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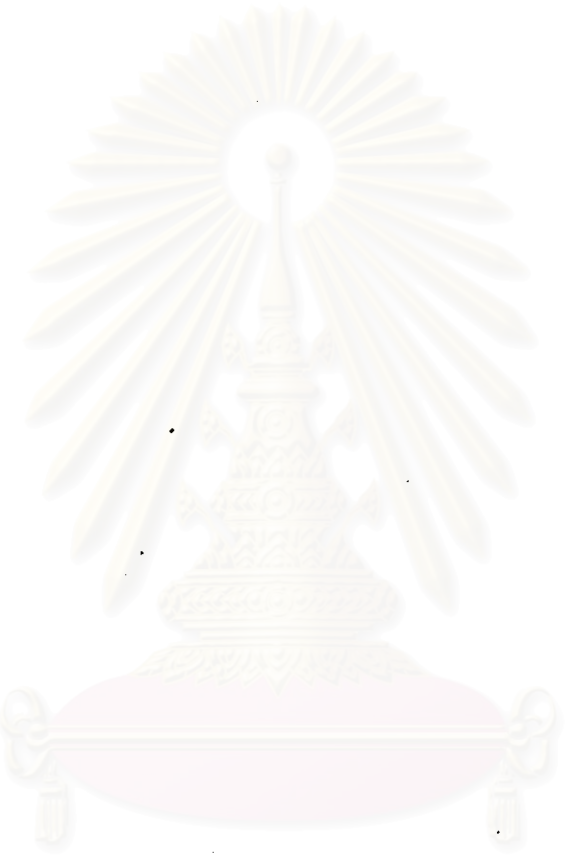

APPENDIX

APPENDIX - I

1. Meteorological data of Chiang Mai

1996

Month	Air temperature (°C)		Relative humidity (%)		Rainfall (mm)	Wind speeds (km/hour)
	Max	Min	Max	Min	Mean	
January	30.6	12.2	89.8	64.2	0.0	1.6
February	30.7	15.5	87.7	44.0	40.6	2.5
March	35.6	19.0	77.5	38.8	9.2	3.6
April	36.2	22.2	79.1	47.6	213.8	4.1
May	34.9	23.5	84.7	56.3	84.3	3.8
June	33.5	23.4	89.7	64.6	106.9	3.6
July	32.6	23.6	88.5	67.1	123.8	3.7
August	31.7	23.0	91.9	71.0	215.5	3.1
September	32.7	22.6	91.9	66.7	224.6	3.0
October	33.0	21.9	91.4	60.8	222.7	2.2
November	31.7	19.8	92.3	56.7	73.6	2.0
December	29.8	16.2	91.2	46.1	0	2.0

1997

Month	Air temperature (°C)		Relative humidity (%)		Rainfall (mm)	Wind speeds (km/hour)
	Max	Min	Max	Min	Mean	
January	30.6	12.2	89.8	64.2	0.0	1.6
February	30.7	15.5	87.7	44.0	0.0	2.6
March	35.6	19.0	77.5	38.8	6.7	3.3
April	36.2	22.2	79.1	47.6	85.7	3.6
May	34.9	23.5	84.7	56.3	64.5	3.9
June	33.5	23.4	89.7	64.6	31.1	4.2
July	32.6	23.6	88.5	67.1	211.6	3.6
August	31.7	23.0	91.9	71.0	210.6	3.1
September	32.7	22.6	91.9	66.7	135.3	2.9
October	33.0	21.9	91.4	60.8	150.1	2.1
November	31.7	19.8	92.3	56.7	30.3	2.1
December	29.8	16.2	91.2	46.1	0.0	1.6

1998

Month	Air temperature (°C)		Relative humidity (%)		Rainfall (mm)	Wind speeds (km/hour)
	Max	Min	Max	Min		
January	30.6	12.2	89.8	64.2	0.5	0.0
February	30.7	15.5	87.7	44.0	0.0	4.4
March	35.6	19.0	77.5	38.8	0.0	6.9
April	36.2	22.2	79.1	47.6	181.8	7.1
May	34.9	23.5	84.7	56.3	1.8	6.7
June	33.5	23.4	89.7	64.6	66.4	7.5
July	32.6	23.6	88.5	67.1	101.3	6.0
August	NR	NR	NR	NR	NR	NR
September	NR	NR	NR	NR	NR	NR
October	NR	NR	NR	NR	NR	NR
November	NR	NR	NR	NR	NR	NR
December	NR	NR	NR	NR	NR	NR

NR = Not Reading

APPENDIX - II

MATERIALS

Equipment

-Aluminum foil

-Beakers

-Bee suits

-Bench-top centrifuge (13,000rpm)

-Cooker

-Dark room

-Deep freezer

-Dry oven

-Eppendrof centrifuge tubes (5 ml and 50 ml)

-Forceps

-Film

-Film case

-Film developer

-Gel running tank (Model S_2 sequencing apparatus)

-Gel sealing tape (blue)

-Hot plate (heater)

-Glass plates (front and back pair)

-Knife

-Ladders

-Nitrogen tank

-Paster pipette man (0.5 , 1.0, 2.0 and 50 µl)

-Polymerase chain reaction machines (PCR Hybaid omnigene)

-Plastic mesh (sheets)

-Refrigerators

-Sate sticks (wooden)

-Scalper

-Scapula

-Scissors

-Spinders (Magnetic stirrer model sigma 112)

-Stop watch (laboratory)

-String

-Syringe

-Tape

-Thermometers

-Tissue papers

-Tray (metal)

-Vinyl sharktooth combs (0.35mm)

-Water bath

-X-ray film

Chemicals

-Acrylamide (6%)

-Adhesive glue

-Alcohol (70-90%)

-Ammonium persulfate (10%)

-Acetic acid (10% 300 μl)

-Blue dye (bromophenol blue marker)

-Buffer (T^{th}×10 reaction)

-Chelex® resin (5%, 5 grams)

-Cold primer I A88 non radioactive labeled

-Cold II B124 non radioactive labeled

-Denaturing acrylamide mix (5×TBE)

-Deoxynucletides (dNTPs)

-Distilled water (dH_2O)

-Dry ice

-Ethonal (90%)

-Hot primer I A88 non radioactive labeled

-Hot primer II B124 non radioactive labeled

-γ^{33}P-ATP nucleotides (Ci $mmol^{-1}$)

-γ ^{33}P-dATP (radio active)

-Liquid nitrogen

-$MgCl_2$ (1.5 mM)

-Mineral oil

-NH_4Ps (10%)

-N'N'N'N' tetra methyl ethylenediamine (TEMED)

-One phor all buffer (10×PNK)

-Polynucleotide kinase (T_4 PNK)

-Primers A88, A14 and B124

-Radio active (γ^{33}P)

-Saline (13.00 µl)

-Taq+ plus polymerase

-T_4 polynucleotide kinase (Pharmacia)

-Urea

-0.1 M TE

APPENDIX - III

IIIa. Chelex® preparation protocol

Reagents Added	Amount (µl)
Chelex®	5.00 gm
Buffer (0.1 M TE buffer pH 7.5)	100.00 ml

IIIb. Preparation of ammonium persulfate

Reagents Added	Amount
Ammonium persalfate	1.00 gm
MQ H_2O	10.00 ml

IIIc. Silane Preparation

Reagents Added	Amount (µl)
Silane	13.00 µl
Acetic acid (10%)	130.00 µl
Ethanol	5.00 ml

APPENDIX - IV

Control DNA Sequence

The control DNA from bacteriophage M13mp 18, a single strand circular DNA of 7.3.Kb. A partial sequence of this DNA beginning at the priminng site given below (19).

```
                G  TTTTCCCAGT  CACGAC →                                  0          10
AACGCCAGGG  TTTTCCCAGT  CACGACGTTG  TAAAACGACG  GCCAGTGCCA  AGCTTGCATG
        20          30          40          50          60          70
CCTGCAGGTC  GACTCTAGAG  GATCCCCGGG  TACCGAGCTC  GAATTCGTAA  TCATGGTCAT
        80          90         100         110         120         130
AGCTGTTTCC  TGTGTGAAAT  TGTTATCCGC  TCACAATTCC  ACACAACATA  CGAGCCGGAA
       140         150         160         170         180         190
GCATAAAGTG  TAAAGCCTGG  GGTGCCTAAT  GAGTGAGCTA  ACTCACATTA  ATTGCGTTGC
       200         210         220         230         240         250
GCTCACTGCC  CGCTTTCCAG  TCGGGAAACC  TGTCGTGCCA  GCTGCATTAA  TGAATCGGCC
       260         270         280         290         300         310
AACGCGCGGG  GAGAGGCGGT  TTGCGTATTG  GGCGCCAGGG  TGGTTTTTCT  TTTCACCAGT
       320         330         340         350         360         370
GAGACGGGCA  ACAGCTGATT  GCCCTTCACC  GCCTGGCCCT  GAGAGAGTTG  CAGCAAGCGG
AvaII  380         390         400         410         420         430
TCCACGCTGG  TTTGCCCCAG  CAGGCGAAAA  TCCTGTTTGA  TGGTGGTTCC  GAAATCGGCA
       440         450         460  AvaI   470         480         490
AAATCCCTTA  TAAATCAAAA  GAATAGCCCG  AGATAGGGTT  GAGTGTTGTT  CCAGTTTGGA
       500         510         520         530         540         550
ACAAGAGTCC  ACTATTAAAG  AACGTGGACT  CCAACGTCAA  AGGGCGAAAA  ACCGTCTATC
       560  DraIII 570         580         590         600         610
AGGGCGATGG  CCCACTCAGT  GAACCATCAC  CCAAATCAAG  TTTTTTGGGG  TCGAGGTGCC
       620         630         640  BanII  650         660         670
GTAAAGCACT  AAATCGGAAC  CCTAAAGGGA  GCCCCCGATT  TAGAGCTTGA  CGGGGAAAGC
NaeI   680         690         700         710         720         730
CGGCGAACGT  GGCGAGAAAG  GAAGGGAAGA  AAGCGAAAGG  AGCGGGCGCT  AGGGCGCTGG
       740         750         760         770         780         790
CAAGTGTAGC  GGTCACGCTG  CGCGTAACCA  CCACACCCGC  CGCGCTTAAT  GCGCCGCTAC
       800         810         820         830         840         850
AGGGCGCGTA  CTATGGTTGC  TTTGACGAGC  ACGTATAACG  TGCTTTCCTC  GTTGGAATCA
```

APPENDIX -V

A particular window of Health Care Center Building (HCC)

1. Colony-1993

	Microsatellite locus			
	A88		A14	
Queen allele:1	99		167	
Queen allele:2	103		165	
Worker-1	99	103	167	169
Worker-2	-	-	165	169
Worker-3	-	-	167	169
Worker-4	103	105	-	-
Worker-5	103	109	167	168
Worker-6	103	109	165	167
Worker-7	103	105	167	168
Worker-8	103	105	167	171
Worker-9	99	105	167	169
Worker-10	99	105	165	169
Worker-11	103	105	165	167
Worker-12	94	99	165	167
Worker-13	103	105	165	168
Worker-14	99	99	167	171
Worker-15	99	99	165	168
Worker-16	103	105	167	167
Worker-17	103	105	167	167
Worker-18	103	103	167	169
Worker-19	99	99	167	169
Worker-20	99	103	167	169

2. Colony-1995

	Microsatellite locus			
	A88		A14	
Queen allele:1	94		167	
Queen allele:2	111		171	
Worker-1	-		169	171
Worker-2	-	-	169	171
Worker-3	103	111	169	171

	Microsatellite locus			
	A88		A14	
Worker-4	-	-	168	171
Worker-5	94	101	-	-
Worker-6	-	-	167	171
Worker-7	94	101	167	167
Worker-8	92	111	167	171
Worker-9	97	111	167	169
Worker-10	94	107	167	169
Worker-11	105	111	167	171
Worker-12	94	99	165	167
Worker-13	94	101	169	171
Worker-14	92	94	167	167
Worker-15	97	111	-	-
Worker-16	99	111	165	171
Worker-17	94	95	167	169
Worker-18	107	111	167	169
Worker-19	94	107	169	171
Worker-20	94	101	169	171

3. Colony–1996

	Microsatellite locus			
	A88		A14	
Queen allele:1	96		165	
Queen allele:2	108		172	
Worker-1	96	108	165	170
Worker-2	96	96	165	165
Worker-3	104	108	165	172
Worker-4	104	108	165	172
Worker-5	-	-	165	172
Worker-6	98	108	165	167
Worker-7	100	108	165	165
Worker-8	96	100	165	173
Worker-9	-	-	165	172
Worker-10	96	98	165	165
Worker-11	104	108	165	165
Worker-12	102	108	-	-
Worker-13	96	100	165	172
Worker-14	96	102	165	172
Worker-15	104	108	165	172
Worker-16	96	100	165	173

	Microsatellite locus			
	A88		A14	
Worker-17	96	98	-	-
Worker-18	93	108	165	167
Worker-19	96	98	165	172
Worker-20	96	96	165	165

4. Colony–1997

	Microsatellite locus			
	A88		A14	
Queen allele: 1	87		169	
Queen allele: 2	109		171	
Worker-1♣	102	147	169	165
Worker-2	87	127	169	171
Worker-3	87	102	171	165
Worker-4	87	109	169	171
Worker-5	87	117	169	171
Worker-6	87	109	169	171
Worker-7	87	109	171	171
Worker-8	87	117	171	173
Worker-9	87	109	169	171
Worker-10	87	109	169	171

♣ worker-1 has been shared any locus from her mother which seems unlikely. Therefore, it has been discarded considering sample error.

5. Colony-1998

	Microsatellite locus			
	A88		A14	
Queen allele 1	109		171	
Queen allele 2	117		173	
Worker-1	117	124	171	165
Worker-2	117	124	171	167
Worker-3	117	102	171	171
Worker-4	109	109	173	169
Worker-5	109	117	171	169
Worker-6	109	92	171	173
Worker-7	109	109	171	171
Worker-8	109	109	171	171
Worker-9	109	117	171	165
Worker-10	109	102	171	171
Worker-11	109	117	173	165

APPENDIX-VI

Aggregated colonies on single supports

1. Water tower of Maejo University colony-1

	Microsatellite locus			
	A88		A14	
Queen allele 1	99		164	
Queen allele 2	118		169	
Worker-1	118	103	164	169
Worker-2	99	109	169	166
Worker-3	99	103	164	164
Worker-4	99	99	169	166
Worker-5	99	103	169	169
Worker-6	99	109	164	171
Worker-7	118	103	164	169
Worker-8	118	109	164	167
Worker-9	118	103	169	171
Worker-10	118	109	164	171
Worker-11	99	103	169	167
Worker-12	99	97	164	169
Worker-13	99	103	164	169
Worker-14	99	103	169	167
Worker-15	99	103	164	169
Worker-16	99	118	164	169
Worker-17	118	97	164	169
Worker-18	118	103	164	167
Worker-19	118	103	169	169
Worker-20	99	103	169	169
Worker-21	118	103	169	169
Worker-22	99	97	169	167
Worker-23	99	97	169	169
Worker-24	118	109	164	167
Worker-25	118	103	169	171
Worker-26	99	109	169	167
Worker-27	118	109	164	167
Worker-28	118	97	169	169
Worker-29	99	99	169	166
Worker-30	99	103	169	167
Worker-31	99	103	164	164
Worker-32	118	109	169	167

	Microsatellite locus			
	A88		A14	
Worker-33	99	109	169	167
Worker-34	118	109	164	164
Worker-35	99	103	164	167
Worker-36	118	103	164	164
Worker-37	99	103	164	169
Worker-38	99	103	164	169
Worker-39	118	103	164	169
Worker-40	99	103	164	171
Worker-41	118	103	164	169
Worker-42	118	97	164	167
Worker-43	118	103	164	167
Worker-44	118	103	164	169
Worker-45	118	103	164	169
Worker-46	99	109	169	167
Worker-47	99	109	169	171
Worker-48	99	109	169	171
Worker-49	99	97	164	167
Worker-50	99	103	164	169
Worker-51	118	103	164	164
Worker-52	118	103	164	167
Worker-53	118	103	164	169
Worker-54	118	109	169	171
Worker-55	99	118	164	166
Worker-56	99	118	169	167
Worker-57	99	109	164	166
Worker-58	118	103	164	169
Worker-59	118	118	169	167
Worker-60	118	109	169	171
Worker-61	99	103	169	171
Worker-62	118	97	169	169
Worker-63	99	103	169	167
Drone 64	99	103	164	164
Worker-65	99	95	169	167
Worker-66	99	99	164	169
Worker-67	118	97	164	167
Worker-68	99	95	164	169
Worker-69	118	109	164	171
Worker-70	99	103	169	171
Worker-71	118	118	164	169

2. Water tower of Maejo University colony-2

	Microsatellite locus			
	A88		A14	
Queen allele 1	99		164	
Queen allele 2	103		169	
Worker-1	103	136	169	169
Worker-2	99	103	169	169
Worker-3	103	103	164	169
Worker-4	99	99	169	169
Worker-5	103	109	169	166
Worker-6	99	99	164	169
Worker-7	103	136	164	169
Worker-8	99	103	169	169
Worker-9	99	97	164	169
Worker-10	99	95	164	169
Worker-11	99	109	169	169
Worker-12	103	109	164	164
Worker-13	99	105	169	169
Worker-14	103	103	169	169
Worker-15	99	103	164	169
Worker-16	103	95	164	169
Worker-17	103	109	164	166
Worker-18	99	103	164	169
Worker-19	103	118	164	164
Worker-20	99	109	169	166
Worker-21	99	99	164	164
Worker-22	99	99	169	169
Worker-23	99	136	164	164
Worker-24	99	103	169	169
Worker-25	103	136	164	164
Worker-26	103	97	164	169
Worker-27	99	109	169	169
Worker-28	99	136	169	171
Worker-29	103	103	169	169
Worker-30	103	97	169	169
Worker-31	103	105	165	167

3. Water tower of Maejo University colony-3

	Microsatellite locus			
	A88		A14	
Queen allele 1	103		164	
Queen allele 2	109		165	
Worker-1	109	109	165	167
Worker-2	103	118	164	169
Worker-3	103	95	164	165
Worker-4	109	109	164	165
Worker-5	103	118	164	165
Worker-6	103	95	165	167
Worker-7	109	95	165	167
Worker-8	103	95	165	167
Worker-9	103	97	164	164
Worker-10	109	93	169	169
Worker-11	103	97	165	169
Worker-12	103	109	165	167
Worker-13	103	97	164	169
Worker-14	103	109	164	165
Worker-15	103	103	164	167
Worker-16	103	118	164	165
Worker-17	103	103	165	169
Worker-18	103	118	164	169
Worker-19	103	99	165	169
Worker-20	103	93	165	171
Worker-21	109	95	164	167
Worker-22	109	118	165	169
Worker-23	109	95	164	165
Worker-24	103	99	164	169
Worker-25	109	118	165	167
Worker-26	109	97	165	167
Worker-27	109	95	165	169
Worker-28	103	103	165	169
Worker-29	109	118	164	164
Worker-30	103	97	165	169
Worker-31	109	95	165	169
Worker-32	103	99	164	164
Worker-33	109	99	164	164
Worker-34	109	93	165	169
Worker-35	103	118	164	164
Worker-36	109	118	165	169
Worker-37	109	118	165	169
Worker-38	103	109	165	165

4. East facing window of the health care center building- colony-1998

	Microsatellite locus			
	A88		A14	
Queen allele 1	109		171	
Queen allele 2	117		169	
Worker-1	117	102	171	171
Worker-2	117	102	171	165
Worker-3	109	109	171	165
Worker-4	109	136	171	171
Worker-5	117	117	171	167
Worker-6	109	127	169	167
Worker-7	117	102	171	169
Worker-8	117	92	171	165
Worker-9	117	124	171	169

5. South facing window of the health care center building- colony-1998

	Microsatellite locus			
	A88		A14	
Queen allele 1	109		169	
Queen allele 2	109		167	
Worker-1	109	117	169	169
Worker-2	109	96	169	171
Worker-3	109	127	169	166
Worker-4	109	85	169	167
Worker-5	109	117	169	169
Worker-6	109	127	169	167
Worker-7	109	127	169	167
Worker-8	109	109	169	169
Worker-9	103	109	169	167

6. Tree-1-colony-1

	Microsatellite locus			
	A88		A14	
Queen allele 1	140		165	
Queen allele 2	117		169	
Worker-1	140	117	165	174
Worker-2	140	124	165	165
Worker-3	103♣	103	169	167
Worker-4	117	109	171♣	171
Worker-5	103♣	124	169	169
Worker-6	140	117	165	165
Worker-7	140	109	165	165
Worker-8	140	117	169	169
Worker-9	140	109	165	167
Worker-10	140	117	165	169
Worker-11	140	117	169	169
Worker-12	140	124	165	171

♣ homozygous queen alleles. Therefore, the queen allele could be 140/103 or 140/117 on locus A88 and 165/171 or 165/169 on locus A14.

7. Tree-1-colony-2

	Microsatellite locus			
	A88		A14	
Queen allele: 1	103		165	
Queen allele: 2	140		169	
Worker-1	140	140	165	179
Worker-2	140	140	165	169
Worker-3	103	109	165	169
Worker-4	140	124	169	169
Worker-5	140	85	165	167
Worker-6	140	124	169	169
Worker-7	103	124	165	169
Worker-8	140	124	169	171
Worker-9	103	94	165	171
Worker-10	140	124	169	171
Worker-11	103	124	165	165
Worker-12	140	117	165	169

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i. **Bee Biology and Beekeeping** from Bee Biology Research Unit, Faculty of Science, Chulalongkorn University, Bangkok, Thailand.

ii. **Radiation Safety in laboratory**, Radio Safety Section, The University of Sydney, NSW Sydney, Australia.

iii. **Microsatellite techniques to identify honeybee genetic lines,** School of Biological Sciences, The University of Sydney, NSW Sydney, Australia.

iv. **Queen rearing and breeding,** Weather bee apiaries, Ipswich, Queensland , Australia.

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i. USAID - Scholarship, Bee Biology Research Unit, Research affairs Division, Chulalongkorn University, Bangkok, Thailand.

ii. GTZ - Scholarship, Germany.

iii. Her Majesty the Queen Sirikit Scholarship of Thailand since 1993-1999, Royal Project, Chitralada Palace, Bangkok, Thailand.

iv. Chulalongkorn Graduate Scholarships –1996.

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8. PARTICIPATION AND PAPERS PRESENTED IN VARIOUS INTERNATIONAL CONGRESS

i. 1st Asian Apiculture Association Conf. Bangkok, Thailand – 1992.

ii. 2nd Asian Apiculture Association Conf. Jakarta, Indonesia – 1994.

iii. 3rd Asian Apiculture Association Conf. Hanoi, Vietnam – 1996.

iv. XXXIV APIMONDIA Inter'l. Apic. Conf. Lausanne, Switzerland- 1995

v. Inter'l. Symposium on Biopesticides, Phitsanulok, Thailand –1996

vi. 16th Biennial Conf. "Asian Association for Biology Education", Chiang Mai, Thailand-1997.

vii. 4th Asian Apiculture Association Conf. Kathmandu, Nepal – 1998.

viii. XIII International Congress of the international Union for the Study of Social Insects (IUSSI). Adelaide, Australia 1998-1999.

11. PREVIOUS RESEARCH AND CURRENT ACTIVITIES

i. Survey of Bumblebee and Large Carpenter bee of Kathmandu and Adjoining Areas of Nepal.

ii. Biology Control of Mites, Bee Biology Research Unit, Faculty of Science, Chulalongkorn University, Bangkok, Thailand.

iii. Study the Duration of Development Stages of Queen, drones and workers bees , BBRU, Chulalongkorn University, Bangkok, Thailand.

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