Male mate location behaviour and encounter sites in a community of tropical butterflies: taxonomic and site associations and distinctions

Ashish D Tiple, Sonali V Padwad, Leonardo Dapporto and Roger Lh Dennis

J. Biosci. **35(4), December 2010, 629–646 © Indian Academy of Sciences**

Supplementary tables 1-3

Supplementary table 1. Mate location behaviours and groups (clusters) for butterfly species at Nagpur, India

Species	Family	Base Clusters[1]	Main clusters[1]	Perch[2]	Patrol[2]	Site fidelity[2]	Territorial defence[2]	Lek assembly[2]	Number sampled
Graphium agamemnon (Linnaeus)	Papilionidae	15	3	0	1	2	0	0	47
Graphium doson (C&R Felder)	Papilionidae	6	1	1	1	2	1	0	95
Pachliopta aristolochiae (Fabricius)	Papilionidae	15	3	0	1	2	0	0	44
Pachliopta hector (Linnaeus)	Papilionidae	15	3	0	1	2	0	0	48
Papilio demoleus (Linnaeus)	Papilionidae	5	1	1	1	2	1	1	109
Papilio polytes (Linnaeus)	Papilionidae	14	3	1	1	2	0	0	56
Anaphaeis aurota (Fabricius)	Pieridae	11	2	1	0	2	1	0	10
Catopsilia pomona (Fabricius)	Pieridae	5	1	1	1	2	1	1	112
Catopsilia pyranthe (Linnaeus)	Pieridae	14	3	1	1	2	0	0	102
Cepora nerissa (Fabricius)	Pieridae	10	2	1	0	2	0	0	40
Colotis etrida (Boisduval)	Pieridae	13	3	0	1	1	0	0	9
Delias eucharis (Linnaeus)	Pieridae	9	2	1	0	1	0	0	11
Eurema hecabe (Linnaeus)	Pieridae	4	1	1	1	2	0	1	45
Eurema andersonii (Moore)	Pieridae	15	3	0	1	2	0	0	44
Eurema blanda (Boisduval)	Pieridae	15	3	0	1	2	0	0	30
Eurema brigitta (Cramer)	Pieridae	14	3	1	1	2	0	0	90
Eurema laeta (Boisduval)	Pieridae	10	2	1	0	2	0	0	45
Pareronia valeria (Cramer)	Pieridae	8	2	1	0	1	1	0	4
Ariadne ariadne (Linnaeus)	Nymphalidae	9	2	1	0	1	0	0	46
Ariadne merione (Cramer)	Nymphalidae	13	3	0	1	1	0	0	49
Byblia ilithyia (Drury)	Nymphalidae	9	2	1	0	1	0	0	38
Charaxes polyxena (Fabricius)	Nymphalidae	9	2	1	0	1	0	0	9

Supplementary table 1. *(Continued)*

Danaus chrysippus (Linnaeus)	Nymphalidae	5	1	1	1	2	1	1	103
Danaus genutia (Cramer)	Nymphalidae	10	2	1	0	2	0	0	50
Euploea core (Cramer)	Nymphalidae	5	1	1	1	2	1	1	131
Euthalia nais (Forster)	Nymphalidae	9	2	1	0	1	0	0	14
Hypolimnas bolina (Linnaeus)	Nymphalidae	11	2	1	0	2	1	0	11
Hypolimnas misippus (Linnaeus)	Nymphalidae	6	1	1	1	2	1	0	98
Junonia almana (Linnaeus)	Nymphalidae	11	2	1	0	2	1	0	37
Junonia atlites (Linnaeus)	Nymphalidae	15	3	0	1	2	0	0	43
Junonia hierta (Fabricius)	Nymphalidae	3	1	0	1	2	1	0	10
Junonia iphita (Cramer)	Nymphalidae	11	2	1	0	2	1	0	11
Junonia lemonias (Linnaeus)	Nymphalidae	6	1	1	1	2	1	0	103
Junonia orithya (Linnaeus)	Nymphalidae	11	2	1	0	2	1	0	38
Lethe europa (Fabricius)	Nymphalidae	13	3	0	1	1	0	0	10
Limenitis procris (Cramer)	Nymphalidae	9	2	1	0	1	0	0	10
Melanitis leda (Linnaeus)	Nymphalidae	7	2	1	0	1	0	1	50
Melanitis phedima (Cramer)	Nymphalidae	9	2	1	0	1	0	0	9
Mycalesis mineus (Linnaeus)	Nymphalidae	9	2	1	0	1	0	0	41
Mycalesis perseus (Fabricius)	Nymphalidae	9	2	1	0	1	0	0	49
Mycalesis subdita (Moore)	Nymphalidae	9	2	1	0	1	0	0	8
Neptis columella (Cramer)	Nymphalidae	10	2	1	0	2	0	0	8
Neptis hylas (Linnaeus)	Nymphalidae	14	3	1	1	2	0	0	84
Neptis jumbah Moore	Nymphalidae	10	2	1	0	2	0	0	9
Phalanta phalantha (Drury)	Nymphalidae	1	1	1	1	1	1	0	61
Tirumala limniace (Cramer)	Nymphalidae	5	1	1	1	2	1	1	92
Actolepis puspa (Horsfield)	Lycaenidae	12	3	1	1	1	0	0	18
Anthene emolus (Godart)	Lycaenidae	13	3	0	1	1	0	0	11
Anthene lycaenina (C&R Felder)	Lycaenidae	9	2	1	0	1	0	0	8
Castalius rosimon (Fabricius)	Lycaenidae	13	3	0	1	1	0	0	37
Catochrysops Strabo (Fabricius)	Lycaenidae	2	1	0	1	1	1	0	43
Chilades laius (Stoll)	Lycaenidae	10	2	1	0	2	0	0	41
Chilades pandava (Horsfield)	Lycaenidae	5	1	1	1	2	1	1	91

Supplementary table 1. *(Continued)*

Chilades parrhasius **(***Butler)*	Lycaenidae	14	3	1	1	2	0	0	77
Euchrysops cnejus (Fabricius)	Lycaenidae	12	3	1	1	1	0	0	69
Everes lacturnus (Godart)	Lycaenidae	9	2	1	0	1	0	0	9
Chilades trochylus Freyer	Lycaenidae	13	3	0	1	1	0	0	11
Lampides boeticus (Linnaeus)	Lycaenidae	9	2	1	0	1	0	0	48
Leptotes plinius Fabricius	Lycaenidae	1	1	1	1	1	1	0	49
Prosotas nora (C. Felder)	Lycaenidae	7	2	1	0	1	0	1	57
Psuedozizeeria maha (Kollar)	Lycaenidae	13	3	0	1	1	0	0	9
Tarucus nara Kollar	Lycaenidae	12	3	1	1	1	0	0	79
Zizeeria karsandra (Moore)	Lycaenidae	13	3	0	1	1	0	0	43
Zizina otis (Fabricius)	Lycaenidae	9	2	1	0	1	0	0	23
Zizula hylax (Fabricius)	Lycaenidae	12	3	1	1	1	0	0	53
Baoris farri (Moore)	Hesperiidae	10	2	1	0	2	0	0	11
Borbo cinnara (Wallace)	Hesperiidae	6	1	1	1	2	1	0	86
Caltoris kumara (Moore)	Hesperiidae	12	3	1	1	1	0	0	21
Parnara naso (Bremer & Grey)	Hesperiidae	8	2	1	0	1	1	0	9
Pelopidas mathias (Fabricius)	Hesperiidae	15	3	0	1	2	0	0	46
Spialia galba (Fabricius)	Hesperiidae	9	2	1	0	1	0	0	9
Telicota ancilla (Herrich-Schaffer)	Hesperiidae	1	1	1	1	1	1	0	40

[1]Clusters derived from SAHN UPGMA cluster analysis on Euclidean distances for 5 mate location behaviours (patrolling, perching, site fidelity, territorial defence and lek assembly). Base clusters are discrete groups with identical behaviour; main clusters are highest level groups prior to complete amalgamation in dendrogram; 1 to 3 relate to A to C in table 3 and figure 3. [2]Scores for perch, patrol, territorial defence and lek assembly: 0 absent, 1 present; scores for site fidelity: 1 low, 2 high.

Supplementary table 2. Significant associations between mate location behaviour and butterfly taxa with butterfly morphology, biotopes, landscape structures, resources and population variables.

(a) Significant associations between mate location behaviours and biotopes

Variable pairs	Kendall tau	*P*
Perch and Sere 4	0.26	*
Patrol and Sere 2‡	0.31	***
Patrol and Sere 6	0.19	†
Invariant perching and Sere 2‡	–0.31	***
Invariant perching and Sere 6	–0.19	†
Invariant patrolling and Sere 4	–0.26	*
Perch-patrol and Sere 2	0.22	*
Perch-patrol and Sere 4	0.26	*
Perch-patrol and Sere 6	0.27	**
Site fidelity and Sere 2	0.17	†
Site fidelity and Sere 3‡	0.32	***
Site fidelity and Sere 4‡	0.39	***
Site fidelity and Sere 5	0.24	*
Territorial defence and Sere 2	0.19	†
Territorial defence and Sere 3‡	0.38	***
Territorial defence and Sere 4‡	0.45	***
Territorial defence and Sere 5	0.25	*
Territorial defence and Sere 6‡	0.39	***
Lek assemblyand Sere 4	0.19	†
Lek assembly and Sere 5‡	0.32	***
Lek assembly and Sere 6‡	0.58	***
N = 72 species		

(b) Significant associations between butterfly taxa (families) and biotopes in which mate location behaviour has been observed

Variable pairs	Kendall tau	*P*
Papilionidae and Sere 4	0.18	†
Pieridae and Sere 5	0.23	*
Lycaenidae and Sere 3	–0.24	*
Lycaenidae and Sere 4‡	–0.25	**
Lycaenidae and Sere 5‡	–0.31	***
Lycaenidae and Sere 6	–0.20	†
Nymphalidae and Sere 2	–0.22	*
Nymphalidae and Sere 5	0.22	*
Hesperiidae and Sere 1	–0.16	†
Hesperiidae and Sere 5	–0.17	†
N = 72 species		

(c) Significant associations between mate location behaviours and landscape structures (landmarks and edges)

Variables pairs	Kendall tau	*P*
Perch and Bare patch	0.23	*
Perch and Track‡	–0.38	***
Perch and Shrub edge‡	0.39	***
Perch and Wood edge	0.22	*
Perch and Rock face‡	0.63	***
Perch and Stream bank‡	0.41	***
Patrol and Track‡	0.89	***
Patrol and Shrub edge	–0.17	†
Patrol and Rock face‡	–0.33	***
Patrol and Stream bank	0.17	†
Invariant perching and Track‡	–0.89	***
Invariant perching and Shrub edge	0.17	†
Invariant perching and Rock face‡	0.33	***
Invariant perching and Stream bank	–0.17	†
Invariant patrolling and Bare patch	–0.23	*
Invariant patrolling and Track‡	0.38	***
Invariant patrolling and Shrub edge‡	–0.39	***
Invariant patrolling and Wood edge	–0.22	*
Invariant patrolling and Rock face‡	–0.63	***
Invariant patrolling and Stream bank‡	–0.41	***
Perch-patrol and Bare patch	0.22	*
Perch-patrol and Track‡	0.59	***
Perch-patrol and Shrub edge	0.17	†
Perch-patrol and Wood edge	0.19	†
Perch-patrol and Rock face	0.21	*
Perch-patrol and Stream bank‡	0.55	***
Perch-patrol and Hilltop‡	0.27	**
Site fidelity and Track	0.20	†
Site fidelity and Wood edge	–0.20	†
Site fidelity and Hilltop	0.16	†
Territorial defence and Shrub edge‡	0.33	***
Territorial defence and Rock face‡	0.31	**
Territorial defence and Stream bank‡	0.38	***
Territorial defence and Hilltop‡	0.29	**
Lek assembly and Bare patch	0.17	†
Lek assembly and Track	0.18	†

Lek assembly and Rock face	0.25	*
Lek assembly and Stream bank‡	0.30	**
Lek assembly and Hilltop‡	0.56	***

N = 72 species; track includes tracks through vegetation. Territorial defence and Wood edge P = 0.057

(d) Use of number of edge features[1] and male mate location behaviours

	Kendall tau	*P*
Use of number of edge features and Perch‡	0.43	***
Use of number of edge features and Patrol	0.19	†
Use of number of edge features and Territorial defence‡	0.43	***
Use of number of edge features and Lek assembly‡	0.27	**
Use of number of edge features and Invariant perching	–0.19	†
Use of number of edge features and Invariant patrolling‡	–0.43	***
Use of number of edge features and Perch-patrol‡	0.58	***

N = 72 species; [1]sum of the number of five edge features (vegetation and landform) used each variable having a binary score

(e) Significant associations between butterfly taxa (families) and landscape structures at which mate location behaviour has been observed

Variable pairs	Kendall tau	*P*
Papilionidae and Shrub edge	0.22	*
Papilionidae and Track‡	0.28	**
Papilionidae and Rock face‡	–0.35	***
Papilionidae and Stream bank	–0.19	†
Pieridae and Wood edge	–0.24	*
Lycaenidae and Track	0.17	†
Lycaenidae and Shrub edge‡	–0.27	**
Lycaenidae and Wood edge‡	0.29	**
Lycaenidae and Hilltop	–0.16	†
Nymphalidae and Shrub edge	–0.18	†
Nymphalidae and Track‡	–0.35	***
Nymphalidae and Shrub edge	0.18	†
Nymphalidae and Wood edge‡	–0.36	***
Nymphalidae and Rock face	0.22	*
Nymphalidae and Stream bank	0.19	†
Nymphalidae and Hilltop	0.23	*
Hesperiidae and Shrub edge	0.18	†
Hesperiidae and Wood edge‡	0.50	***

N = 72 species

(f) Significant associations of mate location behaviours with butterfly resource variables

Variable pairs	Kendall tau	*P*
Perch and HP predictability‡	0.29	**
Perch and HPela‡	0.34	***
Patrol and HP life form	0.17	†
Patrol and HPela‡	0.32	***
Patrol and HP dispersion‡	0.33	***
Patrol and HP abundance	0.22	*
Patrol and NE plants number‡	0.30	**
Patrol and NE events	0.23	*
Patrol and NE plants (relative number)	0.22	*
Invariant perching and HP life form	–0.17	†
Invariant perching and HPela‡	–0.32	***
Invariant perching and HP dispersion‡	–0.33	***
Invariant perching and HP abundance	–0.22	*
Invariant perching h and NE plants number‡	–0.30	**
Invariant perching and NE events	–0.23	*
Invariant perching and NE plants (relative number)	–0.22	*
Invariant patrolling and HP predictability‡	–0.29	**
Invariant patrolling and HPela‡	–0.34	***
Perch-patrol and HP life form	0.16	†
Perch-patrol and HP predictability‡	0.40	***
Perch-patrol and HPela‡	0.64	***
Perch-patrol and HP dispersion‡	0.45	***
Perch-patrol and HP abundance‡	0.29	**
Perch-patrol and NE plants number‡	0.36	***
Perch-patrol and NE events‡	0.31	**
Perch-patrol and NE plants (relative number)	0.25	*
Site fidelity and HP life form	0.20	†
Site fidelity and HP abundance	0.18	†
Site fidelity and NE plants number‡	0.39	***
Site fidelity and NE events‡	0.37	***
Site fidelity and NE plants (relative number) ‡	0.31	**
Territorial defence and HP predictability	0.23	*
Territorial defence and HPela‡	0.40	***
Territorial defence and HP dispersion	0.26	*
Territorial defence and HP abundance	0.18	†
Territorial defence and NE plants number‡	0.36	***
Territorial defence and NE events‡	0.44	***

Territorial defence and NE plants (relative number)	0.26	*
Lek assembly and HP predictability	0.17	†
Lek assembly and HPela‡	0.35	***
Lek assembly and HP dispersion	0.23	*
Lek assembly and HP abundance‡	0.33	***
Lek assembly and NE plants number	0.21	†
Lek assembly and NE plants (relative number)	0.19	†
MLB number and HP predictability‡	0.34	***
MLB number and HPela‡	0.62	***
MLB number and HP dispersion‡	0.37	***
MLB number and HP abundance‡	0.33	***
MLB number and NE plants number‡	0.41	***
MLB number and NE events‡	0.39	***
MLB number and NE plants (relative number) ‡	0.29	**

N = 69 to 72 species; MLB number, number of different mate location behaviours for species; HPela, HP edge and landform affiliation; HP, larval host plant; NE, nectar source.

(g) Significant associations of mate location behaviours with specific butterfly host plant edge and landform distributions

	Kendall tau	*P*
Perch and HP track through herbs	–0.26	*
Perch and HP track through shrubs‡	–0.40	***
Perch and HP shrub edge‡	0.43	***
Perch and HP wood edge	0.23	*
Perch and HP on rock face‡	0.68	***
Perch and HP on hilltop	0.20	†
Perch and HP along stream bank‡	0.43	***
Patrol and HP track through herbs‡	0.62	***
Patrol and HP track through shrubs‡	0.80	***
Patrol and HP on rock face‡	–0.35	***
Site fidelity and HP track through shrubs	0.23	*
Territorial defence and HP shrub edge‡	0.43	***
Territorial defence and HP wood edge	0.20	†
Territorial defence and HP rock face‡	0.28	**
Territorial defence and HP on hilltop	0.25	*
Territorial defence and HP along stream bank‡	0.36	***
Lek assembly and HP wood edge	0.19	†
Lek assembly and HP on rock face	0.23	*
Lek assembly and HP on hilltop‡	0.67	***
Lek assembly and HP along stream bank‡	0.29	**
Invariant perching and HP track through herbs‡	–0.62	***
Invariant perching and HP track through shrubs‡	–0.80	***
Invariant perching and HP rock face‡	0.35	***
Invariant patrolling and HP track through herbs	0.26	*
Invariant patrolling and HP track through shrubs‡	0.40	***
Invariant patrolling and HP shrub edge‡	–0.43	***
Invariant patrolling and HP wood edge	–0.23	*
Invariant patrolling and HP rock face‡	–0.68	***
Invariant patrolling and HP on hilltop	–0.20	†
Invariant patrolling and HP along stream bank‡	–0.43	***
Perch-patrol and HP track through herbs‡	0.42	***
Perch-patrol and HP track through shrubs‡	0.48	***
Perch-patrol and HP shrub edge	0.26	*
Perch-patrol and HP wood edge‡	0.37	***
Perch-patrol and HP rock face	0.24	*
Perch-patrol and HP on hilltop‡	0.31	***
Perch-patrol and HP along stream bank‡	0.53	***

N = 72 species; HP, larval host plant

(h) Significant associations of mate location behaviours with population variables

Variable pairs	Kendall tau	*P*
Perch and Female abundance‡	–0.25	**
Patrol and Relative population size	0.22	*
Invariant perching and Relative population size	–0.22	*
Invariant patrolling and Female abundance‡	0.25	**
Perch-patrol and Relative population size‡	0.32	**
Site fidelity and Relative population size‡	0.32	***
Territorial defence and Relative population size‡	0.30	**
Lek assembly and Relative population size	0.24	*
MLB number and Relative population size‡	0.40	***

N = 72 species. Female abundance, number of females/total numbers of males and females; Relative population size, trnasect counts of species.

(i) Significant associations of butterfly taxa (families) with butterfly resources and population variables

Variable pairs	Kendall tau	*P*
Papilionidae and HP life form‡	0.28	**
Papilionidae and NE plants (relative number)	0.20	†
Pieridae and NE plants number‡	0.27	**
Pieridae and NE events	0.24	*
Pieridae and NE plants (relative number)	0.21	†
Nymphalidae and NE plants (relative number)	–0.21	†
Hesperiidae and HP predictability	–0.18	†
Hesperiidae and HP abundance	–0.16	†

N = 69 to72

(j) Significant associations of butterfly taxa (families) with specific butterfly host plant edge and landform distributions

Variable pairs	Kendall tau	*P*
Papilionidae and HP track through herbs	0.18	†
Papilionidae and HP track through shrubs	0.25	*
Papilionidae and HP on rock face‡	–0.37	***
Papilionidae and HPsbanks	–0.20	†
Lycaenidae and HP track through shrubs	0.25	*
Lycaenidae and HP shrub edge‡	–0.31	**
Lycaenidae and HP wood edge	0.19	†
Nymphalidae and HP track through herbs‡	–0.43	***
Nymphalidae and HP track through shrubs‡	–0.42	***
Nymphalidae and HP shrub edge‡	0.26	*
Nymphalidae and HP wood edge‡	–0.38	***
Nymphalidae and HP on rock face	0.24	*
Nymphalidae and HP along stream bank	0.23	*
Hesperiidae and HP track through herbs	0.20	†
Hesperiidae and HP wood edge‡	0.37	***

N = 72 species
† $P < 0.05$, *P < 0.01, **$P < 0.001$ *** $P < 0.0001$; (non significant pairs of relations at $P < 0.05$ not shown).
‡ Bonferoni $P < 0.05$

Supplementary table 3. Accession numbers of COI sequences retrieved from Genbank

Species	Number
Graphium agamennnon	AF170874
Pachliopta hector	EU792488
Papilio demoleus	DQ227731
Papilio polytes	AB192474
Anaphaeis aurota	EU792496
Catopsilia pomona	EF584854
Catopsilia pyranthe	EF584855
Cepora nerissa	EF584857
Eurema hecabe	EF584863
Eurema blanda	EF584861
Eurema brigitta	EF584862
Pareronia valeria	AY954753
Ariadne ariadne	AB501207
Danaus chrysippus	AF426165
Danaus genutia	AY256344
Euthalia nais	EU729476
Hypolimnas bolina	AY090224
Hypolimnas misippus	AY788635
Junonia almana	EU053289
Junonia hierta	EU053307
Junonia iphita	AY090225
Junonia lemonias	EU053308
Junonia orithya	EU053315
Lethe europa	EF053315
Melanitis leda	AY090207
Mycalesis mineus	EF545704
Neptis hylas	DQ821137
Phalanta phalanta	EU650049
Tirumala limniace	GQ864815