Climate Change and its Impact on Biodiversity: Research requirements in Sarawak, Borneo

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Workshop on Climate Change and Biodiversity: Mobilizing the Research Agenda

Universiti Kebangsaan Malaysia, Bangi
13-14 December 2010

Federal Legislation & Policy

1. Irrigation Areas Act 1953
2. Drainage Works Act 1954
3. Land Conservation Act 1960
4. Wildlife Protection Act 1972
5. Environmental Quality Act 1974
6. National Parks Act 1980
7. Forestry Act 1984
8. Fishery Act 1985
9. National Forestry Policy 1978 (1993)
10. National Energy Policy 1979
11. Vision 2010, 1991-2020
12. National Conservation Strategy 1993
13. National Conservation Strategy 1993
14. Marine Parks Malaysia Order 1994
15. National Ecotourism Plan 1996
16. National Biodiversity Policy 1998
17. Third National Agricultural Policy 1998-2010
18. National Policy on the Environment, 2002
19. National Environment Policy 2006
20. National Physical Plan 2006
21. National Policy for Integrated Coastal Zones Management
22. Malaysian Biofuel Industry Act 2006
23. Green Technology Policy 2009
24. Government Transformational Programme Roadmap, 2010

Sarawak Legislation & Policy

1. Sarawak Land Code 1958
2. Natural Resource and Environmental Ordinance, Chapter 84, 1958
3. Forest Rules, 1962
4. Natural Resources and Environment Ordinance 1993 (Amended 2001)
5. Public Parks and Green Ordinance 1993
6. Sarawak Rivers Ordinance 1993
7. Water Ordinance 1994
8. Sarawak Forestry Corporation Ordinance, 1995
9. Forest Ordinance (Cap.126), Amendment 1996
10. Sarawak Biodiversity Centre Ordinance, 1997 (Cap. 24).
11. Forests (Planted Forests) Rules, 1997
12. National Parks and Nature Reserves Ordinance, 1998
13. Wild Life Protection Ordinance, 1998
14. Wildlife Protection Rules, 1998
15. Wildlife (Edible Birds' Nests) Rules, 1998
16. National Parks and Nature Reserves Regulations, 1999
17. Veterinary Public Health Ordinance 1999
18. Local Authority (Cleanliness) By-Law 1999
19. Second State Tourism Master Plan (1993)

Background

Global environment

GHG 25% increase fossil fuel

Global warming increase 0.2°C/decade

Sea level increase 3.1 ± 0.7 mm/ yr

Malaysia

- 15,500 species of higher plants (686 spp plants threatened)
- 746 birds (42 spp)
- 300 mammals (70 spp)
- 379 reptiles (21 spp)
- 198 amphibians (47 spp)
- 368 species of fish (49 spp)
- 19 spp molluscs
- Other inverts 207
- 1,141 species endangered (IUCN 2008)

Total forest area: 20,890,000 ha
% of land area: 63.6%
Primary forest cover: 3,820,000 ha
% of land area: 11.6%

Annual change in forest cover: -140,200 ha(2000-2005)
Annual deforestation rate: -0.7%

Oil palm cultivation in 2008: 4.48 mil. Ha

Palm oil (crude) production in 2008: 17.73 mil. T

Sarawak Background

- Population in 2006: 2,357,500.
- Area: 124,450 km² or 12 million ha
- **Forest cover 5.9 million hectares (30%)**
- **1.5 million ha peatland** around Kuching, Kota Samarah, Sibu, Sri Aman, Mukah & Miri

  cleared for oil palm plantation
- **Permanent Forest Estate, PFE : 6 million ha; timber production**
- **TPAs : 880,000 ha, 8% land area; 19 NPs, 5NRs & 4 WSs**
- Stateland: 1.7 million ha, can be alienated

Forests in Malaysia: 19.4 million hectares (59.5% of the total land area); approximately 1.55 million hectares of swamp forests in Malaysia. Of this total, 0.31 million hectares or 19% are in Peninsular Malaysia and 1.12 million hectares or 73% in Sarawak.
The peat swamp forest cover in Sarawak is about 0.88 million hectares

Table 2: Distribution and extent of major forest types in Malaysia, 2005 (Million hectares).

Region	Land Area	Natural Forest			Plantation Forest	Total Forested Land	Percentage Total of Forested Land
		Dry Inland Forest	Swamp Forest	Mangrove Forest			
Peninsular Malaysia	13.16	5.40	0.31	0.10	0.09	5.90	44.8
Sabah	7.37	3.83	0.12	0.34	0.11	4.40	59.7
Sarawak	12.30	7.92	1.12	0.14	0.06	9.24	75.1
Malaysia	**32.83**	**17.15**	**1.55**	**0.58**	**0.26**	**19.54**	**59.5**

http://www.cites.org/eng/com/sc/57/E57-37.pdf. CITES. 2008. Interpretation and implementation of the Convention Species trade and conservation. RAMIN.

Land Use Pattern

Region	Oil palm (ha)	Peat Land (ha)	Oil palm on peat	%
P. Malaysia	2,503,682.02	716,944.00	207,458.01	8.29
Sabah	1,340,317.39	121,514.00	21,405.75	1.60
Sarawak	**1,167,172.51**	**1,588,142.00**	**437,174.27**	**37.45**
Total	**5,011,171.92**	**2,426,600.00**	**666,038.03**	**13.29**

Wahid Omar *et al.*, 2010.

Fauna have no equivalent list in Borneo?

Bornean Fauna	Reference
mammals : 288 terrestrial spp, of which 102 are bats, 61 rodents, 91 marine spp within territorial waters, *c.*7.2% of global total ~5400 spp.	Abdullah. 2006. Mammals of Borneo. Wikipedia. http://en.wikipedia.org/wiki/Mammals_of_Borneo
50 mammalian spp as Bornean endemics	Wilson & Reeder, 2005
622 spp birds	Davison, 1999
105 spp lizards, plus crocodiles and turtles; 166 spp snakes	Das & Ghazally, 2001, 2002 Das, 2008
150 spp frogs	Inger & Stuebing, 2005
~4500 spp macromoths	Holloway, 1985 – 2008
>350 spp phasmids	Bragg, 2001
275 spp dragonflies	Orr, 2003
550 spp beetle, family Cerambycidae	~1000 ha plot in Kalimantan Timur; Fatawa & Mori, 2000
394 spp fish, 149 spp Bornean endemic 249 spp in Sarawak & Brunei	Kottelat *et al.* 1993 Kottelat & Lim, 1995.
186 spp of freshwater fish, 13 endemic to Borneo A miniature fish, a tree frog, and a catfish are among 52 new species	Betung Kerihun National Park , Kalimantan Barat. National Geographic News 2006

Lesson from LGM-Holocene climate change

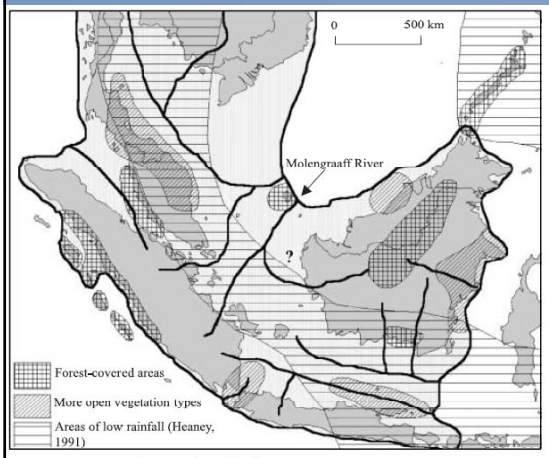


Figure 5 Overview of areas where the data from this and other researches suggest closed forest vegetation during the LGM, and where the data indicate that more open vegetation types may have existed. Also shown is the Late Pleistocene area of seasonality and low rainfall as suggested by Heaney (1991). Area in light grey is the exposed land during times of lowest sea levels; darker grey depicts present-day land areas.

Meijaard, 2003

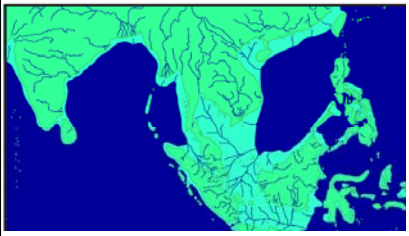
Rain forest contraction & expansion.

Pleistocene refugia & ancient Sunda River with moist forest

- Refugia and Sunda River network facilitate movement and genetic exchange
- Post LGM isolation resulting in allopatric speciation.
- Niah & Borneo extinction
- Speciation; Borneo's elephants are indigenous to Borneo, have undergone independent evolution 300K yr since a Pleistocene colonisation and isolation (Fernando, 2003).

Lesson on LGM-Holocene climate change

Pleistocene refugia & ancient Sunda River wit moist forest



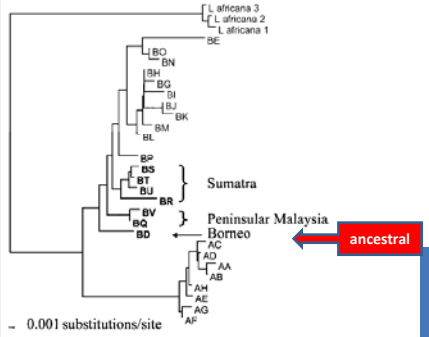


Figure 3. A Neighbour-Joining Phylogram of Asian Elephant Haplotypes Rooted with an African Elephant Out-Group

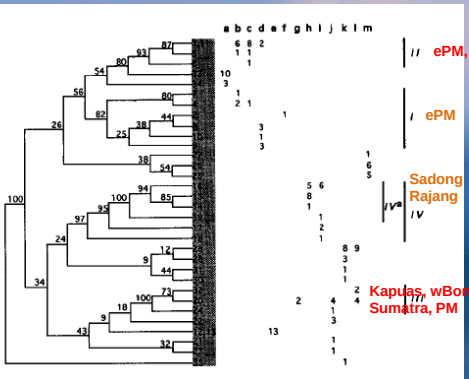


Fig. 8 Majority rule consensus tree clustering 34 mtDNA haplotypes of *H. nemurus* and their geographical distribution. Numbers at the forks indicate the percent of times the group consisting of the haplotypes located to the right of the fork occurred among the trees, out of 10 000 trees. The tree was rooted with haplotype 35.

ESU vs MU?

Chiropteran Case Studies in UNIMAS

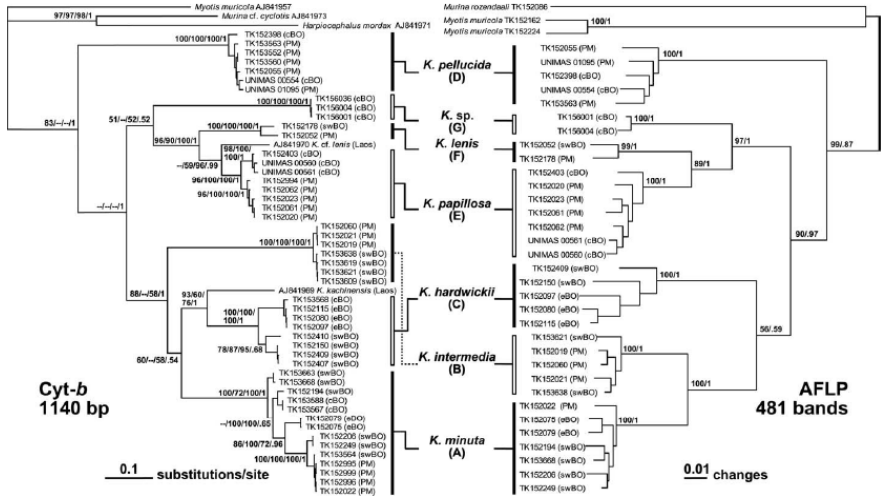


FIG. 2.—Bayesian phylogram of left) cytochrome-*b* (*Cytb*) sequences and right) neighbor-joining phylogram of amplified fragment length polymorphisms (AFLPs). Scores on the *Cytb* branches refer to bootstrap support values (1,000 iterations) from maximum likelihood (1st score), maximum parsimony (2nd score), minimum evolution (3rd score), and Bayesian posterior probabilities (4th score); -- = no support value. Maximum parsimony (1st score) and Bayesian posterior probabilities (2nd score) are shown on the AFLP phylogram. Clades (A, B, C, D, E, F, and G) are identified according to species identification. Some internal branches and similar haplotype support values were omitted from the figure. Specimen labeled by tissue number (TK, UNIMAS) and collecting region: swBO = southwestern Borneo, cBO = central Borneo, eBO = eastern Borneo, and PM = Peninsular Malaysia. Refer to "Materials and Methods" for suggested changes in voucher specimen numbers in Stadelmann et al. (2004).

Faisal Ali *et al.* 2010: Systematic of wooly bats. *J. Mammology* 91(5):1058-072.

Faisal Ali *et al.* 2010: Systematic of wooly bats. *J. Mammology* 91(5):1058-072.

1. **MtDNA Cyt b, COI & nuclear amplified fragment length polymorphisms & cranial-dental morphology.**
2. **Supported species level clades with one unidentified *Kerivoula* species.**
3. **Intraspecific diverspecification events coincided with Pliocene and Pleistocene epochs .**
4. **Northeastern Sabah specimens had high genetic divergence indicating Pleistocene or Pliocene refugia in Borneo.**

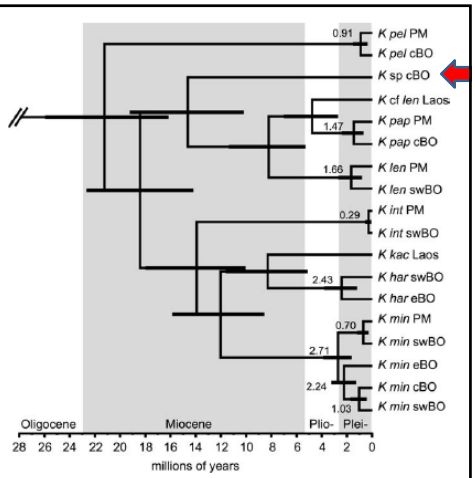
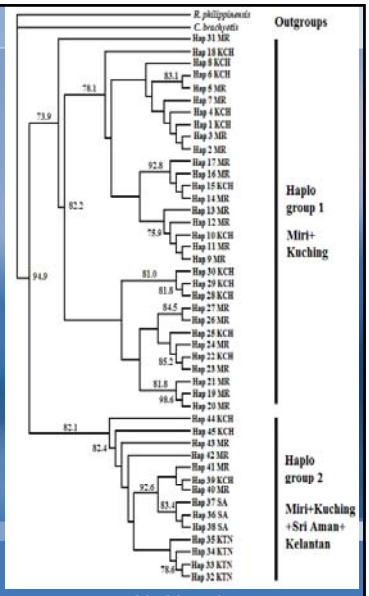


FIG. 3.—Chronogram of Southeast Asian *Kerivoula* studied here. Values at each node represent mean time to most recent common ancestor estimates from dating analyses performed in BEAST version 1.5. Gray bars represent the 95% highest posterior density intervals for the divergence estimates. Specimens: *K har* = *K. hardwickii*, *K int* = *K. intermedia*, *K kac* = *K. kachinensis* (AJ841969), *K len* = *K. lenis*, *K min* = *K. minuta*, *K pap* = *K. papillosa*, *K pel* = *K pellucida*, *K* cf *len* = *K.* cf. *lenis* (AJ841970), and *K* sp = potential undescribed species (see "Discussion"; TK 156001). Collecting regions: swBO = southwestern Borneo, cBO = central Borneo, eBO = eastern Borneo, and PM = Peninsular Malaysia. Geological time: Plio = Pliocene and Plei = Pleistocene. Outgroup not shown.

Phylogeography & Evolution

- **77 inds of *P. lucasi*** - Miri (33); Kuching (33); Sri Aman (5) & Kelantan (5)
- **mtDNA Cytochrome *b* (cyt *b*) gene**
- 1061 bp of cyt *b* -77 sequences; 45 unique haplotypes; 6 shared haplotypes
- **Two haplogroups - Haplogroup 1** (Kuching & Miri); **Haplogroup 2** (Miri, Kuching, Sri Aman & Kelantan)**(3.88%)**
- **High** genetic divergence between haplotypes **(4.9%).**
- High gene flow **(N_m>1.0)** between **Kuching-Miri**
- Two haplogroups- **multiple colonisation during Pleistocene**
- Sharing haplotypes between Kuching & Miri - **past geographical (migration) histories**
- **Two putative species** was detected within Kuching & Miri populations .

Rahman & Abdullah. 2010. Morphological variation in dusky fruit bats. *Tropical Natural History* 10(2): 141-158.



A maximum likelihood 50% majority rule consensus tree of mtDNA cyt *b* of *P. lucasi*. Bootstrap values above 50 % are indicated below branch.

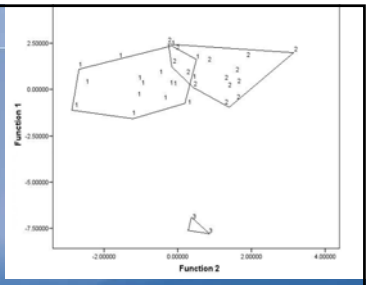
Intraspecific Morphological Diversity

- **70 adult** specimens of *P. lucasi* ; Kuching – 38 (14 M & 24 F); Miri – 25 (16 M & 9 F) & Sri Aman – 7 (2 M & 5 F)
- **33 characters** (15 external & 18 skull)

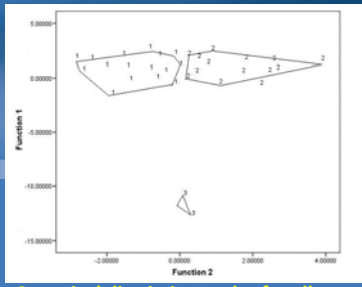
Result & Discussion

- **Sexual dimorphism-** separate analyses
- Best loading character- **D4MCL** & **BL** for **male**; **HF** & **DL** for **female**
- *P. lucasi* from different populations - **able to be distinguished accordingly**
- **Bio-ecological factors;**
  - breeding,
  - foraging behaviour
  - resource availability
  - crowding effect
  - selective pressure
  - **climate change**
- Absence or minimum number of **migrations** have occurred between these populations.
- Thus, populations have **adapted** to their ecological environments.

Rahman & Abdullah. 2010. Morphological variation in dusky fruit bats. *Tropical Natural History* 10(2): 141-158.



Canonical discriminant plot for all external characters of male *P. lucasi*. 1 - Miri; 2 - Kuching; 3 - Sri Aman



Canonical discriminant plot for all skulls characters of male *P. lucasi*. 1 - Miri; 2 - Kuching; 3 - Sri Aman

Study in Niah NP	No. spp
Present study	29
Hall *et al.* (2002)	23
Harrison (1966)	16
Nyaun *et al.* (2004)	14
Lim *et al.* (1972)	11
Medway (1959)	7

Study in BLA	No. spp
Mohd-Azlan *et al.* (2005) - Fairy	23
Jub *et al.* (2003) – Fairy	23
Pathe *et al.* (2005) – Jambusan	21
Present – Wind Cave	17
Karim *et al.* (2004) –BLA	12

Recommendations;

- 9 new distribution records - 7 Niah NP; 2 Wind Cave
- Niah NP- *H. ater, H. bicolor, H. cineraceus, C. robinsoni, R. trifoliatus, M. rozendaali* & *K. hardwickii*;
- Wind Cave NR- *H. ridleyi* & *T. robustula*.
- Limestone areas- higher number of bats spp Niah NP and BLA - 41 and 37 spp of bat.
- Hotspot areas - rich bat diversity in Sarawak.
- Bats in Borneo are threatened due to habitat loss, cave disturbance, ecotourism, climate change and hunting.
- The proper management of bats in these areas should be implemented by management authorities

Sigit Wiantoro, Ibnu Maryanto and M.T. Abdullah. 2010. Phylogeny and Phylogeography of *Myotis muricola* (Gray, 1846) (Chiroptera: Vespertilionidae) from the West and East of Wallace's Line Inferred from Partial MtDNA Cytochrome *b* Gene. Accepted by *Pertanika Journal of Tropical Agricultural Science* (JTAS).

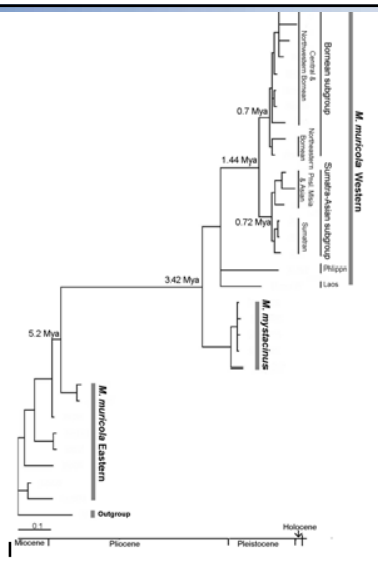


Figure 7: Chronogram showing the estimated time of divergence of *M. muricola* and *M. mystacinus* obtained from partial cytochrome *b* gene. Ages were inferred from the average genetic distance (Irwin *et al.*, 1991) calculated using the Kimura two-parameter model (Kimura, 1980) implemented in MEGA version 3 (Kumar *et al.*, 2004). Bayesian phylogram is used to show the relationships among these populations.

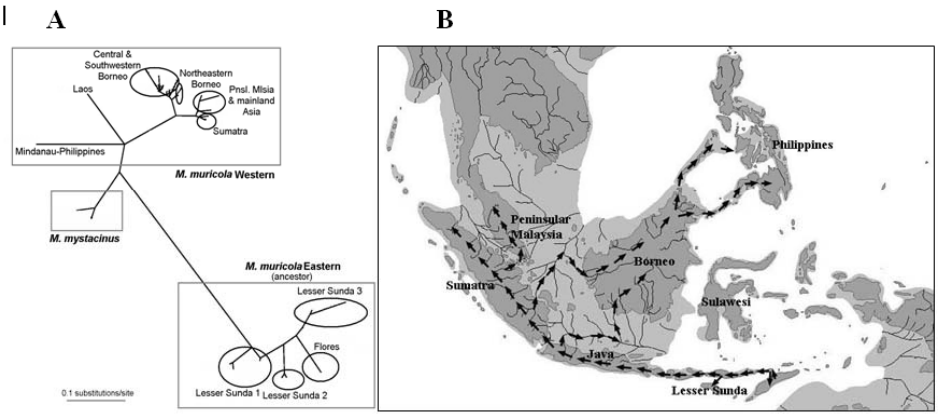


Figure 8: Hypothetical routes (⟶) of dispersal of *M. muricola* in the Malay Archipelago. **A**: Radial tree showing the relationships between *M. muricola* and *M. mystacinus* and within *M. muricola* in the Malay Archipelago inferred from Bayesian method. **B**: Map showing the routes of dispersal of *M. muricola* in the Malay Archipelago. Map was modified from Voris (2000), when the sea level dropped 120 m below the present sea level and gave rise to some river systems.

Sigit Wiantoro, Ibnu Maryanto and M.T. Abdullah. 2010. Phylogeny and Phylogeography of *Myotis muricola* (Gray, 1846) (Chiroptera: Vespertilionidae) from the West and East of Wallace's Line Inferred from Partial MtDNA Cytochrome *b* Gene. Accepted by *Pertanika Journal of Tropical Agricultural Science* (JTAS).

1. Discovered two *Hampala bimuculata* in Borneo.
2. One in central and southern parts of Sarawak, *Hb* type A.
3. Second *Hb* in northern Sarawak and west coast of Sabah.
4. Sharing of *H. macrolepidota* in southern PM and southern Sarawak hyplotypes showed of Pleistocene migration.

Ryan & Esa. 2006. Phylogenetic analysis of *Hampala* fishes in Malaysia. *Zoological Sciences* 23:893-901.

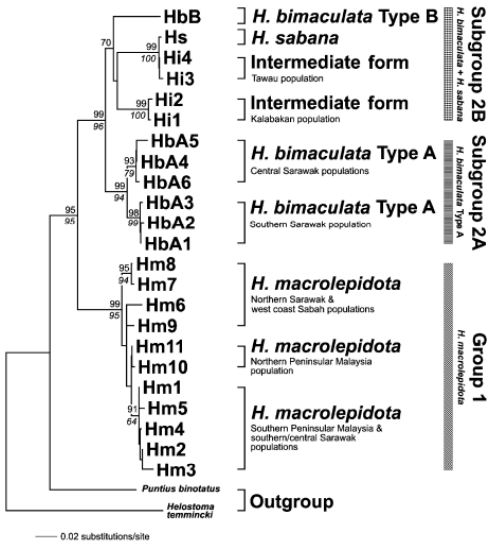


Fig. 2. *Hampala* phylogenetic relationships based on nucleotide sequences of part of the mitochondrial cyt *b* gene. The phylogeny shown is a single tree recovered using NJ analysis. The ML tree (-ln L= 1255.92874) was highly congruent and identified the same topology. Values above branches are NJ bootstrap estimates; those below branches are ML estimates, based on 1,000 replicates in both cases. Only bootstrap values>50% are shown.

Contemporary climate change & biodiversity

- Human-induced cases
  - Land use conversion, deforestation, logging, habitat loss & degradation
  - Agricultural development – market economy
  - Settlement, urbanisation & infrastructural development - population increase.
  - Industrialisation, combustion, slash and burn
  - Uncontrolled consumptive use
- Natural phenomena activities
  - Climate itself
  - Tsunami
  - Volcano

Pleistocene-Holocene Extinction

Sarawak	Malaysia
Cuon alpinus *C. familiaris* ?	*Palaeoloxodon namadicus* *Elephantidae*
Panthera tigris	*Hexaprotodon* sp. Hippopotamus
Tapirus indicus	*Duboisia santeng* Bovidae
Rhinoceros sondaicus	
Manis palaeojavanicus	

Contemporary Disappearance

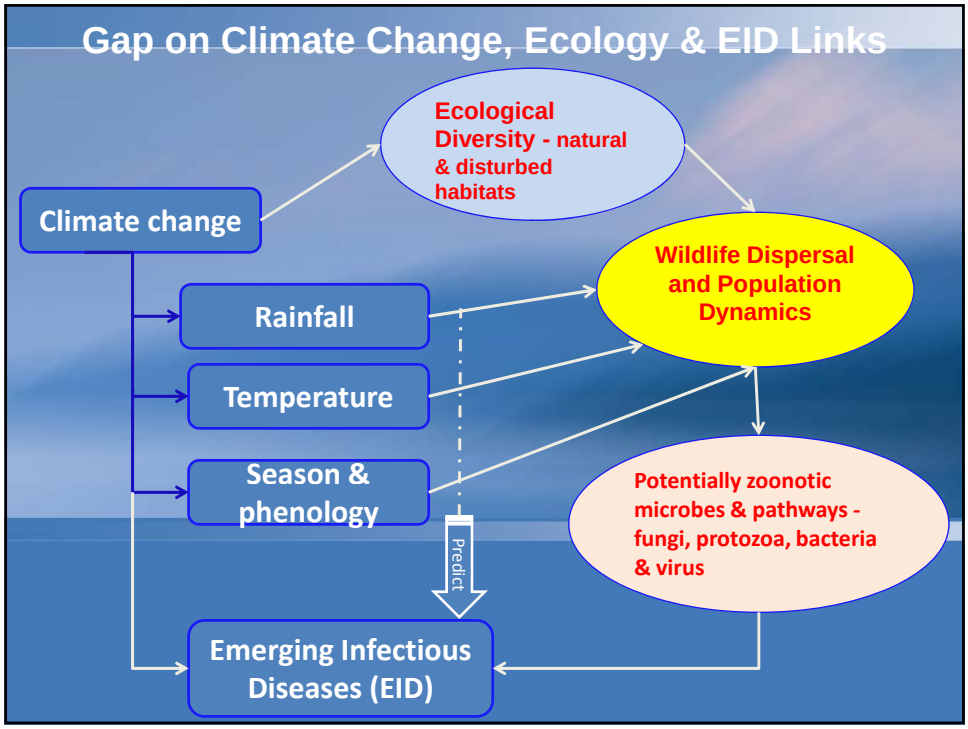
Sarawak*	Malaysia
Carnivora/Felidae[A]	Carnivora/Felidae[A]
	Tapirus indicus[A]
Dicerorhinus sumatrensis	*Dicerorhinus sumatrensis*[A]
	Rhinoceros sondaicus
	Bos gaurus[A]
	Bos javanicus
	Elephas maximus[A]
Primates[A]	
Flying fox[A]	Flying fox[A]
Pheasant[A] & Hornbill[A]	Pheasant[A]
Amphibians? Reptiles?	Amphibians? Reptiles?

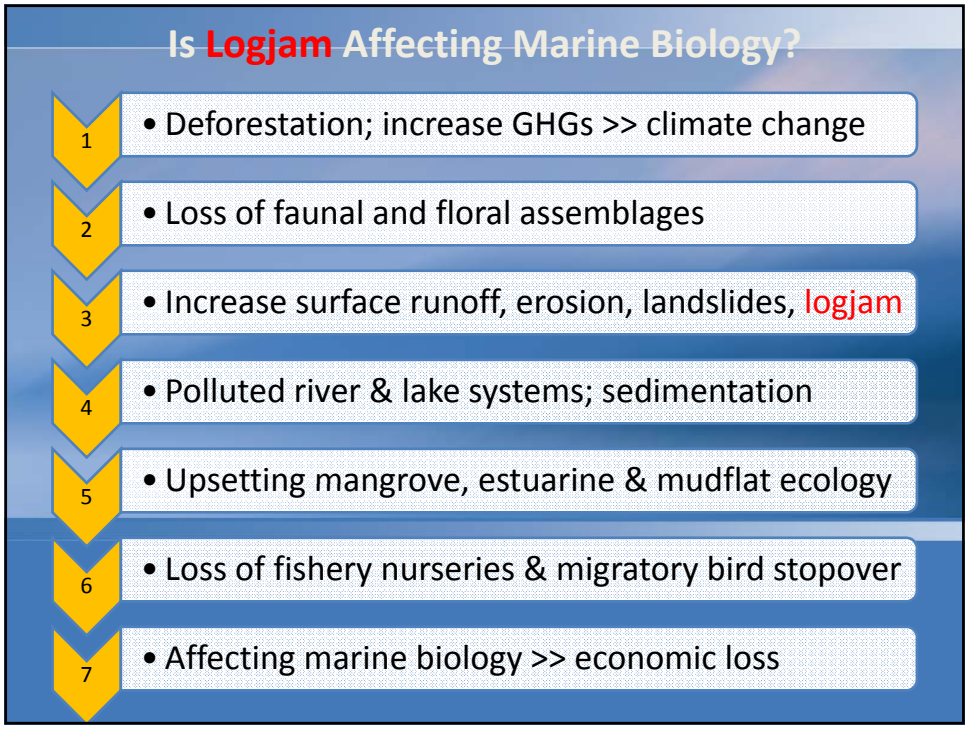
*58 spp hunted & eaten (Abdullah *et al.* 2010)

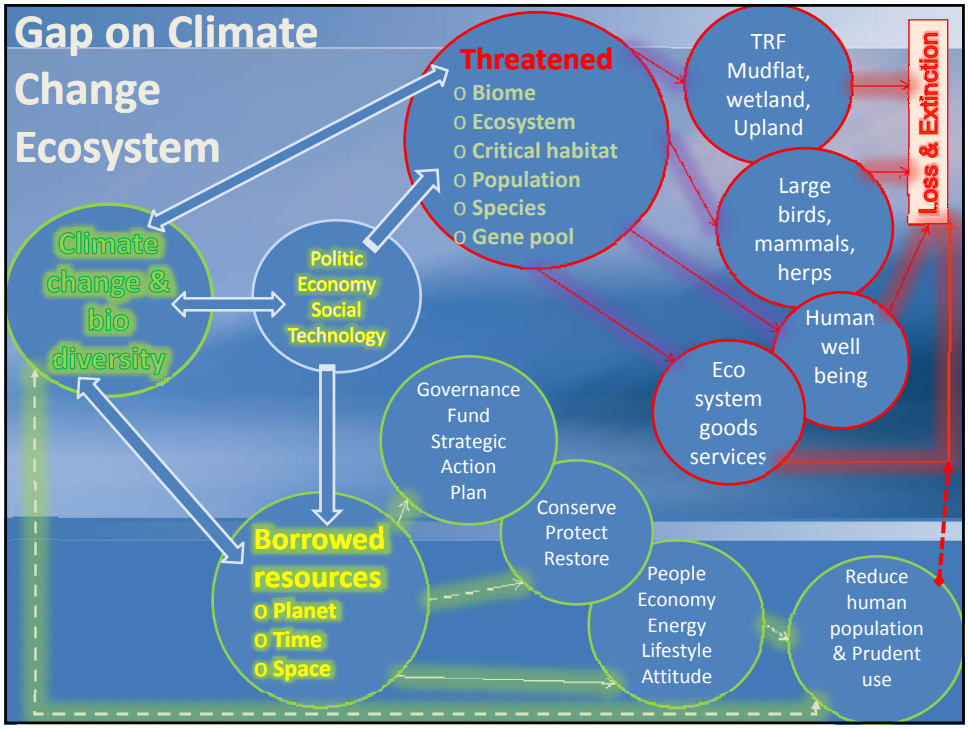
A = localised

Knowledge Gaps in Sarawak

1. Incomplete knowledge on biodiversity : Ecosystem, Taxonomic, Cultural (e.g. frog & microbats vocalisation) & Genetic diversity
2. Protected areas (PA) & land use (LU) : define PAs, TPAs, assumptions, methods; is 10% PAs enough?
3. PAs & species diversity not fully understood
4. Interconnected PA network for better management? ESU vs MU; Single vs metapopulations.
5. Specific biodiversity priorities? Rare vs charismatic
6. Long term impact of climate change on faunal and floral assemblages not fully understood.


Gap on Climate Change, Ecology & EID Links
Ecological Diversity - natural & disturbed habitats
Climate change
Wildlife Dispersal and Population Dynamics
Rainfall
Temperature
Season & phenology
Potentially zoonotic microbes & pathways - fungi, protozoa, bacteria & virus
Predict
Emerging Infectious Diseases (EID)


Is Logjam Affecting Marine Biology?
1
• Deforestation; increase GHGs >> climate change
2
• Loss of faunal and floral assemblages
3
• Increase surface runoff, erosion, landslides, logjam
4
• Polluted river & lake systems; sedimentation
5
• Upsetting mangrove, estuarine & mudflat ecology
6
• Loss of fishery nurseries & migratory bird stopover
7
• Affecting marine biology >> economic loss



Example: Strategic Framework & Actions

Strategy	Action
1. Strengthen and integrate climate change, biodiversity , agriculture, fishery, energy & water agenda into Federal legal framework and governance.	Harmonize & coalesce Federal and State regional laws and policies on climate change, biodiversity, energy and waterbodies
	JPM > Science Advisor > Akademi Sains Negara > Coordinating Agency
	Integrate climate change, biodiversity , energy & water resources into sectoral planning
	Enhance research and training skills using state of the art technologies and predictive modeling.
	Enhance institutional capabilities and competence
	Centre of Excellence in Biological Diversity & Climate Change in Sarawak

Strategy	Action
2. Creative, sustainable & guaranteed funding mechanism; **less addiction** on the government grant handouts.	**A new species name for a million; YTL, Ananda, Bukhari, Kouk, Genting, etc, etc.**
	5-10% green tax on private large-scaled agricultural plantations & timber extraction
	5-10% tax on extractive natural resources projects
	5-10% f the Federal budget.
	Ecological compensation for water and wetland-based alienation projects
	1% ecological compensation on fossil fuel use
	Tax break for private research on green technology
	Tax break on environmental and ecological project donations.

Strategy	Action
3. Promote conservation of resource to reduce carbon footprint	Manage, maintain and preserve renewable and non-renewable resources.
	Systematic inventory on forest, wildlife, climate change water and energy use
	National grid of research plots to be monitored by research institutions
	GHGs monitoring, modeling and prediction
	Green lung in all urban, settlement and schools
	Institutional support, capacity building & management
	Promote socio-environmental projects
	Maintain ecosystems to deliver goods and services for our livelihood.
	Maintain of sensitive ecosystem; mountain, wetlands and caves
	Promote awareness

Strategy	Action
4. Restoration of ecosystem, population and species.	Established irrevocably TPAs and forest reserves
	Reforestation and afforestration >> carbon sequestration.
	Sustainable forest management practices
	Restocking & restoration of endangered or depleted wildlife resources; Gene bank; cryopreservation
	Habitat connectivity >> animal movement
	Monitor and assess vulnerability
	Promote awareness & education
5. Sustainable utilisation	Use of wild stock or type for agriculture & animal husbandry
6. Prevent Emerging Infectious Diseases	Predictive modelling based on ecological, hosts and climatic data.

Acknowledgements

- Majlis Profesor Negara, NRE & LESTARI UKM for giving us the opportunity to express our views.
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- BioD Research Team Members : Mohd Ridwan Abd Rahman, Muhamad Ikhwan Idris, Shazwani Abdul Aziz, Mardhiyyah Mohd Pauzi, Noor Haliza Hasan, Faisal Ali, Roberta Chaya, Eileen Lit, Kishen Bunya, Madinah Idrus, Hanif, Aida, Wahap Marni, Huzal Hussin, Isham, Sigit & Anang.

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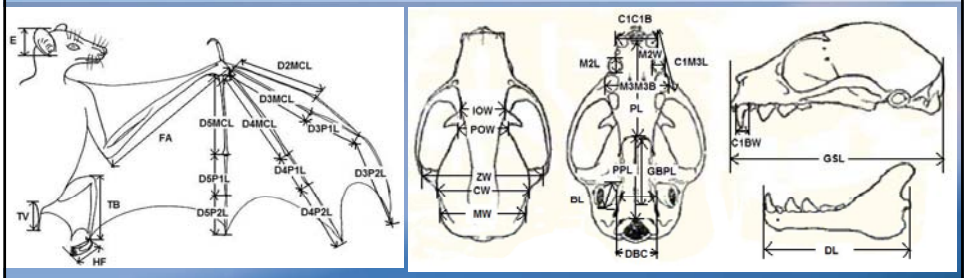

Forearm length (FA), ear length (E), tibia length (TB), **hind foot length (HF)**, tail to ventral length (TVL), second digit metacarpal length (D2MCL), third digit metacarpal length (D3MCL), third digit first phalanx length (D3P1L), third digit second phalanx length (D3P2L), **fourth digit metacarpal length (D4MCL)**, fourth digit first phalanx length (D4P1L), fourth digit second phalanx length (D4P2L), fifth digit metacarpal length (D5MCL), fifth digit first phalanx length (D5P1L) and fifth digit second phalanx length (D5P2L).

Greatest skull length (GSL), interorbital width (IOW), postorbital width (POW), cranial width (CW), mastoid width (MW), zygomatic width (ZW), post palatal length (PPL), palatal length (PL), distance between cochleae (DBC), **bulla length (BL),** greatest basial pit length (GBPL), and **dentary length (DL).**

Canine tooth basal width (C1BW), breadth across both canine outside surfaces (C1C1B), breadth across both third molar teeth outside surfaces (M3M3B), canine molar length or maxillary tooth row length (C1M3L), second molar tooth crown length (M2L), and second molar tooth crown width (M2W).

Back