Vector Hazard Report:

Malaria in Cambodia

Part 1: Climate, Disease and Distribution Maps

Information gathered from products of
The Walter Reed Biosystematics Unit (WRBU)

VectorMap

Systematic Catalogue of the Culicidae

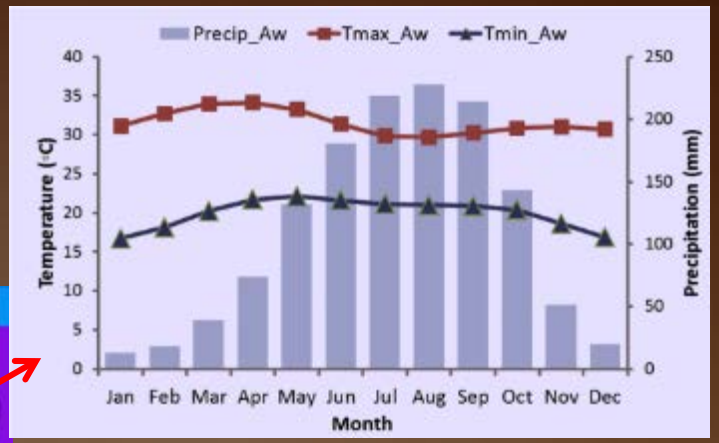
WRAIR
Walter Reed Army Institute of Research

WRBU
WALTER REED BIOSYSTEMATICS UNIT
Know the vector, know the threat

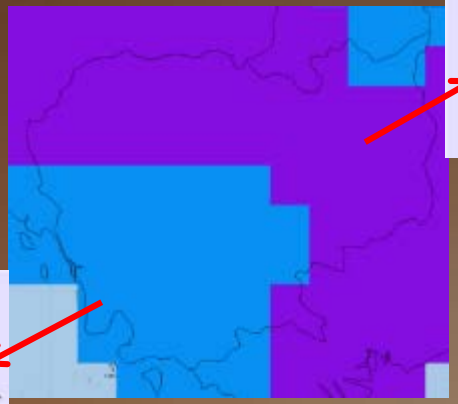
Table of Contents

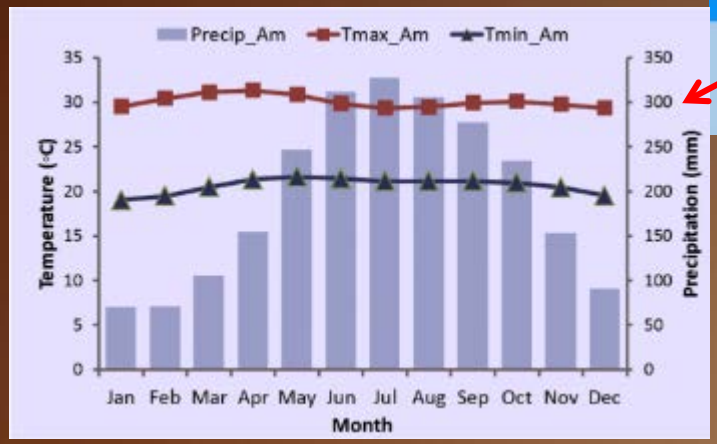
Climate Zones: Cambodia

Average monthly temperature and precipitation is presented below according to the Köppen-Geiger Climate classification.



Zone: N_Aw

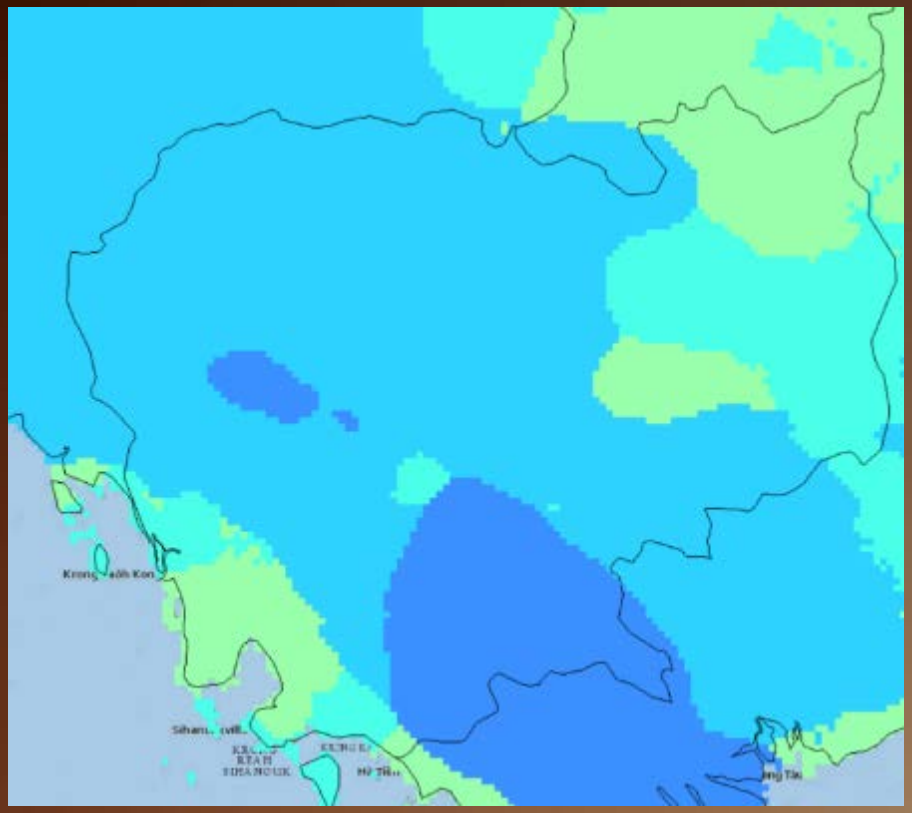


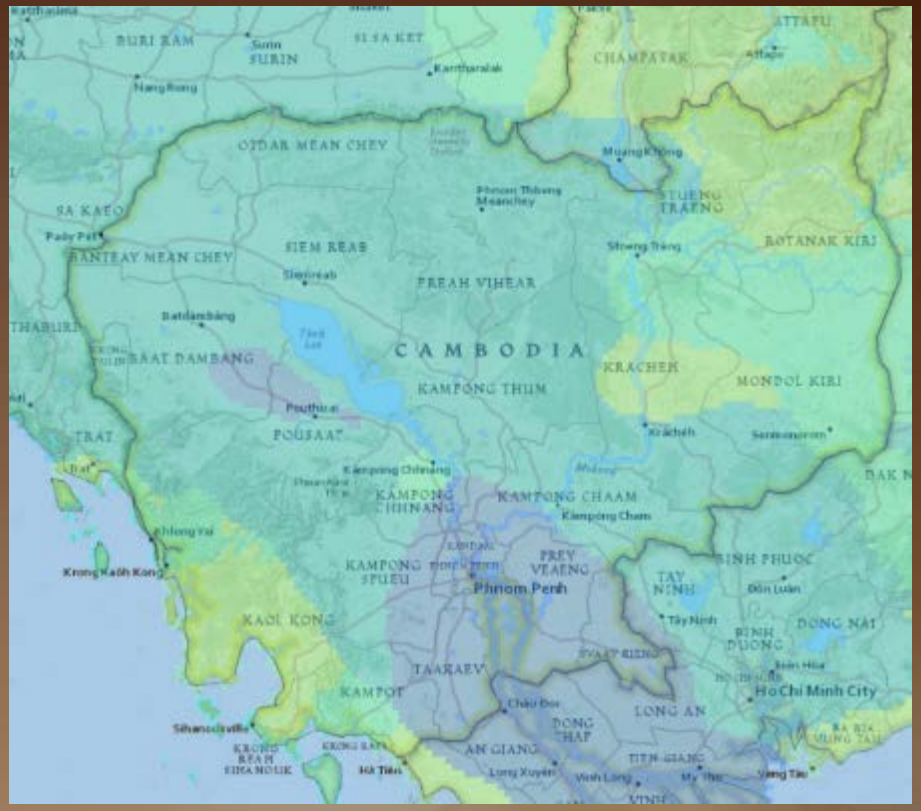


Zone: N_Am

Back to Table of Contents

Climate of Cambodia: Month of Maximum Precipitation



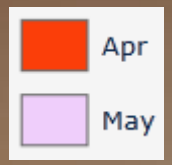


- 6. Jun
- 7. Jul
- 8. Aug
- 9. Sep
- 10. Oct

Month of maximum precipitation compiled from the 50 year average of the WorldClim dataset.

Back to Table of Contents

Climate of Cambodia: Month of Maximum Temperature

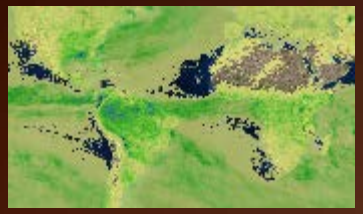


Month of maximum temperature compiled from the 50 year average of the WorldClim dataset.

Back to Table of Contents

Monthly Climate Maps

Click here to view the maps described below



Rainfall

This map shows the accumulated rainfall for the past month. Updated monthly.
-NASA Earth Observations

Consistent Above and Below Average Precipitation

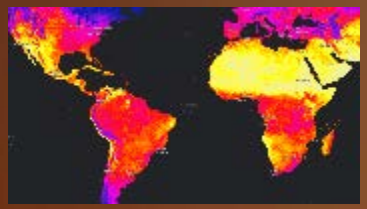
Areas with consistent above average monthly rainfall over the past 3 months may indicate increased mosquito breeding sites which may lead to increased mosquito-borne disease transmission. Areas with consistent below average rainfall may also indicate increased water storage or ponding which can provide additional habitat for mosquito species that lay eggs in human containers, protected micro environments, or long lasting pools. Updated monthly. -NASA Earth Observations.

Drought Breaking Rain

Areas receiving above average rainfall for the past month and below average rainfall for the previous 12 months. Drought breaking rain may indicate recent suitable conditions for vectors and diseases in a stressed environment or human population. Updated monthly. -WorldClim, Giovanni online data system NASA GES DISC, Tropical Rainfall Measuring Mission (TRMM).

Temperature anomaly

This map shows where earth's temperatures were warmer or cooler in the daytime for the past month than the average temperatures for the same month from 2001-2010. Updated monthly.
-NASA Earth Observations

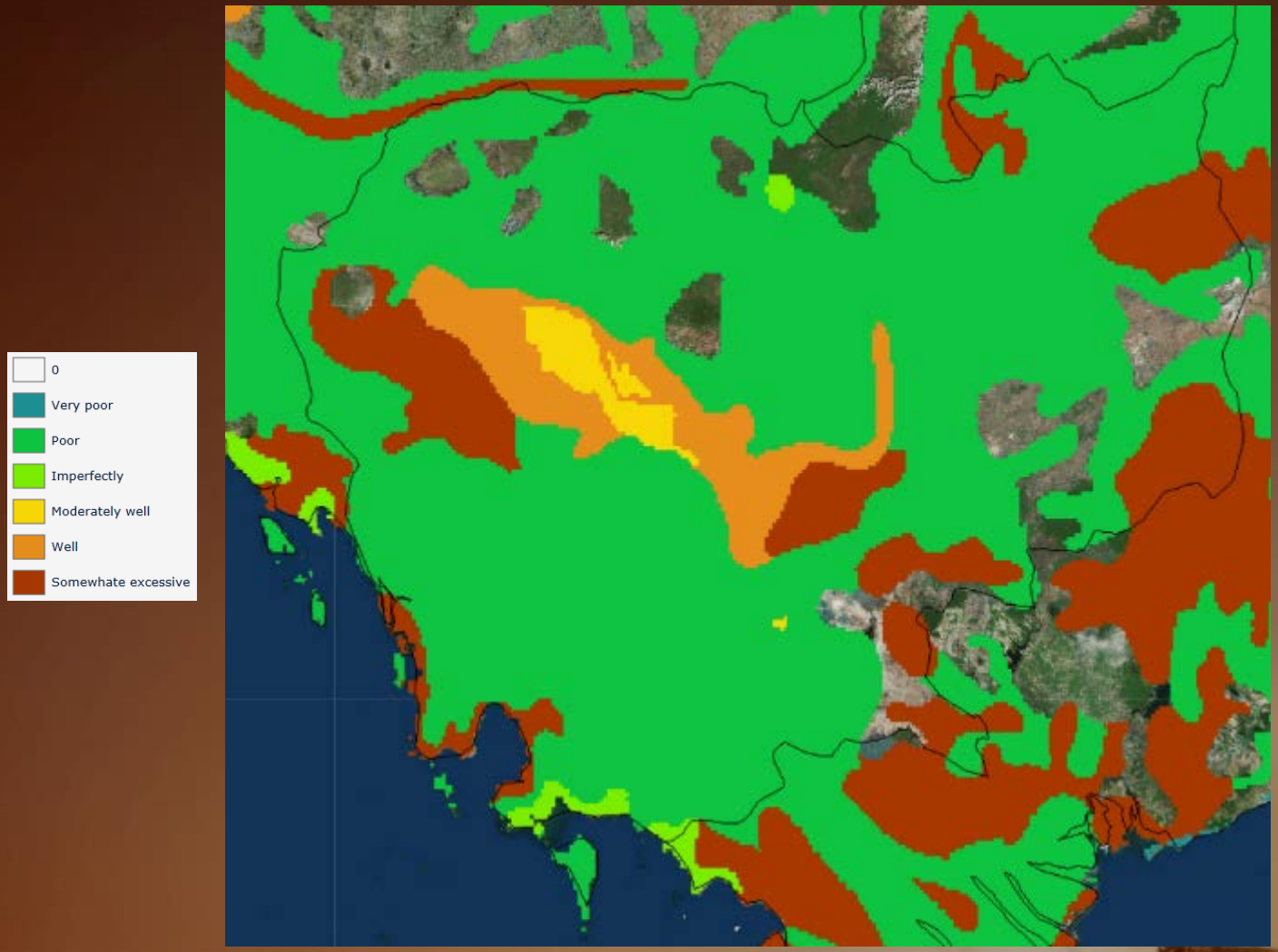


Land Surface Temperature

This map shows the temperature of the earth's lands during the daytime. Updated monthly.
-NASA Earth Observations

Back to Table of Contents

Soil Drainage

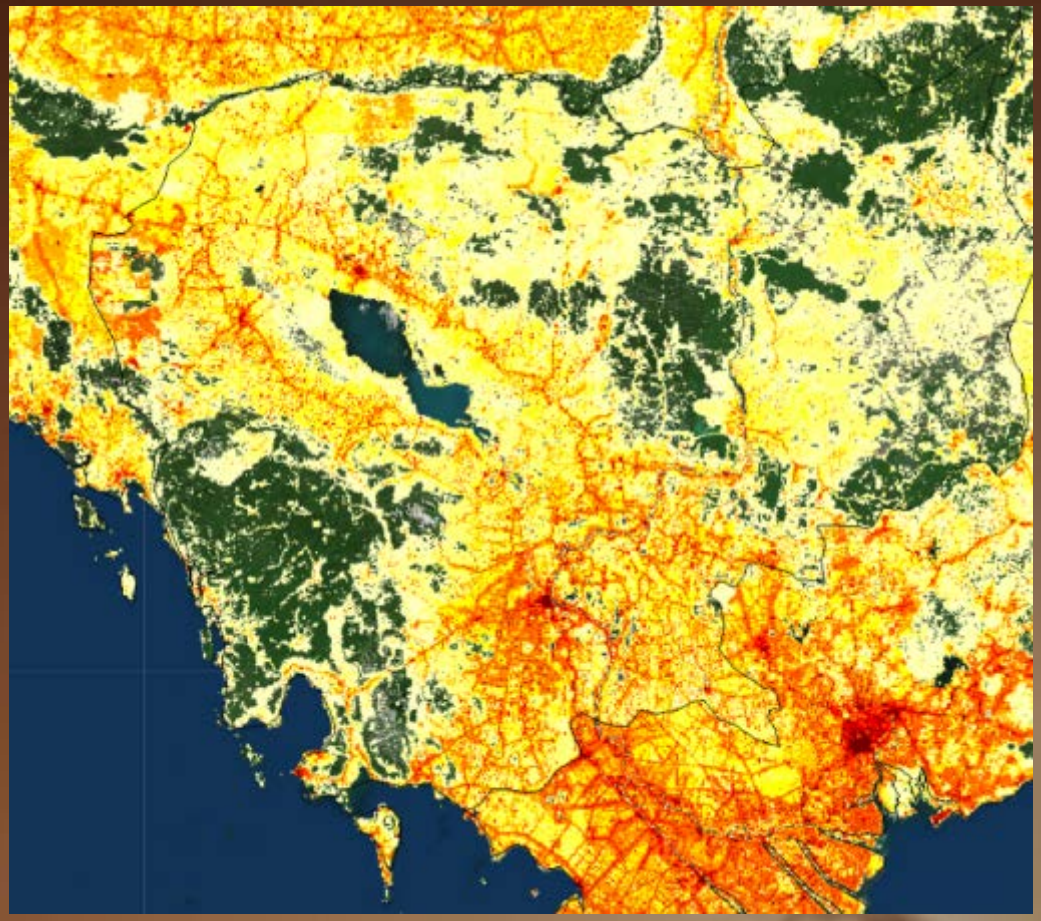


Soil Drainage (Harmonized World Soil Database 1.1; 0.02 Deg resolution)

Back to Table of Contents

Human Density

LandScan 2011



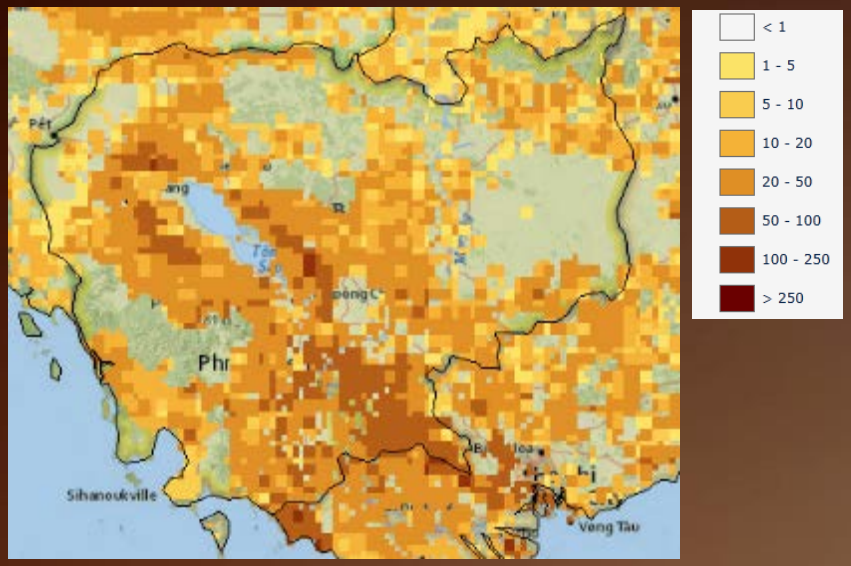
- 0
- 1 - 5
- 6 - 25
- 26 - 50
- 51 - 100
- 101- 500
- 501 - 2,500
- 2501 - 5,000
- 5001 - 130,000

People/1 sq Km. This product was made utilizing the LandScan (2011)™ High Resolution global Population Data Set copyrighted by UT-Battelle, LLC, operator of Oak Ridge National Laboratory

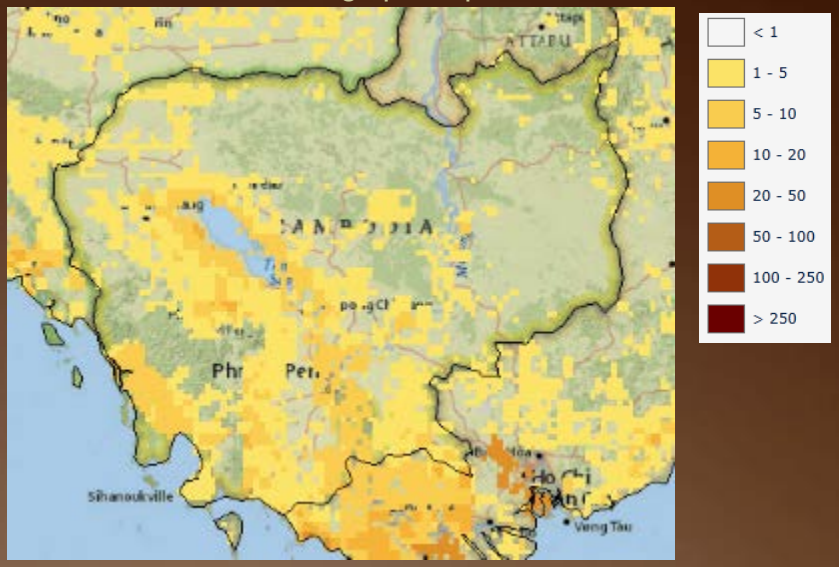
Back to Table of Contents

Host Densities, Food and Agriculture Organization of the United Nations, 2005

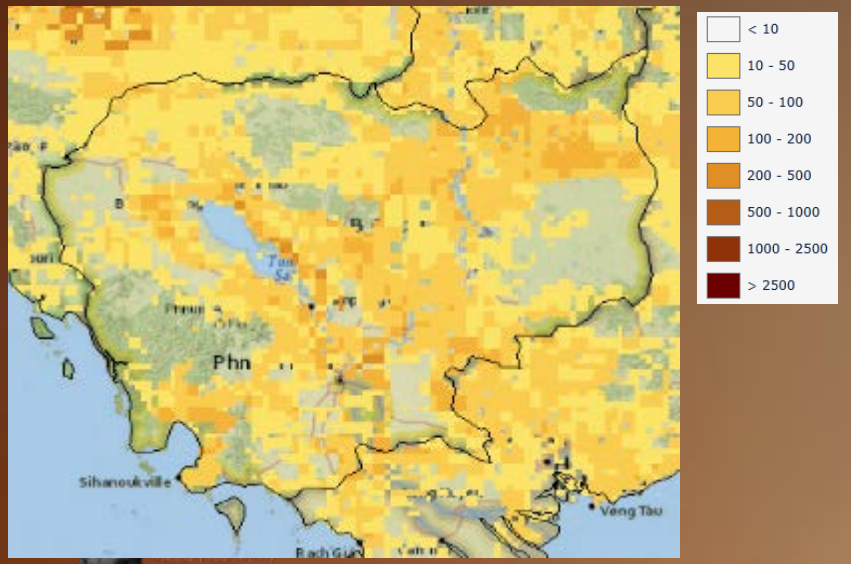
Cows per sq. km



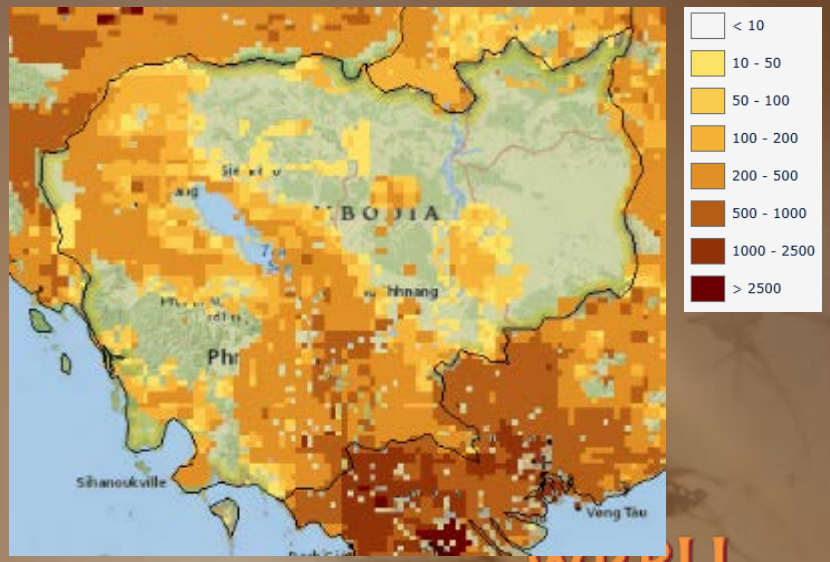
Pigs per sq. km



Buffalo per sq. km



Poultry per sq. km



Back to Table of Contents

Malaria in Cambodia

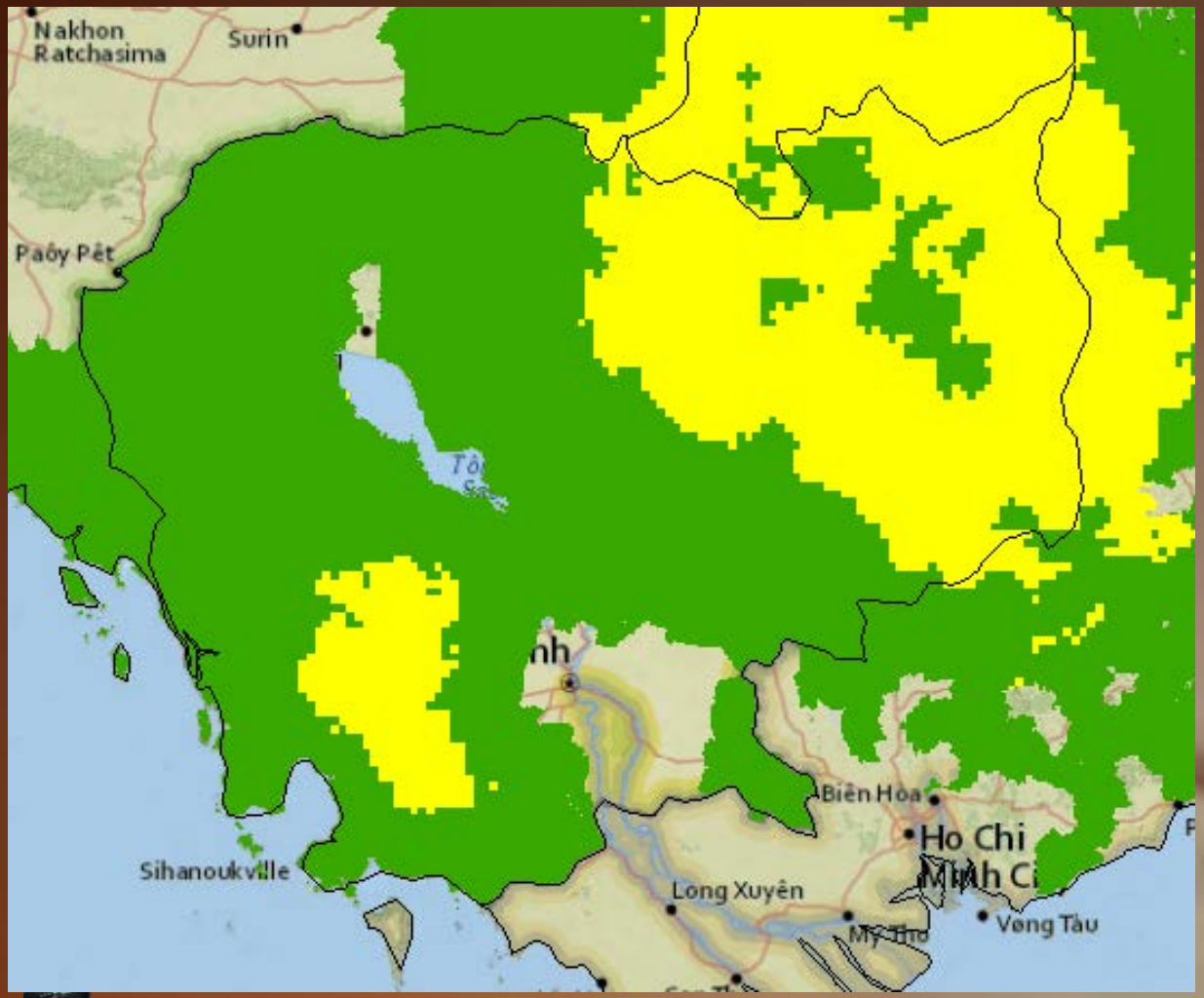
Malaria is a mosquito borne disease caused by parasites of the genus Plasmodium. In Cambodia, both P. falciaparum and vivax are present. It is primarily spread through the bite of mosquitoes of the genus Anopheles. Symptoms of malaria are flu-like including high fever and chills. According to the CDC there were an estimate 219 million cases of malaria world-wide in 2010 with approximately 91% of infections occurring in Africa (CDC, 2014).

Back to Table of Contents

Malaria Risk Maps

Stratified estimate proportion of 2-10 year olds in the general population that are infected with *P. falciparum* at any one time averaged over the 12 months of 2010.

-Malaria Atlas Project



- Lower risk (PR <5%)
- Intermediate risk (PR 5-40%)
- Higher risk (PR >40%)

Back to Table of Contents

Malaria Risk Maps

Stratified estimate proportion of the general population that are infected with *P. vivax* at any one time averaged over the 12 months of 2010.

-Malaria Atlas Project

Lower risk (PR<1%)

Intermediate risk (PR 1-5%)

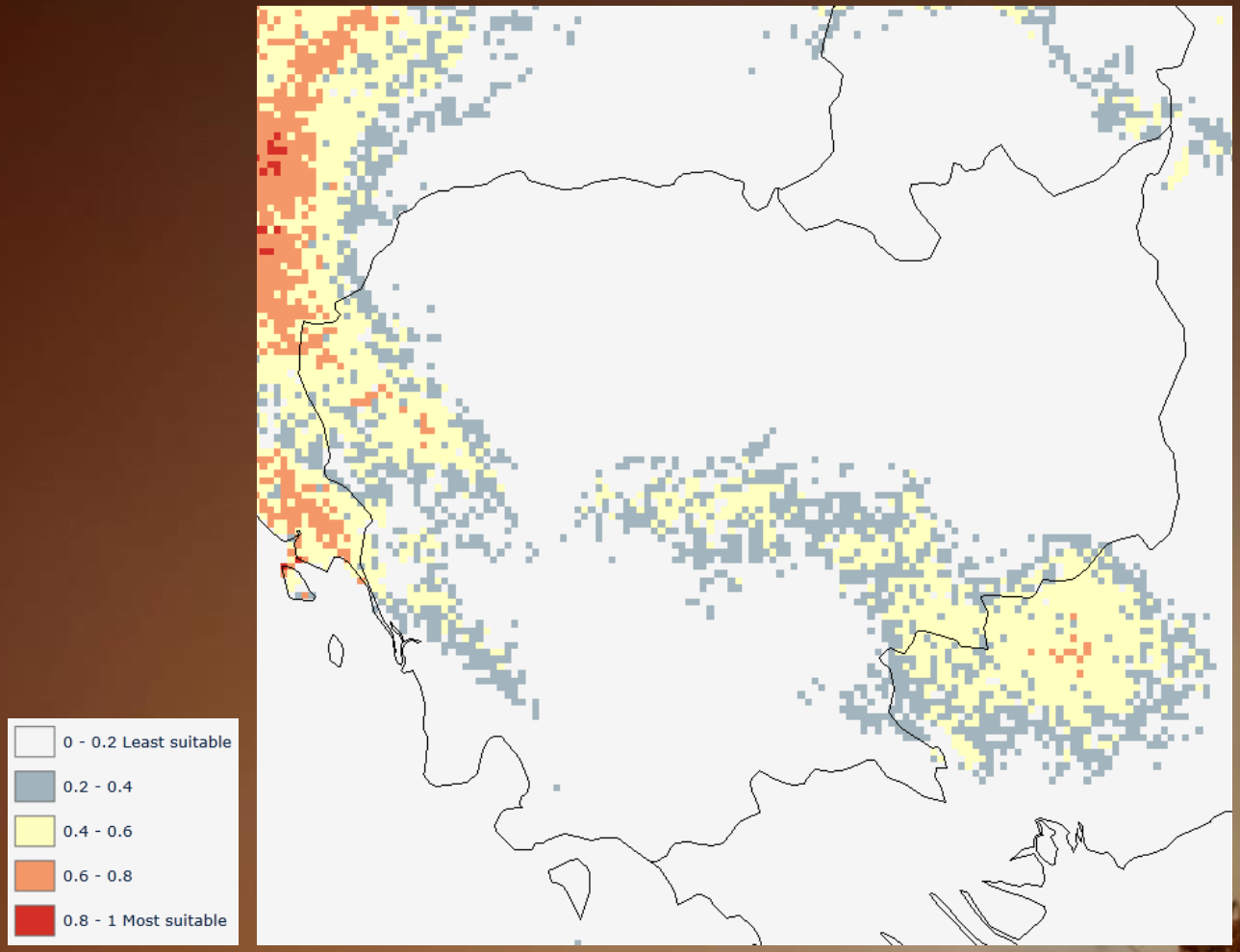
Higher risk (PR >5%)

Back to Table of Contents

Malaria Vector Habitat Suitability Models

Back to Table of Contents

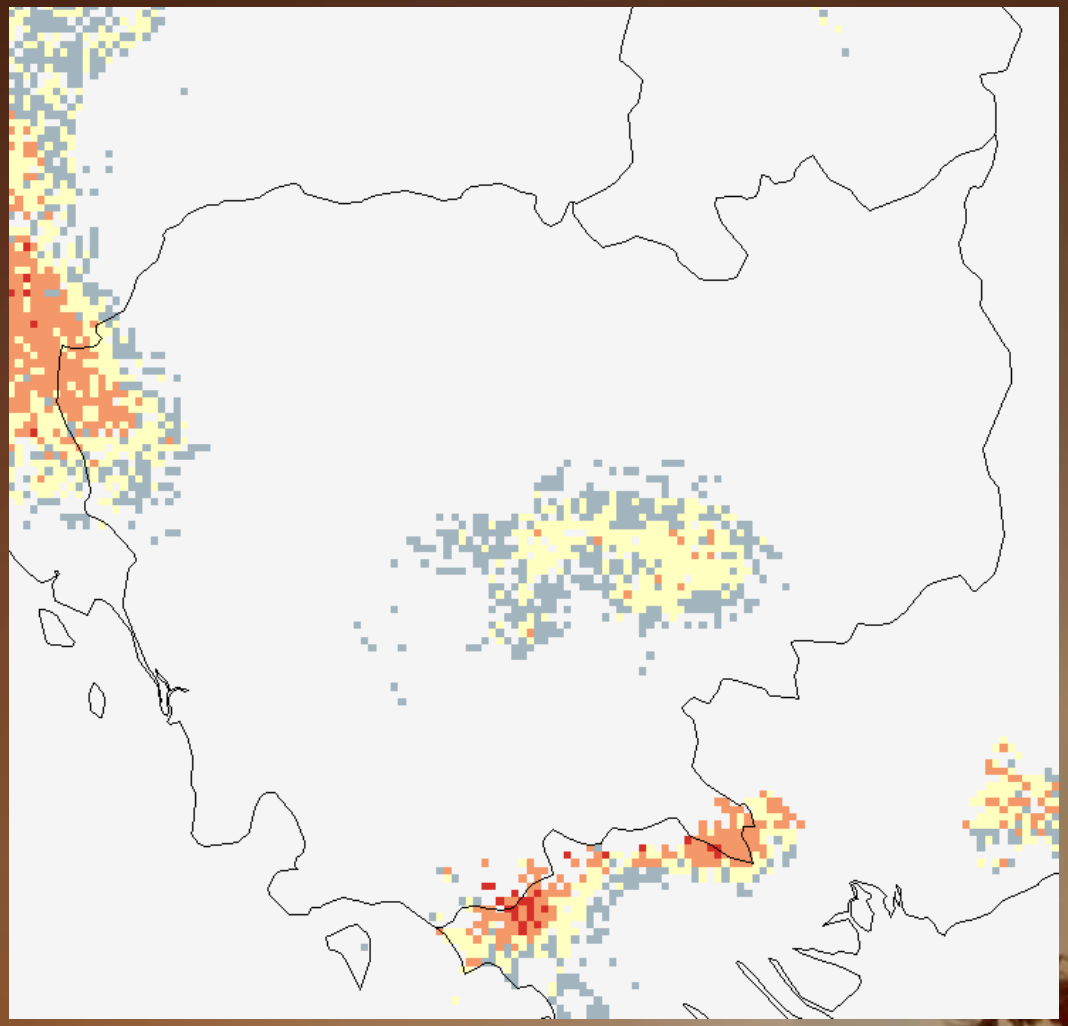
Habitat Suitability Model: *Anopheles aconitus*



Maxent model of *An. acontius*, Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles campestris*

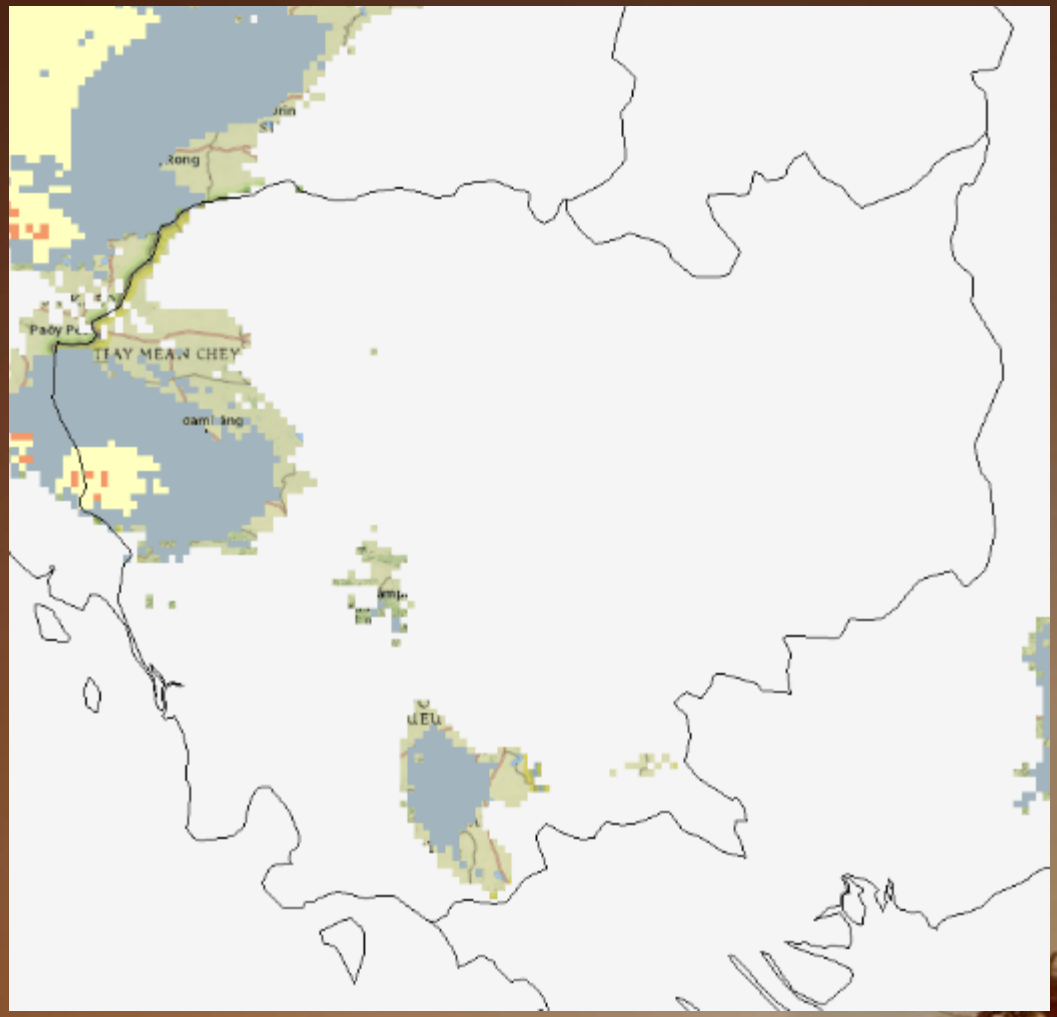


- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. campestris*, Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles culicifacies*

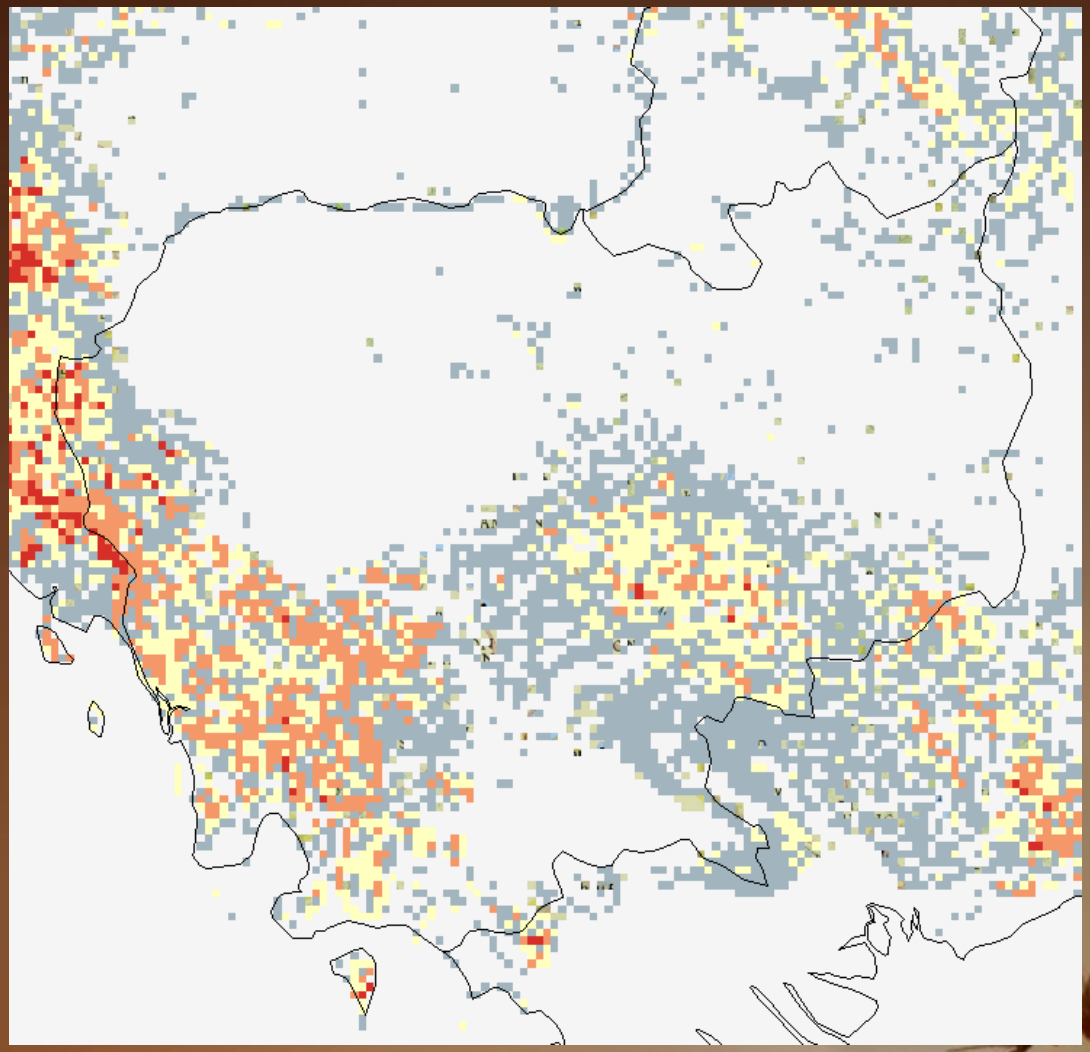


- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. culicifacies*, Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles dirus*

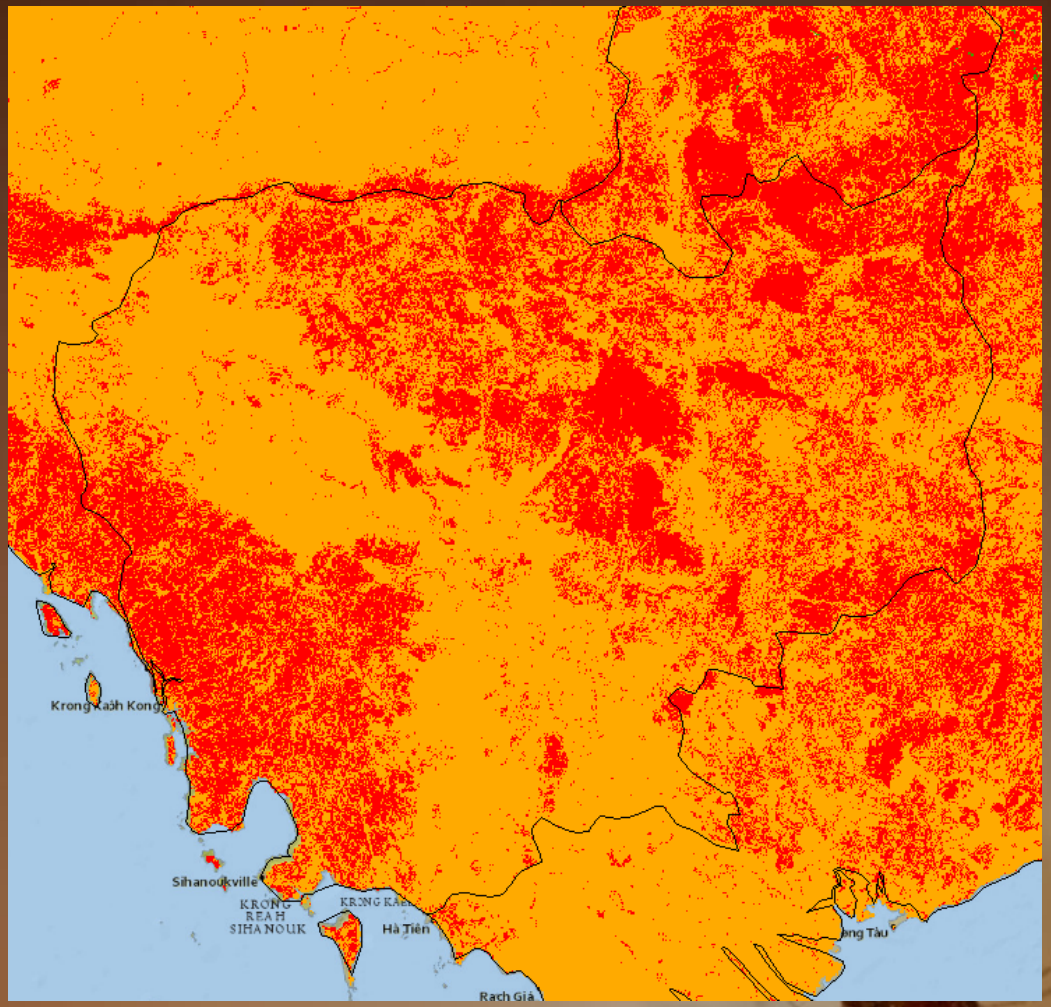


- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. dirus* s.l., Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles dirus* complex



- Not favorable
- abiotic favorable but no forest
- forested area but abiotic factors not favorable
- current distribution 2005

An. dirus complex Obsomer, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles fluviatilis*

Model of *An. fluviatilis* s.l. Foley, D.

Back to Table of Contents

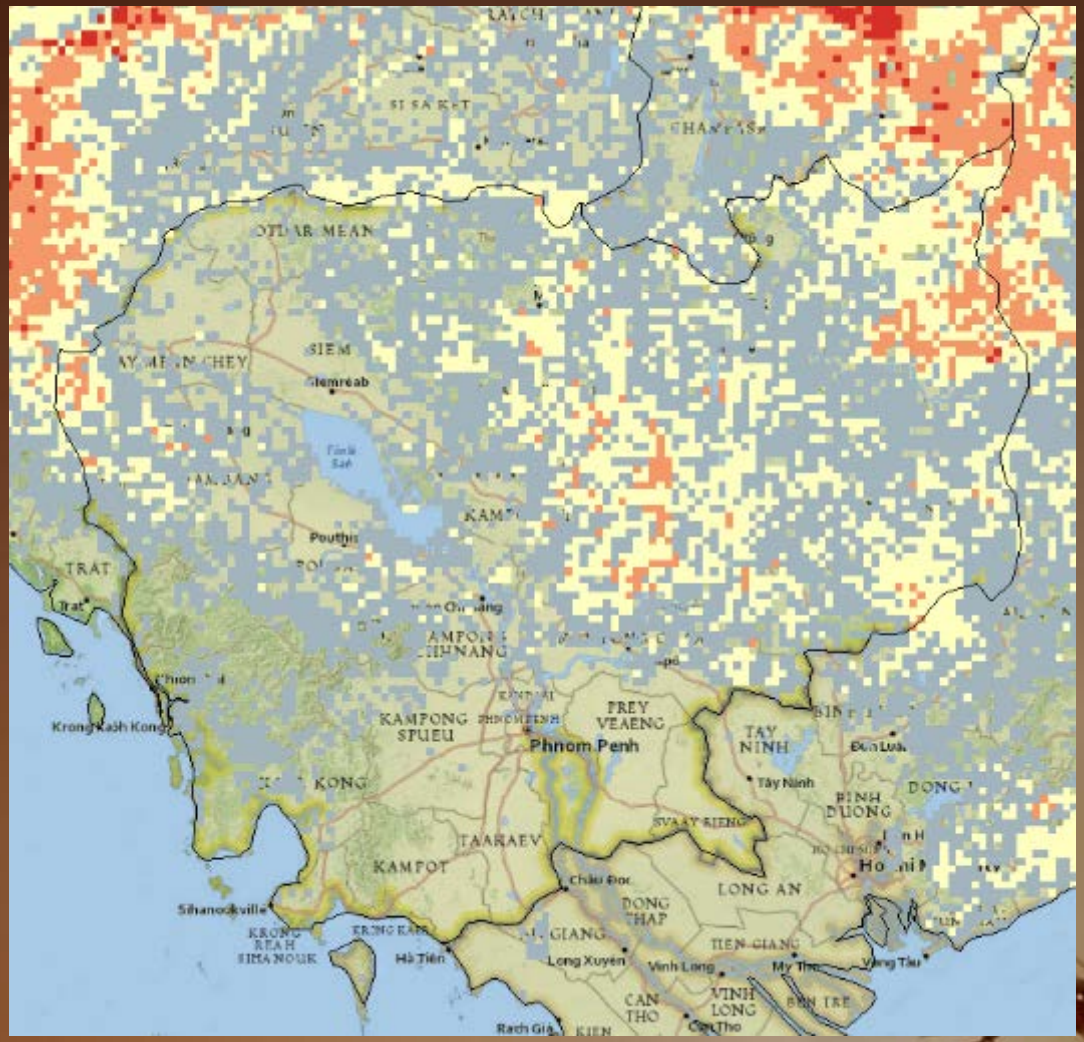
Habitat Suitability Model: *Anopheles maculatus*

- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. maculatus*, Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles minimus*



- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. minimus*, Nyari, A. 2011

Back to Table of Contents

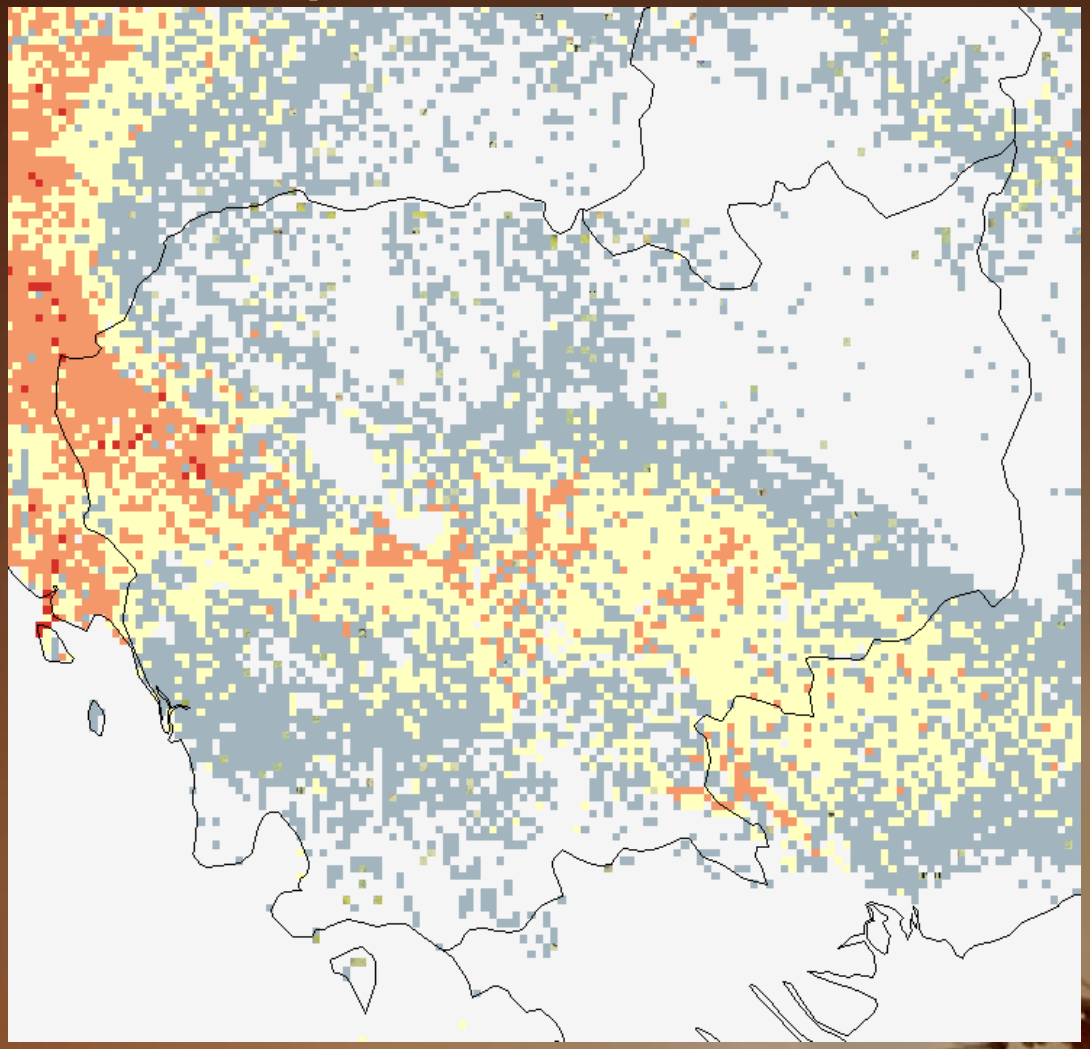
Habitat Suitability Model: *Anopheles sundaicus*

- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. sundaicus*, Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles annularis*

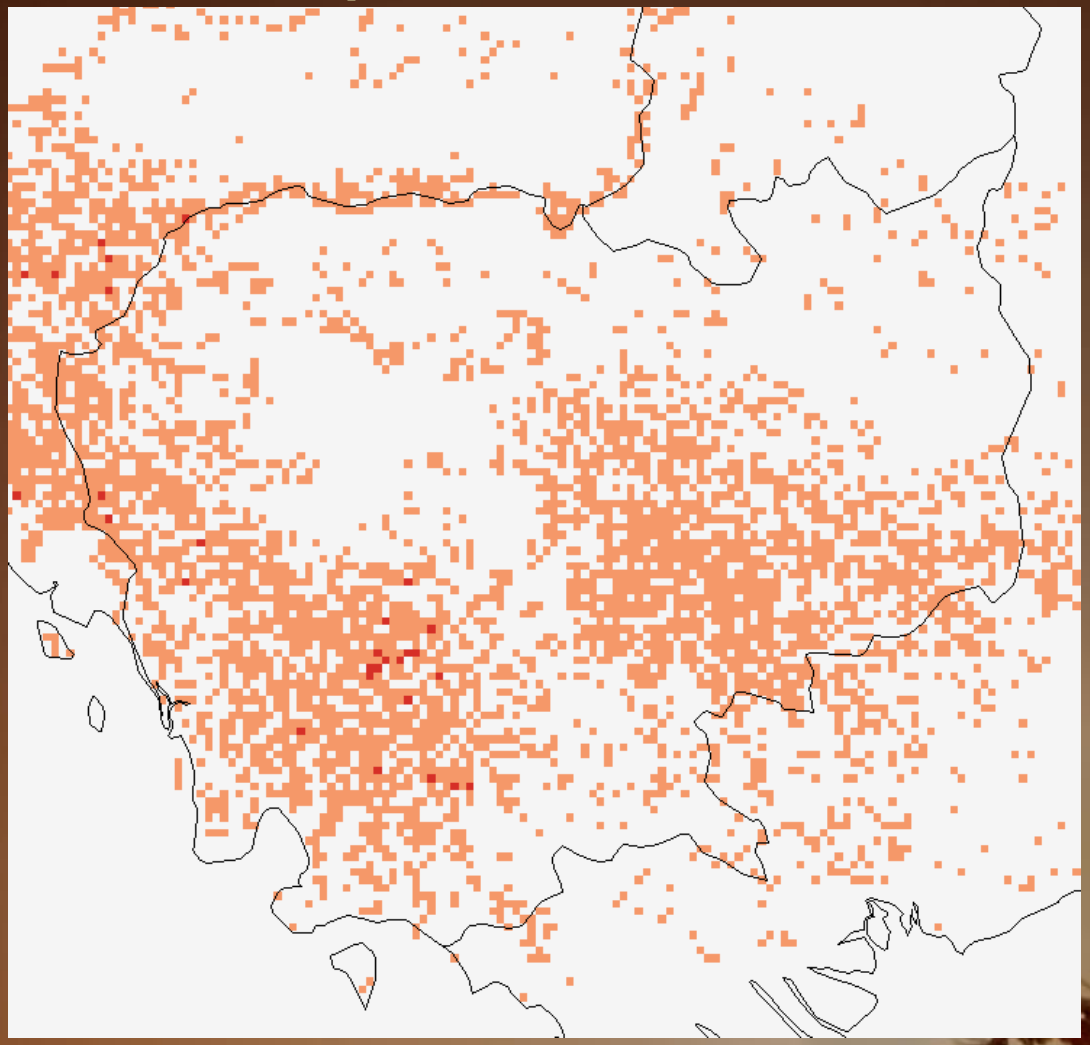


- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. annularis*, Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles baimaii*

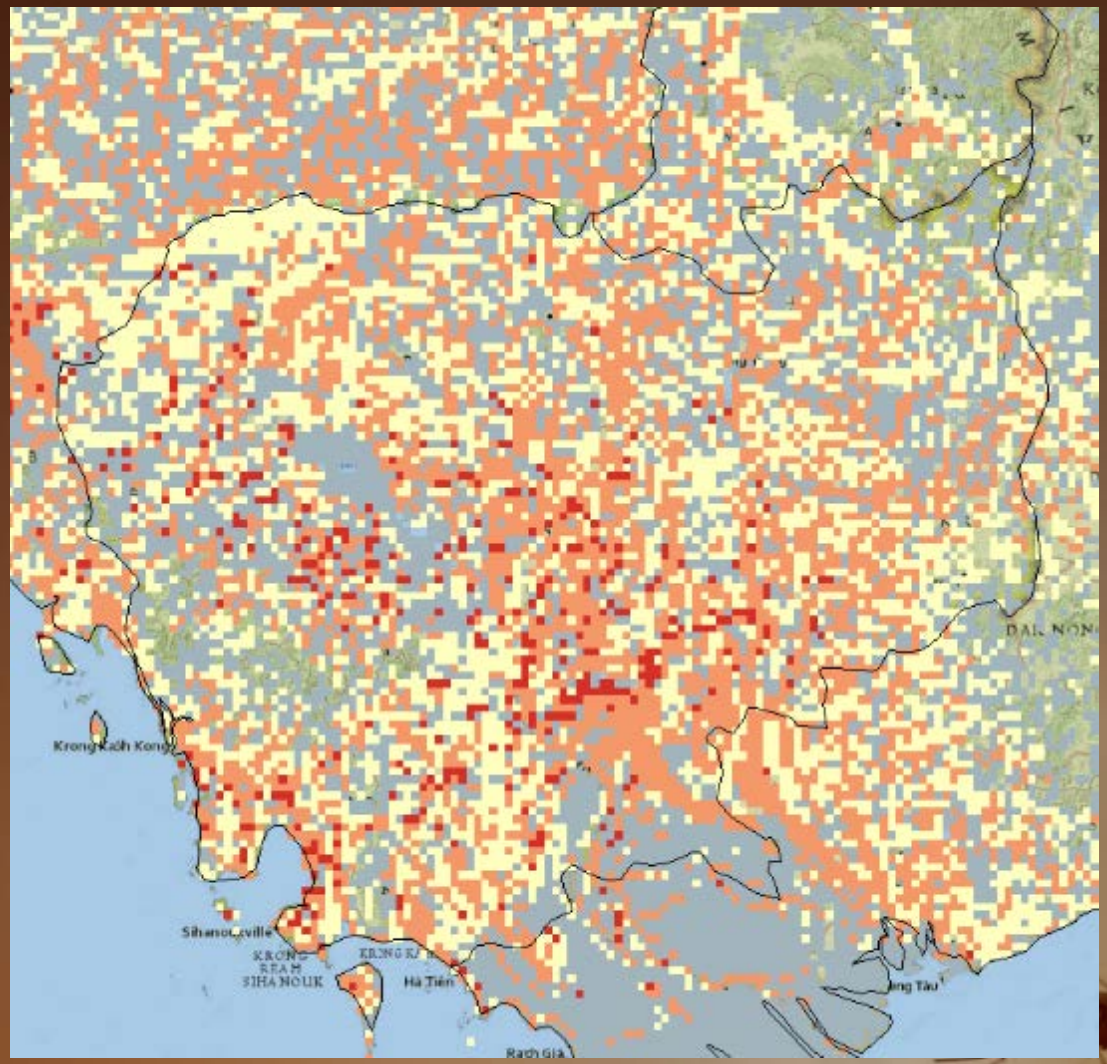


- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. baimaii*, Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles karwari*



- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0 Most suitable

Maxent model of *An. karwari* Nyari, A. 2011

Back to Table of Contents

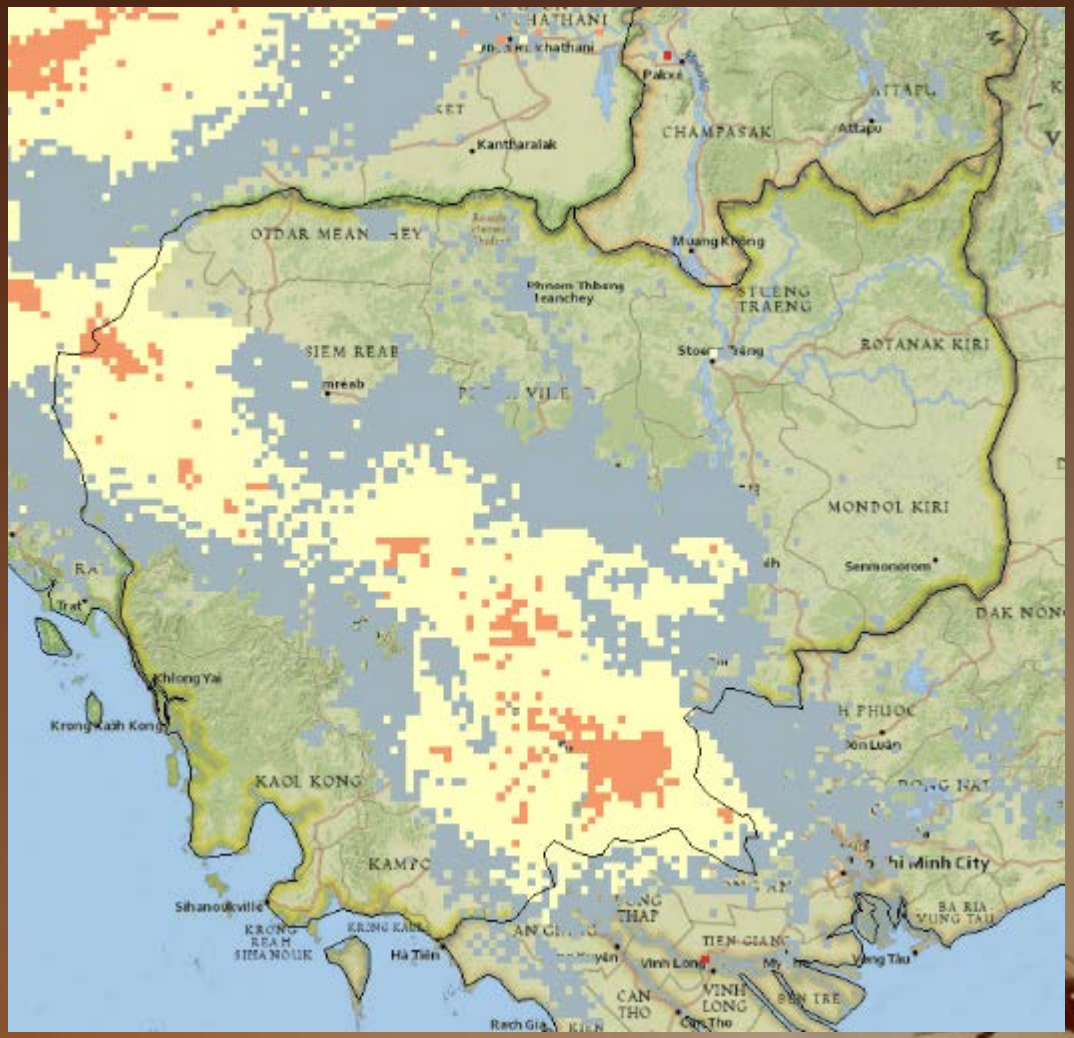
Habitat Suitability Model: *Anopheles philippinensis*

- 0 - 0.2 Least suitable
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1 Most suitable

Maxent model of *An. philippinensis* Nyari, A. 2011

Back to Table of Contents

Habitat Suitability Model: *Anopheles sinensis*



0 - 0.2 Least suitable
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1 Most suitable

Maxent model of *An. sinensis* Nyari, A. 2011

Back to Table of Contents

Keys to the Mosquitoes of Cambodia

WRBU Keys to the Medically Important Mosquitoes of Asia and the Pacific Region
Rattanarithikul R. et al. 2005. Illustrated Keys to the Mosquitoes of Thailand, Part 1. Background; Geographic Distribution; Lists of Genera, Subgenera, and Species; and a Key to the Genera. Southeast Asian J Trop Med Public Health. 36(suppl 1)
Rattanarithikul R. et al. 2005. Illustrated Keys to the Mosquitoes of Thailand, Part 2. Genus Culex. The Southeast Asian J Trop Med Public Health 2005. 36 (suppl 2)
Rattanarithikul R. et al. 2006. Illustrated Keys to the Mosquitoes of Thailand, Part 3. Genera Aedeomyia, Ficalbia, Mimomyia, Hodgesia, Coquilletidia, Mansonia, And Uranotaenia. The Southeast Asian J Trop Med Public Health. 37 (Suppl 1)
Rattanarithikul R. et al. 2006. Illustrated Keys to the Mosquitoes of Thailand, Part 4. Anopheles. The Southeast Asian J Trop Med Public Health. 37 (suppl 2)
Rattanarithikul R. et al. 2007. Illustrated Keys to the Mosquitoes of Thailand, Part 5. Genera Orthopodomyia, Kimia, Malaya, Topomyia, Tripteroides, And Toxorhynchites. The Southeast Asian Journal of Tropical Medicine and Public Health. 38(2)
Rattanarithikul R. et al. 2010. Illustrated Keys to the Mosquitoes of Thailand, Part 6. Tribe Aedini. The Southeast Asian Journal of Tropical Medicine and Public Health. 41(1)
Mattingly, Peter F. 1971. Illustrated Keys to The Genera Of Mosquitoes. Contributions of the American Entomdogiccd Institute. 7(4).
Russell, Paul F. et al. 1943. Keys to the Anopheline Mosquitoes of the World. The American Entomological Society The Academy of Natural Sciences. Prepared for The Preventive Medicine Division, Office of The Surgeon General, U. S. Army

Introduction Literature

This literature was compiled to provide a basic introduction to mosquito taxonomy, ecology and insecticide resistance reported from this country. For more information please visit wrbu.org or contact a staff member using our directory here.

Taxonomy

Harrison, Bruce A. & Klien, J. M. 1975. A Revised List of the Anopheles of Cambodia. Mosquito Systematics. 7(1).

Klien, J.M. 1973. Contributions to The Mosquito Fauna Of Southeast Asia. Xvii, the Cambodian Aedes (Tyeomacleaya) Species, With Some New Descriptions (Diptera: Culicidae). Contributions of the American Entomdogiccd Institute. 10(1).

Harrison, B.A. et al. 1990. Taxonomic Changes, Revised Occurance Records and Notes on the Culicidae of Thailand and Neighboring Countries. Mosquito Systematics 22(3).

Chow, C.Y. et al. 1970. Bionomics of Malaria Vectors in the Western Pacific Region. Southeast Asian J Trop Med Public Health. 1(1): 40-58

Ecology

Paupy C. et al. Factors influencing the population structure of Aedes aegypti from the main cities in Cambodia. Heredity (2005) 95, 144–147

Kar, Narayani Prasad et al. 2014. A review of malaria transmission dynamics inforest ecosystems. Parasites & Vectors2014,7:265

Wai, K.T. et al. 2012. Estimating dengue vector abundance in the wet and dry season: implications for targeted vector control in urban and peri-urban Asia. Pathogens and Global Health 106(8): 436-445

Paupy, C. et al. 2004. Influence of breeding sites features on genetic differentiation of Aedes aegypti populations analyzed on a local scale in Phnom Penh Municipality of Cambodia. Am. J. Trop. Med. Hyg., 71(1): 73–81

Insecticide Resistence

Van Bortel, Wim. et al 2008. The insecticide resistance status of malaria vectors in the Mekong region. Malaria Journal 2008, 7:102

Verhaeghen, Katrijn et al. 2010. Knockdown resistance in Anopheles vagus, An. sinensis, An. paraliae and An. Peditaeniatus populations of the Mekong region. Parasites & Vectors, 3:59

Back to Table of Contents

References

- People/1 Sq Km. This Product Was Made Utilizing The Landscan (2011)™ High Resolution Global Population Data Set Copyrighted By UT-Battelle, LLC, Operator Of Oak Ridge National Laboratory Under Contract No. DE-AC05-00OR22725 With The United States Department Of Energy. The United States Government Has Certain Rights In This Data Set. Neither Ut-Battelle, Llc Nor The United States Department Of Energy, Nor Any Of Their Employees, Makes Any Warranty, Express Or Implied, Or Assumes Any Legal Liability Or Responsibility For The Accuracy, Completeness, Or Usefulness Of The Data Set. Available At Http://Www.Ornl.Gov/Sci/Landscan/
- Gething, Peter W. et al. A new world malaria map: Plasmodium falciparum endemicity in 2010. Malaria Journal 2011, 10:378.
- Bhatt, S. et al. 2013. The Global Distribution and Burden of Dengue. Natrure, 496: 504-507.
- Maroli, M. et al. 2012. Phlebotomine Sandflies and the Spreading of Leishmaniases and other Diseases of Public Health Concern. Medical and Veterinary Entomology (2012), doi: 10.1111/j.1365-2915.2012.01034.x

Back to Table of Contents

WRBU
WALTER REED BIOSYSTEMATICS UNIT
Know the vector, know the threat

The Walter Reed Biosystematics Unit is part of the Walter Reed Army Institute of Research and is based at the Smithsonian Institution Museum Support Center. To access taxonomic keys, the Systematic Catalog of Culicidae or to learn more about WRBU visit www.wrbu.org.

VECTORMAP

VectorMap is only as good as the data you provide. If you have collection records, models or pathogen testing results please contact the VectorMap team to learn how to contribute data at mosquitomap@si.edu.

Vector Photos Provided by Judith Stoffer, Walter Reed Biosystematics Unit

WRAIR
Walter Reed Army Institute of Research

The published material reflects the views of the authors and should not be construed to represent those of the Department of the Army or the Department of Defense.

WRBU
WALTER REED BIOSYSTEMATICS UNIT
Know the vector, know the threat