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Temperature and Termination of Diapause in *Epicauta
gorhami* Marseul (Coleoptera, Meloidae), with
Particular Reference to the Mechanism of
Contemporaneous Emergence

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緒 言

マメハンメヨウの成虫は8—9月に出現して土中に産卵する。ついで幼虫はイナゴやバッタの卵塊に食い入り，3回の脱皮後寄主を離れて土中に房室を作り，第5令で越冬する。そして7—8月第6令に進み，房室を更新してこの中で蛹化，羽化する。第1令を三爪虫 (triungulin)，第5令を擬蛹 (pseudopupa) といひ，他の令と劇然と形態を異にする。

成虫は1週間置きに数回産卵し，また同一卵塊からの孵化幼虫が寄主卵塊に到着するまでの日数に変異が生ずるので摂食開始期の幅は広くなる。その上次第に秋深くなつて温度が下降するため，擬蛹化期にさらに大きな遅速の差ができる。それにもかかわらず翌年の羽化はいっせいで，短期間に終る。

成虫出現の同期化はどのような仕組によって起るのであろうか。以下にその解明を試みたい。

なおマメハンメヨウに関する従来の知見の詳細は Nagatomi and Iwata⁶⁾ および永富⁵⁾を参照されたい。

本文に入るに先立ち常に御指導と御鞭撻を賜わった渋谷正健教授，有益な示唆を与えられた田島良男博士 (造林学教室)，実験上の便宜をいただいた故西郷力教授 (養蚕学および昆虫生理学教室) ならびに宮司佑三教授 (育種学および遺伝学教室) に深く感謝の意を表する。

作業仮認の設定と実験方法

マメハンメヨウ幼虫の摂食開始期と主要な変態期および第1—4令期間 (摂食開始前の寄主卵塊探索期間を含まない) と擬蛹期間を Nagatomi and Iwata⁶⁾ から引用すると第1—3表の通りとなつて，第1—4令期間が延長するとそれに続く擬蛹期間が短縮し，この結果羽化期の幅が擬蛹化期のそれよりもはるかに狭くなる事情が判然とする。

Table 1. Rate of development in *Epicauta gorhami* Marseul (at Sasayama, Hyogo-Pref. ; after Nagatomi and Iwata⁶⁾)

Year		1954-55	1955-56
Date of	start of feeding	Sept. 24-Oct. 19 (25 days)	Sept. 1-Oct. 4 (33 days)
	pseudopupation	Oct. 25-Dec. 19 (55 ")	" 18-Nov. 29 (71 ")
Date of	change into 6th instar	July 7*-July 23 (16 ")	July 13-Aug. 9 (27 ")
	pupation	" 16*- " 29 (13 ")	" 24- " 14 (21 ")
	emergence	" 25*-Aug. 7 (13 ")	Aug. 2- " 25 (23 ")
	emergence		
Period (days) of	1st** -4th instars	30- 61	17- 60
	5th instar (pseudopupa)	217-268	230-310
	6th instar	6- 10	5- 12
	pupa	7- 10	6- 11
No. of individuals		31	28

Notes : (1)* One ♀ was excluded from this table. This individual emerged on July 10 and seems to be too early one.

(2)** After the start of feeding.

Table 2. Relation of period of 1st-4th instars to that of pseudopupa in ♂ of *E. gorhami* (see Table 1)

Year	No.	Period (days)		
		1st to 4th instars	pseudopupa	total
1954-55	1	32	265	297
	2	33	252	285
	3	34	251	285
	4	34	250	284
	5	38	257	295
	6	40	248	288
	7	43	246	289
	8	43	239	282
	9	43	235	278
	10	44	241	285
	11	44	237	281
	12	49	217	266
	13	50	231	281
	14	50	230	280
	15	53	220	273
	16	?	220	?
	17	56	224	280
	18	57	225	282
	19	57	224	281
1955-56	1	19	296	315
	2	24	279	303
	3	27	289	316
	4	27	278	305
	5	27	274	301
	6	28	274	302
	7	29	272	301
	8	29	266	295
	9	30	272	302
	10	30	?	?
	11	32	267	299
	12	32	?	?
	13	34	268	302
	14	38	257	295
	15	39	267	306
	16	42	245	287
	17	49	251	300
	18	56	242	298
	19	58	230	288

第1—4令と擬蛹の両期間相互の反比例関係の原因として次の2つの場合が考えられる。(1) 第1—4令期間が直接擬蛹期間すなわち休眠の深さに影響する。いいかえれば経過代償作用が存在する。(2) 休眠からの覚醒はマメハンメヨウの場合越冬中の低温と越冬後の積算温度のみを必要とし、越冬前に接触する温度の影響をまったく受けない。とすれば休眠消去に要する温度条件は擬蛹化期の早晚とは無関係にすべての個体を通じて同一となる。

この2つの仮定のいずれが当てはまるかを明らかにするため、1963—64年と1966—67年の両度、暗状態

で第4—5表に示される温度処理をほどこした。材料は鹿児島大学構内(鹿児島市上荒田町)産で、飼育方法は永富⁵⁾に記したと同様である。

結果および考察

第6—8表に示される飼育成績(詳細は付表参照)から次の事実を知り得る。(1) 温度区D—Kの低温処理後の擬蛹期間、すなわちz期間はGを除きほぼ等しい。(2) 温度区Aのz期間はBのそれよりも長い。(3) 温度区Cのz期間はBのそれよりも短い(統計学上の有意差はない。しかし標本数が増加すればはっき

Table 3. Relation of period of 1st-4th instars to that of pseudopupa in ♀ of *E. gorhami* (see Table 1)

Year	No.	Period (deys)		
		1st to 4th instars	pseudopupa	total
1954-55	1	30	268	298
	2	31	262	293
	3	34	261	295
	4	37	257	294
	5	40	252	292
	6	43	247	290
	7	44	248	292
	8	47	239	286
	9	50	231	281
	10	52	234	286
	11	52	231	283
	12	61	?	?
1955-56	1	17	310	327
	2	25	285	310
	3	29	278	307
	4	29	?	?
	5	31	278	309
	6	45	251	296
	7	52	249	301
	8	54	242	296
	9	60	239	299

Table 4. Rearing temperature (1963-64)

Stage		2nd-4th instars	pseudopupa	
Process		x (°C)	y (°C)	z (°C)
Temperature treatment	A	25	5 (80 days)	25
	B	15	5 (80 ")	25
	C	15	15 (80 ")	25

Table 5. Rearing temperature (1966-67)

Stage		2nd-4th instars	pseudopupa			
Process		x (°C)	y (°C)		z (°C)	
			y'	y''		
Temperature treatment	D	25	→	10 (90 days)	25	
	E	15	→	10 (90 ")	25	
	F	15 (2nd-3rd instars)+10 (4th instar)	→	10 (90 ")	25	
	G	15 (2nd instar)+10 (3rd-4th instars)	→	10 (90 ")	25	
	H	25	→	10 (120 ")	25	
	I	25	→	20 (30 days)	10 (90 ")	25
	J	25	→	25 (30 ")	10 (90 ")	25
	K	25	→	25 (60 ")	10 (90 ")	25

Note : In D-H, the pseudopupa just after molt was put into 10°C at once.

Table 6. Result of rearing (see Table 4)

Temperature treatment	No. of individuals	Period (days)		
		x	z	x + z
A	3	13.1(12-14)	107.0(95-116)	120.0(109-128)
B	5	29.8(28-33)	88.2(79-93)	118.0(107-125)
C	5	26.6(25-28)	79.8(66-87)	106.4(92-115)

Table 7. Result of rearing (see Table 5)

Temperature treatment	No. of individuals	Period (days)			
		x	z	x + z	y + z
D	52	14.4(9-23)	92.5(65-110)	106.9(74-124)	182.5(155-200)
E	31	33.6(25-47)	89.1(78-100)	122.7(106-145)	179.1(168-190)
F	38	41.0(32-48)	90.1(78-102)	131.1(117-148)	180.1(168-192)
G	27	45.6(34-57)	82.9(60-99)	128.5(109-144)	172.9(150-189)
H	19	14.3(10-21)	89.6(78-104)	103.9(93-120)	209.6(198-224)
I	15	13.6(10-21)	88.7(76-97)	102.3(92-113)	208.7(196-217)
J	19	14.2(10-19)	93.2(83-104)	107.4(95-120)	213.2(203-224)
K	18	14.1(10-17)	90.7(80-101)	104.8(96-116)	240.7(230-251)

Table 8. Result of rearing (see Tables 5 and 7)

Temperature treatment	No. of individuals	♂		No. of individuals	♀	
		Period (days) of			Period (days) of	
		x	z		x	z
D	24	14.4(10-21)	92.5(80-103)	19	14.8(11-23)	94.8(76-104)
E	16	32.4(25-45)	87.9(78-98)	7	35.6(30-47)	93.3(86-98)
F	16	39.6(32-48)	88.9(78-97)	12	42.1(38-46)	93.1(85-102)
G	9	42.1(34-54)	81.7(70-91)	17	46.8(38-57)	84.9(65-99)
H	10	14.2(10-18)	86.4(78-92)	7	14.6(10-21)	94.9(90-104)
I	11	13.5(10-21)	88.7(76-97)	4	13.8(10-18)	88.8(84-93)
J	13	13.6(10-18)	90.8(83-101)	6	15.5(13-19)	98.5(90-104)
K	9	13.8(11-16)	89.0(80-101)	8	14.0(10-17)	91.6(87-101)

Table 9. Rate of individuals which reached to 6th instar

Temperature treatment	No. of individuals				(b)/(a) (%)
	examined (a)	which died at the time of pseudopupa	which stopped at pseudopupa*	which changed into 6th instar (b)	
A	12	5	4	3	25
B	11	4	1	6	55
C	6	0	1	5	83
D	63	11	0	52	83
E	34	2	0	32	94
F	41	3	0	38	93
G	31	4	0	27	87
H	20	1	0	19	95
I	20	5	0	15	75
J	23	4	0	19	83
K	24	3	0	19	86

Note : * The experiment was closed on May 28, 1964 and even if these individuals reached to 6th instar, they would be different physiologically. The date of pseudopupation was Nov. 2-7, 1963 in 4 individuals of A, Nov. 25, 1963 in 1 of B, and Nov. 17, 1963 in 1 of C. Refer to Appendixes 1-3.

りした差が生ずるかも知れない)。

(1) は次のことを意味する。(a) 擬蛹期間 ($y+z$) は第1—4令 (あるいは2—4令) 期間 (x) の相違によって変化しない。(b) 低温処理後の擬蛹期間 (z) は低温処理前の擬蛹期間 (y^1) の存在によって変動しない。もっとも温度区Gの z 期間は他の区よりも短く(統計学上の有意差がある), この説明は今のところ困難であるが, 顕著な差とはいえない。(2) は(1)と矛盾するが, 急激な温度変化 ($25^{\circ}\text{C} \rightarrow 5^{\circ}\text{C}$) に基いたと解される。(3) は 5°C — 15°C 間の温度差に原因しよう。以上の結果および考察から前述の第2仮説の实在が結論として導き出される。

諸星^{3,4)} は家蚕の研究から「発育の初期低温によって経過を延長させると次の発育期を短縮して経過を促進させいわゆる経過代償現象を現す」とする発育平衡説を提唱した。しかし少くともマメハンメヨウに関する限りこのような現象は認められないことになる。

第6—7表中の供試虫数は第6令に達した個体のみを示すが, 擬蛹時死亡, および期待以上に長く擬蛹のままとどまった虫数をかかげると第9表の通りで, 5°C 80日の接触は 10°C 90日のそれよりも脱皮6令率を低くするものようである。休眠離脱に必要な低温刺激の正確な範囲(温度とその接触期間)は不明であるが, 鹿児島地方産のマメハンメヨウの場合 5°C はやや低きに過ぎ, 一方 15°C (第6表の温度区C参照) は低温刺激作用とともに発育進行作用(morphogenesis)をもあわせ持つものようである。

マメハンメヨウ第4令幼虫を5cmの高さに土を盛った腰高シャーレ中に放った場合, 大部分シャーレ底で擬蛹化した(Nagatomi and Iwata⁶⁾)ことから, 自然下における越冬場所は地中かなり深いと想像され, もしこれが事実であれば光は休眠消去に対しなんら役割を果たし得ないことになる。

マメハンメヨウは本州, 四国, 九州に広く分布するが, 成虫出現期はいずれも7—9月, とくに8月中下旬であって, はっきりした地域差はないようである(桑山ら¹⁾)。この原因として次の2つの場合が考えられる。

(1) 長期間の低温接触によってその後の発育が促進される。(2) 温度反応に地理的変異が存在する。しかし第7表に示した温度区HとD—Gの z 期間がほぼ等しいことから(2)の公算が濃厚である。

マメハンメヨウ個体群の羽化期の幅は狭くなるとい

っても20—30日位あり, これは低温接触後の擬蛹期間(z)に生ずる個体変異に基くが, この変異は生存上重要であって, とくに分布域拡大の場合大変役立つであろう。温度反応の地理的変異は自然淘汰によって比較的短期間に達成されよう。

最後に本論文表題の範囲からやや逸脱するが, マメハンメヨウの令について思うところを述べたい。幼虫の形態は寄主卵塊探索のために適応した第1令と休眠に適応した第5令を除き基本的には同じである。Riley⁷⁾ は第2令をオサムシ幼虫形, 第3—4令をコガネムシ幼虫形, 第6令をキクイムシ幼虫形と命名したが, このような名称から印象づけられる形態上の激しい変化は実際にはない。幼虫は第1令末期から第4令初期までの寄主卵塊中の期間を除いてまったく摂食しない。そして高温(30°C)に置かれると大部分の個体が第4令から直接蛹化する(永富⁵⁾)。第4—6令は本来同一の令であろう。特別な形態変化(擬蛹化)が間に起きたため, はからずも3つの令へ分化したに過ぎないと考えられる。

摘 要

マメハンメヨウ個体群の羽化期の幅は前年の擬蛹化期の幅に比していちじるしく短くなるが, これは休眠消去に対して低温接触前の温度がまったく作用しないことに基く。つまり休眠離脱に必要な温度条件が休眠開始の早晚とは無関係にすべての個体を通じて同一になるからである。

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Summary

In *Epicauta gorhami* Marseul, the emergence period is much shorter than the pseudopupation period (see Tables 1-3). This is due to the fact that the temperature of precold season (before winter) does not operate at all upon the elimination of diapause, i. e. the temperature necessary for the termination of diapause in all of the individuals becomes equal in condition (or in start) to one another regardless of pseudopupation time (see Tables 4-9).

Appendix 1. Detail of rearing result in temperature treatment A

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo-pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Oct. 13	Oct. 26	May 3	—	—	13	110	?
2	" 20	Nov. 3	April 26	May 4	—	14	95	?
3	" 20	" 1	May 15	" 22	June 2	12	116	♀

Note : The individuals, whose sexes remained unknown, died at the time of 6th instar or pupa (as well as in Appendixes 2-11).

Appendix 2. Detail of rearing result in temperature treatment B

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo-pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Oct. 16	Nov. 16	May 5	May 13	May 24	31	91	♂
2	" 23	" 19	" 9	" 18	" 29	33	92	♀
3	" 22	" 20	" 4	" 13	" 23	29	86	♂
4	" 22	" 19	" 10	" 19	" 31	28	93	♀
5*	" 22	" 15	Feb. 11	—	—	24	8	?
6	" 20	" 17	April 24	May 1	May 12	28	79	♂

Note : * This individual was regarded as exceptional one and not included in Table 6.

Appendix 3. Detail of rearing result in temperature treatment C

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo-pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Oct. 25	Nov. 20	April 14	April 22	May 3	26	66	♀
2	" 22	" 17	May 1	May 11	" 20	26	85	♂
3	" 22	" 19	" 4	" 12	" 22	28	87	♂
4	" 22	" 19	April 27	" 4	" 15	28	80	♀
5	" 22	" 16	" 25	" 2	" 13	25	81	♀

Appendix 4. Detail of rearing result in temperature treatment D

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo- pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Sept. 19	Sept. 29	March 17-19	March 24	April 3	10	79-81*	♂
2	" 19	Oct. 1	April 4	April 12	" 22	12	95	♂
3	" 19	" 2	" 7	" 15	" 25	13	97	♂
4	" 18	" 3	March 17-19	March 26	" 7	14	75-77*	♂
5	" 19	" 3	April 13	April 19	" 30	14	102	♂
6	" 23	" 3	" 4	—	—	10	93	♀
7	" 23	" 4	" 5	April 13	April 23	11	93	♀
8	" 21	" 5	" 6	" 14	" 25	14	93	♀
9	" 21	" 5	March 31	" 8	" 19	14	87	♂
10	" 27	" 6	" 10	March 17-19	—	9	65	♀
11	" 24	" 7	April 16	April 27	May 4	13	101	♀
12	" 25	" 7	" 11	" 18	April 29	12	96	♂
13	" 27	" 7	" 6	" 12	" 22	10	91	♂
14	" 19	" 8	" 11	" 19	" 30	18	95	♂
15	" 20	" 8	" 20	" 27	May 8	18	104	♂
16	" 23	" 8	" 20	" 30	" 11	15	104	♂
17	" 23	" 8	" 12	" 20	April 30	15	96	♂
18	" 24	" 8	" 1	" 9	—	14	85	♀
19	" 24	" 8	" 26	May 3	—	14	110	♀
20	" 26	" 8	" 19	April 26	May 6	12	103	♀
21	" 27	" 8	" 6	" 13	April 24	11	90	♂
22	" 19	" 9	" 4	" 12	" 23	20	87	♂
23	" 22	" 9	" 14	" 23	May 5	17	97	♂
24	" 23	" 9	" 5	" 14	April 25	16	88	♂
25	" 23	" 9	" 3	" 11	" 22	16	86	♂
26	" 24	" 9	" 19	" 26	May 6	15	102	♂
27	" 24	" 9	" 5	—	—	15	88	♀
28	" 25	" 9	" 14	April 22	May 3	14	97	♀
29	" 26	" 9	" 5	" 12	April 22	13	88	♂
30	" 27	" 9	" 16	" 23	May 4	12	99	♂
31	" 27	" 9	" 19	" 26	" 6	12	102	♂
32	" 28	" 9	" 17	" 24	" 5	11	100	♂
33	" 23	" 10	" 7	" 15	April 27	17	89	♂
34	" 23	" 10	" 10	—	—	17	92	♀
35	" 24	" 10	" 1	—	—	16	83	♀
36	" 24	" 10	" 21	April 30	May 11	16	103	♂
37	" 26	" 10	" 11	" 18	April 29	14	93	♂
38	" 26	" 10	" 20	" 28	May 9	14	102	♂
39	" 27	" 10	" 14	" 22	" 2	13	96	♂
40	" 27	" 10	" 10	—	—	13	92	♀
41	Oct. 16	" 31	May 7	May 14	May 24	15	98	♀
42	" 19	" 31	April 29	" 7	" 18	12	90	♂
43	" 17	Nov. 3	May 6	" 13	" 23	17	94	♂
44	" 19	" 3	" 6	" 14	" 25	15	94	♂
45	" 19	" 4	" 1	" 8	" 19	16	88	♂
46	" 25	" 6	" 1	" 8	" 18	12	86	♂
47	" 23	" 7	April 28	" 6	" 17	15	82	♂
48	" 24	" 8	May 12	" 22	June 2	15	95	♂
49	" 21	" 11	April 30	" 9	May 20	21	80	♂
50	" 20	" 12	May 16	" 26	June 5	23	95	♂
51	" 23	" 12	" 8	" 16	May 26	20	87	♂
52	Nov. 6	" 22	" 11	—	—	16	80	♀

Note : * In the calculation of z period, "79-81" was regarded as 80 and "75-77" as 76.

Appendix 5. Detail of rearing result in temperature treatment E

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo-pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Sept. 19	Oct. 16	April 3	April 9	—	27	79	♀
2	" 21	" 16	" 15	" 21	May 1	25	91	♂
3	" 19	" 19	" 5	" 11	April 22	30	78	♂
4	" 21	" 19	" 19	" 27	May 7	28	92	♂
5	" 19	" 20	" 22	" 29	" 10	31	94	♂
6	" 19	" 21	" 27	May 5	" 16	32	98	♂
7	" 21	" 21	" 24	—	—	30	95	♀
8	" 19	" 22	" 12	April 26	May 6	33	82	♂
9	" 22	" 22	" 11	" 18	April 29	30	81	♂
10	" 19	" 23	" 17	" 26	May 6	34	86	♂
11	" 19	" 25	" 27	May 5	" 16	36	94	♂
12	" 21	" 25	" 25	" 3	" 14	34	92	♂
13	" 22	" 26	" 20	April 28	" 9	34	86	♂
14	" 24	" 26	" 17	" 24	—	32	83	♀
15	" 22	" 27	" 26	May 5	May 16	35	91	♂
16	" 20	" 28	" 19	—	—	38	83	♀
17	" 19	" 30	" 21	—	—	41	83	♀
18	" 19	" 30	" 28	May 5	May 16	41	90	♂
19	" 22	Nov. 1	" 19	April 28	" 9	40	79	♂
20	Oct. 5	" 1	" 29	May 5	" 15	27	89	♂
21	" 5	" 1	" 28	" 5	" 15	27	90	♂
22	" 5	" 4	May 6	" 14	" 25	30	93	♀
23	" 5	" 6	" 8	" 15	—	32	93	♀
24	" 10	" 7	" 8	" 15	May 25	28	92	♂
25	Sept. 23	" 9	" 16	" 25	June 4	47	98	♂
26	Oct. 10	" 9	" 7	" 15	May 26	30	89	♂
27	Sept. 26	" 10	" 14	" 25	June 4	45	95	♂
28	Oct. 6	" 10	" 8	—	—	35	89	♀
29	" 7	" 12	" 18	May 25	June 4	36	97	♀
30	" 6	" 15	" 24	June 2	—	40	100	♀
31	" 26	" 29	" 20	May 27	June 6	34	82	♂

Appendix 7. Detail of rearing result in temperature treatment G

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo-pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Oct. 13	Nov. 16	May 6	May 13	May 23	34	81	♂
2	" 10	" 17	" 10	" 18	" 29	38	84	♀
3	" 6	" 18	" 17	" 25	June 4	43	90	♀
4	" 9	" 18	" 17	" 25	" 4	40	90	♂
5	" 10	" 19	" 9	" 17	May 27	40	81	♂
6	" 10	" 19	" 16	" 24	June 2	40	88	♂
7	" 10	" 22	" 16	" 25	" 4	43	85	♂
8	" 10	" 22	" 22	" 30	" 9	43	91	♂
9	" 11	" 23	" 23	" 31	" 10	43	91	♀
10	" 13	" 23	" 10	" 18	May 28	41	78	♂
11	" 10	" 24	" 28	June 6	June 15	45	95	♂
12	" 11	" 25	June 2	" 11	" 22	45	99	♀
13	" 16	" 26	May 12	May 19	May 29	41	77	♂
14	" 16	" 29	" 28	June 8	June 18	44	90	♀
15	" 16	" 30	" 22	May 30	" 9	45	83	♀
16	" 17	" 30	" 4	" 11	May 21	44	65	♀
17	" 16	Dec. 2	" 22	" 31	June 11	47	81	♀
18	" 20	" 2	" 11	" 20	May 30	43	70	♂
19	" 16	" 5	" 24	June 1	June 11	50	80	♂
20	" 17	" 6	" 17	May 25	" 4	50	72	♀
21	" 16	" 7	" 28	June 7	" 18	52	82	♀
22	" 19	" 8	June 7	" 16	" 28	50	91	♀
23	" 20	" 11	" 7	" 16	" 28	52	88	♀
24	" 16	" 12	May 27	" 4	" 14	57	76	♀
25	" 22	" 12	June 8	" 17	" 28	51	88	♀
26	" 23	" 16	" 6	" 16	" 27	54	82	♀
27	" 22	" 18	May 17	May 26	—	57	60	♀

Appendix 6. Detail of rearing result in temperature treatment F

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo- pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Sept. 23	Oct. 27	May 1	May 9	—	34	96	♀
2	" 22	" 28	April 20	April 28	May 8	36	84	♂
3	" 26	" 28	" 25	May 2	" 12	32	89	♂
4	" 26	" 29	" 21	April 29	" 8	33	84	♂
5	" 23	" 31	" 28	—	—	38	89	♀
6	" 26	Nov. 1	" 29	May 6	May 17	36	89	♂
7	" 26	" 1	May 7	" 22	June 1	36	97	♂
8	" 22	" 2	" 8	" 16	May 27	41	97	♂
9	" 24	" 2	April 28	" 6	—	39	87	♀
10	" 22	" 3	May 3	" 13	May 23	42	91	♂
11	" 24	" 3	" 5	" 13	" 23	40	93	♂
12	" 26	" 3	" 8	" 16	" 27	38	96	♂
13	" 22	" 4	April 28	" 6	" 17	43	85	♂
14	" 24	" 4	May 6	" 14	" 24	41	93	♂
15	" 23	" 4	" 2	—	—	42	89	♂
16	" 26	" 4	" 8	May 16	May 27	39	95	♀
17	" 24	" 5	" 9	" 17	" 28	42	95	♂
18	" 23	" 5	April 30	" 7	—	43	86	♀
19	" 25	" 5	May 6	" 14	May 24	41	92	♂
20	" 23	" 5	" 5	" 13	" 24	43	91	♂
21	" 25	" 5	" 5	" 14	" 24	41	91	♂
22	" 26	" 5	" 8	" 15	" 25	40	94	♂
23	" 24	" 7	" 12	" 19	" 30	44	96	♂
24	" 23	" 7	" 12	" 21	June 1	45	96	♂
25	" 26	" 7	" 7	" 28	—	42	91	♂
26	" 24	" 8	" 6	" 15	May 26	45	89	♂
27	" 24	" 8	April 28	—	—	45	81	♂
28	" 26	" 8	May 3	May 12	May 22	43	86	♂
29	" 22	" 9	" 17	" 25	—	48	99	♂
30	" 24	" 9	" 7	" 15	May 26	46	89	♂
31	" 23	" 10	" 1	—	—	48	82	♂
32	Oct. 5	" 10	" 2	May 10	May 19	36	83	♂
33	Sept. 24	" 11	" 6	" 14	" 25	48	86	♂
34	" 26	" 11	" 22	" 30	June 9	46	102	♂
35	Oct. 5	" 12	" 14	" 23	" 2	38	93	♂
36	" 5	" 14	" 8	" 16	—	40	85	♂
37	" 5	" 16	" 10	" 19	May 30	42	85	♂
38	" 13	" 24	" 11	" 19	" 28	42	78	♂

Appendix 9. Detail of rearing result in temperature treatment I

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo- pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Oct. 1	Oct. 12	May 13	May 22	May 31	11	93	♂
2	" 2	" 14	" 13	" 21	" 31	12	91	♂
3	Sept. 27	" 15	" 7	" 17	" 28	18	84	♀
4	Oct. 2	" 15	" 17	" 25	June 4	13	94	♂
5	Sept. 27	" 16	" 11	" 19	May 30	19	87	♂
6	Oct. 5	" 16	" 13	" 21	" 31	11	89	♂
7	" 2	" 17	" 16	" 24	June 3	15	91	♂
8	" 5	" 17	" 14	" 21	May 31	12	89	♂
9	" 7	" 17	" 7	" 14	" 25	10	82	♂
10	" 7	" 17	" 12	" 19	" 29	10	87	♂
11	" 1	" 19	" 22	" 29	June 9	18	95	♂
12	" 7	" 19	" 20	" 29	" 8	12	93	♂
13	" 9	" 19	" 10	" 17	May 27	10	83	♂
14	" 9	" 21	" 26	June 2	June 12	12	97	♂
15	" 1	" 22	" 6	May 16	May 27	21	76	♂

Appendix 8. Detail of rearing result in temperature treatment H

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo- pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Oct. 1	Oct. 12	May 8	May 15	May 26	11	88	♂
2	Sept. 27	" 14	" 7	" 15	" 25	17	85	♂
3	" 27	" 15	" 12	" 21	" 31	18	89	♂
4	" 27	" 15	" 9	" 17	" 28	18	86	♂
5	" 29	" 15	" 15	" 24	June 3	16	92	♂
6	Oct. 5	" 15	" 13	" 20	May 30	10	90	♂
7	Sept. 29	" 16	" 11	—	—	17	87	♀
8	Oct. 3	" 16	" 15	May 21	May 31	13	91	♂
9	" 6	" 16	" 7	" 14	" 24	10	83	♂
10	Sept. 29	" 17	" 27	June 3	June 14	18	102	♂
11	Oct. 5	" 17	" 18	May 26	" 5	12	93	♀
12	" 6	" 17	" 15	" 23	" 2	11	90	♀
13	Sept. 28	" 19	" 17	" 26	" 6	21	90	♀
14	Oct. 8	" 19	" 14	" 21	—	11	87	♀
15	" 10	" 20	June 1	June 9	June 18	10	104	♀
16	" 1	" 21	May 24	May 31	" 10	20	95	♀
17	" 10	" 21	" 16	" 24	" 3	11	87	♂
18	" 10	" 21	" 14	" 21	May 31	11	85	♂
19	" 5	" 22	" 8	" 16	" 26	17	78	♂

Appendix 10. Detail of rearing result in temperature treatment J

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo- pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Sept. 24	Oct. 7	May 14	May 21	May 31	13	99	♂
2	" 28	" 8	" 17	" 23	June 2	10	101	♂
3	" 26	" 9	April 30	" 8	May 18	13	83	♂
4	" 27	" 9	May 17	" 23	June 2	12	100	♂
5	" 27	" 10	" 21	" 29	" 9	13	103	♀
6	" 28	" 10	" 9	" 16	May 27	12	91	♂
7	" 27	" 11	" 6	" 14	" 25	14	86	♂
8	" 28	" 11	" 12	" 22	" 31	13	93	♂
9	" 26	" 12	" 12	" 21	" 31	16	92	♀
10	" 28	" 12	" 24	June 2	June 12	14	104	♀
11	" 28	" 12	" 3	May 11	May 21	14	83	♂
12	" 24	" 13	" 22	June 1	June 12	19	101	♀
13	" 27	" 13	" 15	May 22	" 2	16	94	♂
14	" 28	" 13	" 22	" 29	" 7	15	101	♀
15	" 26	" 14	" 15	" 22	" 2	18	93	♂
16	" 27	" 14	" 8	" 16	May 26	17	86	♂
17	Oct. 16	" 30	" 24	June 1	June 11	15	86	♂
18	" 20	" 30	" 23	May 30	" 9	10	85	♂
19	" 17	Nov. 2	" 31	June 10	" 20	16	90	♀

[Appendix 11. Detail of rearing result in temperature treatment K

No.	Date of					Period (days) of		Sex
	change into 2nd instar	pseudo- pupation	change into 6th instar	pupation	emergence	2nd-4th instars	pseudopupa after cold treatment	
1	Sept. 25	Oct. 7	June 4	June 11	June 23	12	90	♂ ♂ ♀ ♀ ♂ ♂ ♀ ♀ ♂ ♂ ♀ ♀ ♂ ♂ ♀ ♀ ♂ ♂ ♂
2	" 28	" 8	" 8	" 15	" 25	10	93	
3	" 27	" 10	" 18	" 26	July 7	13	101	
4*	" 28	" 10	April 20	May 1	May 11	12	42	
5	" 29	" 10	June 7	June 14	June 25	11	90	
6	" 24	" 11	" 10	" 18	" 30	17	92	
7	" 26	" 11	" 3	" 12	" 23	15	85	
8	" 26	" 11	" 10	" 20	July 1	15	92	
9	" 27	" 11	" 8	" 17	June 28	14	90	
10	" 30	" 11	" 19	" 26	July 6	11	101	
11	" 25	" 12	" 18	" 29	—	17	99	
12	" 27	" 12	" 7	" 17	June 28	15	88	
13	" 27	" 12	" 6	" 14	" 25	15	87	
14	" 28	" 12	" 8	" 16	" 27	14	89	
15	" 27	" 13	" 11	" 21	July 2	16	91	
16	" 27	" 13	" 5	" 11	June 22	16	85	
17	Oct. 1	" 13	" 11	" 19	" 30	12	91	
18	" 16	" 30	" 26	July 3	July 14	14	89	
19	" 16	Nov. 1	" 19	June 28	" 8	16	80	

Note : * This individual was regarded as exceptional one and not included in Tables 7-8.