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UNDERC Research Project

Habitat Selection and Color Change in Four Odonate Species

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Abstract

Odonates occupy very diverse aquatic habitats. Many factors such as food and refuge availability affect their habitat choice. This study examined the role that substrate color has in determining habitat preference and the possibility for color change in response to habitat color. Two species of Odonata, *Libellula sp.*, and *Cordulia shurtheffi*, were placed in shoebox sized containers that were divided by dark and light color on the bottom. Their positions were recorded after 24 and 48 hours in order to determine color preference. Both species showed a preference for dark substrates. To examine color change, two species, *Leucorrhinia sp.*, and *Epitheca sp.*, were placed in almond, brown, black, or green colored jars for four weeks. Half were kept in a light environment and half were kept in a dark environment. They were photographed at one week intervals and the photographs were then analyzed for change in color. There was some evidence for color change among the larvae, especially in those that molted. The results from both sections suggest that Odonata larvae respond to the color of their environments. This can have implications in predator avoidance as well as in avoiding detection by prey. Both of these effects can help the dragonfly's individual survival.

Introduction

Odonata larvae are one of the most ubiquitous types of aquatic invertebrates. They occupy a large variety of habitats, both lentic and lotic. Among this diverse range though, microhabitats can differ greatly among species. Several factors influence this choice of habitat. Water chemistry, food availability, and predation risk are important issues. A proper habitat choice will protect the species from predation as well as providing them sufficient cover for hunting activities (Corbet 1999).

It is known that there can be color variation among individuals of one species. An example of this is *Leucorrhinia dubia* (Henrikson 1993). This variation suggests that larvae may choose their microhabitat based on their own color and how well they camouflage themselves within their habitat. This would provide the larvae protection from visual predators such as fish.

In addition to choosing a background color that matches their own, some larvae have been shown to change color in response to background colors. Corbet has indicated that color can change slightly after a molt to more closely match their habitat (1999). In a study, Moum and Baker showed that the odonate, *Ischnura verticalis* was able to change color between green and

brown (1988). Other aquatic insect larvae have been known to show color change in response to habitat as well. Black flies (*Simulium vittatum*) were shown to be significantly darker when reared under dark conditions (Zettler et al 1998). Color change is not unknown in other areas of the animal world, chameleons and cuttlefish being classic examples (Edmunds 1974). Gray tree frog tadpoles (*Hyla chrysoscelis*), show a variation in color when they are reared in the presence of predators (McCoullum and Van Bushkirk 1996). These representatives of camouflage from other organisms in the animal world show the possibility of similar occurrences with Odonates.

This study attempts to illuminate these two aspects pertaining to the importance of color to Odonate larvae. It attempts to determine if the larvae of *Libellula sp.* and *Cordulia shurtheffi* preferred a light background or a dark background. Secondly, it attempts to show color change in response to different background color and light regimens with two different species of odonata, *Epitheca spiniyera* and *Leucorrhinia sp.*

Materials and Methods

Part One: Substrate color and habitat selection

Eight experimental tanks and four control tanks were set up. The experimental tanks consisted of shoebox sized plastic containers that were divided into two colors- brown and off-white. The treatments were created by taping colored paper on the bottom of each tank. The color went up approximately 1.5 inches on the sides of the tank. The control tanks were solid colors. Two were brown and two were off-white. They were created in the same way as the experimental tanks. The tanks were filled with water up to the line where the color ended. The tanks were randomly situated on the shelves. In each tank six Odonata larvae were dropped in the center and allowed to establish themselves across the tank. The tanks were then left for two days. The larvae's positions were recorded after 24 hours and after 48 hours. The experiment was done

with *Cordulia shurtheffi* and *Libellula sp.*

Part Two: Larval Response to Different Substrate Color

Forty small jars were painted four colors- hunter green, black, almond, and brown. Both the sides and bottom of the jars were painted. Twenty jars were placed in a completely dark environment and twenty were placed in a light environment.

Before each larva was placed into a jar, all of the larvae were allowed to sit in holding tanks for one week. This was done in order to minimize any environmental biases they may have already had. After this pre-treatment, one larva was placed in each jar. Each was photographed under water against a white background using a digital camera. After the larvae were placed into their respective jars and respective treatments (light or dark), they were allowed to sit for a total of four weeks. After each week, the larvae were photographed again against a white background with the digital camera.

This experiment was done with two species of Odonata, *Epitheca spiniyera* and *Leucorrhinia sp.*

Results

Cordulia

The larval positions were recorded after 24 and 48 hours. The *Cordulia shurtheffi* showed a preference for dark substrate after 24 hours (Mann-Whitney Rank Sum Test, n=16, P=.002), and after 48 hours (t-test, n=16, P=.002). The control tanks were photographed, and showed a spaced and random arrangement of larvae.

Libellula

After 24 and 48 hours, the larval positions were also recorded. The *Libellula sp.* Showed a preference for the dark substrate after 24 hours (t-test, n=8, P=.002), and after 48 hours (t-test, n=8, and P=.004). The larvae in the control tanks showed a random placement throughout the tank.

Camouflage

Some of the *Leucorrhinia* and *Epitheca* showed distinct changes in their body color, though not necessarily correlating to the color of the jar in which they had been living. Some of the *Epitheca* kept in a light environment became lighter (Figure 5). Some of the *Epitheca* kept in a dark environment also showed this response (Figure 8).

The only very distinct changes occurred in those larvae that molted during the course of the experiment. Two *Epitheca* (D24, D30) from the dark treatment molted and stayed considerably lighter (Figures 9 and 10). One *Epitheca* (L22) from the light treatment molted and also stayed considerably lighter (Figure 6). It had been in an almond colored jar.

Two *Leucorrhinia* from the dark treatment (D2, D16) were obviously green tinted initially, and were not so tinted at the end of the experiment (Figure 7). These *Leucorrhinia* had not molted, yet still showed this response. Most of the other individuals showed some change in shading (Table 1).

Table 1: This table shows how many individuals for each species were lighter, darker, or did not change in each light regime.
Leucorrhinia

Type of Environment	Number lighter	Number Darker	Number no change
Light	0	0	4
Dark	0	7	2

Epitheca

Type of Environment	Number Lighter	Number Darker	Number no change
Light	5	1	1
Dark	8	1	2

Discussion

In the first part of the experiment, the Odonata larvae showed distinct preference for different colored habitats. Both the *Cordulia* and *Libellula* preferred the dark substrate. There must be selective advantages to choosing a dark habitat. Predator avoidance is one such issue. It has been shown in previous studies that habitat complexity, of which color is one facet, significantly affected the consumption of a larval mayfly *Cloeon cognatum* (Swisher et al. 1998). This could similarly apply to Odonata. Since predation, especially that of fishes, which tend to be visual predators, is such a selective force, predator avoidance is an important issue for aquatic invertebrates.

In addition to habitat selection, other predator avoidance tactics have been documented, such as hiding and reduced activity (Steiner et al 2000). Most previous studies have looked at

habitat structures as determinants of habitat choice, but these results suggest that color may also be a factor.

In addition to color and refuge availability, Odonates choose their habitat based on several other factors. The type of substrate may cause certain species to prefer one habitat over another. In addition, the particle size may have similar effects (Cummins and Lauff 1969). Food resources are also a factor affecting the distribution of odonata, especially in *Sphagnum* mats (Henrikson 1993). All of these factors affect the distribution of Odonate larvae, and it is not conclusive whether one is more important than others. Yet, the results of this study do indicate that color may play an important role in habitat selection.

This indication leads into the next question of this study- Can Odonata larvae change their own color to better camouflage themselves in their environment? The results seem to suggest that this is possible. Overall, there was a trend towards lightening in light and dark environments for *Epitheca*, and darkening in dark environments for *Leucorrhinia*. It is interesting that the two species showed different responses to the dark environment. The *Leucorrhinia* tended to get darker whereas the *Epitheca* tended to get lighter. This may suggest for *Epitheca* that in the dark environment, there is a tendency for a complete loss of color. Perhaps the individual organisms cannot sense that they are losing their camouflage in the dark. The *Leucorrhinia* showed what may be a more intuitive response of becoming darker in the dark environment.

There was less variation in the response in the light environment. First of all, most of the *Leucorrhinia* in the light environment died, and the survivors showed no change in color. The *Epitheca* mostly got lighter, though there were a few that did not change and one that became darker. The death of so many *Leucorrhinia* could suggest several things. In addition to the obvious problems of food supply and artificial environment, perhaps the color and light regimes of

their individual jars was too stressful for survival.

The most interesting responses occurred in the three individuals that molted during the experiment. One was in an almond jar in a light environment, one was in an almond jar in a dark environment and one was in a green jar in a dark environment. All three showed the same response. They were all considerably lighter after molting. Since the individual in the light environment was in a light colored jar, this suggests possibly that it was remaining lighter to blend in with the background. The other two did not change according to the color jar they were in, but responded to the completely dark environment. They show evidence for the idea that perhaps the dark environment causes a lack of color all together since the larvae cannot see their surroundings.

From these results it is also clear that molting is a key factor in seeing a more dramatic response. While several other individuals showed some shading differences, they were extremely subtle and hard to quantify. Molting may thus be necessary for the Odonates to camouflage themselves. This idea was also expressed by Corbet (1999). The color of the jars also seemed not to have an effect on what color the Odonates turned. There were only trends in lightening or darkening. Again, this suggest that molting is necessary for active camouflage by Odonates.

The results obtained for this half of the experiment were too few to show any real statistical significance, yet, they are still important. They suggest that camouflage is possible in larval Odonates, and may in fact be an important means of predator avoidance. Other studies have shown more convincing results. Henrikson showed that the Odonate *Leucorrhinia dubia* could change color between green and brown when placed in *Sphagnum* of the opposite color. He also suggested that the probable reason for such camouflage is predation avoidance (1993). In another study, Moum and Baker showed that *Ischnura verticalis* reared on green or brown

substrates would match the substrate color and that these color variations were important in predator avoidance as well as in avoiding detection by prey (1990). Since this study reared the larvae on different colored substrates, it seems likely that molting and color change at molting was what occurred. While this study supports the color change findings of both previous studies, it did not show significant differences based on the effects of different colored jars, only on different light regimes. It seems to suggest that perhaps light regime, and not specific color, is crucial to Odonate color change.

In conclusion, the results of this study are a stepping stone to further study in the arena of Odonate camouflage. Clearly, color has an effect on camouflage choice and some evidence of larval response to different color substrates has been shown. The extent to which these factors affect the life histories of the larvae is still not completely known. Predation avoidance and being camouflaged from potential prey are two possible reasons for larval coloration. Further study should be done involving Odonate color changing in order to further elucidate the purpose of larval coloration variation.

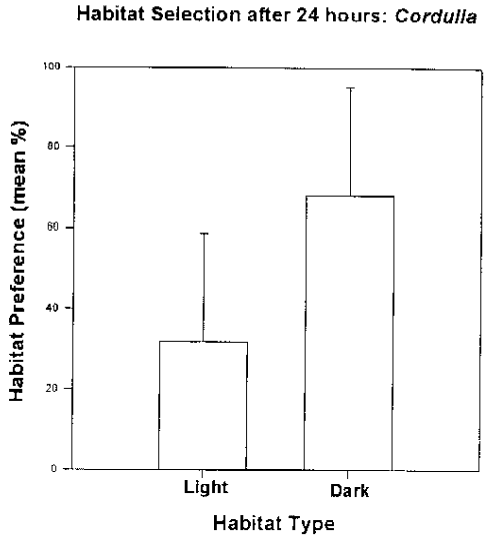

Figure 1: This graph shows the distribution of *Cordulia* after 24 hours. *Cordulia* showed a preference for dark substrate. (Mann Whitney Rank sum test, N=16, p=.002)

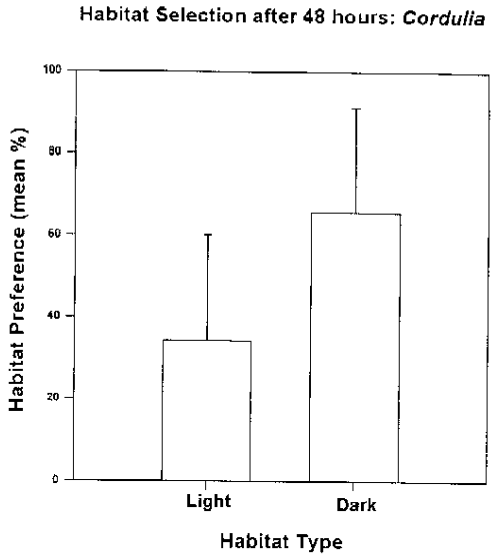

Figure 2: This graph shows the distribution of *Cordulia* after 48 hours. They preferred a dark background. (t test n=16, p=.002)

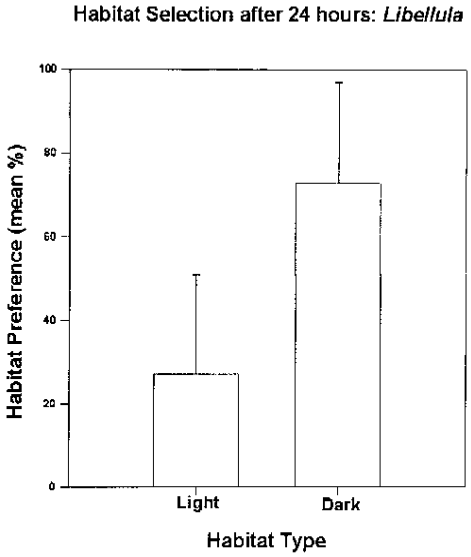

Figure 3: This graph shows habitat selection after 24 hours by *Libellula*. There was a preference for dark substrate. (t test n=8, p=.002)

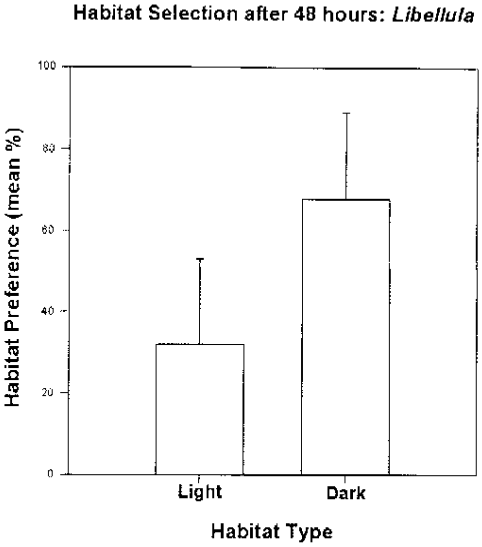

Figure 4: This graph represents the distribution of *Libellula* after 48 hours. They preferred dark substrate. (t-test n=8, p=.002)

Figure 5: *Epitheca* kept in a light environment in different colored jars. L21 and L25 show noticeable shading differences. L21 was in a black jar and L25 was in a brown jar

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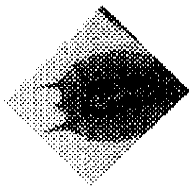

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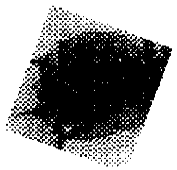

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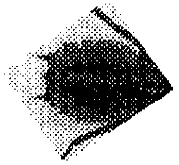

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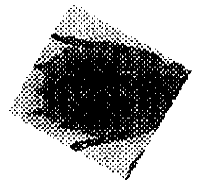

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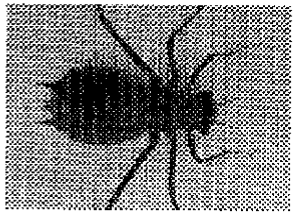
Figure 6: This *Epitheca* (L22) was kept in a black jar in a light environment. It molted during the experiment and became considerably lighter.



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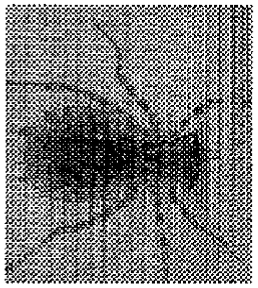

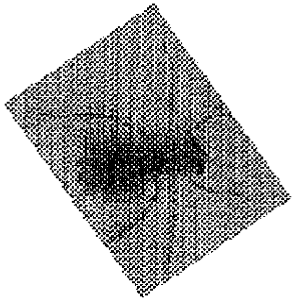

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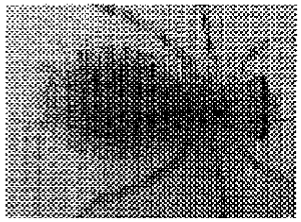


Figure 7: *Leucorrhinia* were kept in a dark environment. D2, D3 and D16 all became darker over the time period. D16 lost its distinctive green coloration.

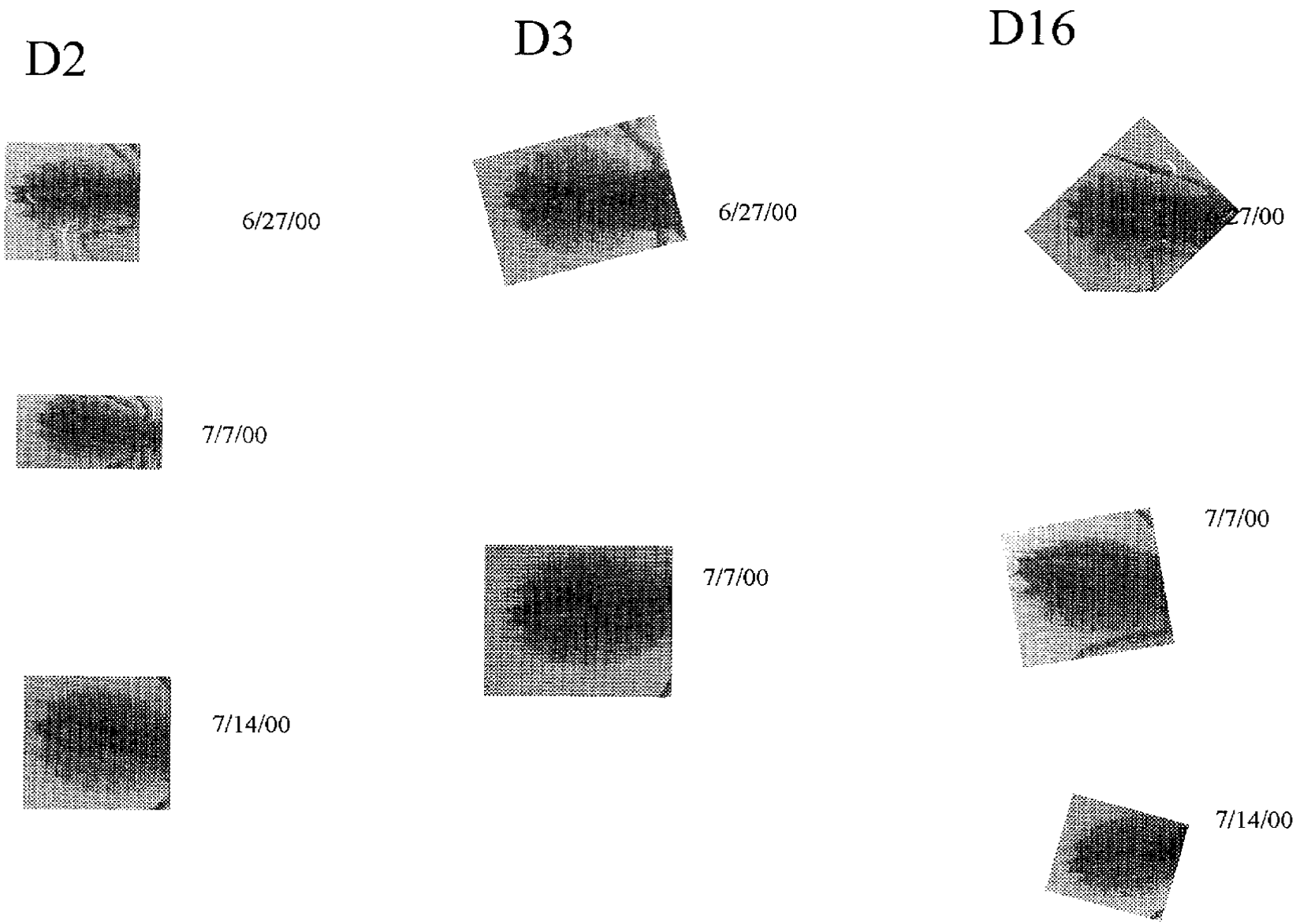
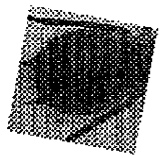


Figure 8: These *Epitheca* were kept in a dark environment. D21 and D23 both became lighter over the time period. Both were in brown jars.

D21



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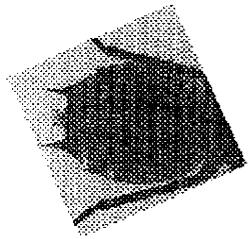

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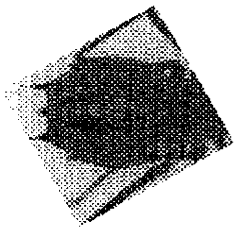

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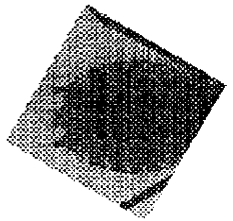

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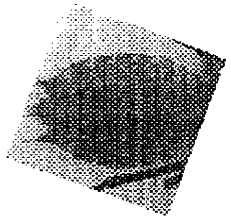

Figure 9: This individual *Epitheca* was kept in a dark environment and molted during the experiment. After molting, it remained considerably lighter. It was in an almond colored jar.

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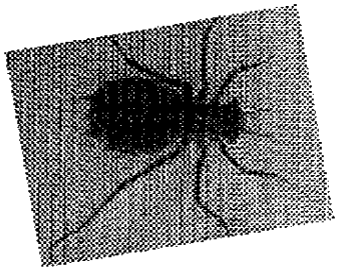

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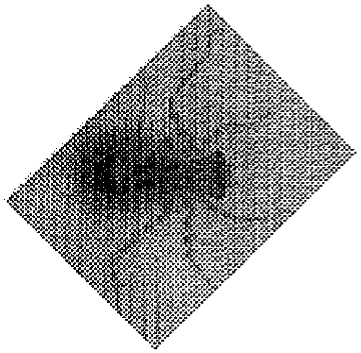

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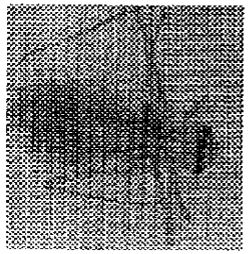
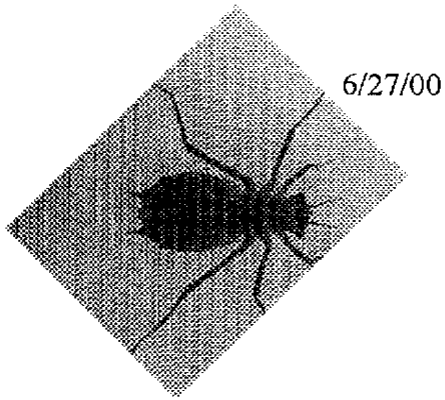
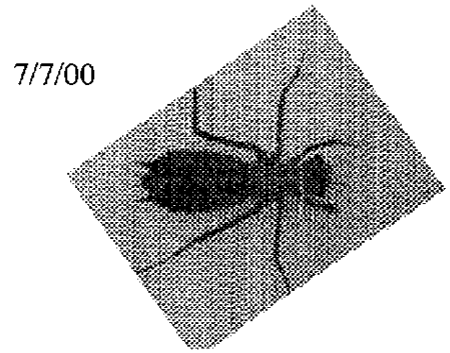
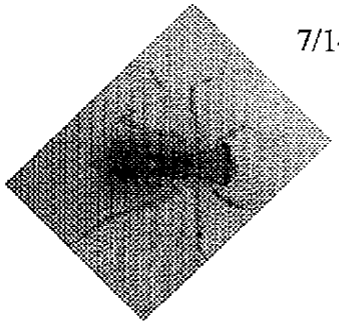
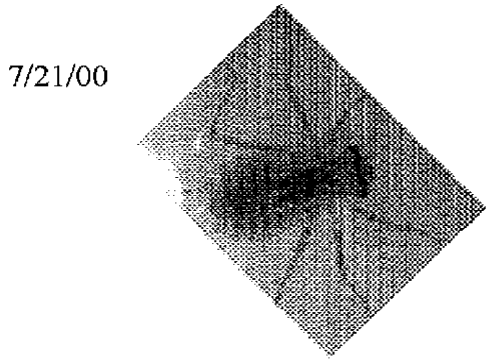


Figure 10: This individual *Epitheca* was kept in a dark environment. It molted during the experiment and remained considerably lighter. It was in a green jar.









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