
The Life Tables of *Dactylopius Coccus Costa* (Homoptera: Dactylopiidae) at Different Temperatures and Humidities

Zhonghe Zhang

Research Institute of Resource Insects, Chinese Academy of Forestry, Kunming, China

Email address:

Zhzhang.caf@163.com

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Abstract: A laboratory study on the life tables at different temperatures and humidities of the cochineal, *Dactylopius coccus Costa*, is summarized to reveal proper culturing environment for the insect. It is found that constant temperature 19°C and 31°C are not suitable for cochineal culture while constant temperature 22°C, 25°C and 28°C are appropriate. Among them, 22°C is the most ideal temperature. In the experiments of humidity, the results show that under 90% RH, the number of the female adult of cochineal in the population is the most, and 70% RH is the next, while 50% RH is the lowest, it demonstrates that high humidity can be helpful for the insect. The main death period of the cochineal is from egg to the first instar, which death rate can be over 70%, it means that more attention should be paid to the period to decrease the death rate when the insect is cultured.

Keywords: *Dactylopius Coccus Costa*, Life Table, Temperature, Humidity, Population, Death Rate

1. Introduction

Dactylopius coccus Costa is an important insect species. Its female adults can be used to produce a natural pigment---carmines, which is extensively used in cosmetic, food, and pharmaceuticals industries. *Dactylopius coccus Costa* belongs to *Dactylopius*, Dactylopiidae, Homoptera. Its origin is in south Africa and its host plants are cactus. In China, it was introduced and bred in Yunnan and Guizhou province from the year of 2004 [1, 2, 3, 4, 6, 8, 10, 12, 13].

Dactylopius coccus Costa is a kind of coccid insect, its' female is incomplete metamorphosis insect, the life cycle of the female has four states: egg, the first instar, the second instar and adult. While its' male is complete metamorphosis insect, the life cycle of the male has six states: egg, the first instar, the second instar, pupa, pupae and adult. The male adults die quickly after mating with female adults, carmine is produced from female adult bodies.

Effects of temperature and humidity on other species of *Dactylopius* were previously studied. *D.austrinus* population number was reported to increase most quickly at 30°C [7, 10]. A *D.confusus* experimental life table was established at 22°C and 26°C [5]. *D.ceylonicus* population was studied at 18°C, 22°C, 26°C, 30°C, and 34°C [11]. A brief report was made on the biology of *D.coccus* at 80% [9], 65%, and 60% humidity

[4]. In this paper, a detailed account of *D.coccus* life tables at different temperatures and humidities is presented.

2. Material and Methods

Adult females of *D.coccus* and cladophylls of cactus *Opuntia ficus-indica* under study were put into controlled laboratory environment chambers. The type of controlled laboratory environment chambers RTOP-800D was used. The variation of temperature in these chambers was $\pm 1^\circ\text{C}$ and the variation of humidity was $\pm 7\%$. Adult females of *D.coccus* were collected from Lufeng county, 100km far away from Kunming, Yunnan province. Cladophylls of cactus *Opuntia ficus-indica* were collected from Xingyi city, Guizhou province.

Each cladophyll was enclasp on the transverse rods of controlled laboratory environment chambers by an ironwire hook. Each chamber was put into 30 cladophylls. In each cladophyll, ten adult females of *D.coccus* were first put into a small folded paper pocket. Then the paper pocket was fixed on to the cladophyll by a stud. Totally 300 adult females were put into one chamber.

The temperature experiments were started in two groups on July 7 and October 10, 2008. The temperatures of chambers were maintained individually at 19°C, 22°C, 25°C, 28°C, or

31°C. Among them, 22°C, 25°C, and 28°C experiments were started on July 7, and three chambers were used. 19°C and 31°C experiments were started on October 10 and two chambers were used. In all experiments, the humidity was set on 75%, and illumination intensity was 2600 lux.

The humidity experiments were started on April 7, 2009. Three chambers were used and the humidity of chambers was set individually at 90%, 70%, and 50%. The temperature of all the chambers was set to 25°C, and illumination intensity was 2600 lux.

At the beginning of all experiments, 30 adult females of *D. coccus* from the same insect group being put into chambers were randomly selected to be dissected to count the eggs of each female. The observed number was used as an estimated egg value per adult in the experiments.

Cochineal's morphological development has three main stages: the first instar, the second instar, and the adult stage. To study its population number dynamic at these three stages, the number of insects at each stage for a fixed number of

cladophylls was counted. In this study, 30 cladophylls are equally divided into 3 groups, 10 cladophylls per group. One group per stage is used for counting the number of cochineal insects. That means 10 cladophylls were used to count the number of the first instar, another 10 cladophylls were used for the second instar, and the remained 10 cladophylls for adults. An observation was made every 4~5 days. All new insects appeared at the observed stage were removed out of the chambers to count the number of cochineal insects at that stage. When no new insect appeared, the 10 cladophylls used to count that stage's cochineal insects were discarded.

3. Results

3.1. The Life Tables at Different Temperatures

The cochineal population number dynamics and life tables at different temperatures are summarized in table 1~2.

Table 1. The population number dynamics of *Dactylopius coccus Costa* at different temperatures.

Temperature	Number of eggs	Number of the first instar	Number of the second instar	Number of adult		
				Female adult	Male adult	sum
19°C	26800±1075	1436±218	938±230	189±37	55±17	244±52
22°C	28787±1230	7703±514	5229±453	2780±319	1604±148	4384±427
25°C	28787±1230	8583±501	3793±355	1911±199	1611±159	3522±326
28°C	28787±1230	8646±228	4801±436	1410±149	1355±155	2765±280
31°C	26800±1075	2031±257	795±160	0±0	0±0	0±0

Note: The datum in the table are mean±standard error of the mean ($\bar{x} \pm \text{SEM}$).

Table 2. The life tables of *Dactylopius coccus Costa* at different temperatures.

Temperature	egg			First instar			Second instar			Adult			Female adult
	l_x	d_x	q_x	l_x	d_x	q_x	l_x	d_x	q_x	l_x	d_x	q_x	l_x
19°C	26800	25364	0.95	1436	498	0.35	938	694	0.74	244	55	0.23	189
22°C	28787	21084	0.73	7703	2474	0.32	5229	845	0.16	4384	1604	0.37	2780
25°C	28787	20204	0.70	8583	4790	0.56	3793	271	0.07	3522	1611	0.46	1911
28°C	28787	20141	0.70	8646	3845	0.44	4801	2036	0.42	2765	1355	0.49	1410
31°C	26800	24769	0.92	2031	1236	0.61	795	795	1.00	0	0	0	0

Note: l_x ----- live number; d_x -----number of death; q_x -----rate of death.

3.1.1. Egg to the First Instar

In the experiments of 22°C, 25°C, 28°C, the average eggs per adult are 287.87, which means there are 28787 eggs in the adults of 10 cladophylls. In 22°C, the total number of the first instar of 10 cladophylls is 7703, the death rate in the egg period is 73%. In 25°C, the total number is 8583, the death rate is 70%. While in 28°C, the total number is 8646, the death rate is also 70%. In the experiments of 19°C and 31°C, the average eggs per adult are 268.00, i.e, there are totally 26800 eggs in the adults of 10 cladophylls. In 19°C, the total number of the first instar of 10 cladophylls is 1436, the death rate is 95%. While in 31°C, the total number is 2031, the death rate is 92%.

3.1.2. The First Instar to the Second Instar

In 22°C, the total number of the second instar of 10 cladophylls is 5229, the death rate in the first instar period is 32%. In 25°C, the total number is 3793, the death rate is 56%.

While in 28°C, the total number is 4801, the death rate is 44%. In 19°C, the total number of the second instar of total 10 cladophylls is 938, the death rate is 35%. While in 31°C, the total number is 795, the death rate is 61%.

3.1.3. The Second Instar to Adult

In 22°C, the total number of adults of 10 cladophylls is 4384, the death rate in the second instar period is 16%. In 25°C, the total number of adults is 3522, the death rate is 7%. While in 28°C, the total number is 2765, the death rate is 42%. In 19°C, the total number of adults of total 10 cladophylls is 244, the death rate in the second instar is 74%. While in 31°C, the total number is 0, the death rate is 100%.

3.1.4. Female Adult

In 22°C, the number of the female adult of total 10 cladophylls is 2780, while the male is 1604, the death rate is 37% for all the male die after mating. In 25°C, the number of female is 1911, male is 1611, the death rate is 46%. While in

28°C the number of female is 1410, male is 1355, the death rate is 49%. In 19°C, the number of female adult is 189, male is 55, the death rate is 23%.

3.2. The Life Tables at Different Humidities

The cochineal population number dynamics and life tables at different humidities are summarized in table 3~4.

Table 3. The population number dynamics of *Dactylopius coccus* Costa at different humidities.

Relative Humidity	Number of eggs	Number of the first instar	Number of the second instar	Number of adult		
				Female	Male	sum
50%	22767±708	5514 ±262	1595 ±245	393 ±92	665±92	1058 ±159
70%	22767±708	4766±218	2734±133	934 ±51	893±51	1827±70
90%	22767±708	6675±290	3579± 184	1059 ±61	1245 ±88	2304 ±106

Note: the datum in the table are mean±standard error of mean ($\bar{x} \pm \text{SEM}$).

Table 4. The life tables of *Dactylopius coccus* Costa at different humidities.

Temperature	egg			First instar			Second instar			Adult			Female adult
	l_x	d_x	q_x	l_x	d_x	q_x	l_x	d_x	q_x	l_x	d_x	q_x	l_x
50%	22767	17253	0.76	5514	3919	0.71	1595	537	0.34	1058	665	0.63	393
70%	22767	18001	0.79	4766	2032	0.43	2734	907	0.33	1827	893	0.49	934
90%	22767	16092	0.71	6675	3096	0.46	3579	1275	0.36	2304	1245	0.54	1059

Note: l_x ----- live number; d_x -----number of death; q_x -----rate of death.

3.2.1. Egg to the First Instar

In the experiments of humidity, the average eggs per adult are 227.67, which means totally 22767 eggs in the adults of 10 cladophylls. In 50% relative humidity, the number of the first instar of total 10 cladophylls is 5514, the death rate in the egg period is 76%. In 70% relative humidity, the number of the first instar is 4766, the death rate is 79%. While in 90% relative humidity, the number of the first instar is 6675, the death rate is 71%.

3.2.2. The First Instar to the Second Instar

In 50% relative humidity, the number of the second instar of total 10 cladophylls is 1595, the death rate in the period of the first instar is 71%. In 70% relative humidity, the number of the second instar is 2734, the death rate is 43%. While in 90% relative humidity, the number of the second instar is 3579, the death rate is 46%.

3.2.3. The Second Instar to Adult

In 50% relative humidity, the number of adult of total 10 cladophylls is 1058, the death rate in the period of the second instar is 34%. In 70% relative humidity, the number of adult is 1827, the death rate is 33%. While in 90% relative humidity, the number of adult is 2304, the death rate is 36%.

3.2.4. Female Adult

In 50% relative humidity, the number of the female adult of total 10 cladophylls is 393, the death rate in the period of adult is 63% for the death of male after mating. In 70% relative humidity, the number of female adult is 934, the death rate is 49%. While in 90% relative humidity, the number of female adult is 1059, the death rate is 54%.

4. Discussion

In the temperature experiments, the number of the first instar, second instar and adult in Table 1 demonstrate that 19°C and 31°C are obviously not suitable for cochineal

culture. At 19°C, only a few of adults can be developed. While at 31°C, no adults can be developed. Constant 22~28°C can be selected to culture the insect.

Among the 22°C, 25°C, and 28°C, the results of survival number of female adult and death rate of the second instar as well as the number of female adult show that 22°C is the most appropriate temperature for culturing cochineal. This conclusion is contradictory to a previous report that 25°C is the most appropriate temperature for cochineal culturing [8].

In the humidity experiments, the numbers of the second instar and adult increase with increased relative humidity. The number of 90% RH is the largest. That means high humidity is helpful for hatching and culturing of cochineal.

In the all experiments, cochineal death mainly appeared in the period from egg to the first instar, the death rate can be over 70% percentage. It means that more attention should be paid to the period to decrease the death rate when the insect is cultured.

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