Effects on Growth of Ectropis grisescens Warren under Illumination

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Abstract: The 2nd and 5th instar of Ectropis grisescens Warren larvae were exposed to 400~405 nm illumination for 0, 60, 90, 120, 150 or 180 min to determine the effects of the irradiation on the development time as well as the rates of pupation, pupa emergence, aberration rate, eclosion rate, adult longevity and oviposition rate. The results showed that, as compared with control, as the processing time increases, the developmental duration was significantly shortened with 5 instar of E. grisescens Warren larvae. The eclosion rate and aberration rate were significantly increased. At the same time, the pupa weight was significantly higher than that of the 2nd instar larvae. The mortality increased significantly in 2nd of E. grisescens Warren larvae. There was no difference in adult eclosion rate between the two groups, and there was also no difference in the average oviposition. There was no significant difference between the two groups under 400~405 nm illumination, Male adults live longer than female adults.

1. Introduction
Grey tea looper occurs severely in the provinces south of the Yangtze River basin. When it is damaged, it can eat up all the old leaves, new leaves, tender stems and young fruits of tea trees, leaving only the branches and stems, and even the plant death, which seriously affects the quality and quality of tea[1-3]. In this study, using the phototaxis characteristics of insects, different wavelengths of LED spectra were used to treat the 2nd and 5th instar larvae of the gray tea looper for different periods of time, and then kept them under conventional conditions to observe the changes in their growth period. It provides new ideas for prevention and control methods such as using insects’ light-tending/shading properties to trap larvae, drive away or interfere with their developmental rhythm, and reduce the amount of eggs laid in the field.

2. Materials and methods

2.1 Insect source and breeding method
The origin of gray tea geometrids came from the tea garden in Baimiao Village, Shihegang Township. They were successively reared on fresh leaves in an artificial climate room for 5 generations. The breeding environment was 22~26°C, relative humidity 60~70%, and photoperiod of 12L:12D.
2.2 Test equipment
Rtop-310y artificial weather box, Zhejiang top yunnong Technology Company.; pm6612 digital illuminance meter, Shenzhen Huayi Intelligent Measurement Technology Company.; insect cage (50cm × 50cm × 60cm), light reaction device (self-made).

2.3 Test light source
The wavelength of LED light source is 400 ~ 405nm. The light intensity is 200-220lux.

2.4 Test method
The 2nd and 5th instar larvae of geometrid cinerarius on the same day were put into the culture dish and placed 15 cm away from the light source (400-405 nm). The radiation time was set at 0 (CK), 60, 90, 120, 150 and 180 min in turn. Each treatment was repeated three times, with 20 larvae per replicate. After treatment, they were raised under conventional conditions. The number of dead, pupated, deformed, weight, eclosion, longevity of male and female adults (paired feeding), number of eggs laid and eggs hatched were recorded every day.

2.5 Data processing
The data were processed by SPSS16.0 (SPSS Inc., Chicago, IL). F test was used to analyze the significant difference among different light sources, and LSD test was used for multiple analysis.

3. Results and analysis
3.1 Effects of different radiation time on larvae
3.1.1 Effects on 2nd instar larvae

| Radiation time/min | Larval stage/d | Mortality/% | Pupation rate/% | Abnormal pupa rate/% | Pupa weight/mg | Eclosion rate/% |
|-------------------|---------------|-------------|-----------------|--------------------|----------------|----------------|
| 0 (CK)            | 11.73±0.72a   | 2.55±1.13d  | 93±0a           | 5.84±0.16b         | 119.83±1.17a   | 91.58±2.81a    |
| 60                | 8.78±0.55b    | 35±1.73c    | 65.33±1.45b     | 15.68±0.80a        | 105.54±4.33b   | 73.55±3.18b    |
| 90                | 10.79±0.33ab  | 33.13±2.03c | 67.33±1.12b     | 16.77±0.78a        | 98.5±3.18b     | 70.45±4.33b    |
| 120               | 10.14±0.67ab  | 42.25±1.45b | 57.67±2.03c     | 15.94±0.93a        | 93.59±2.78b    | 64.95±4.04b    |
| 150               | 10.41±0.63ab  | 50.17±2.60a | 49.67±2.05d     | 17.59±1.00a        | 92.64±4.06b    | 64.14±3.77b    |
| 180               | 9.95±0.10ab   | 53.22±0.88a | 47±1.73d        | 19.07±0.90a        | 79.37±2.60c    | 63.63±5.49b    |

Note: different letters in the same column indicate significant difference at the level of 0.05, while the same letter means no significant difference; the values in the table are average ± standard error, the same below.

Compared with the control, the second instar larvae of A. cinerarius were all shortened after spectral treatment, and 60 min treatment was more significant; with the extension of UV irradiation time, the mortality of the 2nd instar larvae increased significantly, but the control was the lowest; the pupation rate showed a downward trend, and the pupation rate of 60-180 min treatment was significantly different from that of the control, especially the pupation rate of the 2nd instar larvae was the lowest under 150 min and 180 min treatments; there was no significant increase in the rate of abnormal pupae, and the difference was significant with the control; the pupa weight of the control was the heaviest, with the increase of treatment time, the pupa weight showed a downward trend, and the pupa treated with 180 min was the lightest; with the increase of irradiation time, the pupa emergence rate of geometrid cinerarius decreased gradually, which was significantly different from that of the control (Table 1).
3.1.2 Effects on 5th instar larvae

Table 2: Effects of different radiation time on growth and development of 5th instar larvae

| Radiation time/min | Larval stage/d | mortality/% | Pupation rate/% | Abnormal pupa rate/% | Pupa weight/mg | Eclosion rate/% |
|--------------------|---------------|-------------|-----------------|---------------------|----------------|-----------------|
| 0 (CK)             | 4.93±0.35a    | 3.33±1.67b  | 96.67±1.67a     | 8.4±0.50b           | 126.78±4.92a  | 89.95±2.31a     |
| 60                 | 3.89±0.10a    | 15.33±1.76a | 85±2.89b        | 28.75±0.70a         | 115.75±3.83ab | 87.76±3.47a     |
| 90                 | 4.36±0.36a    | 12.67±1.45a | 88±2.31b        | 29.28±1.09a         | 104.28±6.93b  | 77.91±5.77ab    |
| 120                | 4.05±0.11a    | 13.33±2.03a | 87±1.73b        | 30.13±0.78a         | 98.78±5.20b   | 77.23±4.05ab    |
| 150                | 3.87±0.48a    | 17.67±1.45a | 83±2.72b        | 30.18±0.86a         | 96.38±4.91b   | 73.64±2.96ab    |
| 180                | 4.7±0.41a     | 16.67±1.67a | 84±1.15b        | 32.18±1.05a         | 94.19±3.47b   | 67.93±2.63b     |

Table 2 shows that there is no difference between the 5th instar gray looper larva stage treatments and the control. The reason may be related to the 5th instar larvae's strong resistance. The difference in mortality under 60~180min treatment was at the same level, and the mortality did not change significantly with the prolonged exposure time, but they were significantly different from the control.

The performance trends of pupation rate and abnormal pupation rate are the same as mortality. With the extension of the treatment time, the pupal weight gradually decreased, and the pupal weight of 90~180min treatment was significantly different from that of the control; the emergence rate was the lowest when the treatment was 180min; the 5th instar larvae had stronger resistance to stress.

3.1.3 Impact on adult lifespan

Table 3: The effect of radiating the second instar larvae at different times on the lifespan of adults

| treat (min) | Female (d) | Male (d) |
|------------|------------|----------|
| 0 (CK)     | 8.47±0.79a | 9.33±0.88a |
| 60         | 6.33±0.88b | 7.67±0.88ab|
| 90         | 6.03±0.26b | 8.9±0.10ab |
| 120        | 5.7±0.17b  | 6.76±0.39b|
| 150        | 4.8±0.25b  | 6.38±0.36b|
| 180        | 4.7±0.57b  | 6.5±0.36b |

Table 3 shows that spectral treatment of the second instar larvae has a certain impact on the life span of adults. The treatment with 150min and 180min differed significantly from the control. There was no significant difference in the lifespan of males in 60~180min treatments, and the lifespans of males in each treatment were higher than that of females.

Table 4: Effects of 5th instar larvae irradiated at different times on the lifespan of adults

| treat (min) | Female (d) | Male (d) |
|------------|------------|----------|
| 0 (CK)     | 8±1.15a    | 9±1.15a  |
| 60         | 5.98±0.54ab| 7.85±0.20ab|
| 90         | 6.08±0.33ab| 6.3±0.35b |
| 120        | 5.67±0.33ab| 5.8±0.42b|
| 150        | 4.55±0.58b | 5.33±0.88b|
| 180        | 4.02±0.77b | 5.67±0.33b|

After the 5th instar larvae were irradiated with ultraviolet light, with the extension of the treatment time, the life span of both the male and female adults did not decrease significantly (Table 4).
3.1.4 Impact on female worms laying eggs

Table 5: The effect of radiating 2nd and 5th instar larvae at different times on the egg laying rate of adults

| treat (min) | Female (d)        | Male (d)         |
|------------|-------------------|------------------|
| 0 (CK)     | 100±16.02a        | 95±2.89a        |
| 60         | 96.63±4.62a       | 84.74±5.86ab    |
| 90         | 100±6.66a         | 80.47±4.81ab    |
| 120        | 91.67±5.69a       | 74.50±7.69ab    |
| 150        | 61.11±5.86b       | 76±4.33ab       |
| 180        | 43.33±4.36b       | 63±6.33b        |

Table 5 shows that the treatment of 2nd and 5th instar larvae has a certain effect on the egg laying rate of adults. The spawning rate of 2nd instar larvae dropped sharply after treatment, and the oviposition rate decreased most significantly when treated with 180 min, which was 56.7% lower than that of the control. Under the 5th instar treatment, only the 180 min treatment was significantly different from the control, and there was no difference between other treatments and the control. It can be seen that the longer the treatment time, the lower the egg-laying rate of females, especially the decline rate in the 2nd instar stage is more significant than that in the 5th instar stage.

Table 6: The effect of radiating 2nd and 5th instar larvae at different times on the amount of adult eggs laid

| treat (min) | 2 years old | 5 years old |
|------------|-------------|-------------|
|             | Single female egg production/head | Maximum egg production per female/head | Single female egg production/head | Maximum egg production per female/head |
| 0 (CK)     | 422.37±16.02a | 775     | 427.13±8.69a | 564     |
| 60         | 195.26±4.62b | 672     | 163.26±6.69b | 526     |
| 90         | 144.35±6.66c | 622     | 161.18±3.48b | 506     |
| 120        | 145.27±5.69c | 439     | 131.35±5.81c | 359     |
| 150        | 123.56±5.86cd | 365     | 122.62±5.33c | 327     |
| 180        | 107.33±4.36d | 295     | 102.37±6.94d | 210     |

Table 6 shows that the number of eggs laid by a single female decreases with the time. Under the 2-year-old treatment, there were significant differences between the two groups in 60-180 min. The oviposition amount of 60 min treatment was significantly higher than that of other treatments, and the single female oviposition amount of 180 min treatment was the lowest. Under the 5-year-old treatment, there were significant differences between the treatments of 60 min and 90 min, but there was no significant difference between the treatments of 60 min and 90 min. The egg production of single female in 180 min treatment was the lowest. The change trend of the highest egg production of single female was the same as that of single female, and showed a decreasing trend.

3.2 Effect of insect age on the growth and development of larvae under the same radiation conditions

It can be seen from Figure 1 that there is no difference in the mortality of 2nd and 5th instar larvae in the absence of UV irradiation. The mortality of 2nd instar larvae is significantly higher than that of 5th instar larvae under 60 ~ 180 min treatment. With the extension of treatment time, the mortality of 2nd instar larvae increases gradually. The results showed that the mortality caused by UV irradiation was related to the age of the insect. The lower the age, the weaker the resistance, the higher the mortality.
It can be seen from Fig. 2 that the pupation rate of the two treatments is higher, and there is no difference between them. The pupation rate of 2nd instar larvae was significantly lower than that of 5th instar larvae. The results showed that the pupation rate was greatly affected by the instar of larvae under the same UV irradiation.

Fig. 3 shows that the abnormal pupae rate of the 5th instar larvae is higher than that of the 2nd instar larvae, indicating that with the extension of irradiation time, the pupation quality of the 5th instar larvae is greatly affected, and the pupal deformity rate increases.

It can be seen from Figure 4 that the effect of different age treatments on eclosion rate is the most significant in 60 min treatment, and there is no significant difference between the control and other treatments.
Fig. 4: Effect of different radiation duration on eclosion rate

Fig. 5 shows that there is no significant difference in the life span of female adults between the two instar treatments, and the longevity of female adults of 5th instar larvae is higher than that of 2nd instar larvae at 180min treatment.

Fig. 5: Effect of different radiation duration on female adult longevity

Fig. 6 shows that the life span of male adults of 5th instar larvae is higher than that of 2nd instar larvae at 120-180 min, and the difference is most significant under 90 min treatment. The longevity of male adults of 5th instar larvae is significantly longer than that of 2nd instar larvae. It can be seen that the different UV irradiation time can shorten the life span of male adults of tea geometrid, but the effect on the larva with larger instar is relatively small.

Fig. 6: Effect of different radiation duration on male adult longevity
Fig. 7 shows that the oviposition rate of the 2nd instar larvae is higher than that of the 5th instar larvae under the treatment of 0 ~ 120min, and the oviposition rate of the 5th instar larvae is higher than that of the 2nd instar larvae under 150 ~ 180min irradiation.

![Fig. 7: Effect of different radiation duration on oviposition rate](image)

4. Conclusion

The results showed that the growth period of 2-year-old tea geometrid was shortened after spectral radiation treatment, and the mortality rate increased with the extension of treatment time. The pupation rate, pupal weight, pupal deformity rate and eclosion rate of 2-year-old cinerarius cinerarius showed a downward trend. Under the same conditions, the resistance of 5th instar larvae was stronger than that of 2nd instar larvae. The reason may be that the 2nd instar larvae have thin body wall and weak resistance. In order to reduce the harm of the geometrid, we should try to control it before the 2nd instar.

The life span of the 2nd instar larvae was higher than that of the females, and the pupation rate of the 2nd instar larvae was significantly lower than that of the 5th instar larvae. The abnormal pupae rate of the 5th instar larvae was higher than that of the 2nd instar larvae, which indicated that the 5th instar larvae had a greater impact on the pupation quality and led to the increase of pupal deformity rate. In a word, the control effect of spectral radiation on tea geometrid pests is significant, which is of great significance for the promotion of green and scientific control methods.

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