

Morphological Variation in the Ladybird Beetles (Coleoptera: Coccinellidae) Abdominal Segments in Ventral View

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Abstract

Ladybird beetles abdomen consists 1st to 8th or 1st to 9th segments where 1st, 2nd and 3rd segments are invisible. Only 4th to 8th in the male or 4th to 9th in the female ventral segments is clearly visible in the ladybird beetles abdomen. Sixteen experimental ladybird species first abdominal segment is well evaluated and significantly different, which was studied and resulted in the collection of total of 365 specimens. Abdominal shape, size and color are representing strong morphological characters in different species of Coccinellids. Abdominal segments morphological variation can appear to be associated with industrial pollution, behavioral diversity and climatic factors. In their behavioral activity abdomens shape, size, color and hairs may carry seasonal variation for finding odors, meeting a partner and honeydew in their host-plant for complete reproduction. Finally, the abdominal segments character can be used for ladybird beetle species identification.

Keywords: Coccinellids; Morphology; Mimicry; Odors; Ovipositor; Segment.

Introduction

Ladybird beetles abdomen consists 1st to 8th or 1st to 9th segments where 1st, 2nd and 3rd segments are invisible. Only 4th to 8th in the male or 4th to 9th in the female ventral segments is clearly visible in the ladybird beetles abdomen. Biranvand et al [1] said that, morphos of the ladybird beetles have different appearance, such as number, size, color and pattern of spots on the elytra and pronotum; which can be effected for their abdomens or abdominal segments. According to Gordon [2], Weise was apparently the first Coccinellid taxonomist to realize that male genitalia could be useful to distinguish species. The second half of the 20th Century was a 'Golden Age of Coccinellidae Taxonomy'. Their body is divided with three parts which call head, thorax and abdomen. The insect abdomen is the 3rd main segment of the body. Their abdomen is typically 11 segmented, where the eleventh segment is usually much reduced. Borror et al. [3] described that the maximum number of insect abdominal segments rarely appears to be more than ten segments and of segments bear a pair of laterally located spiracles. A ladybird beetles body third part of the abdomen, which is segmented with eight to nine parts and last segment consists male or female sexual organ which are used for ovipositor. Seagraves [4] described that, female ladybirds oviposition strategies which is turn determine the distribution of Coccinellid larvae in habits. Evans et al. [5] identify that, in the host-plant aphids honeydew and odors are exposed Coccinellid ladybird oviposit very quickly. Biology of ladybird beetle species that prey on armored scales (Hemiptera: Diaspididae), and also feeding on soft scale insects [6,7]. Dixon's [8] also described that the ecology of predatory Coccinellidae and their interactions with various prey groups and also discusses the consequences of various ecological traits in ladybirds for their successful application in biological control. Darshana et al [9] described that, coccinellids ladybirds are important natural enemies of agricultural pests and it is important to know the diversity with some of the scientific evidence including morphometric specifications. The purpose of the present study was: 1) how abdominal segments are different with each other? 2) How same species ladybirds abdomen shape and size are different? 3) Is their abdominal segment having seasonal variation effect for ovipositing? And 4) what is the role of the ladybirds abdomen for ecological behavior?

Materials and Methods

The ladybird beetle collection was conducted from various local ecological vegetation in the Joensuu city, Finland. Research works was obtained three years (2011–2013) in five different collecting spots on the summer season. We have taken general preparation before collecting ladybirds and collecting time was two-three days in a week. In this study period, we have collected 16 different species of ladybirds and total collection was 365 specimens. All ladybirds were caught in mosquito net, with hands and after collecting it was preserved proper way in the laboratory. In the laboratory, we have done ladybird beetles abdomens anatomical experiment under the microscope. After experimental study or analysis of the ladybird beetles abdominal segmental variation, we stored their abdomens in the glass bottle for future experiment. A photograph was taken for documentary support with the high regulation camera CANON (ESO 500D and EOS 450D) and a microscopic camera Leica S8APO was used.

Data collected were statistically analyzed using Sigma Plot 11.0 statistical and graph program. Analysis of variance (ANOVA) was applied with (Shapiro-Wilk) One Way analysis of Variance was used. We used Descriptive statistics, experimental design and multiple-comparison test with (Holm-Sidak method) for statistical analyses. For photography, Canon (EOS 500D and EOS 450D) camera and microscope camera Leica S8APO were used.

Results

Our study results show that, ladybird beetles abdomen segments in ventral view as upper one is 1st and lower one 6th or 7th segment (Figure

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1). The dorsal segments are called tergite, the ventral segments sternite. The segments are more heavily chitinized and flexibly connected to each other, allowing the abdomen more flexibility than the head and thorax. The ladybird beetles female genitalia consist of an ovipositor which is formed by the appendages of abdominal segments 8 and 9. The external genitalia of the male is extremely variable in the ladybird beetles, but it is often quite complex and they are frequently of considerable taxonomic value of identification. Statically we analyses all experimental ladybird beetles species abdomen in their ventral view and it was significantly different with each other.

Discussion

Analytical results showed that, collected ladybird beetles abdomen long mean was 6.27 ± 1.30 and wide mean 7.51 ± 1.47 in the experimental condition. In the ventral view of the ladybird beetles abdomen size (long and wide) statistically significant difference was $P < 0.017$ (Figure 3). For our experimental results, we have examined ladybird beetles abdomens analysis and color variation in the different species (Table 1). *Coccinella trifasciata* L abdomen was a round shape with deep brown. It was long 2.90 mm and broad was 3.70 mm. First abdominal segments both upper tip was light brown; upper narrow-curve line was attached with pyramid shape in the middle; pyramids lower area was long and straight with 1st segment line and without joint; both sides of pyramids lower area was visible narrow with convex line; 2nd, 3rd, 4th, 5th and 6th segments were parallel shapely; and 5th & 6th segments were brownish black (Figure 2a). *Coccinella quinquepunctata* L abdomen shape wasn't rounded and colorfully black. First segment upper tip was yellow; abdomen size was long 2.30 mm and broad 2.40 mm. The pyramid was a short and a lower area shortly closed with the 1st abdominal segment. Two narrow visible lines on both sides of the 1st abdominal segment were concave, long; upper side was joining with abdominal tip and lower side was same time joint with pyramid ground and 1st abdominal lining (Figure 2b). *Halyzia sedecimguttata* L abdomen shape was long and broad, not round; color was fully creamy-yellow with light brown shade. It was 3.00 mm long and 3.10 mm wide; pyramid shape was broadly short. In the 1st abdomen pyramids lower area was short and slightly curved; not joint with a 1st abdominal line; there had been a narrow line always invisible (Figure 2c). *Adalia bipunctata* L abdomen both sides of segments corner were a light brown color but middle area always deep brown. Their abdominal size was long 2.80 mm and broad 3.20 mm; slightly rounded with short size. The pyramid was short with broad; lower line was nicely curve; not joint with 1st abdominal line. Narrow line was clearly visible and jointly with pyramid line, which makes a deep convex line. Narrow visible line tip was nearly joined with 1st abdominal tip (Figure 2d). *Psyllobora vigintiduopunctata* L abdomen nearly rounded short and brown color.

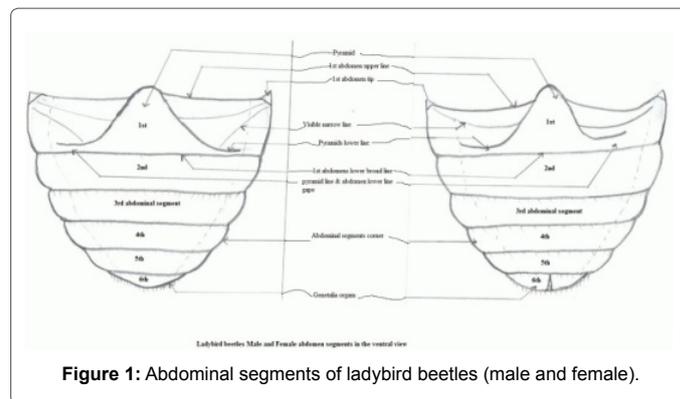


Figure 1: Abdominal segments of ladybird beetles (male and female).

Both sides of the abdominal corner area were light brown. It is 1.60 mm long and 2.10 mm broad in size. The pyramid was short and tip was dark brown and their lower line was straight long, and parallel with the 1st abdominal line; their narrow visible line was absent; 1st abdominal segments upper line was deep convex; 2nd abdominal segment lines middle area was little curve. All others abdominal segment lines were parallel and straight (Figure 2e). *Calvia quatuordecimguttata* L abdomen was small and broadly round shape. Their abdomens middle area was a dark brown color, but both side corner areas were broadly light brown. The abdomen size was 2.80 mm long and wide was 3.10 mm. Pyramid size was shorter, lower, narrow line deeply curved, not joint with a 1st abdominal line; both side narrow lines were visible and join with the pyramid narrow line, which make a deep curved. First abdominal segments, upper line curved, parallel shortly near pyramid tip; line and tip was at the same level; the other segments line was straight and parallel shape (Figure 2f). *Coccinella hieroglyphica* L abdominal size was 2.20 mm long and 2.40 mm wide; nicely rounded; color was dark brown or black. 1st abdominal segments, upper tip was a light orange color; pyramid shape was short and the lower line was shortly parallel with 1st abdominal lines. The narrow visible line was broad, long, slightly curved and nearly closed with 1st abdominal tip. Forth abdominal segment lines, both corners was shortly concave; the others all segmental lines was parallel and straight (Figure 2g). *Adalia sexpustulata* L abdominal size was 2.50 mm long and 2.70 mm wide with short rounded. Abdomens color was deep black; pyramid short and lower area close to the 1st abdominal line. The narrow visible line was joint with lower pyramid line and with upper tip; segments 1st and 2nd both side corner was a light orange narrow band; segments 3rd, 4th and 5th both side was broadly creamy-orange color; last segment was fully creamy-orange. All abdominal segment lines were parallel (Figure 2h). *Propylea quatuordecimpunctata* L abdominal size was 2.80 mm

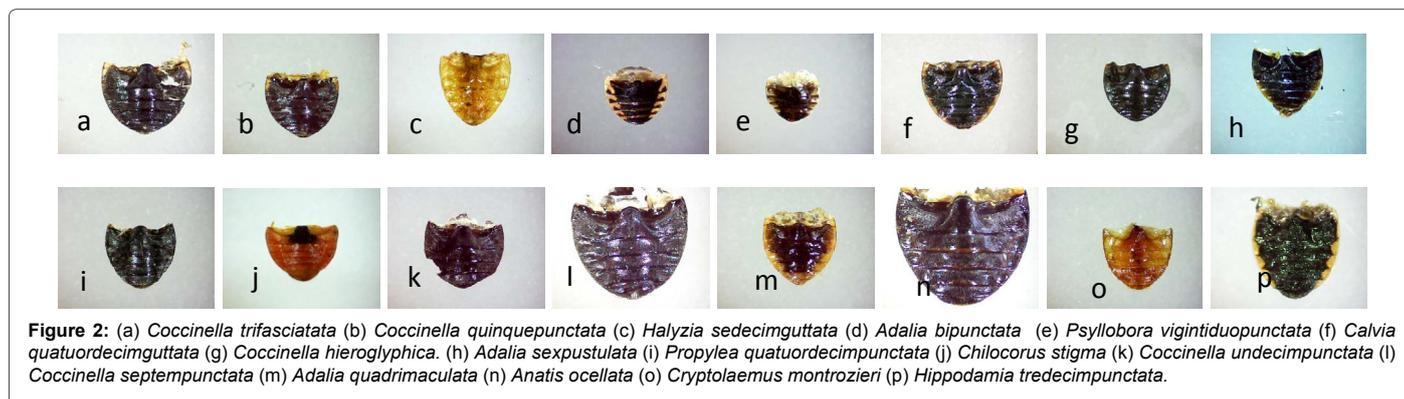


Figure 2: (a) *Coccinella trifasciata* (b) *Coccinella quinquepunctata* (c) *Halyzia sedecimguttata* (d) *Adalia bipunctata* (e) *Psyllobora vigintiduopunctata* (f) *Calvia quatuordecimguttata* (g) *Coccinella hieroglyphica*. (h) *Adalia sexpustulata* (i) *Propylea quatuordecimpunctata* (j) *Chilocorus stigma* (k) *Coccinella undecimpunctata* (l) *Coccinella septempunctata* (m) *Adalia quadrimaculata* (n) *Anatis ocellata* (o) *Cryptolaemus montrouzieri* (p) *Hippodamia tredecimpunctata*.

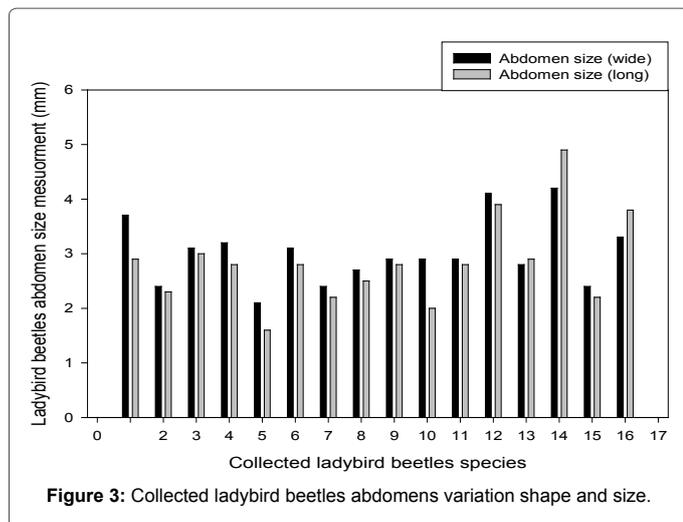


Figure 3: Collected ladybird beetles abdomens variation shape and size.

long and 2.90 mm wide; broadly rounded with black color. Pyramid size was so short and lower area long gap with the 1st abdominal segment; the narrow visible line was long and jointly with the lower line of pyramid with nicely curved. Abdominal segments 1st and 2nd both side corner was a deep orange narrow band; 3rd and 4th segments both corners was broadly orange band; and 5th segment were shortly orange band in both side corners. Abdomen last segment was a light orange color (Figure 2i). *Chilocorus stigma* L abdomen size was 2.00 mm long and 2.90 mm wide with widely rounded. Color was deep bright orange; both sides were a light orange big band in the corner area; pyramid was so short, black and lower line was joining with the 1st abdominal line. The narrow visible line was absent and 1st abdominal segment tip was blocked. Upper side of 1st abdominal segment narrow lines corner was shortly concave and all segments line was parallel with the straight (Figure 2j). *Coccinella undecimpunctata* L abdomen size was 2.80 mm long and 2.90 mm wide with short rounded. Abdomen color was dark brown or orange; but both sides of corner area were light orange. The pyramid was broadly short and the lower line was big gape with a 1st abdominal line; the narrow visible line was long and joining with the lower area of pyramid which making a long, smooth curve; the narrow line tip was joining with the 1st abdominal segments upper line tip. Other lines were parallel and clear visible (Figure 2k).

Coccinella septempunctata L abdomen was the second biggest size then other collected ladybird beetles. It was 3.90 mm long and 4.10 mm wide, almost rounded with a deep black color. The pyramid was long, but not broad; lower line was long, curve and parallels with the 1st abdominal segments line but not joining. The narrow visible line was long, broad and lower are curved, joining with the pyramids lower line middle area. Abdominal all other lines were parallel and long straight (Figure 2l). *Adalia quadrimaculata* L abdomen was broadly rounded and small size. It was 2.90 mm long and 2.80 mm wide; middle area of the abdomen was brownish color, but both sides of the corner creamy-brown color. The pyramid was a short and lower line not gone, big gap with a 1st abdominal, lower line; the narrow visible line was broad, shortly convex and join with the pyramids lower line but upper area was not closed with a 1st abdominal tip or line. First abdominal upper tip was brown color, parallel with pyramid tip and corner area was concave. The other abdominal segments line was narrow, straight and parallel (Figure 2m). *Anatis ocellata* L ladybird beetles abdomen was the biggest size of the total collected ladybird species. It was 4.90 mm long and 4.20 mm wide in size with round shape and black or dark

brown color. The pyramid was short, broad and lower area was broadly curved, very close with a 1st abdomen lower line. The narrow visible line was not clearly visible; a 1st abdominal line upper tip was orange color, the upper line tip area was concave and broadly parallel with the pyramid tip area. Second, 3rd and 4th abdominal segments lower lines middle area was orange band; another segment line was straight with parallel. Both sides of the abdomen corner area were light orange (Figure 2n). *Cryptolaemus montrozieri* L abdomen was the orange color medium size and semi rounded. Their abdomen size was 2.20 mm long and 2.40 mm wide. The pyramid was broadly short, lower lines were deeply curved, but not join with the 1st abdomens lower line. The narrow visible line was long with broadly visible, the lower part was joined by lower pyramid line and the upper part was joining with 1st abdomens tip. First abdominal upper line tip area was shortly concave and the tip was brownish-orange color. Abdomens both sides of the corner area was light orange; the other segments line was straight and parallel (Figure 2o). *Hippodamia tredecimpunctata* L ladybird beetles abdomen was deep black color. It was 3.80 mm long and 3.30 mm wide in size with nearly rounded. Their pyramid was long, broad and the lower line was shortly joined with the 1st abdominal lower line. The narrow visible line was absent; 1st abdomens upper line tip were not concave but middle area was shortly convex and both side corner areas where narrow creamy-brown straps. Abdomens 2nd and 3rd segments both side corner areas where finger nail shape where creamy-brown spots were; the last or the 6th segment was fully dark black color (Figure 2p). Ladybirds abdomen has a great role for oviposition and mimicry behavior for predator. Experiment result indicates that, ladybird beetles abdomen shape and size are affected in their behavioral characters significantly. Different color and structural variation of abdominal segments may be the evolutionary effect or it can be for seasonal variation, which should need more study. Different species of ladybird beetles abdomen structure may have a big role in reproduction and also for host-plant selection to lay eggs. The present study is an attempt to identify different species of ladybird beetles ventral view abdominal segments and color in North-Karelia province, Finland. Although ladybirds abdomen studies can strongly provide important information for identifying the different species for future study.

Conclusion

Our study results showing that, different species of ladybird beetles have own unique shape and size which are their morphological character. Abdominal segments can use for ladybird beetles species identification points. Same time their abdominal segments and color variation also has a big role of different species characters. So for that, it is a clear evidence of morphological variation in the different species of ladybird beetle's abdomen. Ladybird beetle abdomens different color may help for mimicry behavior in their biological life. Abdomen tarsi or hairs (which present in the last two segments than other segment) have a big role in finding a right host-plant for oviposition. The agricultural sector is also proved that, ladybird beetle is a beneficial insect for most of the year; it has contributed to a decrease in pesticide use on many crops and in orchards.

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