6. EFFECTS OF HUMIDITY, TEMPERATURE, AND LIGHT ON THE GROWTH AND DEVELOPMENT OF *CHILOTRAEA POLYCHRYSA* (MEYRICK) AND *TRYPORYZA INCERTULAS* (WALKER)*

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Introduction

To successfully mass rear an insect, in general, considerable basic knowledge of environmental effects on growth and development is necessary. When a mass rearing programme of rice stem borers was initiated in the Department of Entomology and Plant Pathology, Kasetsart University, it was faced with many difficulties due to the lack of such basic information. A recent review of the available literatures (2, 5, 8) revealed that little work has been done on the effect of humidity, temperature, and light on the growth and development of various stages of rice stem borers. Among these limited works, most investigators put more emphasis on *Chilo suppressalis* (Walker) [1, 3, 4, 11, 13], less on *Tryporyza incertulas* (Walker) [6, 7, 12] and almost none on *Chilotraea polychrysa* (Meyrick). In addition, almost all works were confined in temperate climate areas, and very little in tropical zones.

This paper presents information on effects of temperature, humidity, and light on the growth and development of eggs, larvae, pupae, and adults of *C. polychrysa* and *T. incertulas* in laboratory studies. The two species are considered to be the most important rice stem borers in Thailand.

Materials and Methods

Breeding stock of the borers was obtained by capturing adults from light traps and rearing them continuously from generation to generation on rice plants of the variety Luang Yai in an insect proof greenhouse. They were used for a variety of tests reported in this paper.

In collecting egg masses, the adult moths were confined in large glass jars and were allowed to deposit eggs freely on rice leaves in the jars. The use of large paper ice cream containers for the oviposition of adult moths also proved advantageous because individual egg masses, laid on the inner side of the containers could be cut and used for the study.

Careful selection of egg masses for hatchability tests was exercised to minimize variable factors such as size and age. The egg masses attached on the paper strips were placed in $0.5 \times 5''$ test tubes, one mass per tube, and were covered with pieces of fine mesh brass screen to prevent the newly emerged larvae from escaping. The tubes containing egg masses were then exposed to the test conditions. Results of the number of hatch and incubation period were recorded once daily in all tests.

For larval growth and development studies, newly hatched larvae of one day old were released into cut-rice stems in 1×7.5 inches test tubes at the rate of one larva

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per stem per tube, and were covered with sheets of fine mesh brass screen. Changing for fresh rice stems of uniform size and age was made twice weekly using rice of the variety Luang Yai 34. Larvae were exposed to the test conditions and were examined once a week for the weights of larvae and pupae, pupation rates, and percentages of pupation.

Standard condition for larval rearing in order to obtain uniform pupae and adults was obtained by maintaining the rearing room at 27 ±1°C and 51–61% RH. Ten larvae with thirty pieces of cut rice stems were placed per 2.5 × 6 inch wide mouth glass jar and were covered with a petri dish. A small amount of water was applied by spraying just enough to wet the bottom surface of the jars. The larvae received fresh rice stems twice weekly until they reached the pupal stage. Full grown larvae were removed from rearing jars and were allowed to pupae in petri dishes. Where adults were required for tests, the pupae were exposed to high humidity (95%) in moisture chambers until the adults emerged.

Moisture chambers used for humidity studies were 8 × 8 inches wide mouth glass jars containing KOH solution to obtain the desired humidity. Solomon's methods of calibration and estimation of percent RH were followed closely (9, 10). Small glass bowls were used to support test tubes containing insects in order to prevent them from falling into the solutions. The chambers were covered with glass plates. All tests for the effect of temperature were performed in BOD cabinets. Experiments on pupal and adult stages were performed in 1 × 7.5 inch test tubes. Pupae and adults were tested singly for emergence and longevity, while individual pairs were caged to determine egg production.

To determine the effect of fluctuations in environmental conditions, experiments were conducted in a room with temperature, atmospheric moisture, and light intensity maintained at 27 ±1°C, 50–61% RH, and 10 foot-candles, respectively. An equal set of insects were held in another room where temperature, humidity and light were not controlled and dependent on the natural daily fluctuations from the outside. October and December were selected for the time to perform the tests because both months provided relatively daily constant fluctuation of temperature and humidity within the range (i.e. approximately 25–32°C and 50–61% RH) which were comparable to other tests. A space in this room was defined for the test area where the maximum daylight at the spot was measured at 10 foot-candles. When a complete continuous darkness condition (0 foot-candle) was required, a cabinet lining with black cardboard paper inside was used.

Results and Discussions

Egg stage. Results of the experiments on the effects of humidity, temperature, and light on the egg stage of the test species are shown in tables 1–3, and figures 1–3. Doke (1) reported that *C. suppressalis* and *T. incertulas* require 90 to 100% RH for egg hatching and it is severely reduced below 70% RH. The results in this experiment indicated the same trend of humidity effect on eggs of *T. incertulas* and *C. polychrysa* (table 1, figure 1). The percentage of incubation was increased by the increasing of humidity and the relationship between the two factors was significance and linear (r=0.90). Hatching of eggs of *T. incertulas* under high humidity was best when they were treated at early stages, i.e. 1–2 days old. Percentages of hatch were lower when the eggs were three days old (table 2, figure 2). Although the data indicated a tendency to prolong incubation period of eggs by low humidity, this effect was slight.

Light affected the duration of hatch considerably and the two species responsed to light differently. Under optimum temperature at 27 ±1°C, the hatching period of *C. polychrysa* eggs was prolonged by light while with *T. incertulas* eggs, light had a

Table 1. Hatchability of eggs of *C. polycyrysa* and *T. incertulas* as affected by humidity under indicated temperature and light conditions.[1)]

RH %	27±1°C						25-32°C					
	10 ft c.			0 ft c.			0-10 ft c.			0 ft c.		
	Hatch %	Duration (days) Range	Duration (days) Average	Hatch %	Duration (days) Range	Duration (days) Average	Hatch %	Duration (days) Range	Duration (days) Average	Hatch %	Duration (days) Range	Duration (days) Average
	C. polychrysa											
20	5.46	8-9	8.15	13.11	7-7	7.00	5.28	5-6	5.28	0	—	—
32	21.66	8-9	8.03	36.99	7-7	7.00	31.81	5-7	5.67	11.19	6-6	6.00
50	56.37	7-8	7.51	35.55	7-7	7.00	56.02	4-6	5.08	40.47	6-7	6.01
69	79.46	7-8	7.64	84.36	6-7	6.63	88.07	5-5	5.00	81.95	6-7	6.02
80	90.76	7-8	7.08	91.76	6-7	6.55	93.80	5-6	5.11	78.83	6-6	6.00
85	84.51	7-8	7.51	95.36	6-7	6.34	95.25	5-6	5.08	86.36	6-6	6.00
90	97.34	7-8	7.54	97.84	6-7	6.62	96.56	5-6	5.05	88.88	6-6	6.00
92	96.08	7-8	7.77	88.36	6-7	6.42	93.14	4-7	5.11	99.23	6-6	6.00
95	96.68	6-8	7.85	94.26	6-7	6.52	93.33	4-6	5.13	96.85	6-6	6.00
50-61*	45.15	7-8	8.00	35.53	6-7	6.48	82.16	5-6	5.20	94.51	6-6	6.00
r	0.993			0.960			0.967			0.996		
$\bar{y}$	$13.07+0.79\bar{x}$			$10.37+0.82\bar{x}$			$10.41+0.80\bar{x}$			$21.21+0.72\bar{x}$		
	T. incertulas											
20	1.45	9-10	9.31	0	—	—	3.16	8-10	8.67	0	—	—
32	2.53	9-10	9.21	0	—	—	9.49	7-10	8.44	0	—	—
50	21.23	8-9	9.0	0	—	—	25.27	7-9	8.04	9.65	10-12	11.0
69	58.84	8-9	8.39	49.18	9-10	9.75	56.84	7-8	7.50	42.41	8-9	8.62
80	88.36	7-9	8.05	84.66	8-10	9.25	87.22	7-8	7.25	79.02	8-9	8.65
85	90.24	7-9	8.00	93.13	8-10	9.30	92.78	7-8	7.50	92.15	8-9	8.30
90	90.68	7-9	8.15	92.08	8-10	8.90	89.81	7-9	7.25	91.69	8-8	8.00
92	91.56	7-9	8.20	93.10	8-10	8.45	93.02	7-9	7.25	93.14	8-9	8.35
95	92.49	8-10	8.55	92.86	8-10	9.00	95.02	7-8	7.25	92.60	8-8	8.00
50-60*	4.62	8-10	8.89	0	—	—	20.68	7-9	8.08	1.89	8-8	8.00
r	0.979			0.953			0.983			0.964		
$\bar{y}$	$27.81+0.68\bar{x}$			$34.67+0.60\bar{x}$			$25.13+0.70\bar{x}$			$33.06+0.63\bar{x}$		

1) Data based on ten egg masses per treatment, and were concluded at thirty day of the investigation.
r=correlation coefficient
$\bar{y}$=regression equation
* ambient conditions

tendency to shorten the duration.

The optimum hatching temperature for *C. suppressalis* eggs was reported by Kiritani (5) to be from 21° to 33°C and Koyama (6) stated that, the range was 24° to 29°C for *T. incertulas*. The results presented in Table 3 and Fig. 3 indicated that temperatures ranging from 24–32°C greatly affected the percentage hatch of the test

Table 2. Hatching percentages of one to three days old eggs of *T. incertulas* under 75-95% RH and 27±1°C.[1)]

R H	Ages of Eggs								
	1 day			2 days[2)]			3 days[2)]		
	Hatch	Black-Head	Unhatch	Hatch	Black-Head	Unhatch	Hatch	Black-Head	Unhatch
75	80.42	5.19	14.39	77.23	10.14	12.63	68.22	10.85	20.93
80	87.97	3.01	9.02	88.63	5.34	6.03	84.07	7.05	8.88
85	87.05	2.88	10.07	88.67	2.55	8.87	84.87	6.95	8.18
90	96.48	1.37	2.15	94.24	2.13	3.63	75.50	9.27	15.23
95	95.75	1.25	3.00	89.87	5.02	5.02	75.82	12.09	12.09

1) Data based on ten egg masses per treatment, and were concluded at thirty days of the investigation.
2) Eggs were kept in petri-dishes at 27±1°C, 50-61% RH before treatment.

Table 3. Hatchability of eggs of *C. polychrysa* and *T. incertulas* as affected by temperature under dark condition and indicated humidity.[1)]

R H %	Temp. °C	*C. polychysa*			*T. incertulas*		
		Hatch %	Duration (days)		Hatch %	Duration (days)	
			Range	Average		Range	Average
85	24	79.84	10-11	10.97	92.13	13-14	13.05
	26	96.31	8-11	9.29	85.13	10-11	10.50
	28	89.35	5-6	6.04	92.05	8-9	8.45
	30	97.98	5-6	5.85	84.54	6-6	6.00
	32	71.29	5-6	5.63	92.78	5-6	5.65
	34	49.75	5-6	5.50	12.21	6-6	6.00
r		−0.884			−0.931		
$\bar{y}$		$39.24+(-1.42)\bar{x}$			$38.6+(-1.16)\bar{x}$		
50-61	24	43.08	9-11	9.93	48.47	14-15	14.25
	26	30.50	8-13	8.61	50.89	10-12	11.00
	28	49.23	5-6	6.04	41.65	7-9	8.50
	30	63.58	5-6	5.18	42.25	6-6	6.00
	32	41.94	5-6	5.57	59.97	5-6	6.00
	34	0.00	—	—	0.00	—	—
r		−0.920			−0.964		
$\bar{y}$		$34.83+(-0.99)\bar{x}$			$34.64+(-0.74)\bar{x}$		

1) Data based on ten egg masses per treatment, and were concluded at thirty days of the investigation.
r = correlation coeffiicient.
$\bar{y}$ = regression equation.

Table 4. Growth and development of larvae of *C. polychrysa*, reared under different relative humidity, and indicated light and temperature conditions.[1]

RH %	Temp. 27±1°C						Temp. 25–32°C					
	10 ft c.			0 ft c.			0–10 ft c.			0 ft c.		
	Larval stage	Pupae		Larval stage	Pupae		Larval stage	Pupae		Larvel stage	Pupae	
	Average (days)	Weight[2] (mg.)	Pupation (%)	Average (days)	Weight[2] (mg.)	Pupation (%)	Average (days)	Weight[2] (mg.)	Pupation (%)	Average (days)	Weight[2] (mg.)	Pupation (%)
20	29.31	40.24	45.0	20.52	47.50	30.0	23.06	28.68	35.0	22.08	46.59	30.0
32	29.00	42.86	35.0	20.85	46.73	35.0	23.84	37.33	35.0	23.20	47.56	37.5
50	29.50	41.80	40.0	21.83	46.96	15.0	24.50	37.43	32.5	22.92	43.33	32.5
69	27.00	39.14	45.0	21.71	48.46	17.5	23.64	29.71	22.5	22.66	45.42	22.5
80	27.71	34.47	37.5	22.10	48.19	25.0	24.40	40.15	20.0	22.22	36.47	47.5
85	26.80	38.13	57.5	20.50	38.31	37.5	23.90	40.53	25.0	22.22	36.82	40.0
90	29.50	44.87	57.5	20.70	46.90	32.5	26.00	46.08	35.0	21.58	39.11	42.5
92	26.63	41.44	42.5	19.10	38.87	40.0	24.56	31.08	37.0	21.61	39.40	45.0
95	28.41	37.09	57.5	23.70	48.71	32.5	22.95	33.20	30.0	23.83	50.14	30.0
50–61	27.71	38.69	45.0	20.53	41.33	42.5	20.20	32.72	30.0	21.78	38.13	57.5

1) Data based on 40 larvae per treatment.
2) Average weight in mg. per pupa.

Table 5. Growth and development of larvae of *T. incertulas*, reared under different atmospheric humidity, and indicated light and temperature conditions.[1]

RH %	Temp. 27±1°C						Temp. 25–32°C					
	10 ft c.			0 ft c.			0–10 ft c.			0 ft c.		
	Larval stage	Pupae		Larval stage	Pupae		Larval stage	Pupae		Larval stage	Pupae	
	Average (days)	Weight[2] (mg.)	Pupation (%)	Average (days)	Weight[2] (mg.)	Pupation (%)	Average (days)	Weight[2] (mg.)	Pupation (%)	Average (days)	Weight[2] (mg.)	Pupation (%)
20	47.15	30.77	31.25	47.88	30.44	33.75	38.36	35.61	27.50	39.71	41.93	38.75
32	51.42	30.52	31.75	48.96	30.47	36.25	40.86	32.00	26.25	37.17	35.22	36.25
50	48.88	28.83	32.50	50.10	27.17	38.75	42.35	40.17	28.75	39.52	36.81	36.25
69	48.20	27.27	31.25	49.03	28.63	36.25	40.54	39.98	30.00	40.79	33.25	41.25
80	45.17	34.32	36.25	46.65	31.57	38.75	37.56	40.39	33.75	40.18	34.43	42.50
85	47.35	37.04	42.50	48.56	31.16	40.00	39.36	47.05	31.25	42.03	34.40	40.00
90	44.94	33.61	38.75	45.96	32.53	38.75	35.48	36.24	36.25	38.13	31.39	38.75
92	44.51	32.20	48.75	49.81	29.28	40.00	38.84	34.86	40.00	37.75	38.54	45.00
95	45.12	33.02	42.50	46.82	30.27	41.25	38.29	37.65	42.50	35.39	37.93	38.75
50–61	48.46	30.43	32.50	45.60	33.32	31.25	41.61	35.08	28.75	43.50	33.10	32.50

1) Data based on 80 larvae per treatment.
2) Average weight in mg. per one full grown larva.

species only when the eggs were incubated under high humidity (85% RH). Optimum temperature for hatching of *C. polychrysa* eggs under such conditions was 24–30°C which was a narrower range when compared with 24–32°C for *T. incertulas*, however, the threshold of development of *C. polychrysa* under high temperature seems to be higher than *T. incertulas*.

Larval stage. Iarvae grew inconsistently when reared in rice stems and exposed to different relative humidity (Tables 4, 5; Figs. 4, 5). No evidence of direct effect of the humidity was detected. Light, on the hand, lengthened the larval stage of *C. polychrysa*, but showed other effect to *T. incertulas*. The former grew larger in the total darkness while the latter prefered some light. With *C. polychrysa* when reared at 27 ±1°C under continuous illumination, the percentages of pupation were higher than those reared in total darkness in all humidities tests (Table 4, Fig. 4). Larvae of *T. incertulas*, on the other hand seemed to prefer darkness for pupation.

Lin (7) demonstrated that the rate of larval development in *T. incertulas* as positively correlated with temperature between 17° and 35°C. Results in Table 6 (Fig. 6) indicated a significant negative correlation between the temperature ranging from 24–34°C and larval stage, and between full grown larval and pupal weights of both species. Significant positive correlation between the percentage of pupation and temperature, ranging from 24–30°C for *C. polychrysa*, and 24–32°C for *T. incertulas*, was also obtained.

Table 6. Growth and development of larvae of *C. polychrysa* and *T. incertulas* reared under different temperature in the dark condition.

RH %	Temperature °C	*C. polychrysa*[1]			*T. incertulas*[2]		
		Average Larval Stage (days)	Average Pupal Weight (mg./pupa)	Pupation (%)	Average Larval Stage (days)	Average Larval Weight (mg./larva)	Pupation (%)
85	24	44.82	50.66	13.33	68.28	43.33	36.25
	26	36.02	44.49	18.33	55.03	39.59	41.25
	28	28.80	48.13	20.00	43.63	41.08	43.75
	30	23.00	30.08	25.00	29.08	39.26	48.75
	32	20.56	37.73	35.00	28.27	30.80	13.75
	34	21.16	30.45	10.00	—[3]	—	—
r		−0.942	−0.82		−0.976	−0.84	
$\bar{y}$		$39.46+(-0.36)\bar{x}$	$43.09+(-0.35)\bar{x}$		$36.07+(-0.18)\bar{x}$	$34.82+(-0.18)\bar{x}$	
50-61	24	38.90	44.34	16.67	70.97	36.10	38.75
	26	38.00	45.53	16.67	56.24	43.46	41.25
	28	26.54	30.80	26.67	40.97	37.42	40.00
	30	18.90	36.77	30.00	30.21	38.81	41.25
	32	20.27	34.08	33.33	30.47	30.67	18.75
	34	23.30	30.84	11.67	—[3]	—	—
r		−0.846	−0.79		−0.960	−0.53	
$\bar{y}$		$38.95+(-0.36)\bar{x}$	$45.68+(-0.45)\bar{x}$		$35.78+(-0.17)\bar{x}$	$34.28+(-0.17)\bar{x}$	

1) Data based on 10 larvae per treatment.
2) Data based on 80 larvae per treatment.
3) All larvae died after seven days of the experiment.
r = correlation coefficient.
$\bar{y}$ = regression equation.

Table 7. **Emergence of adult moths of *C. polychrysa* and *T. incertulas* from pupae exposed to different humidity and subjected to four different conditions.**[1)]

RH	Temp. 27±1°C						Temp. 25–32°C					
	10 ft c.			0 ft c.			0–10 ft c.			0 ft c.		
	Duration (days)	Average (days)	Emergence (%)	Duration (days)	Average (days)	Emergence (%)	Duration (days)	Average (days)	Emergence (%)	Duration (days)	Average (days)	Emergence (%)
	C. polychrysa											
20	5–9	8.08	80	7–8	7.61	75	4–8	6.19	80	6–7	6.29	75
32	6–9	7.96	90	7–9	7.77	80	5–8	6.00	80	5–7	6.37	80
50	5–9	6.49	85	6–7	6.83	80	5–7	5.78	90	5–7	6.31	80
69	5–9	6.85	95	7–8	7.38	60	4–7	5.51	95	5–8	5.81	85
80	5–10	7.36	85	7–8	7.33	95	5–8	5.72	85	6–7	6.50	80
85	6–9	7.60	100	6–8	7.11	90	5–6	5.73	75	4–8	6.10	85
90	5–8	6.60	100	6–8	6.94	90	5–8	6.28	90	5–8	6.56	85
92	6–9	7.78	95	6–8	7.39	90	5–7	5.81	90	5–8	6.80	95
95	6–10	7.63	95	7–8	7.35	85	5–7	5.89	90	5–7	5.84	95
50–61	7–10	7.91	90	6–8	7.16	95	4–8	5.67	90	6–8	6.61	75
	T. incertulas											
20	—	—	0	—	—	0	—	—	0	—	—	0
	—	—	0	—	—	0	—	—	0	—	—	0
69	—	—	0	—	—	0	—	—	0	—	—	0
80	13	13.0	5	—	—	0	—	—	0	—	—	0
85	10	10.0	5	—	—	0	—	—	0	—	—	0
90	9	9.0	5	—	—	0	—	—	0	—	—	0
92	11–13	12.0	10	—	—	0	—	—	0	—	—	0
95	8–12	10.0	80	8–12	9.71	70	8–12	9.25	80	8–11	9.27	80
50–61	—	—	0	—	—	0	—	—	0	—	—	0

1) Data were concluded at 30 days of observation.

Pupal stage. Results of the tests on pupal stages are shown in Tables 7 and 8 (Figs. 7 and 8). For *T. incertulas* humidity had a marked influence on pupal development (Table 7, Fig. 7). A high percentage emergence of adult was obtained only when pupae were exposed to 95% RH. With *C. polychrysa* the effect of humidity on emergence was not so important. Only a slight difference in the pupal period was detected when pupae were exposed to either continuous illumination or darkness. The shortest duration of the pupal stage without a reduction of the percentage of adult emergence was obtained when pupae were exposed to daily fluctuation of temperature and light. Judging from the percentage of adult emergence, pupae developed best at a temperature of 28°C for both species. The rate of pupal development increased linearly from 24 to 34°C. A similar relationship between pupal development and temperature was obtained with *C. suppressalis* (1, 3, 13).

Adults. The longevity of adult *T. incertulas* and *C. polychrysa* when exposed to 24–34°C as pupae, was prolonged by low temperatures, and there was a significant negative correlation between these two factors (Table 9, Fig. 9). Also the life span of

Table 8. Emergence and longevity of adult moths of *C. polychrysa* and *T. incertulas* from pupae exposed to different temperature under the dark condition.[1)]

RH %	Temperature °C	Emergence of Adults from Pupae			Emergence of Adult (%)	Longevity of Adults		
		Number of Insects	Duration in Days			Number of Insects	Duration in Days	
			Range	Average			Range	Average
			C. polychrysa					
85	24	40	7–14	10.54	87.5	37	3–11	6.70
	26	40	8–14	9.80	92.5	37	2–7	3.97
	28	40	5–9	7.82	97.5	39	2–6	3.36
	30	40	4–6	5.49	90.0	36	1–6	2.79
	32	40	4–6	5.39	82.5	33	1–4	2.41
	34	40	5–7	5.76	47.5	19	1–4	2.08
r			−0.922				−0.900	
$\bar{y}$			$40.23+(-1.51)\bar{x}$				$36.1+(-2.0)\bar{x}$	
50–61	24	40	7–15	10.58	87.5	37	1–9	5.43
	26	40	6–12	8.88	82.5	33	1–7	3.83
	28	40	5–9	7.36	80.0	28	1–4	2.63
	30	40	5–7	5.71	75.0	30	1–4	2.21
	32	40	5–7	5.73	72.5	31	1–4	2.23
	34	40	4–6	5.28	33.3	9	1–2	1.08
r			−0.951				−0.947	
$\bar{y}$			$41.27+(-1.69)\bar{x}$				$35.76+(-2.33)\bar{x}$	
			T. incertulas					
95	24	20	16–20	17.83	60.00	12	2–6	4.20
	26	20	9–12	11.43	70.00	14	2–6	3.90
	28	20	8–13	10.00	75.00	15	2–5	3.20
	30	20	8–10	8.71	70.00	14	2–4	2.70
	32	20	8–9	8.25	40.00	8	1–4	2.20
	34	20	7–8	7.50	20.00	4	1–4	2.00
r			−0.876				−0.991	
$\bar{y}$			$38.21+(-0.87)\bar{x}$				$47.56+(-4.14)\bar{x}$	
50–61	24	20	—	—	0	0	—	—
	to							
	34	20	—	—	0	0	—	—

1) Data were concluded at 30 days of observation.
r = correlation coefficient.
$\bar{y}$ = regression equation.

Table 9. Longevity of adult moths of *C. polychrysa* and *T. incertulas* reared under different humidity and subjected to four different conditions.[1)]

RH %	Longevity in days							
	27±1°C				25-32°C			
	10 ft c.		0 ft c.		0-10 ft c.		0 ft c.	
	Range	Average	Range	Average	Range	Average	Range	Average
	C. polychrysa							
20	2-5	2.89	1-2	1.03	1-4	2.25	1-2	1.54
32	2-8	3.20	1-3	1.41	1-4	2.44	1-3	1.82
50	1-4	2.95	1-3	1.56	2-7	3.06	1-3	2.00
69	2-7	4.44	1-3	2.14	2-5	3.07	1-5	2.50
80	3-11	5.62	1-4	2.14	2-5	3.21	1-4	2.56
85	3-8	5.90	1-4	2.86	3-5	3.60	2-4	2.65
90	3-9	6.71	1-6	3.00	2-5	3.34	1-5	2.70
92	5-10	7.27	2-6	3.11	2-7	4.26	2-7	2.88
95	4-12	7.58	2-6	3.50	2-7	4.41	1-6	3.92
50-61	2-5	3.15	1-3	1.38	2-4	2.82	1-3	1.94
r	0.934		0.968		0.891		0.874	
$\bar{y}$	$-3.65+13.88\bar{x}$		$-31.59+47.68\bar{x}$		$-77.97+34.05\bar{x}$		$-59.56+50.87\bar{x}$	
	T. incertulas							
20	1-3	1.9	1-4	2.4	1-4	2.0	1-3	1.5
32	2-4	2.6	2-4	2.9	1-3	1.6	1-3	1.6
50	1-4	2.4	1-5	3.1	1-3	2.0	1-3	1.7
69	2-5	3.1	1-5	3.4	1-3	2.0	1-3	1.7
80	2-6	4.0	1-5	3.1	1-3	2.1	1-3	2.0
85	2-6	4.1	2-5	3.7	1-3	2.2	1-4	2.2
90	2-6	3.9	2-5	3.4	1-3	2.1	1-3	2.2
92	2-5	3.5	2-5	3.8	1-3	1.9	1-3	2.1
95	2-5	3.3	2-5	3.6	1-3	2.1	1-3	1.9
50-61	2-4	3.4	2-4	3.0	1-4	2.1	1-3	1.7
r	0.870		0.899		0.557		0.871	
$\bar{y}$	$-80.41+31.40\bar{x}$		$-112.47+56.43\bar{x}$		$-111.05+89.58\bar{x}$		$-103.52+91.29\bar{x}$	

1) Data based on 20 moths per treatment.
r=correlation coefficient.
$\bar{y}$=regression equation.

Table 10. The production of eggs by individual pairs of moths of *C. polychrysa* and *T. incertulas* reared under different humidity and subjected to four different conditions.[1)]

RH %	Number of eggs per one female							
	Temp. 27±1°C				Temp. 25–32°C			
	10 ft c.		0 ft c.		0–10 ft c.		0 ft c.	
	Range	Average	Range	Average	Range	Average	Range	Average
				C. polychrysa				
20	0	0	0	0	0–15	3.0	0	0
32	0	0	0–52	21.4	0–42	8.4	0–192	40.0
50	0	0	0–17	4.6	0–80	16.0	0–170	36.2
69	0	0	0–81	35.0	0–192	46.6	0–180	52.8
80	0	0	0–125	58.0	0–193	77.8	0–64	25.4
85	0–12	2.4	0–180	83.4	112–357	240.4	14–141	65.2
90	0–45	18.4	100–350	167.4	91–510	235.2	10–256	131.0
92	0–24	7.6	23–283	103.6	0–509	153.6	34–330	180.4
95	0–123	28.4	0–384	211.8	0–93	53.2	0–79	33.8
50–61	0	0	0–18	3.6	0–48	11.0	3–73	14.6
				T. incertulas				
20 to 95	0	0	0	0	0	0	0	0
50–61	0	0	0	0	0	0	0	0

1) Data based on ten pairs of moths per treatment.

Table 11. The production of eggs by individual pairs of moths of *C. polychrysa* and *T. incertulas* reared under different temperatures in the dark condition.[1)]

RH %	Temp. °C	Number of eggs per one female moth			
		C polychrysa		*T. incertulas*	
		Range	Average	Range	Average
85	24	0–299	126.8	0	0
	26	0–208	155.8	0	0
	28	0–265	108.4	0	0
	30	0–236	51.4	0	0
	32	0–45	18.0	0	0
	34	0–0	0.0	0	0
50–61	24	0–155	40.6	0	0
	26	17–153	82.8	0	0
	28	17–153	82.8	0	0
	30	0–92	32.2	0	0
	32	0–71	18.0	0	0
	34	0–0	0.0	0	0

1) Data based on ten pairs of moths per treatment.

adults obtained from pupae held at 27 ±1°C increased linearly from 20 to 95% for *C. polychrysa,* and 20 to 90% for *T. incertulas* (Table 9, Fig. 10). A strong influence of light was also observed in adult *C. polychrysa.* They lived more than two times longer under continuous illumination as compared with total darkness. No effect of light on longevity of adults of *T. incertulas* could be detected.

Results in Tables 10–11 (Fig. 11) showed that the production of eggs of *C. polychrysa* was best at high humidity (85–92% RH), accompanied by the alternation of light and darkness, and fluctuating temperatures. The species demonstrated the requirement of the complex condition for egg production and oviposition. No proudction of eggs was obtained from adult moths of *T. incertulas* when pairing them individually and exposed to the test conditions. The requirement of environmental conditions by *T. incertulas* moths for egg production and oviposition is not known. We did not determine if the pairs had mated.

Summary

Eggs, larvae, pupae and adult moths of *Chilotraea polychrysa* (Meyrick) and *Tryporyza incertulas* (Walker) were exposed to constant temperatures, ranging from 24–34°C, daily fluctuated temperature at 25–32°C, constant relative humidities, ranging from 20–95%, daily fluctuated relative humidity at 50–61%, constant continuous light intensities at 0 and 10 foot candles, and daily fluctuated light intensity 0–10 foot candles. Their growth and development were compared.

Humidity, ranging from 20~95% greatly affected egg development and adult longevity, and their relationships were significant (positive and linear). Eggs of *T. incertulas* hatched better when they were treated with high humidity at an early age. Emergence of *C. polychrysa* was high when pupae were exposed to 20~95% RH, while emergence of *T. incertulas* was high only at 95% RH. Optimum humidity for egg production and oviposition of adult moths of *C. polychrysa* was between 85~90%.

Temperature, ranging from 24~34°C greatly affected the pupal period, percent emergence of adults, and adult longevity of the two species, and their relationships were significant, negative, and linear. Significant positive-straight line relationships were also observed between the percentage of pupation and temperature ranging from 24~32°C for *C. polychrysa* and 24~30°C for *T. incertulas.* Optimum temperatures for hatching of eggs of *C. polychrysa* and *T. incertulas* under 85% RH were between 24~30, and 24~32°C respectively.

Light, at 10 foot candles, affected *C. polychrysa* and *T. incertulas* eggs by prolonging and accelerating their hatching period. Larval period and adult longevity was extended by exposing *C. polychrysa* to continuous light but not so with *T. incertulas.*

Egg production of *C. polychrysa* was best at high humidity, fluctuating temperatures and a light-dark photoperiod.

Abstract

Eggs, larvae, pupae, and adult moths of *Chilotraea polychrysa* (Meyrick) and *Tryporyza incertulas* (Walker) were exposed to constant temperatures, ranging from 24–34°C, daily fluctuated temperature at 25–32°C, constant relative humidities, ranging from 20–95%, daily fluctuated relative humidity at 50–61%, constant continuous light intensities at 0, 10 foot candles, and daily fluctuated light intensity 0–10 foot candles, and their growth and development were compared.

Humidity, ranging from 20–95%, affected greatly the development of eggs, and adult longevity, and their relationships were significant, positive, and linear. Eggs of *T. incertulas* hatched better when they were treated with high humidity at the early age. While pupae of *C. polychrysa* developed well to adult stage under 20–95% RH,

T. incertulas developed well only at 95% RH. Optimum humidity for the egg production and oviposition of adult moths of *C. polychrysa* was between 85–90%.

Temperature, ranging from 24–34°C, affected greatly the pupal period, % emergence of adults, and adult longevity of the two species, and their relationships were significant, negative, and linear. Significant positive straight line relationships were also observed between the percentage of pupation and temperatures ranging from 24–32 for *C. polychrysa* and 24–30° for *T. incertulas.* Optimum temperatures for hatching of eggs of *C. polychrysa* and *T. incertulas* under 85% RH were between 24–30, and 24–32°C respectively.

Light, at 10 foot candles, affected by prolonging and accelerating the hatching period of eggs of *C. polychrysa* and *T. incertulas* respectively. Larval period and adult longevity was also extended by exposing to continuous light in *C. polychrysa* but, in the case of *T. incertulas,* continuous darkness inflicted the same effect. Larvae of the former showed higher preference in growth to the continuous darkness while this condition increased the percentage of pupation for the latter.

Egg production and oviposition of *C. polychrysa* moths were better when the treated conditions were provided, in addition to high humidity, with high and cool temperatures, and illumination and darkness.

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Discussion

S. A. Moiz: I failed to develop the larvae of *T. incertulas* when they were transferred to young rice plant. Could you explain your method of transferring the larvae?

S. Arrekul: We placed black head stage larvae on the young rice plants by fine camel heir brush.

Kalod: What was the age of plant for rearing the larvae of *T. incertulas*.

S. Arrekul: About one month.

Editor's note: Fig. 1–11 were omitted for convenience of press.