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Trichogramma species parasitisation potential on host insect

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Abstract
Parasitization potential of *T. chilonis* on host insect eggs of *C. cephalonica* It is evident from the overall treatments in the present studies that they were effective in the parasitization of *T. chilonis* at a different rate in comparison to the untreated control. The most effective treatment was with *Corcyra* eggs and Honey 10% (77.20 percent), and lowest percent of egg parasitization was noticed in the untreated control (30.62 percent). *T. chilonis* on nutritional longevity of adult honey 10 percent maximum female longevity of T_4 *Corcyra* eggs + Honey 10% (4.91 days). Male and female parasitoid longevity with *Corcyra* eggs + Honey 10% (3.82 days). Male and female emerged from the *C. cephalonica* eggs; the *Corcyra* eggs plus Honey (10 evident from the overall treatments in the present studies that they were effective in the parasitization of T. chilonis at a different rate in comparison to the untreated control. The most effective treatment was with Corcyra eggs and Honey 10% (77.20 percent), and the lowest percent of egg parasitization was noticed in the untreated control (30.62 percent). *T. chilonis* on nutritional longevity of adult honey 10 percent maximum female longevity of T4 Corcyra eggs + Honey 10% (4.91 days). Male and female parasitoid longevity with corcyra eggs + 10% honey (3.82 days) male and female emerged from the *C. cephalonica* eggs; the corcyra eggs plus Honey (10%) (71.34 percent) were significantly superior. Sex ratio (M: F) of *T. chilonis* emerged the *Trichogramma* was noticed to have a maximum T_4 *Corcyra* eggs + Honey 10% (1:1.81 sex ratio). Now, it is concluded that nutrition is the main factor of life of any organism. Obtained results indicated that *Trichogramma* nutrition type could improve the parasitoid's quality parameters. This improvement varies in different species depending upon their responses to the tested diets. Therefore, providing the right diet of glucose, honey, milk powder, and protinex at suitable concentrations for *Trichogramma* spp. will enhance their biological activities during mass rearing and their efficacy through field application.

Keywords: *Trichogramma* species' parasitisation potential, *Corcyra* eggs, honey

Introduction
Parasite of eggs *Trichogramma* is a genus of tiny Oophagous wasps that endoparasitize insect eggs (Upadhyay, R. K., *et al*., 2001) [1]. Charles V. Riley described the first *Trichogramma* species in North America in 1871. He named the tiny wasps that emerged from viceroy butterfly eggs *Trichogramma minutum* (Consoli, F. L., *et al*., 2010) [2]. *Trichogramma* is one of approximately 80 genera in the *Trichogramma*tidae family, with over 200 species worldwide (Flanders, S. and Quednau, W., 1960; Consoli, F. L., *et al*., 2010 and Knutson, A., 2005) [10, 2, 11]. Although several groups of egg parasitoids are commonly used for biological control around the world, *Trichogramma* spp. have received the most attention (Sumer, F., *et al*., 2009) [12]. *Trichogramma* species include. In a single day, a single female can parasitize up to ten host eggs. Original specimens are critical in taxonomical because they serve as the foundation for subsequent species descriptions. However, the original specimens were destroyed. Riley described a second species, *Trichogramma pretiosum*, in 1879, but these specimens were also lost. For many years, *Trichogramma* spp. has been used to control lepidopteran pests. They can be considered the Drosophila of the parasitoid world, as they have been used for inundative releases, and experiments with these wasps have provided much understanding today (Smith, S. M., 1996; and Burgio, G., and Maini, S., 1995) [13-14]. Entomologists began rearing *Trichogramma* spp. for biological control in the early 1900s. *T. minutum* is one of them. Many countries use oophagous Hymenoptera of the genus *Trichogramma* in biological control programmes to regulate pest populations (primarily lepidopteran species) (Parra and Zucchi 2004) [15]. These parasitoids are typically reared in fictitious host eggs, the most common of which belong to Lepidoptera such as *Ephestia kuehniella* (Zeller), Corcyra cephalonica (Stainton) (Pyralidae), Sitotroga cerealella (Olivier)

(Gelechiidae), or silkworms, but large-scale multiplication remains costly. The possibility of artificial rearing systems can overcome this limitation to their use. For many years, researchers in various countries have been studying the *in vitro* rearing of egg parasitoids. Presently, different kinds of artificial media are available enabling immature development of many species of *Trichogramma*. The best results were obtained using media primarily composed of the indiscriminate and nonselective use of insecticides in pest management has resulted in a number of issues, including the development of insecticide resistance in major crop pests, pest resurgence, the annihilation of natural enemies, and the negative effects of toxic residue in food and the environment (Phokela, *et al*., 1990; Armes, *et al*., 1992; Lande and Sarode, 1993) [16-18]. Following the ineffective control of insect pests with insecticides in recent years, farmers have shown increased interest in biological pest control. Bio-agents are at the forefront of crop protection and are an important component of IPM due to their specificity, safety, and low cost, with no resistance or residue issues. The increased awareness of the environmental and human health consequences of pesticide use has resulted in efforts to reduce reliance.

Materials and Methods

The present study was carried out at the Biological Control Laboratory, Department of Entomology, SVPUA&T, Meerut, (UP), India.

Source of the host

The rice meal moth, *Corcyra cephalonica* (Stainton), laid eggs that were used as a factitious host for evaluating the biological aspects of the tested *Trichogramma* species. Fresh eggs were obtained from the laboratory colony of the Biological Control Laboratory, Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (UP), India. The eggs were stored at 4 °C for 7 days.

Source and rearing of the parasitoids

The *Trichogramma chilonis* was used from tested parasitoid species were obtained from Biological Control Laboratory, Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, and reared on rice meal moth, *Corcyra cephalonica* (Stainton) eggs (< 18 hrs old) glued (gum) to a self-adhesive strip (2.5 × 8 cm). The strips carrying *Corcyra cephalonica* eggs were exposed to *Trichogramma* adults in glass tube covered with cotton cork. Egg sheets were renewed daily. Colonies of parasitoids were reared under the laboratory conditions of temperature (25 ± 1 °C), relative humidity (60 ± 10), and 14:10 hrs day and night (D:N) photoperiod.

Honeybee products

The Honey, glucose, protinex and milk powder products purchase from the market. All honeybee products were freshly collected from honeybee colonies, pure and clean from any chemicals for controlling pests of bee colony.

Experimental procedures

Food supplements preparing

Effect of the four honeybee products: honey, their mixtures, honey solution, milk powder and protinex as food supplements, on the biological parameters, were conducted in comparison with no food as a control.

Table 1: Source of materials for *Trichogramma* rearing

Treatments	Firms
T_1 *Corcyra* eggs + Glucose 5%	M/s. Heinz India Pvt. Ltd.19th Floor, E and G Wing, Lotus corporate Park, Goregaon (East), Mumbai-400 063.
T_2 *Corcyra* eggs + Glucose 10%	M/s. Heinz India Pvt. Ltd.19th Floor, E and G Wing, Lotus corporate Park, Goregaon (East), Mumbai-400 063.
T_3 *Corcyra* eggs + Honey 5%	Dabur India Limited, Kaushambi, Ghaziabad – 201 010, Uttar Pradesh, India.
T_4 *Corcyra* eggs + Honey 10%	Dabur India Limited, Kaushambi, Ghaziabad – 201 010, Uttar Pradesh, India.
T_5 *Corcyra* eggs + Milk powder 5%	Nestle India Limited, New Delhi.
T_6 *Corcyra* eggs + Milk powder 10%	Nestle India Limited, New Delhi.
T_7 *Corcyra* eggs + Protinex 5%	Nutrica International Pvt. Ltd. Phoenix Market City, LBS Marg, Kurla (W), Mumbai.
T_8 *Corcyra* eggs + Protinex 10%	Nutrica International Pvt. Ltd. Phoenix Market City, LBS Marg, Kurla (W), Mumbai.

Feeding of *Trichogramma* species

Fifteen newly emerged and mated parasitoid females distinguished by their antenna were used for each tested diet and placed individually in rearing glass vials (1.0 × 8 cm). Every glass vial contained a label strip (1 × 8 cm), which had a ½ cm disc diameter to glue approximately 120 of *C. cephalonica* eggs, on the other side of the strip, a small drop of tested diet by a toothpick was added (sugar solution was added as a small drop on the bottom of the vial). The last 27 vials with adult female parasitoids and the host eggs were left without food supplement as control. The strips, carrying the parasitized eggs were renewed daily and kept in clean vials. The longevity of each parasitoid female was recorded until death. The numbers of parasitized eggs (black shining eggs) were recorded as fecundity. After adult emergence, the percentage of emerged adults was calculated as follows: (No. of black eggs with emergence holes/total no. of black eggs) × 100. The emerged parasitoid adults were sexed and sex ratio was calculated using the formula [No. of females/(No. of females + No. of males)] × 100 All experiments were carried out under the laboratory conditions of temperature (25 ± 1°C), relative humidity (60 ± 10), and a 14:10 (D:N) hours photoperiod.

Statistical analysis

Data were analyzed, using one-way analysis of variance (ANOVA) and using SPSS computer program. Means were compared using Duncan's multiple range tests. The relationship between longevity and fecundity was determined for the *Trichogramma chilonis* separately by linear regression analysis.

Result and Discussion

Parasitisation potential of *T. chilonis* on *C. cephalonica* eggs with different nutrition.

On the basis of the percentage of eggs that were parasitized, the longevity of the male and female parasitoids, and the sex ratio of the parasitoids that emerged from the eggs of Corcyra cephalonica that were parasitized by females, the effect of feeding females of *Trichogramma* on various food sources was examined. The outcomes are covered under the following headings.

Eggs parasitisation of *Corcyra cephalonica*

During the years 2018-19 and 2019-20, mated *T. chilonis* females fed on the respective food material parasitized the Corcyra cephalonica eggs. Tables 3, 4, 5, and Figure 1 display the data (i). T_4 Corcyra eggs + Honey 10% (76.13) were significantly superior followed by T_2 Corcyra eggs + Glucose 10% (74.17), T_6 Corcyra eggs + Milk powder 10% (71.27), T3 Corcyra eggs + Honey 5% (69.34), T_1 Corcyra eggs + Glucose 5% (68.78), T_7 Corcyra eggs + Protinex 5% (65.81),) and the lowest egg parasitisation T_5 *Corcyra* eggs + Milk powder 5% (65.89) percent egg parasitisation, respectively.

The highest percent eggs parasitized were in T_4 Corcyra eggs + Honey 10% (78.26%), followed by T_2 + Glucose 10% (75.33%), T_8 + Protinex 10% (73.58), T6 + Milk powder 10%, T_3 + Honey 5% (68.26%), T_1+ Glucose 5% (67.76), T_7+ Protinex 5%, and T_5+ Milk powder 5% percent egg parasitisation.

All treatments were effective in the Parasitisation of *T. Chilonis* in 2018-19 and 2019-20. The most effective treatment for *Trichogramma* was T4 Corcyra eggs + Honey 10% (77.20%), followed by T2 Glucose 10% (74.93%), T3 Honey 5% (68.80%), T4 Glucose 5% (66.70), T5 Milk powder 5% (67.42) and T9 untreated control (55.69%). Interaction effects were non-significant indicating consistent performance of treatments over period. It is suggested that adult nutrition through the source of carbohydrates like Glucose of honey may be useful to improve the egg parasitoids.

The present findings are supported by Greenberg S. M. *et al.,* (2000) [3] eggs deposited by raisin (51.1 eggs/female) or honey fed (83.0 eggs/female) females reared *in vitro* or females reared *in vivo* (44.9 or 69.5 eggs/female, respectively) was significantly greater than that deposited by unfed females (35.0 eggs/female). Linda Thomson *et al*., (2001) [8] wasps released to augment an existing population "inoculative release" or they are released in large numbers to coincide with maximum pest pressure "inundative release." Wasp quality can be split into genetic and environmental components. Simon Grenier *et al.,* (2005) [4] the proteins as well as casein added at final concentrations of 1.6 or 3.2% were completely assimilated. Even media containing hemolymph could be improved by protein addition because of the relatively low content of proteins in the hemolymph. The addition of 3.2% casein increased the protein content of *T. pretiosum* pupae by 25% and normal adult emergence yield by 40%. Saljoqi, *et al.*, (2007) [19] the role of different artificial diets comprising honey (50%), glucose (20%), fructose (20%), sucrose (20%) and pure water was examined on the longevity, percent parasitism, sex ratio, emergence period, percent emergence, period and percent emergence of honey solution fed adult was highest i.e. 4.04 days and 96.80%, respectively, and the lowest reproductive period and percent emergence was observed in case of water (2.52 days and 70.20%, respectively). Unmole L. (2010) [9] egg production was highest on the first day. The sex ratio of emerging progeny was 1:2.2 One-day old *M. vitrata* eggs were preferred for oviposition whereas 2 and 3-day old eggs for feeding. No parasitism was observed in 3-day old eggs. The combined effect of egg parasitism and feeding resulted in more than 77% mortality in one and two-day old eggs. Hegade P. B., (2014) highest number of adult emergence (24.25) and it was at par with (21.75). There was very low adult emergence from (5.25). Considering adult longevity (26.25days) was best effective treatment. Whereas, (5.25days) and (water) 7.00 days were less effective treatments. Number of Corcyra larvae paralysed by parasitoid fed on adult diets showed non-significant results. Sex ratio (male: female) was highest in (1:47) i.e. fructose. Mashal Shaimaa (2019) [6] highest fecundity was obtained by honey + royal jelly + propolis, honey + royal jelly, honey alone and honey + pollen grains + royal jelly for *T. evanescens*, honey + royal jelly + propolis, honey + pollen grains + propolis, and honey + pollen grains + royal jelly + propolis for *T. bourarachae*, and by honey + royal jelly.

Effect of nutrition on longevity of adult parasitoid

Effect on female parasitoid longevity

The data on longevity of female parasitoid fed on different food materials during two concussion season trials and in pooled are presented in Table 3, 4, 5 and depicted in Figure 1 (ii). The data during 2018-19 first trial revealed that all the food materials fed to the newly emerged *Trichogramma chilonis* significantly increased the life span compared to water fed females. This clearly indicated that *T. chilonis* females also need extra food material to extend their life which they usually took from food material i.e. Glucose, honey milk powder and protinex with different concentration. The results revealed that significantly higher longevity of parasitoid female was noticed when fed in treatment T_4 *Corcyra* eggs + Honey 10% (4.89 days) significantly superior followed by T_2 *Corcyra* eggs + Glucose 10% (4.12 days), T_8 *Corcyra* eggs + Protinex 10% (3.65 days), T_6 *Corcyra* eggs + Milk powder 10% (3.12 days), T_3 *Corcyra* eggs + Honey 5% (2.89 days), T_1 *Corcyra* eggs + Glucose 5% (2.12 days), T_7 *Corcyra* eggs + Protinex 5% (2.10 days), T_5 *Corcyra* eggs + Milk powder 5% (2.10 days) longevity of *T. chilonis* significantly the lowest longevity compared to the control. The lowest longevity of *Trichogramma* was noticed in T_9 untreated control (1.39 days). Perusal of the data during second year 2019-20 trial also revealed that in the treatments T_4 *Corcyra* eggs + Honey 10% (4.93 days) followed by T_2 *Corcyra* eggs + Glucose 10% (3.98 days), T_8 *Corcyra* eggs + Protinex 10% (3.87 days), T_6 *Corcyra* eggs + Milk powder 10% (3.11 days), T_3 *Corcyra* eggs + Honey 5% (2.98 days), T_1 *Corcyra* eggs + Glucose 5% (2.46 days), T_7 *Corcyra* eggs + Protinex 5% (2.38 days), T_5 *Corcyra* eggs + Milk powder 5% (1.98 days) longevity of *T. chilonis* significantly the lowest longevity compared to the control. The lowest longevity of *Trichogramma* was noticed in T_9 untreated control (1.59 days). The lowest longevity of 1.47 days was recorded in water fed females. Perusal of the pooled data showed that honey 10 percent supported maximum female longevity of T_4 *Corcyra* eggs + Honey 1% (4.91 days) followed by T_2 *Corcyra* eggs + Glucose 10% (4.05 days), T_8 *Corcyra* eggs + Protinex 10% (3.76 days), T_6 *Corcyra* eggs +

Milk powder 10% (3.12 days), T_3 *Corcyra* eggs + Honey 5% (2.94 days), T_1 *Corcyra* eggs + Glucose 5% (2.49 days), T_7 *Corcyra* eggs + Protinex 5% (2.55 days), T_5 *Corcyra* eggs + Milk powder 5% (2.11 days) longevity of *T. chilonis* significantly the lowest longevity compared to the control. The lowest longevity of *Trichogramma* was noticed in T_9 untreated control (1.34 days). Interaction effects were no significant indicating consistent performance of treatments over period. Thus, from above results it can be revealed that glucose like sugar, honey, milk and protinex increased female longevity than protein sources while, food availability definitely increased the female longevity.

Effect on male parasitoid longevity

The data on male parasitoid longevity on different food material during both the trials data on longevity of male parasitoid fed on different food materials during two concussion season trials and in pooled are presented in Table 3, 4, 5 and depicted in Figure 1 (iii). The data during 2018-19 first trial revealed that all the food materials fed to the newly emerged *Trichogramma chilonis* significantly increased the life span compared to water fed females. This clearly indicated that *T. chilonis* females also need extra food material to extend their life which they usually took from food material i.e. Glucose, honey milk powder and protinex with different concentration. The results revealed that significantly higher longevity of parasitoid male was noticed when fed in treatment T_4 *Corcyra* eggs + Honey 10% (3.88 days) were second significantly superior T_2 *Corcyra* eggs + Glucose 10% (3.21 days), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (2.89 days), followed by T_6 *Corcyra* eggs + Milk powder 10% (2.34 days), T_3 *Corcyra* eggs + Honey 5% (1.97 days), T_1 *Corcyra* eggs + Glucose 5% (1.49 days), T_7 *Corcyra* eggs + Protinex 5% (1.17 days), T_5 *Corcyra* eggs + Milk powder 5% (1.12 days) longevity of *T. chilonis* significantly the lowest longevity compared to the control. The lowest longevity of *Trichogramma* was noticed in T_9 untreated control (1.10 days). Perusal of the data during second year 2019-20 trial also revealed that in the treatments T_4 *Corcyra* eggs + Honey 10% (3.76 days), followed by second significant superior T_2 *Corcyra* eggs + Glucose 10% (3.98 days), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (2.87 days) followed by T_6 *Corcyra* eggs + Milk powder 10% (2.43 days), T_3 *Corcyra* eggs + Honey 5% (1.93 days), T_1 *Corcyra* eggs + Glucose 5% (1.44 days), T_7 *Corcyra* eggs + Protinex 5% (1.23 days), T_5 *Corcyra* eggs + Milk powder 5% (1.11 days) longevity of *T. chilonis* significantly the lowest longevity compared to the control. The lowest longevity of *Trichogramma* was noticed in T_9 untreated control (1.00 days). Perusal of the pooled data showed that honey 10 percent supported maximum male longevity of T_4 *Corcyra* eggs + Honey 10% (3.82 days) were second significantly superior T_2 *Corcyra* eggs + Glucose 10% (3.24 days), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (3.76 days), followed by T_6 *Corcyra* eggs + Milk powder 10% (2.88 days), T_3 *Corcyra* eggs + Honey 5% (2.39 days), T_1 *Corcyra* eggs + Glucose 5% (1.95 days), T_7 *Corcyra* eggs + Protinex 5% (1.47 days), T_5 *Corcyra* eggs + Milk powder 5% (1.20 days) longevity of *T. chilonis* significantly the lowest longevity compared to the control. The lowest longevity of *Trichogramma* was noticed in T_9 untreated control (1.11 days). Interaction effects were no significant indicating consistent performance of treatments over period. Thus, from above results it can be revealed that glucose like sugar, honey, milk and protinex increased male longevity than protein sources while food availability definitely increased the female longevity, respectively, while water fed males lived for a short period (1.07 days). Interaction effects were non-significant indicating consistent performance of treatments over period. From the above results it is clear that male of *Trichogramma* needs nutrition to extend their life span, which they get from flower nectar or honeydew in the field.

The present findings are supported by Zhang *et al.* (2001) [20] who showed that longevity of female *T. brassicae* was 12.33 days on honey alone and 2.67 days on water only. Further, *T. brassicae* female lived for 4.97 days on mixture of pollen and water. Similarly, Mcdougall and Mills (1997) [21] found that sugar sources were necessary to prolong longevity of *T. plantneri* but a source of amino acids did not promoted longevity. Honey solution greater than 10 percent and fructose and sucrose 43 percent solutions increased longevity from 10 to 13 fold to 15 to 20 fold in comparison to water feeding. Further, aphid honeydew was a suitable field source of sugars supporting longevity up to 10 days but was not as good as other sugar sources. These results are also in close agreement with the present findings. The work on male parasitic longevity cannot be compared as any such reference or findings are not available.

Effect of nutrition for *T. chilonis* female emerged from the *C. cephalonica* eggs

The adults of egg parasitoid *T. chilonis* emerged from the parasitized eggs of *Corcyra* females fed on the respective diets was determined by segregating the individuals carefully based on sexual dimorphism. The data of the two year 2018-19, 2019-20 and the pooled on the emerged of parasitoid are presented in Table 3, 4, 6 and Figure 1 (iv). The results revealed that feeding the ovipositing females 24 hrs before parasitization improved the parasitoid of the emerging. The female emerge was noted in most of the diets except in water only fed females. In the treatment T_4 *Corcyra* eggs + Honey 10% (75.23 percent) were second significantly superior T_2 *Corcyra* eggs + Glucose 10% (73.22 percent), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (78.34 percent), followed by T_6 *Corcyra* eggs + Milk powder 10% (70.14 percent), T_3 *Corcyra* eggs + Honey 5% (67.43 percent), T_1 *Corcyra* eggs + Glucose 5% (66.58 percent), T_7 *Corcyra* eggs + Protinex 5% (62.38 percent), T_5 *Corcyra* eggs + Milk powder 5% (60.23 percent) longevity of *T. chilonis* significantly the lowest longevity compared to the control. The lowest emerged of *Trichogramma* was noticed in T_9 untreated control (58.15). Perusal of the data during second year 2019-20 trial also revealed that in the treatments T_4 *Corcyra* eggs + Honey 10% (76.12 percent) followed by second significant superior T_2 *Corcyra* eggs + Glucose 10% (74.98 percent), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (70.58 percent) followed by T_6 *Corcyra* eggs + Milk powder 10% >, T_3 *Corcyra* eggs + Honey 5% >, T_1 *Corcyra* eggs + Glucose 5% >, T_7 *Corcyra* eggs + Protinex 5% >, T_5 *Corcyra* eggs + Milk powder 5%, (79.22 Percent) > (66.66 percent) > (62.77 percent) > (61.47 percent) > (58.97) longevity of *T. chilonis* significantly the lowest longevity compared to the control. The lowest longevity of

Trichogramma was noticed in T_9 untreated control (56.29 percent). Perusal of the pooled data showed that honey 10 percent supported maximum female emerged of T_4 *Corcyra* eggs + Honey 10% (75.68 percent) were second significantly superior T_2 *Corcyra* eggs + Glucose 10% (74.10 percent), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (70.92 percent), followed by T_6 *Corcyra* eggs + Milk powder 10% (74.68 percent), T_3 *Corcyra* eggs + Honey 5% (67.05 percent), T_1 *Corcyra* eggs + Glucose 5% (64.68 percent), T_7 *Corcyra* eggs + Protinex 5% (61.93 percent), T_5 *Corcyra* eggs + Milk powder 5% (59.60 percent) longevity of *T. chilonis* significantly the lowest emerged compared to the control, The lowest longevity of *Trichogramma* was noticed in T_9 untreated control (55.35 percent).

Effect of nutrition for *T. chilonis* male emerged from the *C. cephalonica* eggs

The data on the percent male emerged from the *Corcyra* eggs parasitized by the males fed on the respective diet in two experiments as well as their pooled are presented in Table 3, 4, 6 and depicted graphically in Figure 1 (v). The data of the first experiment indicated that all the food sources except water improved the male percent emerged. Food sources *viz.*, treatments T_4 *Corcyra* eggs + Honey 10% (72.32 percent) were second significantly superior T_2 *Corcyra* eggs + Glucose 10% (69.17 percent), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (63.68 percent), followed by T_6 *Corcyra* eggs + Milk powder 10% (62.37 percent), T_3 *Corcyra* eggs + Honey 5% (61.32 percent), T_1 *Corcyra* eggs + Glucose 5% (60.78 percent), T_7 *Corcyra* eggs + Protinex 5% (57.81 percent), T_5 *Corcyra* eggs + Milk powder 5% (55.89 percent) emerged of *T. chilonis* significantly the lowest emerged compared to the control. The lowest emerged of *Trichogramma* was noticed in T_9 untreated control (51.15). During second year 2019-20 experiment the results revealed that T_4 *Corcyra* eggs + Honey 10% (70.36 percent) followed by second significant superior T_2 *Corcyra* eggs + Glucose 10% (68.43 percent), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (67.28 percent) followed by T_6 *Corcyra* eggs + Milk powder 10% >, T_3 *Corcyra* eggs + Honey 5% >, T_1 *Corcyra* eggs + Glucose 5% >, T_7 *Corcyra* eggs + Protinex 5% >, T_5 *Corcyra* eggs + Milk powder 5%, (64.39 percent) > (63.66 percent) > (59.76 percent) > (56.59 percent) > (55.95) male emerged of *T. chilonis* significantly the lowest emerged compared to the control. The lowest emerged of *Trichogramma* was noticed in T_9 untreated control (51.55 percent), respectively. The results of pooled analysis revealed that the treatments T_4 *Corcyra* eggs + Honey 10% (71.34 percent) was significantly superior followed by second significant superior T_2 *Corcyra* eggs + Glucose 10% (68.80 percent), the next treatments in the order of effectiveness were T_8 *Corcyra* eggs + Protinex 10% (65.48 percent) followed by T_6 *Corcyra* eggs + Milk powder 10% (63.99 percent), T_3 *Corcyra* eggs + Honey 5% (63.88 percent), T_1 *Corcyra* eggs + Glucose 5% (61.27 percent), T_7 *Corcyra* eggs + Protinex 5% (57.20 percent), T_5 *Corcyra* eggs + Milk powder 5%, (55.92 Percent), respectively. Emergence of *T. chilonis* significantly the lowest emerged compared to the control, the lowest emerged of *Trichogramma* was noticed in T_9 untreated control (49.85 percent). Interaction effects were significant indicating non-consistent performance of treatments over period. From the above results it is clear that better nutrition of gravid females before the parasitization of host eggs can certainly improve the sex ratio of the emerged progeny. Earlier Zhen *et al.* (2007) [22] in a similar study on effect of adult diet on some biological parameters of *T. ostriniae* revealed that sex ratio (female/male) was significantly higher and at par in treatments of water (4.4 ± 1.8), water + *Bt* maize pollen (5.7 ± 3.4) and water + non *Bt* maize pollen (5.0 ± 2.6). Significantly lower sex ratio was observed in treatments of honey (2.1 ± 1.3), honey + *Bt* maize pollen (2.5 ± 1.7) and honey + non-*Bt* maize pollen (2.9 ± 1.9) and were at par. The present findings differ from that of Zhen *et al* (2007) [22]. The differences in the sex ratio under the present study might be due to difference in food sources used and the different species of *Trichogramma* under study.

Sex ratio (M:F) of *T. chilonis* emerged on different nutrition from the *C. cephalonica* eggs

Based on the number of adults emerged, which were segregated in to males and females, the sex ratio was worked out. The data of both the trials and pooled are presented in Table 3, 4, 6 and depicted graphically in Figure 1 (vi). The sex ratio (M: F) in first experiment revealed that in case of *Corcyra* eggs from T4 Corcyra eggs + Honey 10% (1:1.82 sex ratio) the proportion of more females was noticed (sex ratio) while in case of eggs obtained from *Trichogramma* emerged from different nutrition media where glucose, honey and protinex were added as a source of protein, the sex ratio was female biased as revealed in followed by T2 Corcyra eggs + Glucose 10% (1:1.78 sex ratio), the next treatments in the order of effectiveness were T8 Corcyra eggs + Protinex 10% (1:1.36 sex ratio)) followed by T6 Corcyra eggs + Milk powder 10% (1:1.66 sex ratio), T3 Corcyra eggs + Honey 5% (1:1.63 sex ratio), T_1 *Corcyra* eggs + Glucose 5% (1:1.61 sex ratio), T_7 *Corcyra* eggs + Protinex 5% (1:1.58 sex ratio), T_5 *Corcyra* eggs + Milk powder 5% (1:1.52 sex ratio), respectively. Emergence of *T. chilonis* significantly the lowest emerged compared to the control, the lowest emerged of *Trichogramma* was noticed in T_9 untreated control (1:1.42 sex ratio). In second year 2019-20 significantly superior T_4 *Corcyra* eggs + Honey 10% (1:1.80 sex ratio), T_2 *Corcyra* eggs + Glucose 10% (1:1.79 sex ratio),T_8 *Corcyra* eggs + Protinex 10% (1:1.70 sex ratio)) followed by T_6 *Corcyra* eggs + Milk powder 10% (1:1.62 sex ratio), T_3 *Corcyra* eggs + Honey 5% (1:1.59 sex ratio), T_1 *Corcyra* eggs + Glucose 5% (1:1.56 sex ratio), T_7 *Corcyra* eggs + Protinex 5% (1:1.54 sex ratio), T_5 *Corcyra* eggs + Milk powder 5%, (1:1.51 sex ratio), respectively. Emergence of *T. chilonis* significantly the lowest emerged compared to the control, the lowest emerged of *Trichogramma* was noticed in T_9 untreated control (1:1.41 sex ratio) and in pooled results also a same trend in sex ratio from various *Trichogramma* was noticed. Maximum T_4 *Corcyra* eggs + Honey 10% (1:1.81 sex ratio) T_2 *Corcyra* eggs + Glucose 10% (1:1.79 sex ratio),T_8 *Corcyra* eggs + Protinex 10% ((1:1.72 sex ratio)) followed by T_6 *Corcyra* eggs + Milk powder 10% (1:1.64 sex ratio), T_3 *Corcyra* eggs + Honey 5% (1:1.61 sex ratio), T_1 *Corcyra* eggs + Glucose 5% (1:1.60 sex ratio), T_7 *Corcyra* eggs + Protinex 5% (1:1.59 sex ratio), T_5 *Corcyra* eggs + Milk powder 5%, (1:1.53 sex ratio), respectively. Emergence of *T. chilonis* significantly the lowest emerged compared to the control, the lowest emerged of *Trichogramma* was noticed in T_9 untreated control (1:1.48 sex ratio). This might have produced superior quality

Trichogramma in respect to nutritional and morphological traits being supported by weight and size of the *Trichogramma* as mentioned earlier. Saljoqi, *et al.*, (2007) [19] the role of different artificial diets comprising honey (50%), glucose (20%), fructose (20%), sucrose (20%) and pure water was examined on the longevity, percent parasitism, sex ratio, emergence period, percent emergence, period and percent emergence of honey solution fed adult was highest i.e. 4.04 days and 96.80%, respectively, and the lowest reproductive period and percent emergence was observed in case of water (2.52 days and 70.20%, respectively). Unmole L. (2010) [9] egg production was highest on the first day. The sex ratio of emerging progeny was 1:2.2 One-day old *M. vitrata* eggs were preferred for oviposition whereas 2 and 3-day old eggs for feeding. No parasitism was observed in 3-day old eggs. The combined effect of egg parasitism and feeding resulted in more than 77% mortality in one and two-day old eggs. Hegade P. B. (2014) highest number of adult emergence (24.25) and it was at par with (21.75). There was very low adult emergence from (5.25). Considering adult longevity (26.25days) was best effective treatment. Whereas, (5.25days) and (water) 7.00 days were less effective treatments. Number of Corcyra larvae paralysed by parasitoid fed on adult diets showed non-significant results. Sex ratio (male: female) was highest in (1:47) i.e. fructose. Mashal Shaimaa (2019) [6] highest fecundity was obtained by honey + royal jelly + propolis, honey + royal jelly, honey alone and honey + pollen grains + royal jelly for *T. evanescens*, honey + royal jelly + propolis, honey + pollen grains + propolis, and honey + pollen grains + royal jelly + propolis for *T. bourarachae*, and by honey + royal jelly.

Table 3: Percent parasitisation potential of *T. chilonis* on different nutrition during 2018-19

Treatments	Parasitisation of *T. Chilonis* (%)	longevity of female *T. Chilonis* (days)	Longevity of male *T. Chilonis* (days)	Emerged of *T. Chilonis* Female (%)	Emerged of *T. Chilonis* Male (%)	Sex ratio (M:F)
T_1 *Corcyra* eggs + Glucose 5%	68.78 (56.02)	2.51 (9.11)	1.49 (7.01)	66.58 (54.67)	62.78 (52.39)	1:1.61
T_2 *Corcyra* eggs + Glucose 10%	74.17 (59.44)	4.12 (11.71)	3.21 (10.32)	73.22 (58.82)	69.17 (56.26)	1:1.78
T_3 *Corcyra* eggs + Honey 5%	69.34 (56.36)	2.89 (9.78)	1.97 (8.07)	67.43 (55.19)	64.32 (53.30)	1:1.63
T_4 *Corcyra* eggs + Honey 10%	76.13 (60.75)	4.89 (12.77)	3.88 (11.36)	75.23 (60.14)	72.32 (58.24)	1:1.82
T_5 *Corcyra* eggs + Milk power 5%	65.89 (54.25)	2.23 (8.58)	1.12 (6.07)	60.23 (50.89)	55.89 (48.36)	1:1.52
T_6 *Corcyra* eggs + Milk power 10%	71.27 (57.58)	3.12 (10.17)	2.34 (8.80)	70.14 (56.86)	63.37 (52.74)	1:1.66
T_7 *Corcyra* eggs + Protinex 5%	65.81 (54.20)	2.12 (8.37)	1.17 (6.21)	62.38 (52.15)	57.81 (49.48)	1:1.58
T_8 *Corcyra* eggs + Protinex 10%	72.28 (58.22)	3.65 (11.01)	2.89 (9.78)	78.34 (62.26)	63.68 (52.92)	1:1.36
T_9 *Corcyra* eggs (Alone)	60.17 (58.13)	1.39 (6.14)	1.10 (6.09)	58.15 (53.21)	51.31 (49.11)	1:1.42
SEM ±	0.77	0.09	0.08	0.77	0.67	0.77
CD at 5%	2.34	0.27	0.23	2.31	2.02	2.34

Table 4: Percent parasitisation potential of *T. chilonis* on different nutrition during 2019-20

Treatments	Parasitisation of *C. cephalonica Eggs* (%)	longevity of female *T. Chilonis* (days)	Longevity of male *T. Chilonis* (days)	Emerged of *T. Chilonis* Female (%)	Emerged of *T. Chilonis* Male (%)	Sex ratio (M:F)
T_1 *Corcyra* eggs + Glucose 5%	67.76 (55.39)	2.46 (9.02)	1.44 (6.89)	62.77 (52.38)	59.76 (50.61)	1:1.63
T_2 *Corcyra* eggs + Glucose 10%	75.33 (60.21)	3.98 (11.50)	3.27 (10.41)	74.98 (59.98)	68.43 (55.80)	1:1.79
T_3 *Corcyra* eggs + Honey 5%	68.26 (55.70)	2.98 (9.94)	1.93 (7.98)	66.66 (54.72)	63.66 (52.91)	1:1.59
T_4 *Corcyra* eggs + Honey 10%	78.26 (55.70)	4.93 (12.82)	3.76 (11.18)	76.12 (60.74)	70.36 (57.00)	1:1.80
T_5 *Corcyra* eggs + Milk power 5%	68.95 (62.20)	1.98 (8.09)	1.19 (6.05)	58.97 (50.15)	55.95 (48.40)	1:1.53
T_6 *Corcyra* eggs + Milk power 10%	70.19 (56.12)	3.11 (10.15)	2.43 (8.96)	79.22 (62.88)	64.39 (53.35)	1:1.62
T_7 *Corcyra* eggs + Protinex 5%	67.59 (56.89)	2.38 (8.87)	1.23 (6.36)	61.47 (51.61)	56.59 (48.77)	1:1.59
T_8 *Corcyra* eggs + Protinex 10%	73.58 (55.28)	3.87 (11.34)	2.87 (9.75)	70.58 (57.14)	67.28 (55.09)	1:1.70
T_9 *Corcyra* eggs (Alone)	61.28 (61.17)	1.29 (7.11)	1.11 (5.25)	51.29 (53.31)	50.55 (52.98)	1:1.39
SEM ±	0.79	0.09	0.08	0.77	0.66	--
CD at 5%	2.40	0.27	0.23	2.32	2.00	--

Conclusion

Nutrition is the main factor of life of any organism. Obtained results indicated that wasp nutrition type could improve the parasitoid’s quality parameters. This improvement varies in different species depending upon their responses to the tested diets. Therefore, providing the right diet from honey, pollen grains, royal jelly and propolis at suitable concentrations for *Trichogramma spp*. will enhance their biological activities during mass rearing and their efficacy throughout field application.

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