.33	20.00	31.33
3.	$a_0 b_0 c_2$	5.00	3.67	12.33
4.	$a_0 b_0 c_3$	26.67	34.67	16.67
5.	$a_0 b_0 c_4$	7.67	13.33	11.33
6.	$a_0 b_1 c_0$	4.67	9.67	12.67
7.	$a_0 b_1 c_1$	2.00	18.33	5.33
8.	$a_0 b_1 c_2$	10.00	22.00	8.33
9.	$a_0 b_1 c_3$	9.67	4.00	5.67
10.	$a_0 b_1 c_4$	7.33	7.00	4.33
11.	$a_0 b_2 c_0$	6.67	8.00	35.00
12.	$a_0 b_2 c_1$	21.67	6.33	32.33
13.	$a_0 b_2 c_2$	10.00	11.33	28.33
14.	$a_0 b_2 c_3$	14.33	6.00	21.33
15.	$a_0 b_2 c_4$	11.33	8.00	13.33
16.	$a_1 b_0 c_0$	18.00	16.33	39.33
17.	$a_1 b_0 c_1$	11.00	22.00	64.33
18.	$a_1 b_0 c_2$	13.67	11.67	19.33
19.	$a_1 b_0 c_3$	7.00	7.67	8.67
20.	$a_1 b_0 c_4$	8.33	12.33	9.67
21.	$a_1 b_1 c_0$	17.00	13.67	7.33
22.	$a_1 b_1 c_1$	17.00	20.33	11.67
23.	$a_1 b_1 c_2$	14.67	4.67	6.33
24.	$a_1 b_1 c_3$	14.00	11.67	11.00
25.	$a_1 b_1 c_4$	7.67	8.00	15.33
26.	$a_1 b_2 c_0$	10.67	33.67	12.67
27.	$a_1 b_2 c_1$	7.67	20.67	29.33
28.	$a_1 b_2 c_2$	15.00	14.33	9.00
29.	$a_1 b_2 c_3$	10.33	14.00	18.67
30.	$a_1 b_2 c_4$	12.67	10.00	13.33
31.	$a_2 b_0 c_0$	11.00	17.33	31.33
32.	$a_2 b_0 c_1$	7.00	30.67	20.33
33.	$a_2 b_0 c_2$	12.00	12.67	24.67
34.	$a_2 b_0 c_3$	13.33	8.67	36.00
35.	$a_2 b_0 c_4$	9.67	6.33	9.00
36.	$a_2 b_1 c_0$	3.67	29.00	16.00
37.	$a_2 b_1 c_1$	12.00	9.33	6.00
38.	$a_2 b_1 c_2$	12.00	12.00	7.67
39.	$a_2 b_1 c_3$	9.67	9.33	7.67
40.	$a_2 b_1 c_4$	10.00	8.00	14.00
41.	$a_2 b_2 c_0$	8.33	13.67	40.67
42.	$a_2 b_2 c_1$	14.00	19.33	36.33
43.	$a_2 b_2 c_2$	5.67	15.00	39.00
44.	$a_2 b_2 c_3$	4.67	9.00	26.00
45.	$a_2 b_2 c_4$	5.00	19.00	18.00

*a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

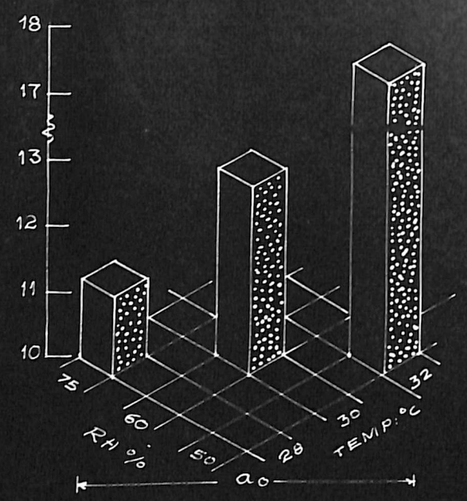
b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

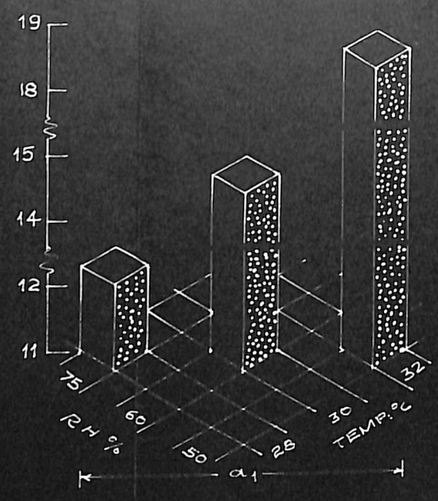
c_0 - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " 2:1 (")
c_2 - " " " " 3:1 (")
c_3 - " " " " 1:2 (")
c_4 - " " " " 1:3 (")

Fig. 3 A - Progeny production of Bracon brevicornis at different temperature-humidity combinations as influenced by the host larval density

Fig. 3 B - Progeny production of Bracon brevicornis at different temperature-humidity combinations as influenced by the weight (size) of host larvae

Fig. 3 C - Progeny production of Bracon brevicornis at different temperature-humidity combinations as influenced by the sex-ratio of the parent parasite population





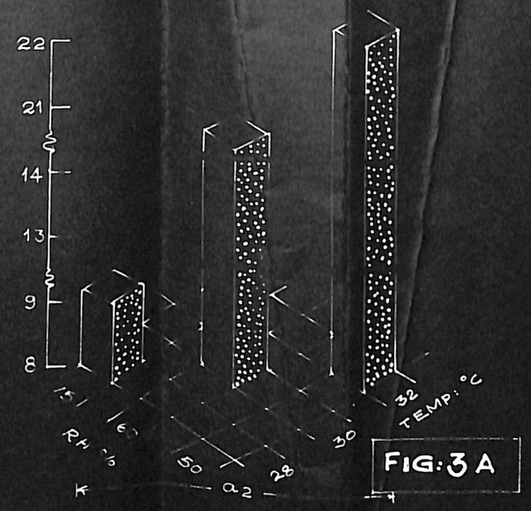
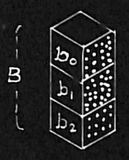
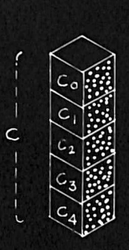


FIG: 3 A

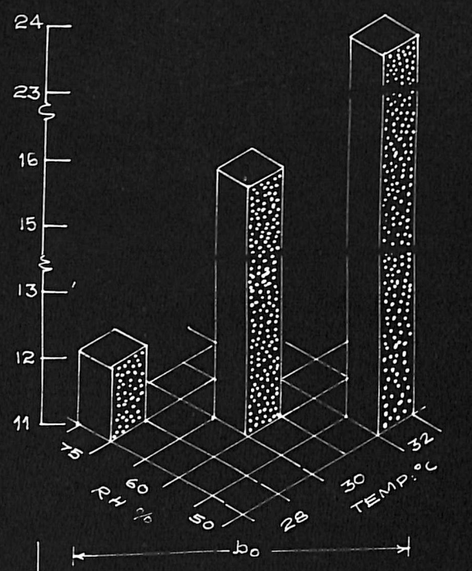
1 HOST LARVA PER FEMALE PARASITE
2 " " " "
3 " " " "

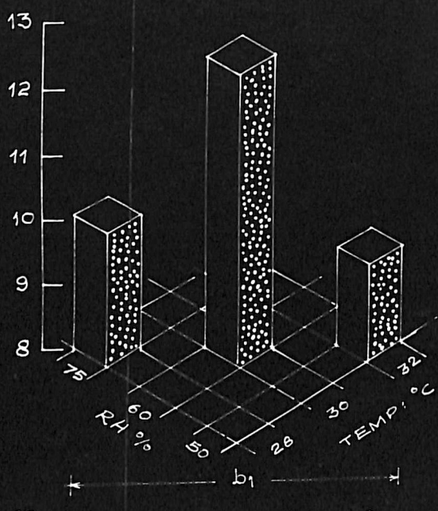


LARVAL WEIGHT 30 – 35 mg
" " 8 – 10 "
HALF OF THE LARVAE OF THE b_0 TYPE AND THE OTHER HALF OF THE b_1 CATEGORY



1 FEMALE : 1 MALE
2 " : 1 "
3 " : 1 "
1 " : 2 "
1 " : 3 "





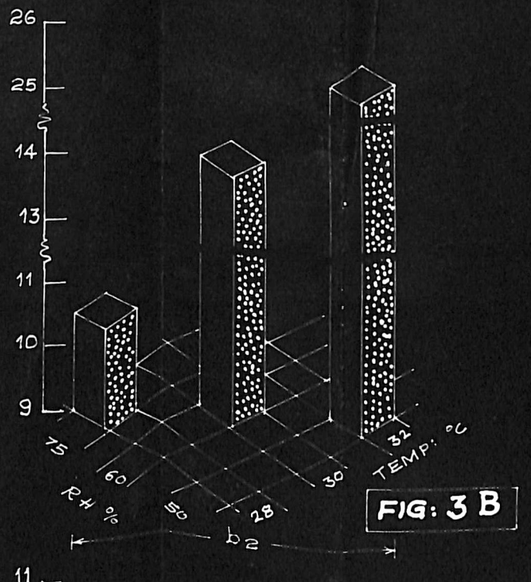
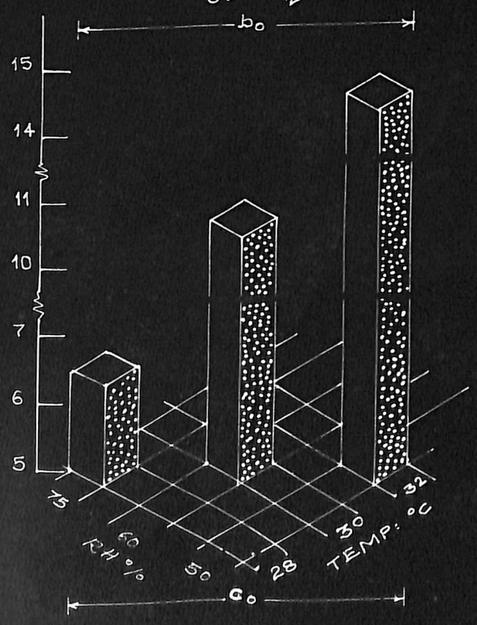
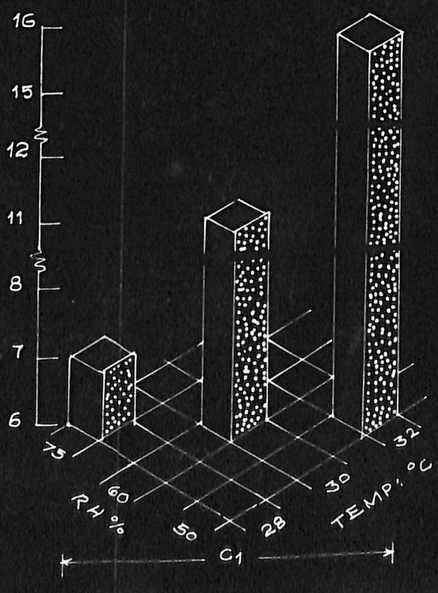
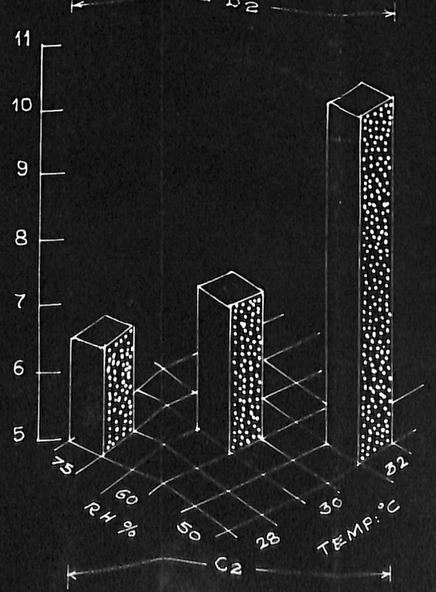
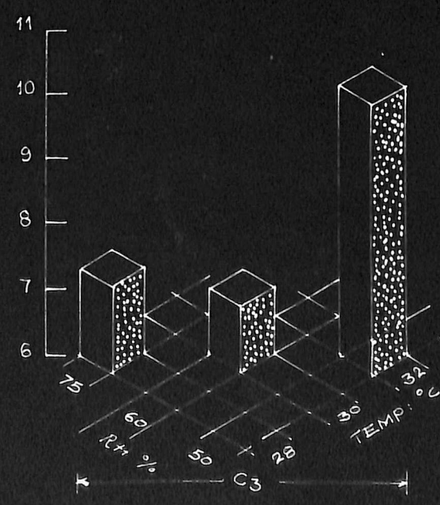


FIG: 3 B









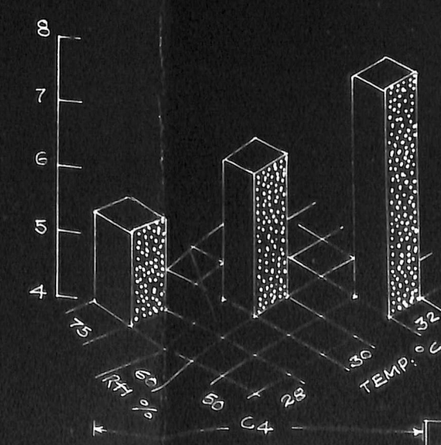


FIG: 3C

Table 3-b

Chi-square values for the effects of the three factors A, B and C at different temperature and humidity combinations on progeny production in H. braviconnis

Source	df	Chi-squares		
		28°C and 75% RH	30°C and 60% RH	32°C and 50% RH
⊕ A	2	20.56**	7.73*	30.70**
⊕ B	2	9.32**	17.68**	350.05**
A x B	4	46.49**	67.09**	94.96**
⊕ C	4	16.22**	114.57**	189.15**
A x C	8	50.64**	50.78**	110.79**
B x C	8	46.75**	55.33**	143.66**
A x B x C	16	98.01**	231.74**	196.77**

* Significant at 5% level
** Significant at 1% level

$\oplus_A$ - Host larval density
$\oplus_B$ - Weight of host larvae
$\oplus_C$ - Sex-ratio of parent parasite population

Table 3-c

Number of progonies produced by *B. brevicornis* at different levels of the main factors at different temperature and humidity combinations.

	28°C and 75% RH		30°C and 60% RH		32°C and 50% RH	
	Total	Mean	Total	Mean	Total	Mean
a_0*	505	11.23	575	12.78	781	17.36
a_1	554	12.31	663	14.73	838	18.62
a_2	414	9.20	658	14.62	1004	22.31
b_0*	545	12.11	710	15.78	1069	23.76
b_1	454	10.09	561	12.47	424	9.42
b_2	474	10.53	625	13.89	1130	25.11
c_0*	294	6.53	482	10.71	661	14.69
c_1	317	7.04	501	11.13	711	15.80
c_2	294	6.53	322	7.16	465	10.33
c_3	329	7.31	315	7.00	455	10.11
c_4	239	5.31	276	6.13	331	7.26

a_0* - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0* - larval weight 30 - 35 mg.
b_0 - " 8 - 10 mg.
b_2^1 - half of the hosts of the 'b_0' type and other half of the 'b_1' type

c_0* - Sex-ratio of parent parasite population - 1:3 (Female:Male)
c_0 - " " " " - 2:1 (")
c_1 - " " " " - 3:1 (")
c_2 - " " " " - 1:2 (")
c_3 - " " " " - 1:3 (")
c_4

Table 3-4

Chi-square values for comparing the progeny production under different levels of the main factors A, B and C at different temperature and humidity combinations in *D. brevicornis*

	Chi-square values					
	28°C and 75% RH	Ranking	30°C and 60% RH	Ranking	32°C and 50% RH	Ranking
a_0 Vs a_1 ⊖	2.07 NS	$a_1 a_0$	6.26*	$a_1 a_0$	2.01 NS	$a_2 a_1 a_0$
a_1 Vs a_2	20.25**		0.02 NS		14.96**	
a_0 Vs a_2	9.01**		5.59*		27.36**	
b_0 Vs b_1 ⊖	0.20**	$b_0 b_2 b_1$	17.47**	$b_0 b_2 b_1$	278.65**	$b_2 b_0 b_1$
b_1 Vs b_2	0.43 NS		3.45 NS		320.74**	
b_0 Vs b_2	4.95*		5.41*		1.69 NS	
c_0 Vs c_1 ⊖	0.07 NS		0.37 NS		1.82 NS	
c_0 Vs c_2	0 NS		31.84**		34.1[illegible]**	
c_0 Vs c_3	1.97 NS	c_4	34.99**	c_4	33.03**	c_4
c_0 Vs c_4	5.68*	c_3	55.98**	c_3	100.70**	c_3
c_1 Vs c_2	0.87 NS	c_2	30.93**	c_2	51.46**	c_2
c_1 Vs c_3	0.22 NS	c_0	43.31**	c_0	56.21**	c_0
c_1 Vs c_4	5.44*	c_1	65.15**	c_1	130.58**	c_1
c_2 Vs c_3	1.97 NS		0.08 NS		0.11 NS	
c_2 Vs c_4	5.68*		3.54 NS		22.56**	
c_3 Vs c_4	14.26**		2.57 NS		10.56**	

* Significant at 5% level
** Significant at 1% level
NS Not significant

a_0 ⊖ - 1 host larva per female parasite
a_0 - 2 " " " "
a_1 - 3 " " " "
a_2

b_0 ⊖ - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

c_0 ⊖ - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " - 2:1 (")
c_2 - " " " " - 3:1 (")
c_3 - " " " " - 1:2 (")
c_4 - " " " " - 1:3 (")

Table 3-c

Chi-square values for comparison of the three main factors A, B and C on progeny production of B. brevicornis at different temperature and humidity combinations

	Chi-square for levels of A			Chi-square for levels of B			Chi-square for levels of C				
	a_0	a_1	a_2	b_0	b_1	b_2	c_0	c_1	c_2	c_3	c_4
TH_1 Vs TH_2	4.54*	9.76**	55.54**	21.69**	11.28**	20.75**	45.55**	41.39**	1.27 NS	0.30 NS	2.66 NS
TH_2 Vs TH_3	31.29**	20.40**	72.03**	72.45**	19.05**	145.31**	28.03**	36.39**	25.98**	25.45**	4.98*
TH_1 Vs TH_3	59.23**	57.94**	245.49**	170.12**	1.03NS	268.29**	141.03**	151.01**	38.53**	20.25**	14.85**

Factors	TH_1 a_0	TH_1 a_1	TH_1 a_2	TH_2 a_0	TH_2 a_1	TH_2 a_2	TH_3 a_0	TH_3 a_1	TH_3 a_2	TH_1 b_0	TH_1 b_1	TH_1 b_2	TH_2 b_0	TH_2 b_1	TH_2 b_2	TH_3 b_0	TH_3 b_1	TH_3 b_2	TH_1 c_0	TH_1 c_1	TH_1 c_2	TH_1 c_3	TH_1 c_4	TH_2 c_0	TH_2 c_1	TH_2 c_2	TH_2 c_3	TH_2 c_4	TH_3 c_0	TH_3 c_1	TH_3 c_2	TH_3 c_3	TH_3 c_4
Progeny																																	

Chi-square due to heterogeneity

Host larval density (A)	44.72**
Weight of host larvae (B)	40.68**
Sex-ratio of parent parasite population (C)	57.86**

OA - Host larval density
a_0 - 1 larva per female parasite
a_1 - 2 " " "
a_2 - 3 " " "

OB - Weight of host larvae
b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

OC - Sex-ratio of parent population
c_0 - 1 female : 1 male
c_1 - 2 female : 1 male
c_2 - 3 female : 1 male
c_3 - 1 female : 2 males
c_4 - 1 female : 3 males

* Significant at 5% level
** Significant at 1% level
NS Not significant

TH_1 - 28°C and 75% RH
TH_2 - 30°C and 60% RH
TH_3 - 32°C and 50% RH

and a_1 (two host larvae per female parasite) levels.

With regard to the weight of host larvae, the maximum progeny production was obtained with the b_0 level having host larvae of weight 30-35 mg, with a mean value of 12.11. The larvae with 8-10 mg weight range (b_1) produced minimum number of progenies having a mean value 10.09. There was no significant difference in progeny production between the b_1 and b_2 levels. The progeny production from heavier larvae (b_0) was significantly better than from larvae of the level b_2 i.e. heavier and lighter larvae in equal proportions.

Among the levels of the sex-ratio of parent parasite population (C), the maximum progenies (7.31) were produced by the c_3 level (1 female: 2 males for the parent parasite population). The level c_4 (1 female: 3 males) gave a much lower (5.31) number of progenies. The level c_3(1 female: 2 males) was found to be on par with the levels c_1 (2 females: 1 male), c_2 (3 females: 1 male), and c_0 (1 female: 1 male).

Progeny production at 30°C and 60% RH

The data on the mean number of progenies produced under various treatments at the above temperature and humidity combination are furnished in column 4 Table 3-a.

The production of progeny ranged from 3.67 under the treatment a_0 b_0 c_2 (one host per female parasite; larval weight range 30-35 mg; sex-ratio of parent parasite population 3 females: 1 male) to 34.67 under the treatment a_0 b_0 c_3 (one host larva per female parasite; larval weight 30-35 mg; sex-ratio of parent population one female: two males).

Chi-square test involving the factors (Table 3-b) have indicated that all the main effects viz., host larval density, weight of host larvae and sex-ratio of parent population as well as their interactions AxB, AxC, BxC and AxBxC are significant. The total and mean values of progeny production at different levels of the factors are summarised in Table 3-c and those are illustrated in Fig.3A, 3B and 3C. The different levels of the factors have been compared using chi-square test and the results are given in Table 3-d.

Among the levels of host density (A) maximum progeny production (14.73) was produced with two hosts per female parasite (a_1). No significant difference was detected between a_1 (two host larvae per female parasite) and a_2 (three host larvae per female parasite). The a_0 level (one host larva per female parasite) gave significantly lower number of progenies of mean 12.70.

With regard to the levels of weight of host larvae (B), larvae with a weight range of 30-35 mg (b_0) recorded the maximum number of progenies, the mean being 15.78 and this was significantly higher than those registered at b_1 (larvae with a weight range 8-10 mg) and b_2 (larvae consisted of lighter and heavier ones in equal proportions) levels. No significant difference was observed between the levels b_1 and b_2.

Among the levels of C (sex-ratio of parent parasite population) progeny production was found to be maximum at the c_1 level (2 females: 1 male) with a mean 11.13. This was found to be not significantly different from the progeny production at c_0 level (1 female: 1 male). The level c_4 (1 female: 3 males) recorded very low number of progenies (6.13). The c_2 and c_3 levels were on par.

Progeny production at 32°C and 50% RH

The data pertaining to the mean progeny production under the various treatment combinations at the above temperature and humidity combination are furnished in column 5 of Table 3-a. The maximum number of progenies (64.33) was registered under the treatment a_1 b_0 c_1 (two host larvae per female parasite; host larvae with a weight range of 30-35 mg, sex-ratio of parent population

two females: one male), while the treatment combination a_0 b_1 c_4 (one host larva per female parasite; host larvae with a weight range 8-10 mg; sex-ratio of parent parasite population one female: three males) recorded the minimum number of progenies (4.33). The total as well as the mean number of progenies produced at different levels of the factors at 32°C and 50% RH are given in Table 3-a and these are diagrammatically represented in Fig. 3A, 3B and 3C. The results of the analysis employing the chi-square test are summarised in Table 3-b.

It will be seen that all the main effects viz., host density (A), weight of host larvae (B), and sex-ratio of parent parasite population (C) as well as their interactions AxB, AxC, BxC and AxBxC are significant. The different levels of the above three factors are compared using the chi-square test and the results are presented in Table 3-d. It is evident that the maximum number of progenies (2 .31) were produced with three host larvae per female (a_2 level) and this was significantly higher than those produced at a_0(one host larva per female parasite) and a_1 (two host larvae per female parasite) levels. No significant variation in progeny production was detected between the a_0 and a_1 levels.

Among the levels of B (weight of host larvae), the b_2 level (larvae consisted of heavier and lighter

ones in equal proportions) registered maximum number of progenies (25.11). The b_2 level recorded significantly higher number of progenies than the b_1 level (larvae with a weight range 8-10 mg). The b_1 level recorded a very low number of progenies (9.42). The b_2 and b_0 levels were on par.

In relation to the levels of sex-ratio of parent parasite population (C), maximum progeny production of 15.30 was registered on the sex-ratio of the parent population was kept at 2 females: 1 male (c_1). But as the parent population was maintained at 1 female : 3 males (c_4) very low number of progenies were produced the mean being 7.36. The levels c_2 (3 females : 1 male) and c_3 (1 female :2 males) have registered more number of progenies than the c_4 level (1 female : 3 males).

Comparisons of progeny production between different levels of temperature and humidity conditions at different levels of the factors A, B and C are presented in Table 3-c. Heterogeneity chi-square is significant for the three factors viz., host larval density (A), weight of host larvae (B) and sex-ratio of parent parasite population indicating that the responses vary with the temperature and humidity conditions.

At the a_0 level (one host larva per female parasite), the progeny production was maximum (17.36) at 32°C and 50% RH (H_3). This was significantly higher than those at 30°C and 60% RH(H_2) and 28°C and 75% RH (H_1). The same trend was observed at the a_1 (2 hosts per female parasite) and a_2 (three hosts per female parasite) levels also. At the three levels of host larval density (A), an increasing trend in the progeny production was observed with increasing temperature and decreasing humidity within the levels tested.

At the b_0 level (host larval weight in the range 30 to 35 mg), maximum progeny production (3.76) was recorded at 32°C and 50% RH (H_3) which is significantly higher than those corresponding to 30°C and 60% RH(H_2) and 28°C and 75% RH (H_1). The progeny production was increased with increasing temperature and decreasing humidity. But at the b_1 level (host larval weight in the range 8 to 10 mg), maximum progeny production was obtained at 30°C and 60% RH (H_2) which was significantly higher than those at 28°C and 75% RH (H_1) and 32°C and 50% RH (H_3). But no significant difference was detected between the counts of progeny at 28°C and 75% RH (H_1) and 32°C and 50% RH (H_3). The b_2 level (a mixture of heavier and lighter larvae in equal proportions) revealed the same trend as that of b_0.

With respect to the progeny production at one female: one male ratio (e_0) of the parent parasite population, the maximum (14.69) was recorded at 32°C and 50% RH (TH_3). This is significantly higher than those corresponding to 30°C and 60% RH (TH_2) and 28°C and 75% RH (TH_1). There is a progressive increase in the progeny production with increasing temperature and decreasing humidity. The same trend was observed with two females: one male (e_1) and three females: one male (e_2) ratios of parent parasite population. But no significant difference was detected between the counts of progeny at 28°C and 75% RH (TH_1) and 30°C and 60% RH(TH_2) at e_2 level. At e_3 level (1 female: 2 males) maximum progenies were produced at 32°C and 50% RH (TH_3) which is significantly higher than those at 28°C and 75% RH (TH_1) and 30°C and 60% RH (TH_2). But no significant difference was detected between the number of progenies recorded at 28°C and 75% RH (TH_1) and 30°C and 60% RH(TH_2). The same trend was observed at e_4 level also (1 female: 3 males).

IV. NUMBER OF FEMALE PROGENY

Number of female progeny at 28°C and 75% RH

The total number of females which emerged out from each replicate was recorded under different treatment

combinations. Data on the mean number of females produced under various treatments at 28°C and 75% RH are furnished in column 3 of Table 4-a and the raw data given in Appendix-IV. The mean number of females ranged from 1.00 under the treatment a_o b_1 c_1 (one host larva per female parasite; weight of host larvae 8-10 mg; sex-ratio of parent population - one female: two males) to 14.00 under the treatment a_o b_2 c_1 (one host larva per female parasite; larvae with a weight of 30-35 mg and 8-10 mg in equal proportions; sex-ratio of parent population one female: two males).

The data being in the form of counts, chi-square test has been adopted to analyse the data as outlined in materials and methods and the results are presented in Table 4-b. It will be seen that all the main effects viz., host density (A); weight of host larvae (B) and sex-ratio of parent parasite population (C) as well as their interactions are significant.

The total as well as the mean values of the number of females produced by the different levels of the factors, host density (A); weight of host larvae (B)and sex-ratio of parent parasite population (C) are shown in Table 4-c and these are graphically depicted in Fig.4A, 4B and 4C. The levels of the above factors are compared in Table 4-d. One host larva per female parasite (a_o) produced the

maximum number of female progonies, the mean being 5.58. This level is not significantly different from the number of progonies produced corresponding to a_1 level (two host larvae per female parasite). But when there were three host larvae per female parasite (a_2), the number of females was significantly lower than those corresponding to one host larva per female (a_0) and two host larvae per female parasite (a_1).

Among the three levels of the weight of the host larvae (B), larvae consisting of 50% of heavier ones with 30-35 mg weight and the remaining 50% with 0-10 mg weight (b_2) produced maximum number of females, with a mean value of 5.51. This was followed by larvae with a weight range of 30-35 mg (b_0) and the two levels b_0 and b_2 being statistically on par. Larvae with a mean weight of 0-10 mg (b_1) produced significantly lower counts of females than those with the b_0 and b_2 levels.

Among the levels of sex-ratio of parent parasite population (C), parent population with a ratio of two females: one male (c_1) have produced the maximum number of female progeny, the mean being 3.64. The number of females at this level (c_1) is significantly higher than those obtained with one female:one male (c_0) and one female: three males (c_4) ratio of the parent population.

Table 4-a

Number of female progeny of B. brevicornis in different temperature and humidity combinations

Sl. No.	Treatments	Mean number of females		
		28°C and 75% RH	30°C and 60% RH	32°C and 50% RH
1.	$a_0 b_0 c_0$	6.33	7.33	15.00
2.	$a_0 b_0 c_1$	7.00	8.00	17.00
3.	$a_0 b_0 c_2$	2.33	1.67	3.00
4.	$a_0 b_0 c_3$	12.00	14.67	10.00
5.	$a_0 b_0 c_4$	2.67	5.33	6.00
6.	$a_0 b_1 c_0$	2.00	2.67	7.33
7.	$a_0 b_1 c_1$	1.00	9.00	4.00
8.	$a_0 b_1 c_2$	4.00	9.33	3.00
9.	$a_0 b_1 c_3$	4.33	3.00	3.33
10.	$a_0 b_1 c_4$	3.33	2.33	2.00
11.	$a_0 b_2 c_0$	3.00	4.00	18.00
12.	$a_0 b_2 c_1$	14.00	2.33	7.00
13.	$a_0 b_2 c_2$	7.33	4.00	17.67
14.	$a_0 b_2 c_3$	6.33	3.33	8.67
15.	$a_0 b_2 c_4$	8.00	2.67	9.00
16.	$a_1 b_0 c_0$	7.67	9.33	26.67
17.	$a_1 b_0 c_1$	5.67	9.00	40.00
18.	$a_1 b_0 c_2$	8.00	3.00	9.33
19.	$a_1 b_0 c_3$	3.67	2.33	5.67
20.	$a_1 b_0 c_4$	3.00	8.67	5.00
21.	$a_1 b_1 c_0$	7.33	6.67	2.00
22.	$a_1 b_1 c_1$	8.33	12.00	5.67
23.	$a_1 b_1 c_2$	5.00	2.33	2.33
24.	$a_1 b_1 c_3$	3.00	4.00	5.33
25.	$a_1 b_1 c_4$	6.00	3.33	[illegible]
26.	$a_1 b_2 c_0$	5.00	10.33	7.00
27.	$a_1 b_2 c_1$	3.00	8.67	14.33
28.	$a_1 b_2 c_2$	6.00	8.00	3.33
29.	$a_1 b_2 c_3$	4.33	8.67	7.00
30.	$a_1 b_2 c_4$	6.67	5.00	8.33
31.	$a_2 b_0 c_0$	4.00	8.00	13.00
32.	$a_2 b_0 c_1$	2.67	18.00	6.67
33.	$a_2 b_0 c_2$	4.33	6.67	5.00
34.	$a_2 b_0 c_3$	7.33	6.00	16.00
35.	$a_2 b_0 c_4$	4.33	3.00	6.00
36.	$a_2 b_1 c_0$	2.00	9.67	5.33
37.	$a_2 b_1 c_1$	6.00	5.33	3.67
38.	$a_2 b_1 c_2$	6.33	4.33	4.33
39.	$a_2 b_1 c_3$	3.67	3.33	2.67
40.	$a_2 b_1 c_4$	2.67	5.33	9.33
41.	$a_2 b_2 c_0$	5.33	4.67	13.67
42.	$a_2 b_2 c_1$	7.00	5.00	13.00
43.	$a_2 b_2 c_2$	2.67	3.33	18.33
44.	$a_2 b_2 c_3$	2.33	5.00	9.67
45.	$a_2 b_2 c_4$	1.67	9.33	11.00

a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0 - larval weight 30 - 35 mg
b_0^1 - " " 8 - 10 mg
b_1 - half of the larvae of the 'b' type

Table 4-b

Chi-square values for the effects of the three factors A, B and C at different temperature and humidity combinations on the number of female progeny in *H. brevicornis*.

Source	df	Chi-square		
		28°C and 75% RH	30°C and 60% RH	32°C and 50% RH
⊕A	2	11.41**	8.51*	3.49 NS
⊕B	2	7.49*	16.37**	180.13**
A x B	4	16.63**	24.78**	83.51**
⊕C	4	9.58*	44.76**	86.92**
A x C	8	27.05**	24.46**	104.66**
B x C	8	27.51**	35.34**	131.74**
A x B x C	16	82.84**	110.13**	149.45**

* Significant at 5% level
** Significant at 1% level
NS Not significant

⊕ A - host larval density
⊕ B - weight of host larvae
⊕ C - sex-ratio of parent parasite population

Table 4-c

Total and mean number of female progeny of *B. brevicornis* produced at different levels of the main factors at different temperature and humidity combinations

	28°C and 75% RH		30°C and 60% RH		32°C and 50% RH	
	Total	Mean	Total	Mean	Total	Mean
a_0*	251	5.58	239	5.31	393	8.73
a_1	248	5.51	304	6.76	445	9.89
a_2	187	4.16	291	6.47	407	9.04
b_0*	243	5.40	333	7.40	553	12.29
b_1	195	4.33	248	5.51	194	4.31
b_2	248	5.51	253	5.62	498	11.07
c_0*	128	2.84	188	4.18	324	7.20
c_1	164	3.64	232	5.16	334	7.42
c_2	136	3.02	128	2.84	199	4.42
c_3	141	3.13	151	3.36	205	4.56
c_4	115	2.56	135	3.00	183	4.07

a_0* - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0* - Larval weight 30 - 35 mg
b_0 - " " 8 - 10 mg
b_2^1 - half of the hosts of the 'b_0' type and other half of the 'b_1' type

c_0* - Sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " - 2:1 (")
c_2 - " " " " - 3:1 (")
c_3 - " " " " - 1:2 (")
c_4 - " " " " - 1:3 (")

Fig. 4 A - Number of female progeny of Bracon brevicornis produced at different temperature-humidity combinations as influenced by the host larval density

Fig. 4 B - Number of female progeny of Bracon brevicornis produced at different temperature-humidity combinations as influenced by the weight (size) of host larvae

Fig. 4 C - Number of female progeny of Bracon brevicornis produced at different temperature-humidity combinations as influenced by the sex-ratio of the parent parasite population

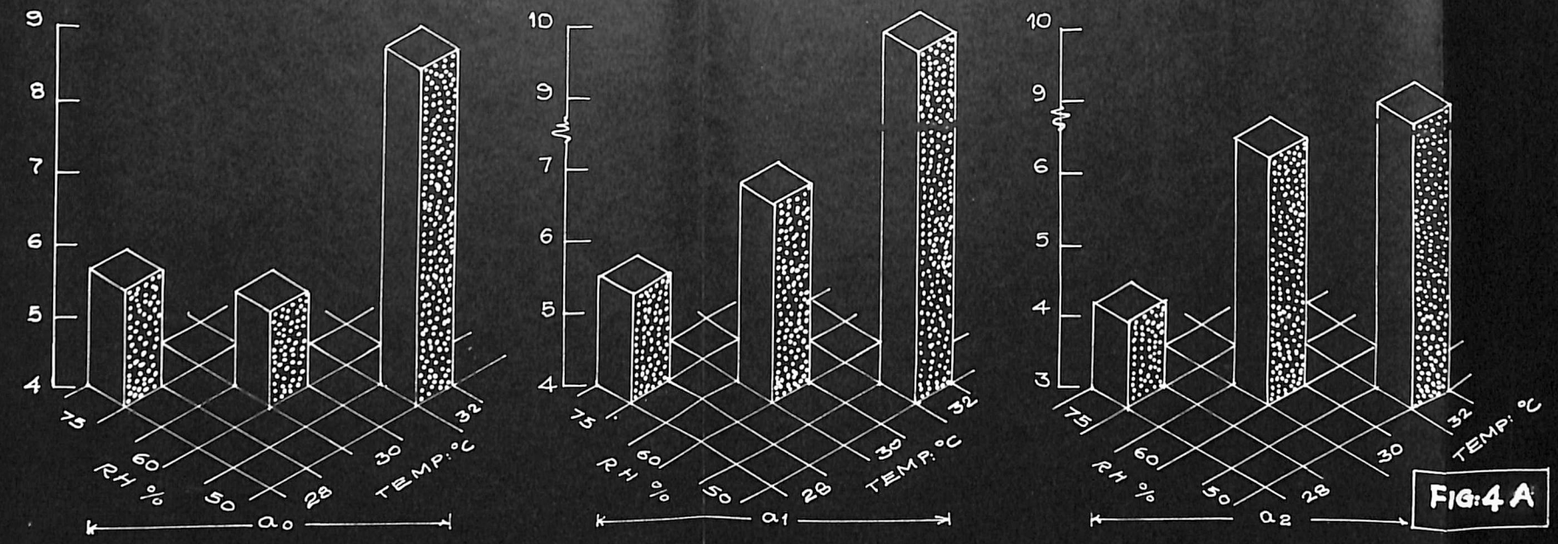


FIG: 4 A

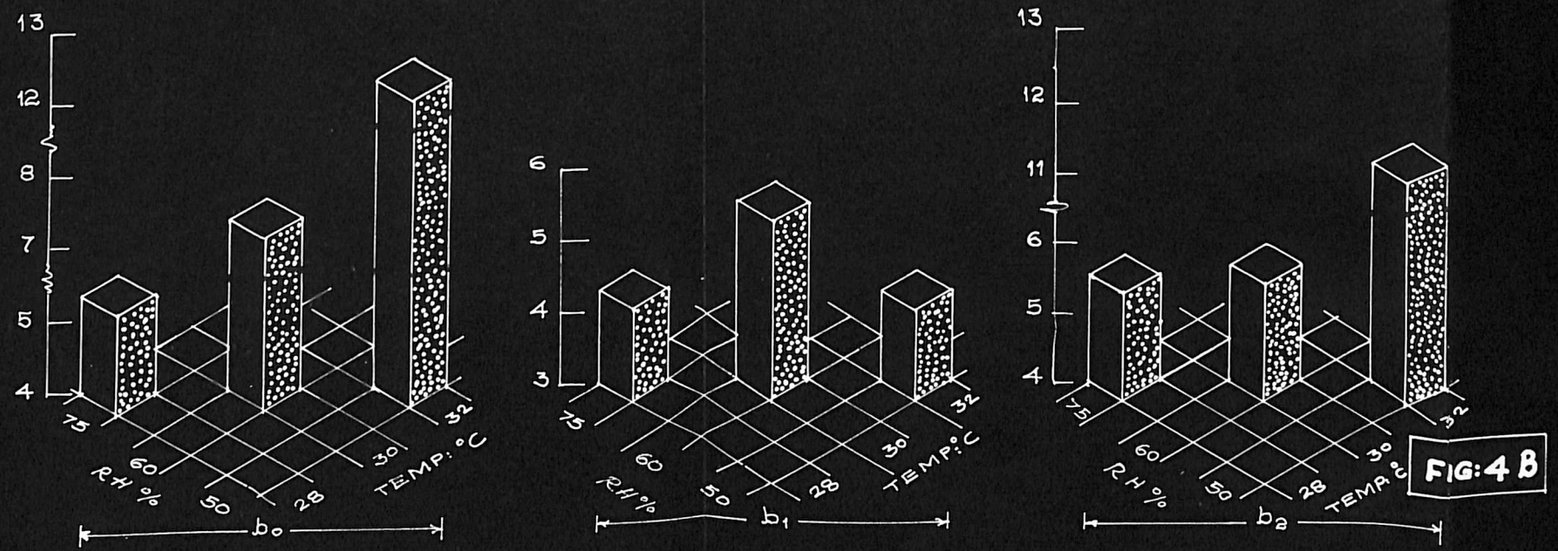
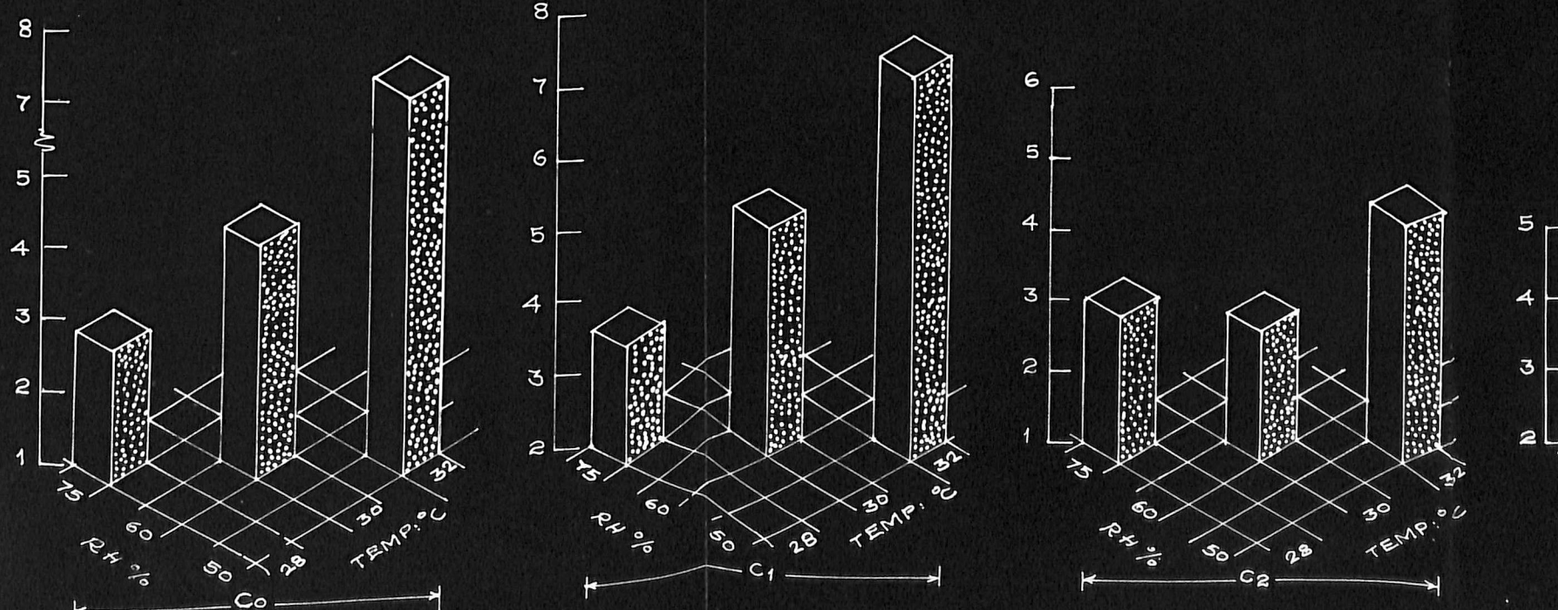
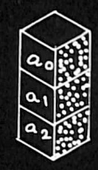


FIG: 4 B



A



1 HOST LARVA PER FEMALE PARASITE
2 " " " " "
3 " " " " "

B

LARVAL WEIGHT 30 – 35 mg.
" " 8 – 10 "
HALF OF THE LARVAE OF THE `b0' TYPE
THE OTHER HALF OF THE `b_1' CATEGO

C

1 FEMALE : 1 MALE
2 " : 1 "
3 " : 1 "
1 " : 2 "
1 " : 3 "

Table 4-d

Chi-square for comparing the effects of different levels of the three factors A, B and C at different temperature and humidity combinations on the number of female progeny of **E. kuriyamensis**

	Chi-square values					
	30°C and 75% RH	Ranking	30°C and 60% RH	Ranking	30°C and 50% RH	Ranking
a_0 Vs a_1	0.02 NS	$a_0^{d^2}a_1$	7.78**	$a_1^{a_2}a_0$	3.23 NS	
a_1 Vs a_2	8.55**		0.28 NS		1.69 NS	
a_0 Vs a_2	9.35**		5.10*		0.35 NS	
b_0 Vs b_1	5.26**	$b_0^{b_1}$	12.44**	$b_0^{b_1}$	172.53**	$b_0^{b_1}$
b_1 Vs b_2	6.34*	$b_1^{b_2}$	0.05 NS	$b_0^{b_2}$	135.55**	$b_0^{b_2}$
b_0 Vs b2	0.05 NS		10.92**		2.83 NS	
c_0 Vs c_1	4.44*		4.61*		0.15 NS	
c_0 Vs c_2	0.24 NS		11.39**		29.88**	
c_0 Vs c_3	0.63 NS	$c_0^{c_4}$	4.04*		26.77**	
c_0 Vs c_4	0.70 NS	$c_0^{c_4}$	8.70**	$c_3^{c_4}$	39.21**	$c_3^{c_4}$
c_1 Vs c_2	2.61 NS	$c_0^{c_2}$	30.04**	$c_3^{c_4}$	34.19**	$c_3^{c_4}$
c_1 Vs c_3	1.73 NS	$c_0^{c_2}$	17.13**	$c_3^{c_4}$	49.09**	$c_3^{c_4}$
c_1 Vs c_4	8.61**	$c_1^{c_3}$	25.64**		44.10**	$c_1^{c_0}$
c_2 Vs c_3	0.09 NS	$c_1^{c_3}$	1.90 NS	$c_0^{c_1}$	0.09 NS	$c_1^{c_0}$
c_2 Vs c_4	1.76 NS	$c_1^{c_3}$	0.19 NS	$c_0^{c_1}$	0.67 NS	$c_1^{c_0}$
c_3 Vs c_4	2.64 NS		0.90 NS		1.25 NS	

*Significant at 5% level
**Significant at 1% level
NS Not significant

a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

c_0 - sex-ratio of parent parasite population - 1:1 (Female: Male)
c_1 - " " " " - 2:1 (")
c_2 - " " " " - 3:1 (")
c_3 - " " " " - 1:2 (")
c_4 - " " " " - 1:3 (")

Table 4-e

Chi-square values for the comparison of the effects of the three main factors A, B and C on the number of female progeny in B. bravicornis at different temperature and humidity combinations.

	Chi-square for levels of A@			Chi-square for levels of B@			Chi-square for levels of C@				
	a_0	a_1	a_2	b_0	b_1	b_2	c_0	c_1	c_2	c_3	c_4
TH_1 Vs TH_2	0.29 NS	5.68*	22.63**	14.06**	6.34*	0.05 NS	11.39**	11.39**	0.24 NS	0.34NS	1.6 NS
TH_2 Vs TH_3	37.53**	26.54**	19.28**	54.63**	6.60*	79.93**	36.13**	18.38**	15.42**	8.19**	7.25**
TH_1 Vs TH_3	31.31**	56.00**	81.58**	120.73**	0.002NS	83.78**	84.99**	58.03**	11.85**	11.84**	15.52**

Pooled error

Chi-square due to heterogenity

Host larval density (A)	14.17**
Weight of host larvae (B)	64.03**
Sex-ratio of parent parasite population (C)	24.48**

@A - Host larval density
a_0 - 1 larva per female parasite
a_1 - 2 " " "
a_2 - 3 " " "

@B - Weight of host larvae
b_0 - larval weight 30 - 35 mg.
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

@C - Sex-ratio of parent population
c_0 - 1 female : 1 male
c_1 - 2 " : 1 " "
c_2 - 3 " : 1 " "
c_3 - 1 " : 2 " "
c_4 - 1 " : 3 " "

* Significant at 5% level
** Significant at 1% level
NS Not significant

TH_1 - 28°C and 75% RH
TH_2 - 30°C and 60% RH
TH_3 - 32°C and 50% RH

But no significant difference was detected between 2:1 (e_1) and 3:1 (e_2) ratios of the parent population; and also between the 2:1 level (e_1) and the 1:2 level (e_3). The number of females produced was minimum when the sex-ratio of parent population was 1:3, the mean being 2.56.

Number of female progeny at 30°C and 60% RH

Treatment-wise data on the mean number of females produced at the above temperature and humidity condition is furnished in column 4 of Table 4-a and the raw data in Appendix IV. The number of female progeny varied from 1.67 under the treatment a_0 b_0 c_2 (one host larva per female parasite; weight of host larva in the range 30 to 35 mg; sex-ratio of parent parasite population 3 female: 1 male) to 18.00 under the treatment a_2 b_0 e_1 (two host larvae per female parasite; weight of host larvae in the range 30 to 35 mg; sex-ratio of parent parasite population 2 females:1male). The results of analysis of the data using chi-square test is presented in Table 4-b. It is indicated from the Table that host larval density (A), weight of host larvae (B) and sex-ratio of parent parasite population (C) have significant effects on the number of female progeny. The interactions of the factors are also significant. The total

and mean values of the number of female progeny produced are presented in Table 4-c and these are represented in Fig. 4A, 4B and 4C. Comparisons of the different levels of the factors A, B and C by chi-square method is given in Table 4-d.

Among the levels of the host larval density (A), the maximum female progeny was produced when two host larvae were provided per female parasite (a_1 level) with mean number 6.76. But at the a_2 level of three host larvae per female parasite, there was no significant difference from the a_1 level. Minimum number of female progeny was produced when one host larva was provided per female parasite (a_0 level), the mean being 5.31.

Among the levels of the weight of host larvae (B), b_0 level i.e.,larvae with a weight range of 30 to 35 mg produced maximum number of female progeny having a mean of 7.40. This is significantly higher than those corresponding to b_2 (a mixture of heavier (b_0) and lighter (b_1) larvae in equal proportions) and b_1 levels (larvae with a weight range 8 to 10 mg). Larvae having a weight of 8 to 10 mg (b_1) produced the minimum number of 5.51 female progeny.

Among the levels of the sex-ratio of parent parasite population (C), the ratio 2 females : 1 male(c_1)

gave the maximum number of females (5.16) this being significantly higher than those obtained at the other levels. With 3 females: 1 male (c_2) in the parent population, minimum number of females were obtained. No significant difference was detected between 1 female : 2 males (c_3) and 1 female: 3 males (c_4) ratios of the parent population.

Number of female progeny at 32°C and 50% RH

Data on the mean number of females produced under various treatments are furnished in column 5 of Table 4-a. Minimum of 2.00 females were recorded by the treatments a_0 b_1 c_4 (one host larva per female parasite; weight of host larvae in the range 8 to 10 mg; sex-ratio of parent population 1 female: 3 males) and a_1 b_1 c_0 (two host larvae per female parasite; weight of host larvae in the range 8 to10 mg; sex-ratio of parent population 1 female: 1 male) while maximum number of 40.00 females were recorded by the treatment a_1 b_0 c_1 (two host larvae per female parasite; weight of host larvae in the range 30 to 35 mg; sex-ratio of parent population 2 females : 1 male).

Analysis of the data by the chi-square test is given in Table 4-b. The effects of weight of host larvae (B), sex-ratio of parent parasite population (C) and the

interactions AxB, AxC, BxC and AxBxC are found to be significant whereas host larval density (A) had no significant effect on the number of female progeny. The total and mean number of females produced at different levels of the factors A, B and C are expressed in Table 4-c and these are illustrated in Fig.4A, 4B and 4C. Comparisons of the different levels of the factors are carried out by the chi-square test which are presented in Table 4-d.

Among the levels of the weight of host larvae (B), maximum number of females (12.29) were produced with host larvae of weight range 30 to 35 mg (b_0 level). Host larvae having a weight range of 8 to 10 mg (b_1) produced very low number (4.31) of females. No significant difference was detected between b_0 (larval weight range 30 to 35 mg) and b_2 levels (50% of 30 to 35 mg type + 50% of 8 to 10 mg type).

Among the levels of the sex-ratio of parent parasite population (♂), 2 females: 1 male ratio (c_1) produced maximum number of 7.42 females. Parent population in the ratio 1 female : 3 males (c_4) produced the minimum number of 4.07 female progeny. No significant variation was observed between parent parasite populations with

1 female: 1 male (e_0) and 2 females : 1 male (e_1) sex-ratios. Parent parasite population with a sex-ratio of 3 females: 1 male (e_2) is not found to be significantly different from those with 1 female : 2 males (e_3) and 1 female : 3 males (e_4) sex-ratios with reference to the number of females produced. But parent population with 1 female : 2 males (e_3) and 1 female : 3 males (e_4) are statistically on par.

Comparisons between different levels of temperature and humidity combinations at different levels of the factors A, B and C are given in Table 4-e. The heterogenity chi-square for A, B and C are significant indicating that the responses vary with temperature and humidity conditions. The number of females produced at a_0 level (one host per female parasite) was maximum at 32°C and 50% RH (TH_3). This is significantly higher than those at 28°C and 75% RH (TH_1) and 30°C and 60% RH (TH_2). But no significant difference was detected between the counts of females at 28°C and 75% RH (TH_1) and at 30°C and 60% RH (TH_2).

When two hosts per female parasite were given (a_1) the maximum number of female progeny was again recorded at 32°C and 50% RH (TH_3). This is significantly

higher than those at 30°C and 50% RH (TH_2) and 28°C and 75% RH (TH_1). Thus when the host larval density is two per female parasite (a_1) there is a progressive increase in the number of females with increasing temperature and decreasing humidity. The same trend was observed when there were three hosts per female parasite (a_2).

There is an increasing trend of female progeny production with increasing temperature and decreasing humidity when the host larvae had a mean weight of 30 to 35 mg (b_0), all the differences between the three temperature and humidity combinations being significant. But when lighter larvae with a weight range of 8 to 10 mg (b_1) were given, the maximum number of female progeny was recorded at 30°C and 60% RH (TH_2), this being significantly higher than those at 28°C and 75% RH (TH_1) and 32°C and 50% RH (TH_3). No significant difference in the female progeny number was detected between 28°C and 75% RH (TH_1) and 32°C and 50% RH (TH_3). Corresponding to b_2 level (a mixture of heavier and lighter larvae in equal proportions), there is an increase in the number of females with increasing temperature and decreasing humidity levels, the difference between the counts of females at 30°C and 60% RH (TH_2) and 28°C and 75% RH (TH_1) being not significant.

An increasing trend was observed in the number of

females produced with increasing temperature and decreasing humidity level when there was 1 female : 1 male ratio (o_0) for the parent parasite population. The same trend was observed when the sex-ratio of parent parasite population was 2 females: 1 male (o_1). But when the sex-ratio of parent population is 3 females: 1 male (o_2) minimum number of females were produced at 30°C and 60% RH (TH_2). At o_3 (1 female : 2 males) and o_4 (1 female : 3 males) levels, the maximum number of females were produced at 32°C and 50% RH (TH_3). This was significantly higher than those produced both at 28°C and 75% RH (TH_1) and 30°C and 60% RH (TH_2). But no significant difference was detected between the counts of females at 28°C and 75% RH (TH_1) and 30°C and 60% RH (TH_2) both at o_3 and o_4 levels.

V. FEMALE-MALE COMPOSITION

The sex-wise counts of the parasites under different treatment combinations have been analysed for the following aspects employing the techniques outlined below.

A. Testing the significance of the difference between the levels of the main factors in the expression of the female-male composition of the F_1 progeny by

transforming the ratio $\frac{\text{Number of females}}{\text{Total}}$ as angles and by testing the differences between these angles in pairs by applying the formula

$$\frac{\theta_1 - \theta_2}{\sqrt{820.7\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad \text{where } \frac{820.7}{ni}$$

is the variance of θi

B. Testing the association between the main factors and sex-wise classification of the F_1 progeny, the chi-square values were computed on the basis of the formula $\frac{(an_2 - a' n_1)}{a + a'}$ where a and a' denote the sex-wise frequencies corresponding to the levels, and n_1 and n_2 represent the corresponding total counts in each case.

Data on the mean number of females and males recorded at the three temperature-humidity combinations under various treatments are furnished in Table 5-a and the replication-wise data is given in Appendix V. The mean number of females and males produced at the different levels of the three main factors are graphically depicted in Fig. 5A, 5B and 5C. The female-male composition of the F_1 progeny of B. brevicornis under different levels of

the main factors A, B and C under the three temperature-humidity combinations are furnished in Tables 5-b, 5-c and 5-d.

Female-Male composition at 28°C and 75% RH

It is indicated that out of the three factors tested, the weight of host larvae (B) alone has shown significant influence on the female-male composition of F_1 progeny at 28°C and 75% RH (Table 5-b). The b_2 level has recorded the highest percentage of females (52.32). Significant difference in the sex-ratio was detected between the b_1 (host larval weight 8-10 mg) and the b_2 (heavier and lighter ones in equal proportions) levels.

Female-Male composition at 30°C and 60% RH

At this temperature and humidity combination, the sex-ratio of the parent parasite population (C) alone had significant effect on the female-male composition of the F_1 progeny, while host larval density (A) and host larval weight (B) had no significant effect (Table 5-c). The c_4 level (1 female : 3 males) recorded the highest percentage of females (48.91) while the c_0 level (1 female: 1 male) recorded a low percentage of females (39.00). The sex-ratio recorded at the c_4 level was significantly better than those at c_2 and c_0 but the sex-ratios at the c_2 and c_0 levels were on par.

Table 5-a

Female-Male composition of *B. brevicornis* in different temperature and humidity combinations

Sl. No.	Treatments	Mean number					
		28°C and 75% RH		30°C and 60% RH		32°C and 50% RH	
		Female	Male	Female	Male	Female	Male
1.	$a_0 b_0 c_0$*	6.33	11.67	7.33	12.00	15.00	7.00
2.	$a_0 b_0 c_1$	7.00	6.33	8.00	12.00	17.00	14.33
3.	$a_0 b_0 c_2$	2.33	2.67	1.67	2.00	3.00	9.33
4.	$a_0 b_0 c_3$	12.00	14.67	14.67	20.00	10.00	6.67
5.	$a_0 b_0 c_4$	2.67	5.00	5.33	8.00	6.00	5.33
6.	$a_0 b_1 c_0$	2.00	2.67	2.67	7.00	7.33	5.33
7.	$a_0 b_1 c_1$	1.00	1.00	9.00	9.33	4.00	1.33
8.	$a_0 b_1 c_2$	4.00	6.00	9.33	12.67	3.00	5.33
9.	$a_0 b_1 c_3$	4.33	5.33	3.00	1.00	3.33	2.33
10.	$a_0 b_1 c_4$	3.33	4.00	2.33	4.67	2.00	2.33
11.	$a_0 b_2 c_0$	3.00	3.67	4.00	4.00	18.00	17.00
12.	$a_0 b_2 c_1$	14.00	7.67	2.33	4.00	7.00	25.33
13.	$a_0 b_2 c_2$	7.33	2.67	4.00	7.33	17.67	10.67
14.	$a_0 b_2 c_3$	6.33	8.00	3.33	2.67	8.67	12.67
15.	$a_0 b_2 c_4$	8.00	3.33	2.67	5.33	9.00	4.33
16.	$a_1 b_0 c_0$	7.67	10.33	9.33	7.00	26.67	12.67
17.	$a_1 b_0 c_1$	5.67	5.33	9.00	13.00	40.00	24.33
18.	$a_1 b_0 c_2$	8.00	5.67	3.00	8.67	9.33	10.00
19.	$a_1 b_0 c_3$	3.67	3.33	2.33	5.33	5.67	3.00
20.	$a_1 b_0 c_4$	3.00	5.33	8.67	3.67	5.00	4.67
21.	$a_1 b_1 c_0$	7.33	9.67	6.67	7.00	2.00	5.33
22.	$a_1 b_1 c_1$	8.33	8.67	12.00	8.33	5.67	6.00
23.	$a_1 b_1 c_2$	5.00	9.67	2.33	2.33	2.33	4.00
24.	$a_1 b_1 c_3$	3.00	11.00	4.00	7.67	5.33	5.67
25.	$a_1 b_1 c_4$	6.00	1.67	3.33	4.67	6.33	9.00
26.	$a_1 b_2 c_0$	5.00	5.67	10.33	23.33	7.00	9.00
27.	$a_1 b_2 c_1$	3.00	4.67	8.67	12.00	14.33	15.00
28.	$a_1 b_2 c_2$	6.00	9.00	8.00	6.33	3.33	5.67
29.	$a_1 b_2 c_3$	4.33	6.00	8.67	5.33	7.00	11.67
30.	$a_1 b_2 c_4$	6.67	6.00	5.00	5.00	8.33	5.00
31.	$a_2 b_0 c_0$	4.00	7.00	8.00	9.33	13.00	18.33
32.	$a_2 b_0 c_1$	2.67	4.33	18.00	12.67	6.67	13.67
33.	$a_2 b_0 c_2$	4.33	7.67	6.67	6.00	5.00	19.67
34.	$a_2 b_0 c_3$	7.33	6.00	6.00	2.67	16.00	20.00
35.	$a_2 b_0 c_4$	4.33	5.33	3.00	3.33	6.00	3.00
36.	$a_2 b_1 c_0$	2.00	1.67	9.67	19.33	5.33	14.00
37.	$a_2 b_1 c_1$	6.00	6.00	5.33	4.00	3.67	2.33
38.	$a_2 b_1 c_2$	6.33	5.67	4.33	7.67	4.33	3.33
39.	$a_2 b_1 c_3$	3.67	6.00	3.33	6.00	2.67	3.67
40.	$a_2 b_1 c_4$	2.67	7.33	5.33	2.67	7.33	6.67
41.	$a_2 b_2 c_0$	5.33	3.00	4.67	9.00	13.67	27.00
42.	$a_2 b_2 c_1$	7.00	7.00	5.00	14.33	13.00	23.33
43.	$a_2 b_2 c_2$	2.67	3.00	3.33	11.67	18.33	20.67
44.	$a_2 b_2 c_3$	2.33	2.33	5.00	4.00	9.67	16.33
45.	$a_2 b_2 c_4$	1.67	3.33	9.33	9.67	11.00	7.00

*a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

c_0 - sex ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " - 2:1 (")
c_2 - " " " " - 3:1 (")
c_3 - " " " " - 1:2 (")
c_4 - " " " " - 1:3 (")

Table 5-b

Female-Male composition of *B. brevicornis* under different levels of the main factors A, B and C at 28°C and 75% RH

Levels	Females	Males	Chi-square
● a_0	251 (49.70)	254 (50.30)	
a_1	248 (44.80)	306 (55.20)	3.04 NS
a_2	187 (45.20)	227 (54.80)	
● b_0	243 (44.60)	302 (55.40)	
b_1	195 (42.95)	259 (57.05)	9.55**
b_2	248 (52.32)	226 (47.68)	
● c_0	128 (43.54)	166 (56.46)	
c_1	164 (34.10)	317 (65.90)	6.54 NS
c_2	136 (46.26)	158 (53.74)	
c_3	141 (42.86)	188 (57.14)	
c_4	115 (48.12)	124 (51.88)	

Figures in parenthesis indicate the related percentage values.

** Significant at 1% level
NS Not significant

● a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

● b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the host larvae of the 'b_0' type and the other half of the 'b_1' ty

● c_0 - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " 2:1 (" "
c_2 - " " " " 3:1 (" "
c_3 - " " " " 1:2 (" "
c_4 - " " " " 1:3 (" "

Table 5-c

Female-Male composition of *S. breviocornis* under different levels of the main factors A, B and C at 30°C and 60% RH

Levels	Females	Males	Chi-square
⊕ a_o	239 (41.57)	336 (58.43)	
a_1	304 (45.85)	359 (54.15)	2.32 NS
a_2	291 (44.22)	367 (55.78)	
⊕ b_o	333 (46.90)	377 (53.10)	
b_1	248 (44.21)	313 (55.79)	5.58 NS
b_2	253 (40.48)	372 (59.52)	
⊕ c_o	188 (39.00)	294 (61.00)	
c_1	232 (46.31)	269 (53.69)	17.44**
c_2	128 (39.75)	194 (60.25)	
c_3	151 (47.94)	164 (52.06)	
c_4	135 (43.91)	141 (51.09)	

Figures in parenthesis indicate the related percentage values.

** Significant at 1% level
NS Not significant

⊕ a_o - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

⊕ b_o - larval weight 30 - 35 mg
b_o^1 - " " 8 - 10 mg
b_2 - half of the host larvae of the 'b_o' type and the other half of the 'b_1' type.

⊕ c_o - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_o - " " " " 2:1 (")
c_1 - " " " " 3:1 (")
c_2 - " " " " 1:2 (")
c_3 - " " " " 1:3 (")
c_4 -

Table 5-d

Female-Male composition of *B. brevicornis* under different levels of the main factors A, B and C at 32°C and 50% RH

Levels	Females	Males	Chi-square
⊕ a_0	393 (50.32)	388 (49.68)	
a_1	445 (53.10)	393 (46.90)	3[illegible].56**
a_2	407 (40.54)	597 (59.46)	
⊕ b_0	553 (51.73)	516 (48.27)	
b_1	194 (45.75)	230 (54.25)	13.52**
b_2	498 (44.07)	632 (55.93)	
⊕ c_0	324 (49.02)	337 (50.98)	
c_1	334 (46.98)	377 (53.02)	13.95**
c_2	199 (42.80)	266 (57.20)	
c_3	205 (45.05)	250 (54.95)	
c_4	183 (56.13)	143 (43.87)	

Figures in parenthesis indicate the related percentage values.

** Significant at 1% level
NS Not significant

⊕ a_0 - 1 host larva per female parasite
a_0 - 2 " " " "
a_1 - 3 " " " "
a_2

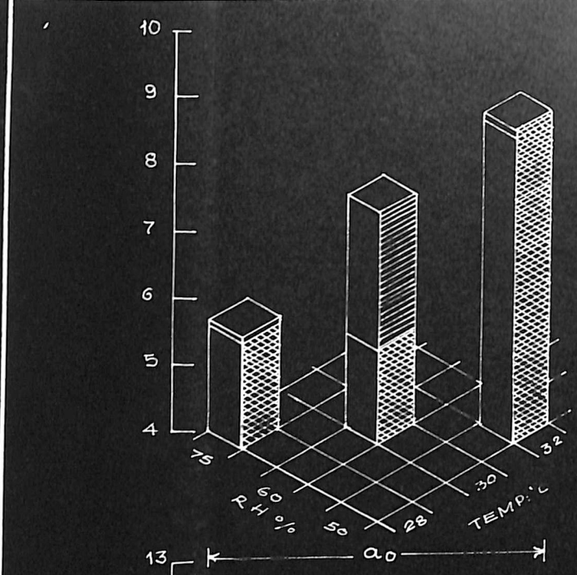
⊕ b_0 - larval weight 30 - 35 mg
b_0 - " " 8 - 10 mg
b_1 - half of the host larvae of the 'b_0' type and the other half of the 'b_1' type.
b_2

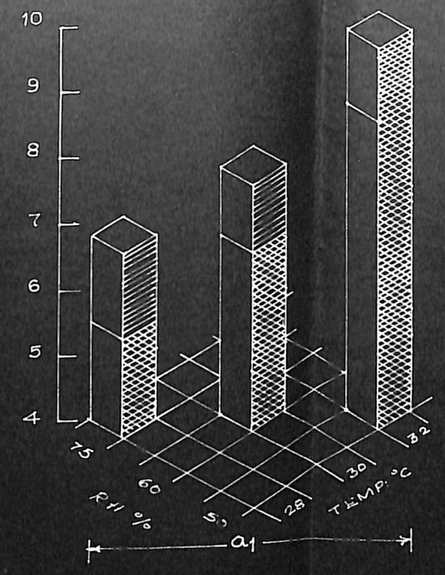
⊕ c_0 - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_0 - " " " " 2:1 (")
c_1 - " " " " 3:1 (")
c_2 - " " " " 1:2 (")
c_3 - " " " " 1:3 (")
c_4

Fig. 5 A - Female-male composition of the F_1 progeny of Bracon brevicornis at different temperature-humidity combinations as influenced by the host larval density

Fig. 5 B - Female-male composition of the F_1 progeny of Bracon brevicornis at different temperature-humidity combinations as influenced by the weight (size) of host larvae

Fig. 5 C - Female-male composition of the F_1 progeny of Bracon brevicornis at different temperature-humidity combinations as influenced by the sex-ratio of the parent parasite population





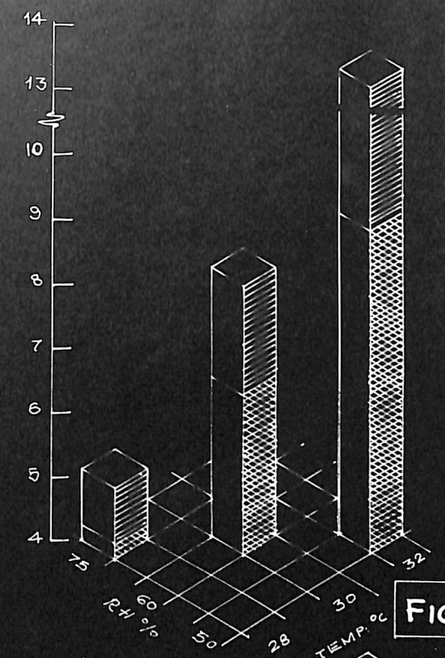
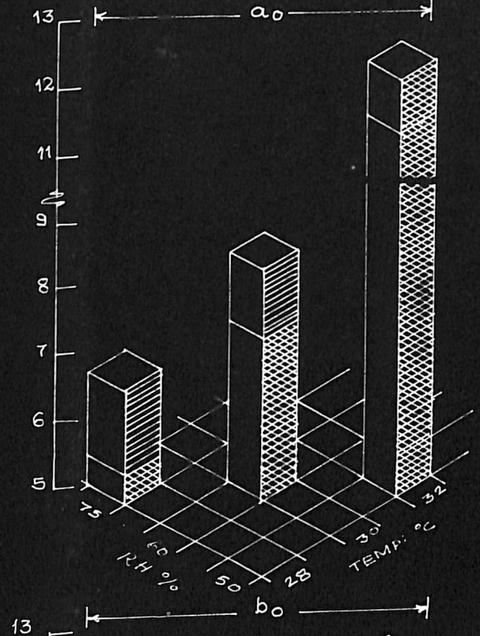
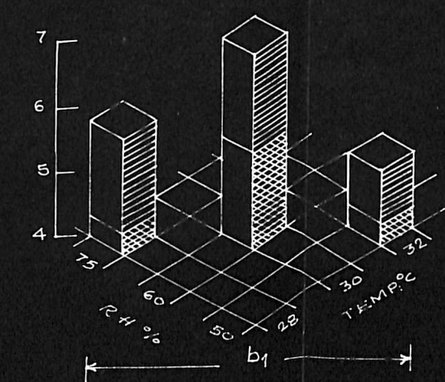


FIG:5A





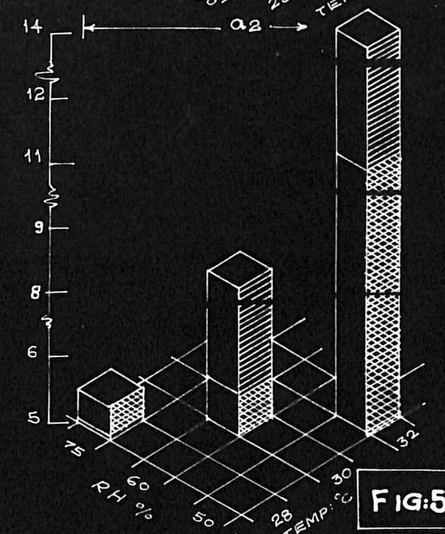
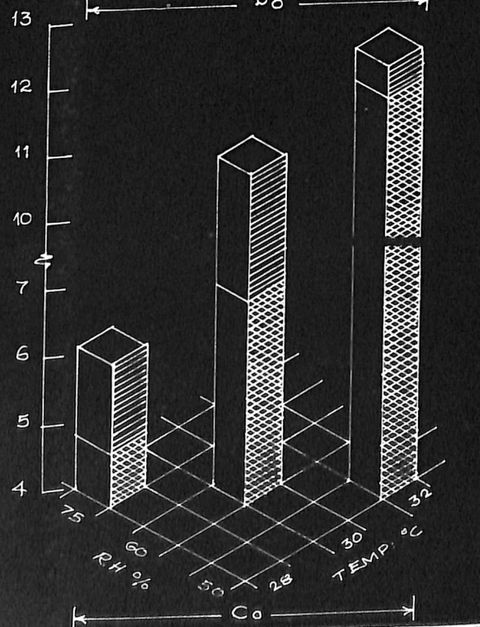
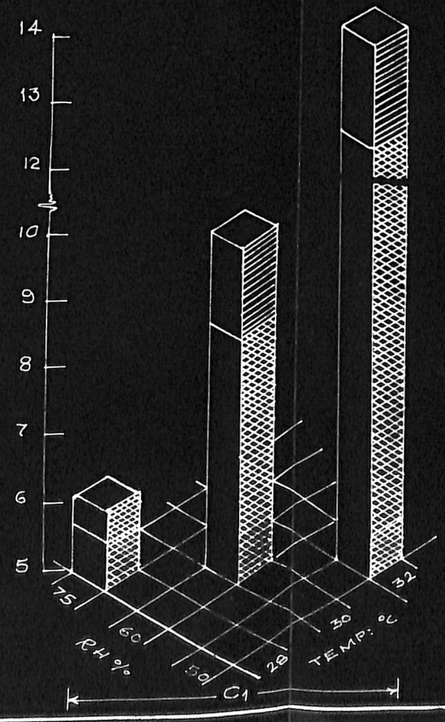
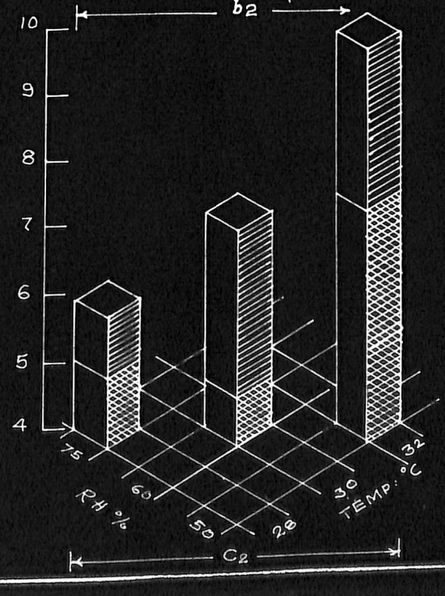
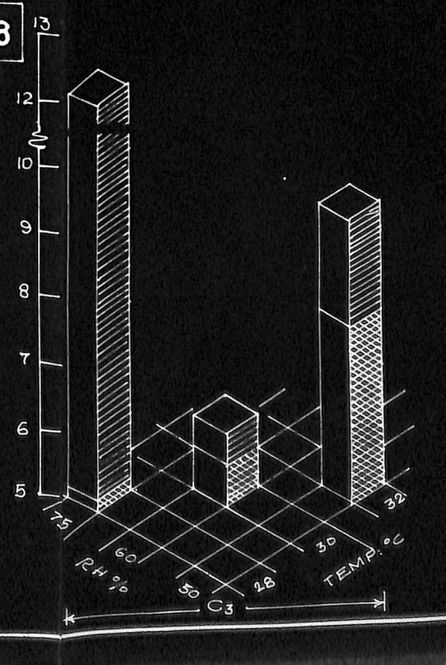


FIG:5B









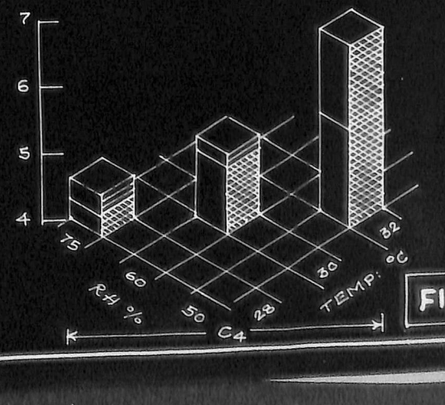
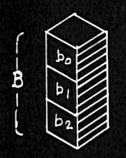
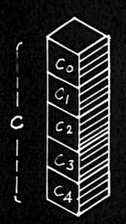


FIG:5C

1 HOST LARVA PER FEMALE PARASITE
2 " " " "
3 " " " "



LARVAL WEIGHT 30 – 35 mg.
" " 8 – 10 "
HALF OF THE LARVAE OF THE 'b0' TYPE AND THE OTHER HALF OF THE 'b1' CATEGORY



1 FEMALE : 1 MALE
2 " : 1 "
3 " : 1 "
1 " : 2 "
1 " : 3 "

Female-Male composition at 32°C and 50% RH

At the above temperature and humidity combination, all the three main factors A (host larval density), B (weight of host larvae) and C (sex-ratio of parent parasite population had significant effects on the sex-ratio of the F_1 progeny (Table 5-d).

Among the levels of A (host larval density), the a_1 level (2 host larvae per female parasite) recorded the highest percentage of females (53.10). The sex-ratio recorded at a_1 level was significantly better than those recorded at the a_2 level (3 host larvae per female parasite). No significant difference in the sex-ratio was detected between the levels a_0 (1 host larva per female parasite) and a_1. But the sex-ratio at the a_0 level was significantly better than that at a_2 level.

Among the levels of B (weight of host larvae), the b_0 level (host larval weight 30-35 mg) recorded the highest percentage of females (51.73) and the sex-ratio at the b_0 level was significantly better than those at b_1 and b_2 levels. But no significant difference was detected between the sex-ratios recorded at b_1 and b_2 levels.

Among the levels of C (sex-ratio of parent parasite population), the c_4 level (1 female : 3 males) recorded the highest percentage of females (56.13) and the sex-ratio was significantly better than those recorded at c_3, c_2 and c_1 levels.

DISCUSSION

DISCUSSION

The fecundity, progeny production and female-male composition of *Bracon brevicornis* Wesmael as influenced by the number and weight of host larvae of *Corcyra cephalonica* Stainton and the sex-ratio of the parent parasite population were studied at three temperature-humidity combinations which represented near optimum condition of 28°C and 75% RH and near-adverse conditions of 30°C and 60% RH and 32°C and 50% RH and these combinations are henceforth referred to as TH_1, TH_2 and TH_3 respectively. The effects of the above three factors on the duration of development were also studied. The following were the levels at which the effects of the three factors were studied.

Factor 1: Host larval density (A)

Levels a_0 - 1 host larva per female parasite

a_1 - 2 " "

a_2 - 3 " "

Factor 2: Weight of host larvae (B)

Levels b_0 - host larval weight 30 to 35 mg

b_1 - " 8 to 10 mg

b_2 - half of the hosts of the b_0 type and the other half of the b_1 type

Factor 3: Sex-ratio of parent parasite population

Levels o_0 - 1:1 (Female: Male)

o_1 - 2:1 (")

o_2 - 3:1 (")

o_3 - 1:2 (")

o_4 - 1:3 (")

FECUNDITY OF B. BREVICORNIS

The fecundity was recorded by examining the host larvae on successive days after confinement with the parasites and directly counting the eggs adhering to the host body. Data on the mean number of eggs laid by the female parasite under the different treatments at the three temperature-humidity levels are furnished in table 1-a and the results of chi-square test are presented in table 1-b. The number of eggs laid at different levels of the three factors are summarised and presented in table 1-c and these are graphically depicted in Fig.1 A, 1 B and 1 C.

All the main effects viz., host larval density (A), weight of host larvae (B) and sex-ratio of parent population were found to be significant.

Influence of host larval density on fecundity of *B. brevicornis*

A significantly higher number of eggs were obtained at all the three TH levels when the host larval density was maintained at two per female parasite (a_1 level) than at the a_0 (1 host larva per female parasite) and a_2 (3 host larvae per female parasite) density levels.

That the fecundity of *Bracon brevicornis* and *Microbracon* sp. increased progressively with the number of hosts available is already reported by Doutt (1959) and Sheshagiri Rao *et al.* (1967). The present finding closely agrees with the results obtained by Subba Rao *et al.* (1974) in the case of *B. hebetor*. In this case, maximum fecundity was registered with two *Corcyra* larvae per parasite pair. The increased fecundity at high host density levels might be partly due to increase in the density of available ovipositional sites (Flanders, 1946) and partly due to increase in the availability of food for the female parasite (Ullyett, 1943, 1945). Perhaps in *B. brevicornis* the optimum density of ovipositional sites and adequate adult nutrition are ensured with two hosts per parasite female. This is, however, not in consonance with Ullyett's (1951) observation that in *B. hebetor*, a fixed number of eggs are laid regardless of the number of hosts.

The chi-square due to heterogenity of host larval density was found to be non-significant indicating lack of heterogenity in respect of this factor over the different TH levels (Table 1-e).

Influence of weight of host larvae (B) on the fecundity of *B. brevicornis*

Heavier larvae (larval weight 30 to 35 mg) and lighter larvae (larval weight 8 to 10 mg) of the same age and an admixture of both types in equal proportions were used in the present studies to ascertain whether parasitic development is influenced by the weight of larvae.

It was revealed that the weight of host larvae exerted significant influence on the fecundity of parasite at all the TH levels. At TH_1 and TH_2 levels, maximum fecundity was registered when host larvae comprising of heavier and lighter ones in equal proportions (b_2) were exposed for parasitisation. The trend at the TH_3 level was, however, different and there was maximum egg production under the b_0 level where relatively heavier larvae were alone used.

At all the TH levels, the exclusive use of light weight larvae as hosts for the parasite (b_1) was found to produce significantly less number of eggs. This

clearly indicates that when lighter larvae are used for rearing H. brevicornis, the oviposition potential is not fully realised. The low egg production by the parasite in lighter larvae may be explained on the basis of the lack of proper ovipositional stimulus in the lighter larvae or based on the reduced availability of body fluid exuding from the oviposition wounds of lighter larvae, for adult feeding as reported by Wylie (1962) in Nasonia vitripennis which is parasitic on Musca domestica.

The chi-square due to heterogenity of host larval weight (B) over the different TH levels was found to be significant. At the b_0 level, the TH_3 combination was superior to the other two TH levels in obtaining higher fecundity. At the b_2 level also maximum number of eggs were obtained at the TH_3 level but there was no significant difference between the TH_3 and TH_1 levels. However, for the lighter larvae (b_1), the superiority of the TH_3 level was not manifested. For this level, the maximum fecundity was obtained for the TH_1 level and the least for TH_3.

The results thus indicate that when heavier host larvae (b_0) were used, maximum fecundity was obtained under TH_3 combination (32°C and 50% RH) while in the case

of lighter larvae (b_1) the TH_1 combination (23°C and 75% RH) was found to be relatively more suitable for better egg production. When heavier and lighter larvae were used in equal proportions (b_2) both TH_3 and TH_1 levels were found to be equally efficient in obtaining maximum egg production. The studies reveal that the preferred levels of temperature-humidity combination for oviposition by B. brevicornis varies with the weight of host larvae. At high temperature - low humidity levels, the host body fluid exuding from oviposition wounds is likely to get dried up faster and hence heavier hosts might be essential for ensuring sufficient body fluid exudates in the required consistency for adult feeding. High fecundity obtained at the TH_3 combination for heavier larvae is perhaps due to this reason. In the present studies all the adult parasites were offered honey-glucose mixture as food, but it is quite probable that the host body fluid will be preferred by the adult females to the honey-glucose solution.

Influence of sex-ratio of parent parasite population (C) on fecundity of B. brevicornis

At all the TH levels tested, the parental sex-ratio levels c_1 (2:1) and c_2 (3:1) were found to produce more number of eggs than under the sex-ratio levels c_0 (1:1),

c_3 (1:2) and c_4 (1:3). This clearly shows that a dominance of females in the parent parasite population (c_1 and c_2) is essential for ensuring higher fecundity and that when the proportion of females remained the same (c_0, c_3, c_4), the fecundity do not increase with increase in the number of males. In arrhenotokous parasites, since eggs are laid even without mating and fertilisation, the sex-ratio of the parental parasite population is apparently not expected to influence fecundity. The present results indicate that the parental sex-ratio influence fecundity and this may be due to effective mating and successful fertilisation and resultant improvement of the stimulus for oviposition leading to better realisation of egg laying potential. It is quite possible that the optimum sex-ratio for successful fertilisation in B. brevicornis is c_1 (2:1) and c_2 (3:1).

The heterogenity chi-square for the factor C (sex-ratio of parent parasite population) over the different MH levels being significant, it is revealed that the response to this varies over the different MH levels.

PROGENY PRODUCTION

The total number of males and females which emerged out from each replicate was recorded as the F_1 progeny production under different treatments. Data on the

mean number of progenies produced under various treatments at the three TH levels are furnished in Table 3-a and the results of chi-square test are presented in Table 3-b. The number of progenies produced at different levels of the three main factors are summarised and presented in Table 3-c and these are illustrated in Fig. 3 A, 3 B and 3 C.

All the main effects viz., host larval density (A), weight of host larvae (B) and sex-ratio of parent parasite population (C) as well as their interactions were found to be significant.

Influence of host larval density on progeny production of B. brevicornis

The maximum number of progenies were produced when two host larvae were exposed per female parasite (a_1) at TH_1 and TH_2 levels and this was significantly higher than the a_2 level of three host larvae per female parasite at TH_1 level. But at the TH_3 level, significantly higher number of progenies were produced when three host larvae were offered per female parasite (a_2).

It was found that the fecundity of the parasite was significantly higher at all the three TH levels for the level a_1 (2 hosts per female parasite). For the TH_1

and TH_2 levels, progeny production was also found to be better under the a_1 level and this is only expected based on the fecundity trend. It is evident that temperature-humidity combination for realisation of fecundity potential also operates in the same manner for embryonic and post-embryonic development leading to similar trend in the progeny production. That at TH_3 level maximum fecundity was obtained at two host larvae per female (a_1) while maximum progeny production was obtained at a_2 level of three host larvae per female parasite is perhaps due to parasite mortality occurring in the immature stages.

The chi-square due to heterogenity for the host larval density (A) was significant indicating that the responses to host larval density vary with the TH levels. At all the three host density levels a_0, a_1 and a_2, the progeny production was found to be significantly higher at the TH_3 level as compared to the TH_1 and TH_2 levels obviously due to the improvement in embryonic and post-embryonic development leading to better progeny production. When TH_3 condition is considered separately, it is seen that higher host density (a_2) was essential for getting maximum progeny production while an overall consideration shows the superiority of TH_3 level for all the three host density levels.

According to Flanders (1935), in Trichogramma evanescens, with increasing host densities, the number of progeny per parasite increased until a maximum was reached. The number of progeny per parent becomes stable beyond a stage when the number of hosts within the sphere of action of the parasites exceeds the total reproductive potential of the parasite. Seshagiri Rao et al., (1967) reported that progeny production in B. brevicornis increased progressively with the number of hosts available, but it showed a decreasing trend in the case of Perisierola nephantidis at high host density levels.

Abraham and Mathew (1978) observed that the number of exposed Corcyra larvae is relatively more important in the progeny production of B. brevicornis. Viktorov and Azizov (1972) recorded that progeny production in Muscidifurax raptor increased with increase in the number of host puparia of Musca domestica. The present results are in general agreement with the early observations, subject to the detection of an optimum level of two larvae per female parasite at TH_1 and TH_2 and three larvae per host at TH_3. Under all host density levels, TH_3 combination was found the best in getting higher progeny production.

Influence of weight of host larvae (B) on progeny production of *B. brevicornis*

It is indicated that significantly higher number of progenies were produced when heavier larvae (b_0) were exposed for parasitisation both at TH_1 and TH_2 conditions. Under the TH_3 level, an admixture of heavier and lighter larvae in equal proportions (b_2) and the heavier larvae (b_0) were on par with reference to progeny production. The better progeny production from heavier larvae can be explained in the light of better larval and pupal development due to better nutritional status of such larvae.

The heterogenity chi-square for the weight of host larvae (B) was found to be significant indicating differential responses of the factor B over the three TH levels. The b_0 (heavier larvae) and b_2 (mixture of heavier and lighter larvae in equal proportions) levels registered maximum progeny production at the TH_3 level (32°C and 50% RH). However, for the b_1 level (lighter larvae), maximum progeny production was registered at the TH_2 combination (30°C and 60% RH). The trend in higher progeny production at the b_0 and b_2 levels is similar to the trend in higher egg production at the TH_3 level. The variations in the trend of progeny

production at different temperature-humidity levels with host weight changes is due to the differential impact of these abiotic environmental components in relation to host nutritional status indicated by host weight.

As in Exenterus abruptorius (Hymenoptera: Ichneumonidae) (Gurjanova, 1974), it is quite possible that B. brevicornis lays fertilised eggs on large larvae and unfertilised eggs on small larvae and thus the male producing eggs will be found only on lighter larvae. The differential response of the weight of host larvae over the different TH levels will then be due to the variations in the temperature-humidity tolerances of the two sexes.

Influence of sex-ratio of parent parasite population (♂) on progeny production of B. brevicornis

A sex-ratio of 1:2 (female:male) in the parent parasite population (o_3) has recorded a significantly higher progeny production as compared to the o_4 level (1:3) at TH_1 combination. At the TH_2 and TH_3 levels, the trend in progeny production was in favour of better progeny production under o_1 (2:1) than under o_4 (1:3). At all the tested TH levels, the parental sex-ratio of

1:3 (e_4) was found inferior to the rest of the sex-ratio levels with reference to progeny production. The e_1 (2:1) and e_2 (3:1) levels of parental sex-ratios characterised by the dominance of females were already found to be consistently better in the production of eggs at all the TH levels. However, similar consistent trends in progeny production at all TH levels were not detected. Thus at TH_2 and TH_3 levels, e_1 (2:1) sex-ratio was found to be superior to e_4 (1:3) and this indicates that for better progeny production also a dominance of females (e_1) rather than of males (e_4) is desirable. This finding is not in full agreement with the earlier report by Abraham and Mathew (1978) that the number of males in the parental population of S. brevicornis is relatively of more important.

The results obtained at the TH_1 level (28°C and 75% RH) are not in consonance with the trend under TH_2 and TH_3 conditions and the superiority of the e_3 ratio (1 female: 2 males) indicates that at relatively low temperature-high humidity conditions the preferred nature of sex-dominance is tilted towards male dominance at the above level. The finding of Abraham and Mathew (1978) that the number of males in the parental population

is relatively more important under room temperature conditions around 28± 1°C is in line with the present observation.

The heterogenity chi-square was found to be significant and this indicates that the responses of the factor C vary with temperature-humidity combinations. At all the levels of C (c_0, c_1, c_2, c_3 and c_4), significantly higher progeny production was consistently obtained at the TH_3 level of 32°C and 50% RH. The improvement of progeny production at the TH_3 condition for all the parental sex-ratios indicates that for embryonic and post-embryonic development of the parasite this particular temperature-humidity combination is relatively more favourable.

NUMBER OF FEMALE PROGENY

The total number of female emergents [illegible] was recorded under different treatment combinations. Data on the mean number of females produced by the parasite under various treatments in different TH combinations are furnished in Table 4-a and the results of chi-square test are presented in Table 4-b. The mean number of females produced by the different levels of the three

main factors are indicated in Table 4-c and these are represented in Fig. 4A, 4B and 4C.

Influence of host larval density (A) on female progeny production of B. brevicornis

It is indicated that the host larval density exerted significant influence on the number of females produced by the parasite at TH_1 (28°C and 75% RH) and TH_2 (30°C and 60% RH) levels only. When one host larva per female parasite (a_0) was exposed for parasitisation at the TH_1 level, a significantly higher number of female progeny was obtained than those obtained from three host larvae (a_2). It is thus observed that as the number of hosts per female parasite increased from one to three, the number of female progeny decreased. Similar trend of production of progeny with a small proportion of females at low host densities was also reported by King (1962) in the case of Nasonia vitripennis.

The trend in female progeny production at TH_2 combination of 30°C and 60% RH was quite different and under this condition significantly more number of female progeny was produced at the a_1 level (two host larvae per female parasite) than at the a_0 level (one host larva per female parasite).

The female progenies are expected to arise from diploid eggs and the variations in the number of female progenies are thus caused by the fertilisation and proportion of diploid eggs that are laid on the hosts. Even after fertilisation, the deposition of diploid eggs is regulated by the presence of adequate stimulus picked up through the ovipositor and/or the antennae and the divergent trends of female progeny production in different TH conditions from varying number of hosts is perhaps due to the modification of ovipositional stimulus under temperature-humidity variations. This is substantiated by the significant heterogenity chi-square for the host larval density (A) over the different TH combinations.

Influence of weight of host larvae (B) on female progeny production of B. brevicornis

The weight of host larvae had significant influence on the number of female progeny produced at all the three TH combinations. At the TH_1 level, an admixture of heavier and lighter larvae in equal proportions (b_2) produced the maximum number of female progeny. This was followed by the heavier larvae with a weight range of 30 to 35 mg (b_0). Lighter larvae with a weight range of 8 to 10 mg (b_1) produced significantly lower number of female progeny.

Both at the TH_2 and TH_3 combinations, the heavier larvae (b_0) produced significantly higher number of female progenies as compared to the b_1 level. It is thus observed that at all the three TH levels, minimum number of females were produced by lighter larvae (b_1). The production of significantly higher number of female progeny from heavier hosts is explicable on the basis of better nutritional status of such larvae and the variations in the nutritional requirements of the parasite larvae belonging to the two sexes. It is thus possible that more number of females develop on large hosts than in lighter hosts which is in consonance with the report by Chewyreuv (1913) that the great majority of individuals of Pimpla from large hosts were females whereas those from small hosts were predominantly males. This finding also agrees with Clausen (1939) and Flanders (1939) who have reported that in the parasitic Hymenoptera generally large hosts favour the production of female parasites, while the smaller hosts tend to favour the production of males. But Fusco and Hower (1973) stated that size of the host Lymantria dispar had no significant effect on the mean percentage of females produced by the parasite Microctonus aethiops in the laboratory. Brunson (1937) found that the female parasite Tiphia popilliavora had the ability to control sex of progeny at the time of

oviposition and that the stimulus to which the female responds in controlling sex of the progeny is definitely associated with the size of the host on which eggs are placed.

In addition to the nutritional factor, the modification of ovipositional stimulus also might be responsible for variations in female progeny production under the influence of host weight. The modification of the ovipositional stimulus may be brought about through the stimulus perceived either by the antennae or by the ovipositor from the host, leading to a change in the ratio of fertilised and unfertilised eggs incited by changes in the activity of the spermatheeal gland (Narayanan and Chaudhuri, 1955).

The chi-square due to heterogenity for the weight of host larvae was found to be significant indicating that the responses due to this factor (B) vary with TH combinations. At the b_0 level, (heavier host larvae with a weight range of 30 to 35 mg) and b_2 level (heavier and lighter larvae in equal proportions), significantly higher number of females were produced at the TH_3 level (32°C and 50% RH) while at the b_1 level (lighter larvae) the TH_2 condition produced maximum number of female progeny. There is thus an increasing

trend of female progeny production with increasing temperature and decreasing humidity levels both at b_0 and b_2 levels.

Influence of sex-ratio of parent parasite population(C) on female progeny production of *S. brevicornis*

At 20°C and 75% RH, with 2 females : 1 male ratio (c_1) among the parent parasite population, significantly higher number of female progenies were produced than those obtained with 1 female: 1 male (c_0) and 1 female : 3 males (c_4).

At TH_2 (30°C and 60% RH) and TH_3 (32°C and 50% RH) combinations, maximum number of females were produced when the sex-ratio of parental population was kept at 2 females: 1 male (c_1). The superiority of the parental sex-ratio of c_1 (2:1), in improving the fecundity at all the TH levels and in enhancing the progeny production at the TH_2 and TH_3 levels has been already established in the present studies. It is now revealed that the same parental sex-ratio is consistently superior at all the TH levels in the production of female progeny also. The female progeny production in successive generations being of vital importance in the maintenance of laboratory cultures at high population

levels, the present finding is considered to be of practical importance. The results reported by Mathew and Nair (1977) that the female-male ratios of 1:3, 2:1, 1:6, 3:1 and 1:4 in the parental populations improved the percentage of female progeny in the offspring, indicated that particular proportions of both sexes are more important than dominance of males or females. The present studies show that dominance of females is definitely essential for ensuring better female progeny production. The influence of female dominance on female progeny production is perhaps due to the necessity of female dominance in the parental population for effective fertilisation. More number of females might also be required to compensate for the sterility among the females.

The heterogenity chi-square for the sex-ratio of parent parasite population (C) was significant indicating differential responses of this factor over three RH levels. At all levels of parental sex-ratios, the female prog ny production showed significant increase at the RH_3 combination of 32°C and 50% RH as compared to the other combinations. This may be due to the selective adverse effect of high temperature

low humidity condition on male offsprings during the embryonic or post-embryonic development. Similar selective susceptibility of the haploid males of Habrobracon juglandis to environmental adversities has been reported by Georgiana (1949). Pilon, (1966) also recorded that the influence of temperature varied with relative humidity in the case of males of Neodiprion swainei but not in the case of females. Kochetrova (1978) had also indicated the possibility of unequal mortality of sexes in the ontogeny of entomophagous insects due to endogenous and exogenous factors.

FEMALE-MALE COMPOSITION OF THE F_1 PROGENY

Data on the mean number of females and males recorded at the three TH levels under various treatments are furnished in Table 5-a. The female-male composition of the F_1 progeny under different levels of the main factors at the three TH combinations are presented in Tables 5-b, 5-c and 5-d and these are graphically illustrated in Fig. 5A, 5B and 5C.

Influence of host larval density (A) on female-male composition of the F_1 progeny

The host larval density (A) had no significant influence on the female-male composition of the F_1

offsprings of B. brevicornis at TH_1 and TH_2 levels. But at the TH_3 level, sex-ratio of the F_1 progeny was significantly influenced by the host larval density. Highest percentage of females were obtained when two host larvae per female parasite (a_1) were offered for parasitisation. The sex-ratio of the F_1 progeny recorded at the a_1 level was significantly better than those recorded at the a_2 level of three host larvae per female parasite. The female-male composition of the progeny is largely influenced by the proportion of diploid eggs by the inseminated females and also by the selective mortality of the sexes during embryonic and post-embryonic development. The host larval density factor might be of importance as ovipositional sites for the parasite and also in modifying the ovipositional stimulus. It is seen that at TH_1 and TH_2 levels the increase or decrease in larval density does not cause changes in the proportion of male and female producing eggs. In this studies, it was already found that at the TH_1 and TH_2 levels, larval density affected the female progeny production. The apparent anomally relating to the importance of host density in deciding the number of female progenies on the one hand and the non-significance of the host density factor as a mechanism regulating female-male composition

of the progeny on the other hand can be resolved on the basis of possible concomitant variations in male progeny production leading to the restoration of female-male proportion in such situations. The influence of host larval density on the sex-wise composition of the F_1 progeny at the TH_3 level is perhaps due to the effect of the level of temperature and humidity in modifying the stimulus of depositing haploid and diploid eggs. This is substantiated by the finding of Abraham and Mathew (1978) that host larval density is relatively important among other factors, in the regulation of sex-ratio of the offsprings.

Influence of weight of host larvae (B) on female-male composition of F_1 progeny

At the TH_1 and TH_3 levels, the sex-ratio of the F_1 progeny was significantly influenced by the weight of host larvae. The highest percentage of females was recorded under the b_2 level (mixture of heavier and lighter larvae in equal proportions) at the TH_1 combination. The sex-ratio registered at the b_2 level was significantly better than those recorded at the b_1 level (lighter larvae). At the TH_3 combination, heavier host larvae (b_0) has recorded a significantly better sex-ratio than those recorded at the b_1 and b_2 levels. However, at the TH_2

level the host weight was found not to have any significant effect on the sex-ratio.

In the present studies, the relative superiority of the heavier host larvae (b_0) in the realisation of egg production potential and female progeny production under T_{H_3} level (32°C and 50% RH) has been already established. It is also revealed that the heavier host larvae are relatively better for a favourable female-male composition of the F_1 offsprings characterised by the dominance of females. These results indicate that for successful laboratory rearing of the parasite, relatively heavier larvae (weight range 30 to 35 mg) are to be preferred under ambient conditions characterised by relatively high temperature (32°C) and low humidity (50% RH). The influence of host weight on female progeny production in *B. brevicornis* might be either due to differences in the nutritional status of larvae of different weights or the variations in the nutritional requirements of males and females. This influence may also be due to the sex of the host larvae as reported by Sithanantham and Subramanian (1977) in the case of *Chilo partellus* and *Stenobracon deesae*. The sex-ratios of *S. deesae* was in favour of males in male hosts while it shifted significantly in favour of females in the

female hosts. In B. brevicornis it is possible that the relatively heavier larvae (b_0) are the females and the lighter ones are males. The better production of female progeny from heavier hosts might then be the influence of host sex possibly manifested in the form of selective mortality of the opposite sex due to some antagonistic hormonal influence. It is further revealed that when the changes in ambient temperature and humidity conditions are varied the preferred level of the host weight also changes. Thus it is observed that at Th_1 combination, an admixture of heavier and lighter larvae in equal proportions (b_2) is to be preferred for the production of a higher proportion of females among the offsprings. The influence of the heavier host larvae on fecundity, female progeny production and the female-male composition of the progeny is found to be inconsistent perhaps due to the changes in the ovipositional stimulus provided by the hosts at different temperature and humidity conditions.

Influence of sex-ratio of the parent parasite population (J) on female-male composition of F_1 progeny.

The female-male composition of the F_1 progeny in the form of proportion of females of B. brevicornis was found to be significantly influenced by the sex-ratio

of the parent parasite population at the TH_2 and TH_3 combinations. The e_4 level (1 female: 3 males) has produced a significantly better proportion of females than those recorded at the levels e_2 (3:1) and e_0 (1:1) under the TH_2 combination. At the TH_3 level also the e_4 level has produced a significantly better proportion of females than under the levels e_3, e_2 and e_1. It has been already established that a dominance of females in the parental population (e_1/e_2) is superior for better egg production, improved progeny production and for the production of more number of female offsprings. It is now found that for ensuring a high proportion of females among the progeny at the TH_2 and TH_3 conditions, the dominance of males (e_4 = 1:3) is essential. This is in general agreement with the finding reported by Mathew and Nair (1977) that particular sex-ratios among the parents ensured satisfactory sex-ratios among the progenies including the one characterised by male dominance. In the present studies, dominance of females was found essential for better fecundity, progeny production and number of female progeny production but the dominance of females is not found critical in deciding the proportion of females among the progeny.

An overall consideration from the point of view of improved fecundity, progeny production and number of

female offsprings is essential for deciding the desirability of a particular sex-ratio among the parental population. The e_1 and e_2 levels characterised by the dominance of females were found superior in the above context, and since the influence of e_4 level characterised by dominance of males cannot be rated as desirable considering the inconsistencies in its regulating influence on other biological attributes such as fecundity, progeny production and female progeny production. Further, the higher number of female progeny production is to be preferred to the higher proportion of females. It is possible that with a few females among a limited progeny, the proportion may appear as quite high, but, this will not be much practical utility.

DURATION OF DEVELOPMENT

The duration of development was found out by calculating the weighted means of the number of days taken by both sexes of B. brevicornis emerging on successive days. For this the emerging parasites were isolated, killed and the female-male composition in relation to the duration of development recorded on each day.

Data on the mean duration of development of the parasites under different treatments at the three TH combinations are furnished in Table 2-a. The results of the analysis of variance are given in Table 2-b and the mean values of the duration of development under the treatment combinations are presented in Table 2-c, 2-d and 2-e. These are illustrated in Fig. 2A, 2B and 2C.

Influence of host larval density (A)

The host larval density had significant influence on the duration of development of the parasites at all the three TH combinations. It was observed that the shortest duration of development was revealed by the a_2 level (3 host larvae per female parasite) at the TH_1 condition. When only one host larva was offered per female parasite (a_0), the duration of development was relatively longer. The above trend in shortening of the duration of development with increase in host density level was also detected for the TH_3 level. Metcalfe and Breniere (1969) in Trichogramma spp. had reported that a high level of parasitism was rapidly attained under high host density levels due to shortening of the life-cycle.

However, at the TH_3 combination, the shortest duration of development was registered at low host density level of one host larva and this was significantly better than the duration for the a_1 level (2 host larvae). The variations in the duration of development at different host larval density levels might be due to the amount of food materials that would be provided by the larvae. Thus shortening of the duration of development at high densities will be possible due to normal development under adequate nourishment. The shortening of duration of development at TH_3 under low density level is perhaps due to the modification of the nutritional requirements under influence of high temperature-low relative humidity levels.

Influence of weight of host larvae (B) on duration of development of B. brevicornis

At the TH_1 and TH_2 combinations, the duration of development was not influenced by the host larval weight (B). But weight of host larvae exerted significant influence at the TH_3 combination. It was observed that the parasites emerging from the lighter larvae (b_1) had a significantly shorter duration of development. The nutritional status

of lighter larvae will be relatively lower and under such condition, the parasitic larvae might be constrained to complete the life cycle faster as an adaptive mechanism. The duration of development of the parasite at the levels b_0, b_2 were not significantly different.

Influence of sex-ratio of the parent parasite population (♀) on the duration of development of *B. brevicornis*

At the TH_1 combination the shortest duration of development was noticed when the sex-ratio of the parent parasite population was kept at c_2 (3 females: 1 male) while at c_3 level (1 female: 2 males), duration of development was the longest. The c_3 level (1:2) has indicated the shortest duration of development at the TH_2 combination. At the TH_3 combination the shortest duration of development was recorded by the c_1 (2:1) and c_2 (3:1) levels and the c_3 level (1:2) has registered the longest duration of development at TH_1 and TH_3 combinations.

The divergent trends in the duration of development at different parent sex-ratio levels at various TH conditions is probably due to the proportion of diploid and haploid eggs laid by parasite females and due to

inherent variations in the speed of development of both sexes. This may ultimately be reflected by causing variations in the duration of development of the parasite.

Overall considerations

The nature of influence of the density and weight of host larvae of Corcyra cephalonica and the sex-ratio of the parent parasite population of Bracon brevicornis on the fecundity, progeny production and the female-male composition of the F_1 parasite offsprings at 28°C-75% RH, 30°C-60% RH and 32°C-50% RH is found to be varying in most of the cases, obviously due to the differential effect of these abiotic components on host parasite interaction.

The implications of the trend in fecundity, progeny production, female-male composition of the progeny and the number of female progeny as regulated by the density and weight of host larvae and the sex-ratio of the parent parasite population under diverse temperature-humidity conditions have been discussed.

Among the different host larval density levels tested, the density of two to three larvae per female

parasite is found to be relatively more effective in attaining higher egg production and improved progeny production.

The studies conclusively proved that among host larvae of the same age, lighter larvae were consistently inferior to the heavier ones with regard to the fecundity, progeny production and number of female progeny.

The desirability of maintaining the parental sex-ratio levels at 2:1 and 3:1 (female: male) for ensuring improved fecundity, progeny production and higher number of female offsprings at the different SR levels is brought out in the present studies.

The identification of temperature-humidity levels suitable for the realisation of the innate capacity for numerical increase as revealed by the biological attributes such as parasite fecundity, progeny production and female-male composition of the F_1 progeny leads to the possibility of manipulating the ambient temperature-humidity conditions in insectaries for the maintenance of laboratory cultures of *B. brevicornis* at the maximum possible levels.

SUMMARY

SUMMARY

The fecundity, progeny production, female-male composition of the progeny and duration of development of Bracon brevicornis Wesmael as influenced by the density and size (weight) of host larvae of Corcyra cephalonica Stainton and the sex-ratio of the parent parasite population were studied at three temperature-humidity (TH) combinations viz., 28°C and 75% RH (TH_1), 30°C and 60% RH (TH_2) and 32°C and 50% RH (TH_3).

FECUNDITY OF B. BREVICORNIS

The host larval density, weight of host larvae and the sex-ratio of the parent parasite population were found to influence the fecundity of the parasite at all the TH levels. The maximum fecundity was registered consistently at all the three TH levels and a host density level of two larvae per female parasite.

The exclusive use of light weight larvae (weight range 8 to 10 mg) as hosts for the parasite produced significantly less number of eggs at all the three tempe-rature-humidity conditions. At the TH_1 and TH_2 levels an admixture of heavier and lighter larvae in equal proportions gave more number of eggs while at the TH_3 level, egg

production was maximum when the heavier host larvae (weight range 30 to 35 mg) were used.

The parental sex-ratio levels of 2:1 and 3:1 (female:male) characterised by the dominance of females led to the production of higher number of eggs than under the sex-ratio levels of 1:1, 1:2 and 1:3.

PROGENY PRODUCTION OF B. BREVICORNIS

The host larval density, weight of host larvae and sex-ratio of parent parasite population were found to exert significant influence on the number of progeny of B. brevicornis. The maximum progeny production at the TH_1 (28°C and 75% RH) and TH_2 (30°C and 60% RH) levels was attained under a host density level of two larvae per female parasite. However, at the TH_3 level (32°C and 50% RH) the progeny production was maximum at the larval density level of three hosts per female parasite.

With regard to the weight of host larvae, it was found that the progeny production was higher at TH_1 and TH_2 levels when heavier larvae were exposed for parasitisation. Under the TH_3 level, the heavier larvae or an admixture of heavier and lighter larvae, were found to be equally effective in the production of higher number of progenies.

The superiority of the parental sex-ratio of 2:1 (female:male) in the production of higher number of progeny was established at the TH_2 and TH_3 levels, while the parental sex-ratio of 1:3 with a preponderance of males was found to be distinctly inferior to the other levels.

NUMBER OF FEMALE PROGENY OF B. BREVICORNIS

Significant influence of the host larval density was detected only at the TH_1 and TH_2 levels. At 30°C and 60% RH (TH_2), higher number of female progeny was produced at a host larval density level of two per female parasite, while at 28°C and 75% RH (TH_1) the female progeny production was higher at a host density level of one larva per female parasite.

Relatively heavier host larvae produced significantly higher number of female offsprings at the TH_2 and TH_3 combinations.

The parental sex-ratio level of 2:1 (female:male) produced maximum number of female progeny at all the tested temperature-humidity combinations.

FEMALE-MALE COMPOSITION OF THE F_1 PROGENY OF B. BREVICORNIS

The influence of host larval density was pronounced only at the TH_3 level (32°C and 50% RH) and under this

condition, a host density of two larvae per female parasite was found to be better with reference to the production of a higher proportion of females among the offsprings.

The highest percentage of females among the progeny was registered at TH_1, in treatments comprising heavier and lighter larvae in equal proportions, while at the TH_3 level, the heavier host larvae recorded a higher proportion of females.

The sex-ratio of the parent parasite population influenced the proportion of females in the F_1 progeny and a ratio of 1:3 (female:male) produced significantly higher proportion of females at the TH_2 and TH_3 combinations.

DURATION OF DEVELOPMENT OF B. BREVICORNIS

The host larval density, weight of host larvae and the sex-ratio of the parent parasite population exerted significant influence on the duration of development of the parasite at various temperature-humidity conditions.

OVERALL CONSIDERATIONS

The nature of influence of the density and weight of host larvae of Corcyra cephalonica and the sex-ratio of the parent parasite population of Bracon brevicornis

of the fecundity, progeny production and the female-male composition of the F_1 parasite offsprings at 28°C - 75% RH, 30°C-60% RH and 32°C-50% RH is found to be varying in most of the cases, obviously due to the differential effect of these abiotic components on host-parasite interaction.

Among the different host larval density levels, the density of two to three larvae per female parasite is found to be relatively more effective in attaining higher egg production and improved progeny production.

The studies conclusively proved that among host larvae of the same age, lighter larvae were consistently inferior to the heavier ones in the realisation of fecundity and progeny production potentials and also with reference to the production of female progeny.

The desirability of maintaining the parental sex-ratio levels at 2:1 and 3:1 (female:male) for ensuring consistency in improved fecundity, better progeny production and higher number of female offsprings at the different RH levels is brought out in the present studies.

The feasibility of manipulating the ambient temperature-humidity conditions for maintaining laboratory cultures of *H. brevicornis* at the maximum possible levels has been discussed.

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APPENDIX - I

Fecundity of B. brevicornis at different temperature and humidity combinations

Sl. No.	Treatments	28°C and 75% RH			30°C and 60% RH			32°C and 50% RH		
		RI	RII	RIII	RI	RII	RIII	RI	RII	RIII
1.	$a_0 b_0 c_0$*	80	44	58	30	36	22	60	32	92
2.	$a_0 b_0 c_1$	49	48	40	78	36	38	75	95	160
3.	$a_0 b_0 c_2$	41	15	40	98	35	8	125	120	122
4.	$a_0 b_0 c_3$	72	52	41	56	88	99	22	44	83
5.	$a_0 b_0 c_4$	15	2	21	35	20	32	53	58	65
6.	$a_0 b_1 c_0$	4	14	2	13	48	42	35	42	5
7.	$a_0 b_1 c_1$	16	27	25	60	45	70	25	22	27
8.	$a_0 b_1 c_2$	85	50	100	45	70	75	13	40	9
9.	$a_0 b_1 c_3$	82	40	35	20	5	17	50	8	18
10.	$a_0 b_1 c_4$	50	52	57	20	40	58	15	24	10
11.	$a_0 b_2 c_0$	80	53	40	80	22	48	65	79	90
12.	$a_0 b_2 c_1$	50	60	52	75	60	85	92	53	95
13.	$a_0 b_2 c_2$	95	100	85	35	40	140	79	11	93
14.	$a_0 b_2 c_3$	73	55	64	48	46	45	40	15	50
15.	$a_0 b_2 c_4$	100	108	38	20	38	18	40	42	49
16.	$a_1 b_0 c_0$	85	100	80	35	55	25	77	80	45
17.	$a_1 b_0 c_1$	45	4	150	97	82	62	140	120	94
18.	$a_1 b_0 c_2$	108	115	65	35	28	100	101	107	150
19.	$a_1 b_0 c_3$	45	30	60	65	15	133	78	95	90
20.	$a_1 b_0 c_4$	40	56	58	50	8	10	103	50	73
21.	$a_1 b_1 c_0$	70	25	113	35	20	50	34	20	28
22.	$a_1 b_1 c_1$	85	110	70	50	65	70	35	25	40
23.	$a_1 b_1 c_2$	49	20	50	60	20	50	40	32	42
24.	$a_1 b_1 c_3$	35	60	40	15	20	55	42	48	50
25.	$a_1 b_1 c_4$	30	48	32	35	28	55	35	38	34
26.	$a_1 b_2 c_0$	73	54	78	95	90	160	67	85	75
27.	$a_1 b_2 c_1$	55	68	103	90	75	70	75	115	125
28.	$a_1 b_2 c_2$	95	45	182	70	140	85	40	28	95
29.	$a_1 b_2 c_3$	38	21	25	45	40	80	24	35	43
30.	$a_1 b_2 c_4$	15	55	59	45	15	30	75	115	125
31.	$a_2 b_0 c_0$	38	3	58	68	75	130	44	50	85
32.	$a_2 b_0 c_1$	35	48	80	97	60	100	63	55	142
33.	$a_2 b_0 c_2$	90	50	58	95	30	45	80	125	133
34.	$a_2 b_0 c_3$	12	44	20	15	18	30	60	30	86
35.	$a_2 b_0 c_4$	44	45	10	55	72	5	64	24	19
36.	$a_2 b_1 c_0$	18	27	17	75	55	56	30	35	27
37.	$a_2 b_1 c_1$	48	105	80	15	45	50	26	30	59
38.	$a_2 b_1 c_2$	24	59	53	36	70	55	54	20	85
39.	$a_2 b_1 c_3$	24	16	43	90	42	18	8	18	25
40.	$a_2 b_1 c_4$	13	40	45	20	14	12	30	33	36
41.	$a_2 b_2 c_0$	42	90	60	20	24	25	50	70	92
42.	$a_2 b_2 c_1$	30	250	182	42	35	34	80	52	75
43.	$a_2 b_2 c_2$	3	68	28	8	28	74	50	160	61
44.	$a_2 b_2 c_3$	40	38	57	25	68	22	47	44	115
45.	$a_2 b_2 c_4$	43	35	15	30	49	18	20	45	18

*a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

c_0 - sex ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " - 2:1 (")
c_2 - " " " " - 3:1 (")
c_3 - " " " " - 1:2 (")
c_4 - " " " " - 1:3 (")

APPENDIX - II

Duration of development of B. brevicornis at different temperature and humidity combinations

Sl. No.	Treatments	28°C and 75% RH			30°C and 60% RH			32°C and 50% RH		
		RI	RII	RIII	RI	RII	RIII	RI	RII	RIII
1.	$a_0 b_0 c_0$*	9.6	9.0	9.5	9.7	10.2	9.7	9.4	8.4	8.6
2.	$a_0 b_0 c_1$	12.0	11.6	11.6	8.7	8.8	8.4	8.5	8.7	9.0
3.	$a_0 b_0 c_2$	11.5	11.4	9.0	11.0	9.7	9.0	9.6	9.3	10.1
4.	$a_0 b_0 c_3$	9.8	9.5	9.1	8.6	8.8	8.5	8.6	8.5	8.5
5.	$a_0 b_0 c_4$	12.7	10.0	9.6	8.0	8.0	9.0	9.5	9.5	8.8
6.	$a_0 b_1 c_0$	10.0	10.1	10.0	11.6	12.8	9.8	8.1	8.1	8.0
7.	$a_0 b_1 c_1$	9.0	9.0	9.0	9.9	9.7	9.2	8.0	8.0	8.0
8.	$a_0 b_1 c_2$	10.1	10.7	9.6	8.4	8.5	9.0	8.0	8.0	8.0
9.	$a_0 b_1 c_3$	10.0	11.0	10.1	8.0	8.0	8.0	9.0	8.0	8.3
10.	$a_0 b_1 c_4$	10.0	10.1	10.3	9.5	9.4	10.3	8.0	8.0	8.0
11.	$a_0 b_2 c_0$	10.3	9.9	9.0	8.5	9.3	8.6	8.0	8.0	8.0
12.	$a_0 b_2 c_1$	10.7	10.7	10.1	9.0	9.0	9.1	8.6	8.3	8.0
13.	$a_0 b_2 c_2$	10.0	9.9	10.0	9.0	8.4	8.6	8.4	8.0	8.5
14.	$a_0 b_2 c_3$	10.0	9.5	9.8	8.3	8.3	8.8	8.0	8.0	8.0
15.	$a_0 b_2 c_4$	9.6	9.8	9.7	9.0	9.0	9.4	8.4	8.7	8.0
16.	$a_1 b_0 c_0$	9.9	9.8	9.9	9.3	9.1	12.9	9.3	9.8	9.6
17.	$a_1 b_0 c_1$	10.0	10.0	10.1	8.9	9.0	9.0	8.8	9.0	8.7
18.	$a_1 b_0 c_2$	10.0	10.0	10.0	9.1	8.1	8.6	8.6	9.0	8.5
19.	$a_1 b_0 c_3$	9.4	10.3	10.2	8.5	9.3	8.3	8.3	9.0	8.1
20.	$a_1 b_0 c_4$	10.0	10.3	10.0	9.3	9.0	9.0	8.5	10.2	9.0
21.	$a_1 b_1 c_0$	9.8	9.0	9.8	8.4	8.4	8.6	8.8	9.7	8.9
22.	$a_1 b_1 c_1$	9.6	9.5	10.0	8.5	8.9	8.7	7.9	8.4	8.3
23.	$a_1 b_1 c_2$	8.4	8.7	8.3	8.0	8.3	8.0	8.1	8.0	8.2
24.	$a_1 b_1 c_3$	9.4	9.6	10.0	8.0	8.0	9.1	8.2	7.8	7.8
25.	$a_1 b_1 c_4$	9.5	9.6	9.9	8.6	9.0	8.7	9.0	8.0	8.4
26.	$a_1 b_2 c_0$	10.0	9.9	10.0	9.6	8.7	9.0	8.2	8.6	8.3
27.	$a_1 b_2 c_1$	9.3	9.2	10.2	8.5	8.7	8.8	8.3	8.8	8.1
28.	$a_1 b_2 c_2$	8.5	9.9	9.6	8.0	8.0	8.0	8.4	8.4	8.3
29.	$a_1 b_2 c_3$	9.9	10.0	11.5	8.0	8.0	8.0	10.6	8.8	9.3
30.	$a_1 b_2 c_4$	9.5	10.9	10.0	9.8	9.2	9.7	9.8	9.3	10.0
31.	$a_2 b_0 c_0$	9.5	9.0	11.2	9.2	9.1	8.9	8.2	8.5	8.9
32.	$a_2 b_0 c_1$	9.3	9.1	8.0	8.0	8.0	8.0	8.2	8.1	8.2
33.	$a_2 b_0 c_2$	9.1	10.0	8.5	8.5	8.0	8.0	8.2	8.3	7.9
34.	$a_2 b_0 c_3$	11.0	10.0	10.2	9.0	9.1	8.8	8.4	8.1	8.2
35.	$a_2 b_0 c_4$	10.4	9.0	10.0	8.9	8.0	8.0	8.3	8.0	8.7
36.	$a_2 b_1 c_0$	9.5	9.1	9.7	8.5	8.5	8.7	8.0	8.5	8.4
37.	$a_2 b_1 c_1$	9.2	8.7	9.3	8.3	8.3	8.3	8.0	8.5	8.0
38.	$a_2 b_1 c_2$	9.0	9.0	9.0	8.2	8.3	8.6	8.0	8.0	8.2
39.	$a_2 b_1 c_3$	9.5	14.0	9.6	8.5	8.2	8.3	8.3	9.8	8.4
40.	$a_2 b_1 c_4$	9.6	9.6	9.8	8.6	8.6	8.8	8.3	8.5	8.0
41.	$a_2 b_2 c_0$	9.3	9.9	9.3	8.4	8.4	8.4	8.6	8.3	8.4
42.	$a_2 b_2 c_1$	9.3	9.7	9.8	8.7	8.6	8.4	8.4	8.4	9.0
43.	$a_2 b_2 c_2$	9.0	10.0	9.3	9.0	8.9	8.9	8.3	8.6	8.6
44.	$a_2 b_2 c_3$	10.0	10.0	9.6	8.4	8.0	8.5	10.0	9.0	10.0
45.	$a_2 b_2 c_4$	9.2	9.0	10.0	8.2	8.6	8.4	11.0	9.1	9.8

*a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the larvae of the 'b_0' type and the other half of the 'b_1' type

c_0 - sex ratio of parent population - 1 Female : 1 Male
c_1 - " " " - 2 Female : 1 Male
c_2 - " " " - 3 Female : 1 Male
c_3 - " " " - 1 Female : 2 Males
c_4 - " " " - 1 Female : 3 Males

APPENDIX - III

Progeny production of *E. brevicornis* at different temperature and humidity combinations

Sl. No.	Treatments	28°C and 75% RH			30°C and 60% RH			32°C and 50% RH		
		RI	RII	RIII	RI	RII	RIII	RI	RII	RIII
1.	$a_0 b_0 c_0$*	19	22	13	22	20	16	29	15	22
2.	$a_0 b_0 c_1$	11	26	3	29	11	20	24	36	34
3.	$a_0 b_0 c_2$	3	9	3	7	2	2	13	3	21
4.	$a_0 b_0 c_3$	36	31	13	15	55	34	9	19	22
5.	$a_0 b_0 c_4$	9	2	12	26	9	5	4	7	25
6.	$a_0 b_1 c_0$	4	8	2	13	5	11	21	15	2
7.	$a_0 b_1 c_1$	2	2	2	27	8	20	6	7	3
8.	$a_0 b_1 c_2$	17	6	7	16	37	13	9	6	10
9.	$a_0 b_1 c_3$	15	3	11	3	4	5	11	3	3
10.	$a_0 b_1 c_4$	8	10	4	4	5	12	7	2	4
11.	$a_0 b_2 c_0$	4	14	2	8	2	14	41	17	47
12.	$a_0 b_2 c_1$	19	9	37	3	4	12	19	29	49
13.	$a_0 b_2 c_2$	7	21	2	6	5	23	45	3	37
14.	$a_0 b_2 c_3$	11	13	19	2	4	12	24	13	27
15.	$a_0 b_2 c_4$	11	12	11	3	14	7	5	31	4
16.	$a_1 b_0 c_0$	18	19	17	12	13	24	69	24	25
17.	$a_1 b_0 c_1$	12	3	18	17	23	26	32	79	82
18.	$a_1 b_0 c_2$	4	18	19	7	10	18	24	26	8
19.	$a_1 b_0 c_3$	5	6	10	7	4	12	8	3	15
20.	$a_1 b_0 c_4$	3	4	18	30	3	34	16	7	6
21.	$a_1 b_1 c_0$	24	7	20	9	9	23	10	3	9
22.	$a_1 b_1 c_1$	21	20	10	15	25	21	7	5	23
23.	$a_1 b_1 c_2$	15	9	20	7	3	4	4	10	5
24.	$a_1 b_1 c_3$	5	19	18	12	13	10	10	5	18
25.	$a_1 b_1 c_4$	4	10	9	9	9	6	31	8	7
26.	$a_1 b_2 c_0$	11	16	5	39	32	30	18	19	11
27.	$a_1 b_2 c_1$	7	5	11	17	26	19	30	34	24
28.	$a_1 b_2 c_2$	6	9	30	5	15	23	7	5	15
29.	$a_1 b_2 c_3$	17	12	2	15	7	20	9	25	22
30.	$a_1 b_2 c_4$	5	6	27	11	5	14	2	25	13
31.	$a_2 b_0 c_0$	8	2	25	10	18	24	22	24	48
32.	$a_2 b_0 c_1$	9	7	5	26	56	10	10	18	33
33.	$a_2 b_0 c_2$	32	2	2	19	17	2	12	20	42
34.	$a_2 b_0 c_3$	7	22	11	7	6	13	36	24	48
35.	$a_2 b_0 c_4$	22	5	2	15	2	2	14	10	3
36.	$a_2 b_1 c_0$	5	3	3	24	22	41	16	12	20
37.	$a_2 b_1 c_1$	15	7	14	4	11	13	8	4	6
38.	$a_2 b_1 c_2$	6	19	11	12	10	14	3	7	13
39.	$a_2 b_1 c_3$	10	3	16	13	9	6	6	5	12
40.	$a_2 b_1 c_4$	8	10	12	9	8	7	8	13	21
41.	$a_2 b_2 c_0$	2	15	8	12	15	14	38	38	46
42.	$a_2 b_2 c_1$	6	18	18	20	17	21	47	24	38
43.	$a_2 b_2 c_2$	2	6	9	3	9	33	20	68	29
44.	$a_2 b_2 c_3$	7	2	5	10	7	10	34	9	35
45.	$a_2 b_2 c_4$	6	3	6	24	25	8	13	33	8

*a_0 - 1 host larva per female parasite
a_1 - 2 host larvae per female parasite
a_2 - 3 host larvae per femalepparasite

b_0 - larval weight 30-35 mg
b_1 - " " 8-10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

c_0 - Sex ratio of parent population - 1:1 (Female : Male)
c_1 - " " " - 2:1 (")
c_2 - " " " - 3:1 (")
c_3 - " " " - 1:2 (")
c_4 - " " " - 1:3 (")

APPENDIX - IV

Number of female progeny of *B. brevicornis* produced at different temperature and humidity combinations

Sl. No.	Treatments	28°C and 75% RH			30°C and 60% RH			32°C and 50% RH		
		RI	RII	RIII	RI	RII	RIII	RI	RII	RIII
1.	$a_0b_0c_0$*	9	8	2	11	10	1	16	12	17
2.	$a_0b_0c_1$	3	17	1	6	3	15	14	10	27
3.	$a_0b_0c_2$	2	4	1	3	1	1	6	1	2
4.	$a_0b_0c_3$	21	9	6	5	36	3	4	13	13
5.	$a_0b_0c_4$	3	1	4	12	3	1	1	5	12
6.	$a_0b_1c_0$	2	5	1	3	4	1	10	11	1
7.	$a_0b_1c_1$	1	1	1	17	5	5	5	5	2
8.	$a_0b_1c_2$	3	5	4	10	7	11	2	3	4
9.	$a_0b_1c_3$	4	1	8	2	3	4	7	1	2
10.	$a_0b_1c_4$	3	5	2	1	4	2	3	1	2
11.	$a_0b_2c_0$	3	5	1	4	1	7	18	11	25
12.	$a_0b_2c_1$	14	2	26	1	1	5	7	13	1
13.	$a_0b_2c_2$	6	15	1	5	2	5	24	1	28
14.	$a_0b_2c_3$	5	4	10	1	2	7	17	2	7
15.	$a_0b_2c_4$	8	7	9	2	2	4	4	22	1
16.	$a_1b_0c_0$	3	10	10	7	10	11	52	13	15
17.	$a_1b_0c_1$	5	1	11	1	14	12	26	51	43
18.	$a_1b_0c_2$	2	14	8	2	1	6	13	12	3
19.	$a_1b_0c_3$	3	3	5	1	3	3	3	1	13
20.	$a_1b_0c_4$	2	2	5	22	2	2	8	6	1
21.	$a_1b_1c_0$	15	2	5	2	4	14	1	1	4
22.	$a_1b_1c_1$	11	7	7	9	13	14	4	2	11
23.	$a_1b_1c_2$	6	3	6	1	2	4	2	4	1
24.	$a_1b_1c_3$	2	4	3	5	5	2	66	3	7
25.	$a_1b_1c_4$	8	8	7	7	10	1	10	6	3
26.	$a_1b_2c_0$	1	3	1	7	6	14	4	15	2
27.	$a_1b_2c_1$	2	7	5	10	6	10	13	17	13
28.	$a_1b_2c_2$	10	2	9	4	3	17	2	1	7
29.	$a_1b_2c_3$	3	5	1	7	4	15	3	11	7
30.	$a_1b_2c_4$	7	1	12	1	4	10	1	16	8
31.	$a_2b_0c_0$	1	3	4	4	8	12	14	4	21
32.	$a_2b_0c_1$	11	1	1	4	36	1	4	1	15
33.	$a_2b_0c_2$	4	1	6	1	11	1	2	7	6
34.	$a_2b_0c_3$	9	12	1	4	2	12	16	10	22
35.	$a_2b_0c_4$	2	5	2	7	1	1	12	5	1
36.	$a_2b_1c_0$	4	9	9	2	11	16	4	5	7
37.	$a_2b_1c_1$	5	1	5	3	9	4	5	2	4
38.	$a_2b_1c_2$	4	5	6	6	1	4	1	4	8
39.	$a_2b_1c_3$	3	9	1	8	1	3	2	2	4
40.	$a_2b_1c_4$	1	1	6	2	2	6	4	9	9
41.	$a_2b_2c_0$	2	5	9	7	3	9	8	25	8
42.	$a_2b_2c_1$	1	3	1	1	4	2	17	6	16
43.	$a_2b_2c_2$	4	1	4	8	2	5	6	37	12
44.	$a_2b_2c_3$	1	1	2	2	2	5	10	2	17
45.	$a_2b_2c_4$	1	1	3	13	12	3	7	24	2

*a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the larvae of the 'b_0' type and the other half of the 'b_1' type

c_0 - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " " 2:1 (" ")
c_2 - " " " " " 3:1 (" ")
c_3 - " " " " " 1:2 (" ")
c_4 - " " " " " 1:3 (" ")

APPENDIX - V

Female-Male composition of *B. brevicornis* at different temperature and humidity combinations

Sl. No.	Treatments	28°C and 75% RH						30°C and 60% RH						32°C and 50% RH					
		RI		RII		RIII		RI		RII		RIII		RI		RII		RIII	
		F*	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
1.	$a_0 b_0 c_0$	9	10	8	14	2	11	11	11	10	10	1	15	16	13	12	33	17	5
2.	$a_0 b_0 c_1$	3	8	17	9	1	2	6	25	3	8	15	5	14	10	10	26	27	7
3.	$a_0 b_0 c_2$	2	1	4	5	1	2	3	4	1	1	1	1	6	7	1	2	2	19
4.	$a_0 b_0 c_3$	21	15	9	22	6	7	5	10	36	19	3	31	4	5	13	6	13	9
5.	$a_0 b_0 c_4$	3	6	1	1	4	8	12	14	3	6	1	4	1	3	5	2	12	11
6.	$a_0 b_1 c_0$	2	2	3	5	1	1	3	10	4	1	1	10	10	11	11	4	1	1
7.	$a_0 b_1 c_1$	1	1	1	1	1	1	17	10	5	3	5	15	5	1	5	2	2	1
8.	$a_0 b_1 c_2$	3	14	5	1	4	3	10	6	7	30	11	2	2	7	3	3	4	6
9.	$a_0 b_1 c_3$	4	11	1	2	8	3	2	1	3	1	4	1	7	4	1	2	2	1
10.	$a_0 b_1 c_4$	3	5	5	5	2	2	1	3	4	1	2	10	3	4	1	1	2	2
11.	$a_0 b_2 c_0$	3	1	5	9	1	1	4	4	1	1	7	7	18	23	11	6	25	22
12.	$a_0 b_2 c_1$	14	5	32	7	26	11	1	2	1	3	5	7	7	12	13	16	1	48
13.	$a_0 b_2 c_2$	6	1	15	6	1	1	5	1	2	3	5	18	24	21	1	2	28	9
14.	$a_0 b_2 c_3$	5	6	4	9	10	9	1	1	2	2	7	5	17	7	2	11	7	20
15.	$a_0 b_2 c_4$	8	3	7	5	9	2	2	1	2	12	4	3	4	1	22	9	1	3
16.	$a_1 b_0 c_0$	3	15	10	9	10	7	7	5	10	3	11	13	52	17	13	11	15	10
17.	$a_1 b_0 c_1$	5	7	1	2	11	7	1	16	14	9	12	14	26	6	51	28	43	39
18.	$a_1 b_0 c_2$	2	2	14	4	8	11	2	5	1	9	6	12	13	11	12	14	3	5
19.	$a_1 b_0 c_3$	3	2	3	3	5	5	1	6	3	1	3	9	3	5	1	2	13	2
20.	$a_1 b_0 c_4$	2	1	2	2	5	13	22	8	2	1	2	2	8	8	6	1	1	5
21.	$a_1 b_1 c_0$	15	9	2	5	5	15	2	7	4	5	14	9	1	9	1	2	4	5
22.	$a_1 b_1 c_1$	11	10	7	13	7	3	9	6	13	12	14	7	4	3	2	3	11	12
23.	$a_1 b_1 c_2$	6	9	3	6	6	14	1	6	2	1	4	0	2	2	4	6	1	4
24.	$a_1 b_1 c_3$	2	3	4	15	3	15	5	7	5	8	2	8	6	4	3	2	7	11
25.	$a_1 b_1 c_4$	3	1	8	2	7	2	6	3	3	6	1	5	10	21	6	2	3	4
26.	$a_1 b_2 c_0$	8	3	6	10	1	4	7	32	10	22	14	16	4	14	15	4	2	9
27.	$a_1 b_2 c_1$	1	6	3	2	5	6	10	7	6	20	10	9	13	17	17	17	13	11
28.	$a_1 b_2 c_2$	2	4	7	2	9	21	4	1	3	12	17	6	2	5	1	4	7	8
29.	$a_1 b_2 c_3$	10	7	2	10	1	1	7	8	4	3	15	5	3	6	11	14	7	15
30.	$a_1 b_2 c_4$	3	2	5	1	12	15	31	10	4	1	10	4	1	1	16	9	8	5
31.	$a_2 b_0 c_0$	7	1	1	1	4	19	4	6	8	10	12	12	14	8	4	20	21	27
32.	$a_2 b_0 c_1$	1	8	3	4	4	1	17	9	36	20	1	9	4	6	1	17	15	18
33.	$a_2 b_0 c_2$	11	21	1	1	1	1	8	11	11	6	1	1	2	10	7	13	6	36
34.	$a_2 b_0 c_3$	4	3	12	10	6	5	4	3	2	4	12	1	16	20	10	14	22	26
35.	$a_2 b_0 c_4$	9	13	3	2	1	1	7	8	1	1	1	1	12	2	5	5	1	2
36.	$a_2 b_1 c_0$	2	3	2	1	2	1	2	22	11	11	16	25	4	12	5	7	7	13
37.	$a_2 b_1 c_1$	4	11	5	2	9	5	3	1	9	2	4	9	5	3	2	2	4	2
38.	$a_2 b_1 c_2$	5	1	9	10	5	6	8	4	1	9	4	10	1	2	4	3	8	5
39.	$a_2 b_1 c_3$	4	6	1	2	6	10	6	7	1	8	3	3	2	4	2	3	4	8
40.	$a_2 b_1 c_4$	3	5	4	6	1	11	8	1	2	6	6	1	4	4	9	4	9	12
41.	$a_2 b_2 c_0$	1	1	9	6	6	2	2	10	3	12	9	5	8	30	25	13	8	38
42.	$a_2 b_2 c_1$	2	4	10	8	9	9	7	13	6	11	2	19	17	30	6	18	16	22
43.	$a_2 b_2 c_2$	1	1	3	3	4	5	1	2	4	5	5	28	6	14	37	31	12	17
44.	$a_2 b_2 c_3$	4	3	1	1	2	3	8	2	2	5	5	5	10	24	2	7	17	18
45.	$a_2 b_2 c_4$	1	5	1	2	3	3	13	11	12	15	3	5	7	6	24	9	2	6

*a_0 - 1 host larva per female parasite
a_1 - 2 " " " "
a_2 - 3 " " " "

b_0 - larval weight 30 - 35 mg
b_1 - " " 8 - 10 mg
b_2 - half of the hosts of the 'b_0' type and the other half of the 'b_1' type

c_0 - sex-ratio of parent parasite population - 1:1 (Female:Male)
c_1 - " " " " 2:1 (")
c_2 - " " " " 3:1 (")
c_3 - " " " " 1:2 (")
c_4 - " " " " 1:3 (")

STUDIES ON THE REGULATION OF PROGENY PRODUCTION AND SEX-RATIO OF *BRACON BREVICORNIS* WESMAEL

(HYMENOPTERA : BRACONIDAE)

By

SOSAMMA JACOB

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirements for the degree of
MASTER OF SCIENCE IN AGRICULTURE
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COLLEGE OF HORTICULTURE
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ABSTRACT

The fecundity, progeny production, female-male composition of the progeny and duration of development of Bracon brevicornis Wesmael as influenced by the density and size (weight) of host larvae of Corcyra cephalonica Stainton and the sex-ratio of the parent parasite population were studied at three temperature-humidity (TH) combinations, viz., 28°C and 75% RH (TH_1), 30°C and 60% RH (TH_2) and 32°C and 50% RH (TH_3).

The maximum fecundity of the parasite was registered consistently at all the three TH levels at a host density level of two larvae per female parasite. The exclusive use of light weight larvae (weight range 8 to 10 mg) as hosts produced significantly less number of eggs at the TH_1 and TH_2 levels, while at the TH_3 level the fecundity was maximum when the heavier host larvae (weight range 30 to 35 mg) were used. The parental sex-ratio levels of 2:1 and 3:1 (female:male) led to the production of higher number of eggs than under the ratios of 1:1, 1:2 and 1:3.

The maximum progeny production in B. brevicornis at the TH_1 and TH_2 levels was attained under a host density level of two larvae per female parasite. The progeny

production was relatively higher at the TH_1 and TH_2 levels when heavier larvae were exposed for parasitisation. The superiority of the parental sex-ratio of 2:1 (female:male) in the production of higher number of progeny was established at the TH_2 and TH_3 conditions.

Significant influence of the host larval density on the female progeny production was detected at the TH_1 and TH_2 levels. The female progeny production was maximum at a host larval density level of two per female parasite at the TH_2 combination, while this was found to be the highest at a density level of one larva per female parasite at the TH_1 level. Relatively heavier host larvae produced significantly higher number of female offsprings at the TH_2 and TH_3 combinations. The parental sex-ratio level of 2:1 (female:male) consistently produced maximum number of female progeny.

The influence of host larval density on the proportion of females was pronounced only at the TH_3 level and a density level of two larvae per female parasite was found to be better with reference to the production of a higher proportion of females. The sex-ratio of the parent parasite population influenced the proportion of females in the F_1 progeny and a ratio of 1:3 (female:male)

produced higher proportion of females at the TH_2 and TH_3 combinations.

The host larval density, weight of host larvae and the sex-ratio of the parent parasite population exerted significant influence on the duration of development of B. brevicornis.

The feasibility of manipulating the ambient temperature-humidity conditions for maintaining laboratory cultures of B. brevicornis at the maximum possible levels has been discussed.