COMPARISON CANNIBALISTIC BEHAVIOR BETWEEN TWO LADYBIRDS, *COCCINELLA.SEPTEMPUNCTATA* L. AND *HIPPODAMIA.VARIEGATA* (GOEZE) UNDER LABORATORY EXPERIMENTS

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ABSTRACT: The cannibalistic behaviour of various developmental stages of *Coccinella septempunctata* L. and *Hippodamia variegata* (Goeze) were investigated at satiety and starved conditions. Both species were cannibalistic. However the rate of cannibalism was greater in the former species. In all experiments and in both coccinellids, no significant differences were detected at satiety conditions but at starved conditions, a significant effect of different predator and prey instar were recorded. Cannibalistic rate of ladybirds increased at low densities of *Schizaphis graminum* (Rondani) population and this is because of high relative frequently of encounters between predator coccinellids and the aphid.

KEY WORDS: *Coccinella septempunctata*, *Hippodamia variegata*, *Schizaphis graminum*, cannibalism.

Ladybirds (Coleoptera: Coccinellidae) are well known for their habits on aphids. They are polyphagous and live in diverse habitats Most of them are Carnivores and both adult and larvae can feed on aphids, whiteflies, psyllids, mealy bugs and scale insects (Pervez et al., 2006).

Cannibalism is a common phenomenon in predaceous ladybirds and endows nutritional and competitive advantages to the cannibals; this behaviour may evolve if the evolutionary costs are less than the advantages (Agarwala, 1991; Pervez et al., 2006; Santi & Mainai, 2007; Timms & Leather, 2007). Cannibalism rates may increase when food is rare but many predators are cannibalistic even when the prey is abundant. This is important in the dynamics of their population. Cannibalistic behaviour in larvae is a survival strategy under food depletion situations and enables larvae to complete their development (Burgio et al., 2005; Al Ansari, 2010).

Coccinella septempunctata and *Hippodamia variegata* are widespread coccinellids in Palearctic (including Iran), Nearctic and Oriental region. They are important biological control agents against aphids on the cultivated crops (Hodek & Honek, 1996). Most of the times, these two species' can be seen simultaneously in the fields. So the present study was undertaken to compare cannibalistic behaviour between these two species.

MATERIALS AND METHODS

1. Stock colony maintenance

H. variegata and *C. septempunctata* were collected from the wheat fields of Badjgah region (Fars province) and reared at 25$\pm$1 °C and photoperiod of 16 h light and 8 h darkness. Groups of thirty males and thirty females of each coccinellids were kept separately in 5 liters plastic boxes that contain moist cotton plugs and a piece of folded filter paper to increase the surface. Every day the ladybirds were fed on ad libitum supply of *S. graminum*. Filter papers were changed every day and egg clusters were removed and incubated at 15± 1°C. Once a week the ladybirds were transferred to new containers to stimulate egg laying. Coccinellids reared in laboratory at least for 4 generations (Agarwala, 1991).

S. graminum also collected from the wheat fields of Badjgah region (Fars province) and brought to the green house to form stock colony. Aphids reared in greenhouse at least for 10 generations (Agarwala, 1991).

2. Rate of food consumption in larvae and adults

Daily food consumption of the two coccinellids was measured at 25±1 °C, 65± 5% humidity and photoperiod of 16h light: 8h darkness in three separate experiments, as follows:

1. Each larval instar or adult female was gently placed in the center of a 9-cm diameter Petri dish with adequate aphids lined with filter paper.
2. Each larval instar or adult female was gently placed in the same situation with adequate conspecific eggs.
3. Each larval instar or adult female was gently placed in the same situation with adequate conspecific eggs and aphids all together.

3. Comparison between larval cannibalism at satiety and starved conditions

Neonates of *H. variegata* and *C. septempunctata* were examined at satiety conditions as bellow:

1. Putting 10 first instar larva + 10 third instar larva+ 100 aphids in each 9-cm diameter Petri dish (e1).
2. Putting 20 fourth instar larva + 500 aphids in each 9-cm diameter Petri dish (e2).
3. Putting 10 fourth instar larva + 10 different larval instars+ 300 aphids in each 9-cm diameter Petri dish (e3).

In starvation conditions, larvae starved for 12h to homogenize their hunger level and number of aphids was halved (Rahim khan et al., 2003). The experiments were replicated 10 times and all experiments were conducted under 25±1 °C, 65± 5% RH and 16L: 8D photo period. After 2h the numbers of eaten larvae were recorded (Burgio et al., 2005). Data on cannibalism events were analyzed by ANOVA (Minitab, 2000).

4. Comparison between adult cannibalism at satiety and starved conditions

Adult females of each coccinellid beetles + 70 aphids + 10 conspecific eggs were put in each 9-cm diameter Petri dish in above conditions (e4) in 10 replications. In starvation conditions, adults starved for 12h and number of aphids was halved. After 2h number of eaten eggs was recorded. Data on cannibalism events were analyzed by T- Test (Minitab, 2000).

RESULTS AND DISCUSSION

Rate of food consumption in larvae and adults Bioecology

a. Feeding with aphids or conspecific eggs

In both coccinellid species, the forth instar larvae were seemed to be more voracious and consumed higher number of aphids. Females appeared to be more reluctant in consuming eggs as compared to forth instar larvae (Table 1).

b. Simultaneous Feeding with aphids and conspecific eggs

In the presence of aphids and conspecific eggs, first and second larval instars didn't consume any eggs. The daily feeding capacity of four instar larva and adult females, were higher on aphids than eggs (Table 1).

Comparison of larval cannibalism at satiety and starved conditions

a. Satiety conditions

Based on the results, in all experiments (e1, e2 &e3) the larvae of two coccinellids didn't differ significantly in term of cannibalism at satiety conditions at 95% Confidence Interval (Table 2).

b. Starved conditions

A significant different between predator larva and prey instar were recorded in all experiments (DFCs=2, FCs= 43.67, PCs= 0.001, α= 0.005& DFH v=2, FHv= 54.40, PHv= 0.001, α= 0.005) (Fig. 1).

Comparison of adult cannibalism at satiety and starved conditions

a. Satiety conditions

No significant differences were detected between adult cannibalism in these two species (T test, P value= 0.9).

b. Starved conditions

Rate of adult cannibalism in *C. septempunctata* was significantly higher than *H. variegata* (T test, P value= 0.026) (Fig. 2).

Comparison of cannibalistic behavior at satiety and starved conditions

1. In *C. septempunctata*

The rate of cannibalism was shown to be significantly higher by starved predators than satiated ones (DF= 1, F= 178.03 and P= 0.001) (Fig. 3).

2. In *H. variegate*

Based on the results, starved *Hippodamia* coccinellids show higher rate of cannibalism than satiated ones (DF=1, F= 167.53 and P= 0.001) (Fig. 3).

Comparison of cannibalistic behavior at satiety and starved conditions

Results didn't show any significant differences between two coccinellids at satiety conditions (DF=1, F= 0.88, P= 0.35), But analyses of variance showed significant differences at starved conditions (DF=1, F= 4.02, P= 0.048) (Fig. 4).

Finally, based on all experiments, grouping information by using tukey method at 95% confidence interval is shown in Table 3.

Cannibalism is a widespread phenomenon in many arthropods. Most of the time, this behavior can be seen during food scarity (Pervez et al., 2006). The results of present experiments revealed that in both coccinellid species the forth instar larvae were seemed to be more voracious and consumed higher number of aphids. Al-Ansari (2011) observed similar results in *C. undecimpunctata*.

Based on our results coccinellid females appeared to be more reluctant in consuming eggs. It's apparently due to the defensive materials like alkaloids, pyrazines and quinolenes in coccinellids eggs. These resources synthesized by coccinellids and protected their eggs from predation (Cottrel & Yeargan, 1998a,b; Agarwala & Yasuda, 2001). Our result is in spite of Agarwala (1991). He reported that coccinellids eat eggs more efficiently than aphids.

In our experiments, in the presence of aphids and eggs, rate of aphid consumption was more than eggs. Our results support the inferences of Burgio et al. (2002), who suggested that in presence of alternative food source, the percentage of eggs attacked was lower than without an alternative food.

In all of our experiments and in both coccinellids, rate of cannibalism at starved conditions was significantly higher than satiety conditions. There is a possibility of high- level cannibalism when aphids are scare. It is because of high relative frequency of encounters between prey and predator (Dixon, 1959). When aphid population collapse, larvae and adults of coccinellids are under great pressure to survive, so unhatched eggs or smaller larvae of ladybirds are the easy targets (Agarwala, 1991).

Situations which form the attack strategy of ladybirds in the selection of food are little understood. Sometime, ladybirds are expected to adjust their attack on prey by assessing its availability. Most of the times they prefer larger and assured food supply for themselves and their offspring. In Food scarcity, cannibalism is an important evolutionary behavior for coccinellids to survive and complete their development.

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Table 1. Rate of food consumption in *C. septempunctata* and *H. variegata* larvae and adult females.

Species	Prey/diet		Larval instars				Adult female
			1st (From 25)	2nd (From 55)	3rd (From 120)	4th (From 250)	(From 150)
C. septempunctata	Aphids		20.5±2.1	50.3±5.5	101.7±6.1	210.1±10.2	125.5±12.1
	Eggs		17.2±4	40.1±3.1	60.3±14.3	110.8±5.5	70.9±8.1
	Eggs with aphids	Eggs	0	0	33.2±5.6	60±3.2	78±9.1
		Aphids	18.4±1.1	28.5±3.2	65.6±3.2	125.4±6.5	80.3±8.7
H. variegata	Aphids		18.2±1.8	45.4±6.2	98.5±5.5	180.1±8.7	115±7.4
	Eggs		15.1±3.5	27.9±6.1	54.3±8.6	97.3±5.5	50.5±8.9
	Eggs with aphids	Eggs	0	0	25.3±2.1	39.8±7.5	51±6.5
		Aphids	15.6±2.1	25±2.2	31.1±2.1	39.1±6.8	46.2±4.6

Table 2. Comparison larval cannibalism of *C. septempunctata* and *H. variegata* at satiety conditions.

Species	DF	F	P
C. septempunctata	2	0.33	0.719
H. variegate	2	0.26	0.769

Table 3. Final grouping information on larval cannibalism between (A) *C. septempunctata* and (B) *H. variegata* by using tukey's method at 95% confidence interval.

Species	Experiment	Number	Mean
A	e3	20	3.2^{a}
A	e4	20	2.8^{ab}
B	e3	20	2.8^{ab}
B	e4	20	2.4^{ab}
A	e1	20	1.9^{ab}
B	e1	20	1.6^{ab}
A	e2	20	1.4^{ab}
B	e2	20	0.9^{b}

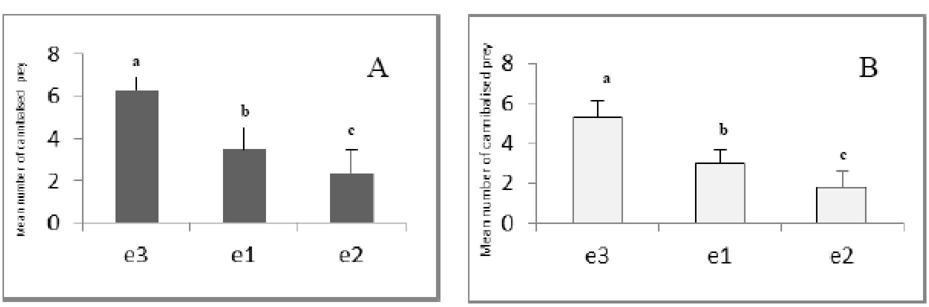

Figure 1. Larval cannibalism in starved conditions (A) *C. septempunctata* and (B) *H. variegata*. Different letters indicate that data are statistically significant.

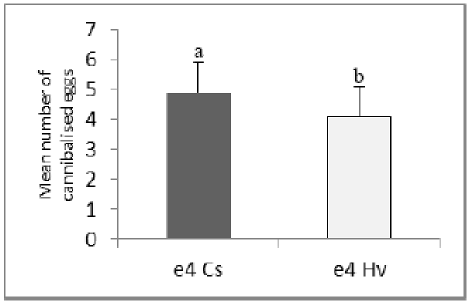

Figure 2. Comparison of adult cannibalism at starved conditions in (Hv) *H. variegata* and (Cs) C. *septempunctata*. Different letters indicate that data are statistically significant.

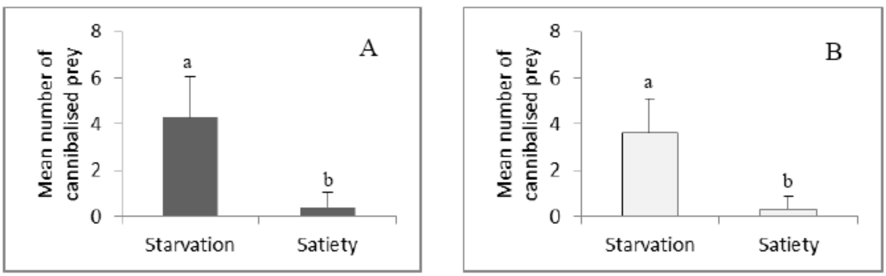

Figure 3. Comparison of cannibalistic behavior in (A) *C. septempunctata* and (B) *H. variegata* at satiety and starved conditions. Different letters indicate that data are statistically significant.

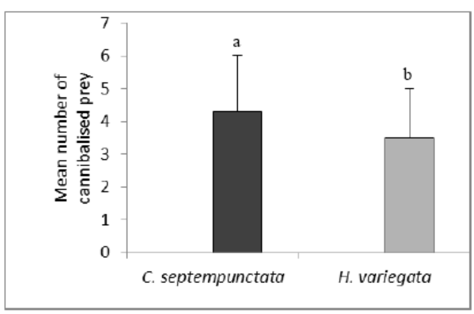

Figure 4. Comparison of cannibalistic behavior between *H. variegata* and *C. septempunctata* at starved conditions. Different letters indicate that data are statistically significant.