A report of a Malayan Krait snake Bungarus candidus mortality as by-catch in a local fish trap from Nakhon Ratchasima, Thailand

Authors: Crane, Matt, Oliver, Katie, Silva, Inês, Aksornneam, Akrachai, Artchawakom, Taksin, et al.

Source: Tropical Conservation Science, 9(1) : 313-320

Published By: SAGE Publishing

URL: https://doi.org/10.1177/194008291600900116

Short Communication

A report of a Malayan Krait snake *Bungarus candidus* mortality as by-catch in a local fish trap from Nakhon Ratchasima, Thailand

Matt Crane[1], Katie Oliver[2], Inês Silva[2], Akrachai Aksornneam[2], Taksin Artchawakom[2] and Colin T Strine[1,2*]
[1] Suranaree University of Technology, Nakhon Ratchasima, Thailand
[2] Sakaerat Environmental Research Station, Nakhon Ratchasima, Thailand
Corresponding author. Email: Colin T. Strine: colin_strine@sut.ac.th

Abstract
Thailand is a world biodiversity hotspot with 176 known snake species. However, anthropogenic influences on snakes associated with growing human populations are poorly understood. Aquatic funnel traps (AFTs) are in widespread use in agricultural areas throughout Thailand, and they have the ability to collect large quantities of by-catch, including snakes. During an on-going study on the human-snake conflict we found, using radio-telemetry, one of our radio-tracked *Bungarus candidus* (Malayan Krait) individuals dead on 13 October 2015. We had tracked the individual for only 14 days before finding it decapitated 10 m from a villager's house. Upon interviewing the owner, we discovered that the snake had been found dead in a fishing trap, in a man-made irrigation canal located 65 m southeast from his house. Our observation is the first documented case of incidental mortality among upland-dwelling snakes as a result of aquatic trapping in Thailand, and may have implications throughout Southeast Asia. This report suggests fishing traps may be another source of mortality for snakes in human-dominated landscapes, and that further studies may reveal significant rates of terrestrial by-catch in agricultural canals.

Key words: *Bungarus candidus*; spatial ecology; venomous; by-catch; mortality

Abstract (Portuguese)
A Tailândia é um hotspot de biodiversidade mundial, com 176 espécies de serpentes. No entanto, as influências antropogénicas associadas à expansão das populações humanas são pouco conhecidas. As armadilhas aquáticas de funil (AAF) estão em uso generalizado em áreas agrícolas por toda a Tailândia, mas têm o inconveniente de coletar grandes quantidades de capturas acessórias, incluindo serpentes. No decurso de um estudo sobre o conflito entre humanos e serpentes usando radiotelemetria, descobrimos um dos nossos indivíduos implantado com um radiotransmissor, da espécie *Bungarus candidus*, morto no dia 13 de Outubro de 2015. Seguimos o indivíduo por apenas 14 dias antes de o encontrarmos decapitado, 10 m da casa de um local. Após entrevistar o morador, descobrimos que o indivíduo foi encontrado morto numa armadilha de pesca, num canal de irrigação localizado 65 m sudeste da sua casa. A nossa observação é o primeiro caso documentado de mortalidade acidental em serpentes terrestres resultante de pesca aquática na Tailândia, e poderá ter implicações em todo o Sudeste Asiático. Este relato sugere que as armadilhas aquáticas podem ser outra fonte de mortalidade para as serpentes em paisagens dominadas pelo homem, e que mais estudos poderão revelar as taxas de captura acessórias de espécies terrestres nos canais agrícolas.

Received: 5 January 2016; **Accepted** 7 February 2016; **Published**: 28 March 2016

Cite this paper as: Crane, M., Oliver, K., Silva, I., Aksornneam, A., Artchawakom, T. and Strine, C. T. 2016**.** A report of a Malayan Krait snake *Bungarus candidus* mortality as by-catch in a local fish trap from Nakhon Ratchasima, Thailand**.** *Tropical Conservation Science* Vol. 9 (1): 313-320. Available online: www.tropicalconservationscience.org

Introduction

Human activities are thought to be the greatest factor influencing species population decline and extinction [1,2]. Agricultural practices pose several major threats to global biodiversity [3]. Environmental consequences, such as habitat loss and fragmentation, are widely acknowledged [4,5]. However, other threats arise from the intensification of agricultural activities, which have broad reaching impacts including increased erosion, nutrient load reduction, and poorer water quality [6]. The tropics, in particular, face additional challenges as in rural areas poor communities commonly depend on wildlife for supplementary income and sustenance [7]. Reliance on wild bush-meat for protein is common throughout the tropics as a supplementary component to diets for rural communities [8], and can have a substantial impact on the ecosystem due to rapid defaunation [9]. When intensive agricultural practices are combined with heavy harvesting in locations adjacent to protected areas, the surrounding areas can serve as biodiversity sinks, and ultimately lead to a loss of functionality in the protected area [10].

Aquatic funnel traps (AFTs) have the advantage of providing continuous trapping with minimal upkeep required [11], and can yield large quantities of edible freshwater fish. Typically, bony fish and eels are targeted by AFTs but by-catch of other non-target organisms is common [12]. By-catch has become a more visible issue in current fisheries management [13], particularly as economic or dietary shifts may increasingly result in by-catch becoming primary food sources [14]. Monitoring the impact of by-catch on terrestrial systems is a challenge, but may yield important conservation information for understudied species [12,14]. Additionally, by-catch in terrestrial systems may be a largely overlooked source of mortality, particularly for well-camouflaged species such as snakes.

Thailand is home to 176 known snake species [15], 59 of which are venomous and considered potentially dangerous to humans. Snake populations are primarily threatened by human encroachment and the destruction of their natural habitat, leading them to come into ever closer proximity to humans, roads and domestic pets [16]. Although data describing worldwide snake population declines are poorly documented, there is evidence that some species have suffered serious population declines [17]. According to Warrell [18], *B. candidus* is one of the three deadliest snake species in Thailand, and is of significant medical importance to the region. Only 14 snake species have legal protection in the country, through the Convention of International Trade in Endangered Species of Wild Fauna and Flora, CITES [19]. Negative perceptions about venomous snakes may be a factor in their lack of protection, and a reason why those encountered are often killed.

In Cambodia, AFTs are recognised as a threat to aquatic and semi-aquatic snakes, not least because those caught are more often sold and consumed instead of being released [20]. In Thailand, AFTs are common and widespread as wild-caught fish are a major component of Thai cuisine [21]. As such, AFTs are highly beneficial to local farmers as both a food source and an alternative source of income [22]. The Thailand Fisheries Act of 1947 [23] focuses directly on the protection of freshwater and marine fisheries, but lacks control in agricultural areas where local people utilize resources without sufficient regulation [24]. The majority of snakes in man-made canals in agricultural areas are found along the edges and ditches, which are also easily accessible to villagers for setting traps [25]. Snakes are obligate predators among reptiles, and increased mortality due to human activities undoubtedly impacts on other aspects of a healthy and functional ecosystem [26]. As a locally abundant mesopredator [27], disturbance to *B. candidus* populations may influence their prey communities, such as amphibians [28].

Through an ongoing radio-telemetry program targeting a variety of venomous snake species, we have observed radio-tracked King Cobras (*Ophiophagus hannah*), Banded Kraits (*Bungarus fasciatus*) and Malayan Kraits (*Bungarus candidus*) utilizing agricultural canals as movement corridors between inhospitable agricultural habitats. The agricultural canals are typically overgrown, providing shelter and facilitating movement with cover from above. Our observation provides insights into a threat common in Thai agricultural systems.

Methods

The observation occurred during an ongoing snake radio-telemetry monitoring program in the Sakaerat Biosphere Reserve (SBR), located in Nakhon Ratchasima Province, Thailand (14.44–14.55°N, 101.88–101.95°E). The reserve has an 80 km^2 core area and a further 360 km^2 that comprises the buffer and transitional zones, which consist mostly of agricultural and settlement areas (Fig. 1). The reserve encompasses 12 subdistricts, and is primarily located in Wang Nam Khieo district which had a total population of 44,728 in 2010 [29]. Agriculture is the primary source of income for the majority of the population residing in the district. The radio-telemetry program is located north of the SBR core area, in a mosaic of rice paddy fields, cassava plantations, and mixed forest plantations including species such as *Acacia* and *Eucalyptus*. Small strips of agricultural canals separate fields, and provide irrigation for crops.

Our research aims to assess the spatial ecology and home range overlap of venomous snakes in human-dominated landscapes bordering a protected area. To capture *B. candidus w*e conducted visual surveys and used funnel traps attached to drift fence arrays. We anesthetized the snakes with vaporized isoflurane and surgically implanted adults of appropriate size with 11 g radio-transmitters (model BD-2T, Holohil Inc., Ontario, Canada), ensuring the transmitter mass was no greater than 5% of each snake's mass. After the snakes had lost complete muscle tone we measured for snout vent length (SVL), total body length (TBL) and tail length (TL) on a custom-made semi-circular measuring pipe. Snout vent length is defined as the distance from the tip of the snout to the posterior tip of the anal scale. Tail length (TL) is defined as the distance from the anterior tip of the first sub-caudal scale to the tip of the tail. Total body length was obtained by adding SVL and TL. We determined each individual's sex by inserting a cloacal probe. We measured head length (HL) and head width (HW) using hand held digital calipers accurate to .01 mm. We gave each individual a unique brand, following Winne *et al*. [30], using a Bovie field sub-cautery unit, which enabled us to identify the individual upon further capture and in camera traps. We weighed each individual using a digital scale accurate to 0.1 g.

We located each individual at least once daily, collecting the coordinates for each relocation using hand-held 64S Garmin GPS units. We also documented various environmental parameters, including habitat and cover type.

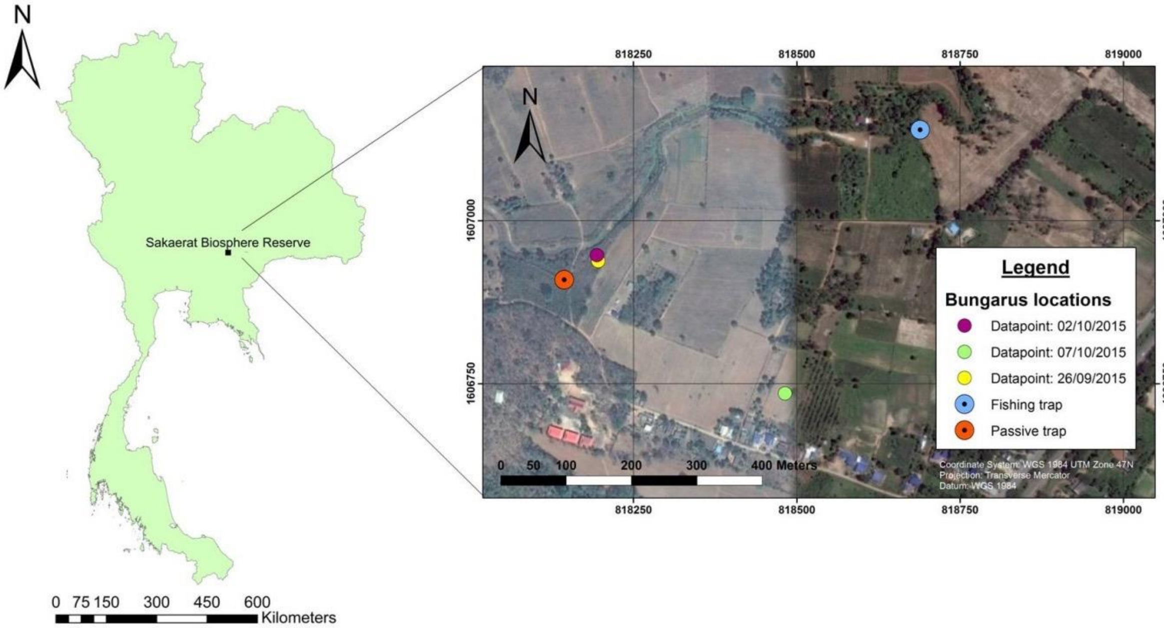

Fig. 1. Individual movements of the tracked (*Bungarus candidus*) and locations of traps in relation to release and capture point. Contrast between the left and right of the map arises because the satellite data are a mosaic of different quality images.

Results

We tracked an individual male *Bungarus candidus* (Malayan Krait) with a mass of 267.7 g, snout to ventral length of 1070 mm, tail length of 130 mm, head length of 34 mm, head width of 43 mm, 20 mm girth at 50% of snake's body and 22 mm at 75%. We captured the individual on 22 September 2015 in a eucalyptus plantation (14° 30' 59.52" N, 101° 57' 5.74" E).

We released the snake on 25 September 2015 and limited our impact on the snake's behavior by increasing our distance to the reptile during relocations for the following two weeks, allowing it a healing period after the surgery. Although we were triangulating from a greater distance we collected data, from 26 September 2015. Normally after the period of isolation we collect more accurate pinpoints of the snake's location from ≥10m, however in this case the snake mortality occurred in the following 2 weeks. After release the snake made a 30 m move where he then sheltered within mixed high vegetation (average height <50 cm) in the margins of a eucalyptus plantation forest and a man-made irrigation canal. The snake made three more significant moves (>5m) between data collection and the mortality event.

During the 14 days that we collected data (26 September 2015 - 9 October 2015), the snake was observed sheltering under patches of mixed vegetation greater than 50 cm high and within ≤60 m of human settlements. All selected shelter sites were within the same agricultural-plantation matrix. On 10 October 2015 the individual moved out of signal range and, after three days, we found it 10 m south of a house in Udom-Sap village, decapitated (Fig. 2b). Putrefaction levels indicated it was not a recent death, and the wound was clean with no visible bite marks.

We spoke to the owner of the house, Term Kaewjuntuek, 85 years old, who reported that there had been heavy rain three days before, which could have brought the snake downstream, as the last known location and the death site were 456 m apart. Mr Kaewjuntuek reported finding the snake dead in the rear compartment of an AFT, with its head forced through the netting towards the water surface, but submerged, suggesting that it had been entangled in the netting and had drowned. The fish trap which caught the snake had been set in a man-made irrigation canal (Fig. 2a) (14° 31' 6.798" N, 101° 57' 24.0552" E). Mr Kaewjuntuek said he had removed the snake from the trap by pulling on the head, which had come away from the body with little resistance, likely due to decay. Mr Kaewjuntuek showed us the trap (Fig. 2c), and we measured a width of 30 holes in the netting to obtain a maximum and average pore size. The head width of the snake was 21 mm, larger than the average pore size (16.9 mm) and the maximum recorded netting pore size (20 mm). The water depth at the trap level was 450 mm. We observed a second ATF in the area set approximate 100 m away along the waterway. However we did not conduct surveys of all traps along the length of the canal.

Since we had tracked the snake for only 14 days, we were unable to determine an accurate home range for it. We know that *B. candidus* live in this agricultural habitat as we have captured six other specimens in the transition area of the reserve since January 2015. One individual we captured was a neonate from the same drift fence array as the deceased reptile.

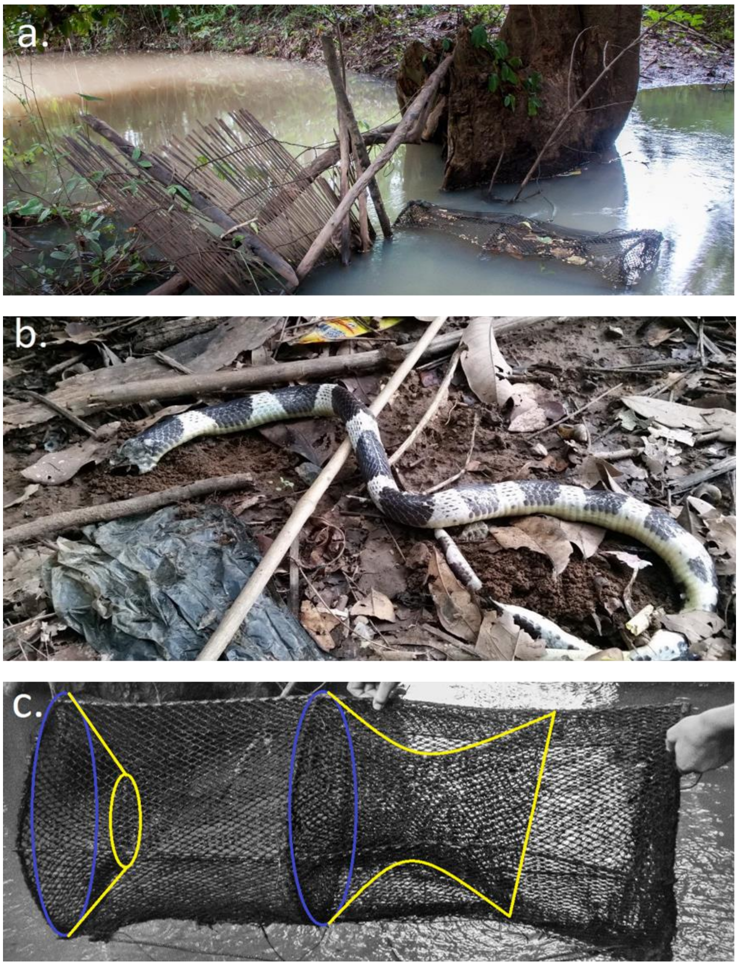

Fig. 2 (a) Aquatic funnel trap positioned in an agricultural canal using artificial fencing and natural features as guides to the trap entrance. (b) The deceased individual B. candidus as found on 13 October 2015. (c) Design of the aquatic funnel trap exhibiting funnels and the size of the netting which would only allow very small fish and snakes to pass through unhindered. The trap was 450 mm high and 1029 mm long, with a width of 504 mm and a circumference of 1420 mm. The end of the funnel entrance circumference was 636 mm.

Discussion

Although *B. candidus* is thought to be primarily land-dwelling and to have a preference for upland forests [31], we observed our individual in agricultural and settlement areas and, specifically, using man-made irrigation canals as corridors through a human-dominated landscape. As we have observed several of our radio-tracked snakes heavily utilizing riparian strips between agricultural landscapes, the pattern indicates the potential importance of riparian corridors for the persistence of this species [32]. It is possible that fishing traps are a significant source of by-catch and mortality for non-targeted terrestrial species, particularly during periods of heavy rainfall, as is indicated by the mortality occurring subsequent to a flooding event.

The large scale removal of snakes in other parts of Southeast Asia has led to massive population declines [33,34]. However, while these removals are due to large scale commercial practices, our observation highlights the potential hazard of small scale by-catch. If multiple traps are set by villagers in local water systems throughout every rainy season, utilizing these agricultural canal corridors may act more as an ecological trap for snakes than a facilitator of movement. Although the placement of AFTs suggests aquatic and semi-aquatic snakes should be the most threatened group as they spend more time in waterways [35], the impact on terrestrial snakes should not be underestimated. If populations of multiple species at various ecological levels are being affected by AFTs, the impacts are likely to be felt on a community level, and cause a ripple effect within the ecosystem [36].

Implications for conservation

Riparian corridors help maintain the regional biodiversity of both amphibians and reptiles. Although capture of non-targeted aquatic organisms by AFTs are known [5,13], our observation suggests the potential for the incidental mortality of several terrestrial species is significant [32]. We suggest implementing a reserve-wide monitoring program: if AFT by-catch rates can be observed without interference it may be possible to quantify AFT-induced snake mortalities in Southeast Asian agricultural ecosystems, particularly during wet seasons. As SBR is a relatively small protected reserve (only 80 km^2 of protected forest cover), it is more vulnerable to species removal in the surrounding transitional zone than larger protected areas [37]. Biosphere reserves serve as laboratories for human-wildlife interaction and activities in the adjacent transitional zones would benefit from a study incorporating the broader implications of by-catch mortalities.

By recording the number and frequency of AFT use in the areas adjacent to the SBR core area, and by mapping riparian strips flowing from this area to the surrounding human-dominated landscapes, the risk of encountering AFTs along riparian corridors can be quantified. Further monitoring of known traps for by-catch diversity and frequency could then be used to assess the frequency of by-catch mortality. Combining that with villager interviews and participation in monitoring efforts may yield greater awareness of potential mortality threats. Measures to increase awareness and help reduce by-catch could be rapidly implemented at relatively low cost: advising local villagers to check traps more frequently, and providing training on the safe removal of venomous snakes from traps, could lead to reduced snake mortality as a result of by-catch. The impact of AFT-induced by-catch mortality warrants further conservation actions as species thought not to be at risk are being captured. Furthermore, snake communities could potentially be at risk if traps limit movement and access to shelter sites within riparian corridors. Understanding how snakes use these corridors could help with the design of different traps and fencing systems, and improve the ability of man-made irrigation canals to serve as ecological corridors.

Acknowledgements

We thank Suranaree University of Technology (SUT) for supporting this radio-telemetry program. All our methods were carried out under the guidelines and with the approval of the SUT animal use and ethics committee. The Thailand Institute of Scientific and Technological Research (TISTR) and Sakaerat

Environmental Research Station (SERS) allowed site access research permission, and provided logistical and technical support throughout the project. Additional thanks must go to the many volunteers who made this project possible, as well as to the local villagers of Udom Sap Subdistrict in the Biosphere Reserve. We also thank homeowner Term Kaewjuntuek for agreeing to have his name published and to be interviewed concerning trap mortality. Filipe Serrano and Jacob Bukoski provided external reviews that improved the manuscript substantially. We also thank Ben Marshall for contributing photographs to the manuscript and Sami Asad for assisting with mapping.

References

[1] Rojstaczer, S., Sterling, S. M. and Moore, N. J. 2001. Human appropriation of photosynthesis products. *Science* 294:2549-2552.

[2] United Nations Environment Programme. 2001. *GLOBIO Global Methodology for Mapping Human Impacts on the Biosphere*. Nairobi: United Nations Environment Programme.

[3] Wilson, E. O. 2002. *The Future of Life*. New York: Vintage Books.

[4] Didham, R. K., Kapos, V. and Ewer, R. M. 2012. Rethinking the conceptual foundations of habitat fragmentation research. *Oikos* 121(2):161-170.

[5] Haddad, N. M., Brudvig, L. A., Clobert, J., Davies, K. F., Gonzalez, A., Holt, R. D., Lovejoy, T. E., Sexton, J. E., Austin, M. P., Collins, C. D., Cook, W. M., Damschen, E. I., Ewers, R. M., Foster, B. L., Jenkins, C., King, A., Laurance, W. F., Levey, D. J., Margules, C. R., Melbourne, B. A., Nicholls, A. O., Orrock, J. L., Song, D. and Townsend, J. R. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. *Scientific Advances* 1:e1500052.

[6] Dale, V. H. and Polasky, S. 2007. Measures of the effects of agricultural practices on the ecosystem. *Ecological Economics* 64(2):286-296.

[7] Swierk, L. and Madigosky, S. R. 2014. Environmental perceptions and resource use in rural communities of the Peruvian Amazon (Iquitos and vicinity, Maynas Province). *Tropical Conservation Science* 7(3):382-402.

[8] De Merode, E., Homewood, K. and Cowlishaw, G. 2004. The value of bushmeat and other wild foods to rural households living in extreme poverty in Democratic Republic of Congo. *Biological Conservation* 118(5):573-581.

[9] Wright, S. J., Stoner, K. E., Beckman, N., Corlett, R. T., Dirzo, R., Muller-Landau, H. C., Nuñez-Iturri, G., Peres, C. A. and Wang, B. C. 2007. The plight of large animals in tropical forests and the consequences for plant regeneration. *Biotropica* 39(3):289-291.

[10] Terborgh, J. and Estes, J. A. 2010. *Trophic cascades: predators, prey and changing dynamics of nature.* Washington: Island Press.

[11] Adeola, O. M. 1992. Importance of Wild Animals and Their Parts in the Culture, Religious Festivals, and Traditional Medicine, of Nigeria. *Environmental Conservation* 19(2):125-134.

[12] Eayrs, S. Ed. 2007. *A Guide to Bycatch Reduction in Tropical Shrimp-Trawl Fisheries*. FAO, Rome.

[13] Hall, A. M., Alverson, L. D. and Metuzals, I. K. 2000. By-Catch: problems and Solutions. *Marine Pollution Bulletin* 41(1):204-219.

[14] Clapham, P. and Waerebeek, V. K. 2007. Bushmeat and bycatch: the sum of the parts. *Molecular Ecology* 16(13):2607-2609.

[15] Chanhome, L. and Cox, M. J. 2011. Characterization of venomous snakes of Thailand. *Asian Biomedicine* 5(3):311-328.

[16] Mullin, S. J. and Seigel, R. A. (2009) *Snakes: ecology and conservation*. New York: Cornell University Press.

[17] Reading, C. J., Luiselli, L. M., Akani, G. C., Bonnet, X., Amori, G., Ballouard, J. M., Filippi, E., Naulleau, G., Pearson, D. and Rugiero, L. 2010. Are snake populations in widespread decline? *The Royal Society* 6:777-780.

[18] Warrell, A. D. 2010. *Guidelines for the management of snakebites*. New Delhi: World Health Organization.

[19] CITES, 2011. *Convention on International Trade in Endangered Species of Wild Fauna and Flora*. Available: www.cites.org. Accessed 5 January 2016.

[20] Stuart, B. L., Smith, J., Davey, K., Din, P. and Platt, S. G. 2000. Homalopsine watersnakes: the harvest and trade of from Tonle Sap, Cambodia. *Traffic bulletin* 18(3):115-124.

[21] Keledjian, A., Brogan, G., Lowell, B., Warrenchuk, J., Enticknap, B., Shester, G., Hirshfield, M., and Cano-Stocco, D. 2014. Wasted Catch: Unsolved problems in U.S. fisheries. *Oceana* March 2014.

[22] Kosulwat, V. 2002. The nutrition and health transition in Thailand. *Public Health Nutrition* 5(1):183-189.

[23] DOF. 1986. Fisheries Act B.E. 2490. Department of Fisheries, Ministry of Agriculture and Cooperatives, Bangkok. *Government Gazette* 64(3).

[24] Tokrisna, R., Boonchuwong, P. and Janekarnkij, P. 1998. *A Review of Fisheries and Coastal Community-based Management Regime in Thailand*. Manila: International Center for Living Aquatic Resources Management.

[25] Murphy, J. C., Voris, K. H., Karns, R. D., Chan-ard, T. and Suvunrafl, K. 1999. The ecology of the water snakes of Ban Tha Win, Songkhla province, Thailand. *Natural History Bulletin Siam Society* 47:129-147.

[26] Beaupre, S. J. and Douglas, L. E. 2009. Snakes as indicators and monitors of ecosystem properties. In: *Snakes: ecology and conservation*. Mullin, S. J. and Seigel, R. A. (Eds.), pp.244-261. Cornell University Press, New York.

[27] Ritchie, G. E. and Johnson, N. C. 2009. Predator interactions, mesopredator release and biodiversity conservation. *Ecology letters* 12(9):982-998.

[28] Matthews, R. K., Knapp, A. R. and Pope L. K. 2002. Garter Snake distributions in high-elevation aquatic ecosystems: is there a link with declining amphibian populations and nonnative trout introductions? *Journal of Herpetology* 36(1):16-22.

[29] National Statistic Office. 2010. *Population and housing census*: Bangkok: National Statistical Office of Thailand.

[30] Winne, C.T., Willson, J. D., Andrews, K. M. and Reed, R. N. 2006. Efficacy of marking snakes with disposable medical cautery units. *Herpetological Review* 37(1):52-54.

[31] Mohammadi, S., Kluever, M. B., Tamashiro, T., Amano, Y. and Hill, G. J. 2014. Spatial and thermal observations of a Malayan Krait (*Bungarus candidus*) from Thailand. *Tropical Natural History* 14(1):21-26.

[32] Brode, J. M. and Bury, R. B. 1984. The importance of riparian systems to amphibians and reptiles. In: *California riparian systems: ecology, conservation, and productive management*. Warner, R. E. and Hendrix, K. M. (Eds.), pp.30-36. University of California Press, Berkeley.

[33] Brooks, S. E., Allison, E. H., and Reynolds, J. D. 2007. Vulnerability of Cambodian water snakes: initial assessment of the impact of hunting at Tonle Sap Lake. *Biological Conservation* 139(3):401-414.

[34] Van Cao, N., Thien Tao, N., Moore, A., Montoya, A., Rasmussen, A.R., Broad, K., Voris, H. K., and Takacs, Z. 2014. Sea Snake Harvest in the Gulf of Thailand. *Conservation Biology* 28(6):1677-1687.

[35] Karns, R. D., Murphy, C. J. and Voris, K. H. 2010. Semi-aquatic Snake Communities of the Central Plain Region of Thailand. *Tropical Natural History* 10(1):1-25.

[36] Read, A. J. and Rosenberg, A. 2002. *Draft international strategy for reducing incidental mortality of cetaceans in fisheries*. Washington D.C: World Wildlife Fund.

[37] Maiorano, L., Falcucci, A. and Boitani, L. 2008. Size-dependent resistance of protected areas to land-use change. *Proceedings of the Royal Society of London Biology* 275(1640):1297-1304.