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Application of geo-informatics for studying abundance and distribution of land snails in Chon Buri, Thailand: A case study of *Hemiplecta* sp.

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Abstract

The land snail is the only group of invertebrate in Phylum Mollusca that has evolved in terrestrial ecosystems successfully. Current environmental issues, e.g. climate change, natural disasters, pollution, and human-encroachment activities so their population decreases rapidly. More importantly, *Hemiplecta* sp. is a biodiversity indicator and plays a key role in the food chain and land snails meat contains a high level of nutrients and is a source of protein, similar to poultry, pork, and beef that are nutritionally suitable for consumption. As result, spatial analysis of geo-informatics data of *Hemiplecta* sp. displayed on a map where the color coding is based on 7 factors of habitats (elevation, landform, geology, water resource, forest, temperature, and relative humidity) and ranked by the amount of suitability of the area from high (S_1), medium (S_2), and low (S_3) using Potential Surface Analysis (PSA) method. The results show that Chon Buri has 270, 411, and 1,166.3 square kilometers for S_1, S_2, and S_3 respectively and the overall of the analysis was 65 percent. The distribution of *Hemiplecta* sp. is topographic dependent of environment and physical indicators found in the area, namely Bo Thong, Ko Chan, Siracha, Bang Lamung, Nong Yai, Ban Bueng, Satthahip, and Mueang Chon Buri. Furthermore, this research will be useful for the management of resource conservation and supporting trade, and food alternatives in case of a shortage of sustainable food in the future.

Keywords: land snails, *Hemiplecta* sp., abundance, Geographic Information System (GIS), Potential Surface Analysis (PSA)

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1. Introduction

Terrestrial gastropods or land snails are in the Phylum Mollusca. The land snail is the only group of invertebrate in Phylum Mollusca that successfully evolved to live in terrestrial ecosystem. The oldest ancestor was in Precambrian Era. Land snails are found around the world, with up to 50,000 different species. In Thailand, their species diversity, abundance, and distribution have been studied since 1994. Past researches identified 15 families, 59 genuses, and 136 species of land snail and then their number of identified species has increased to 600 species [1]. In the past times, land snails were popular food, especially *Theba pisana Otala lactea* and *Helix aspersa* species which were used to make an Escargot menu, which was a famous dish in Europe. A land snail contains a source of protein, iron, magnesium, calcium, selenium, potassium, sodium, vitamins (E, A, K, B12) and omega-3, which are sufficient to fullfil human requirements each day, similarly to chicken, pork, and beef meats. Moreover, they were used in medications, e.g. in anesthetic, astringent, respiratory, and skin care solutions [2] as well as to make tools, toys, decorations, and currency exchange in the past [3]. The high demand for land snails leads to the need of land snail farms. The price of a land snail is 100 baht and eggs of snails (Snail Caviar) sell for up to 63,000 baht per kilogram [4].

Furthermore, *Hemiplecta* sp. is a biodiversity indicator and has a key role in food chain. They are not only herbivores which eat leave litters and logs, but also are food for birds, reptiles, amphibians, and human. The land snails contain an important source of protein and a unique smell when being cooked. Their meat is white meat and also has more fatty acids than amino acids. Current environmental issues, including

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climate change, natural disasters, pollution, and human-encroachment activities, result in decreasing forest area and a longer dry season, have a huge impact on land snail species. The land snails are limited to reducing habitat area and types of food, resulting in fewer eggs production at spawn time. Therefore, the land snail population decreases rapidly and might be endangered. Therefore, the land snail population decreases rapidly and are in endanger crisis. In this research, we need to explore the habitat and the population of land snails [1, 5].

This study investigates the population of *Hemiplecta* sp. and their distribution in Chon Buri, Thailand by using a method of spatial analysis, this method is appropriate for finding areas of the land are best suited and which kind of use is it best suited. Potential Surface Analysis (PSA) is a land evaluation techniques based on a systemic process and mathematic equation. The PSA model requires factor of the project and weighting score from expert discussion. Since the factors of this study based on factors of habitats are elevation, landform, geology, water resource, forest, temperature, and relative humidity then all factor displayed a map of *Hemiplecta* sp. and ranked by the amount of high, medium, and low. Therefore, the objective of this study is to observe the population and the distribution of *Hemiplecta* sp. in Chon Buri, Thailand. The results of this research will be useful for the management of resource conservation, in addition to support trade, culture, and food alternatives, in cases of a lack of sustainable food in the future.

2. Materials and methods

2.1 Study area and sampling

Chon Buri Province is located in Eastern of Thailand at latitude 12 degrees 30 minutes - 13 degrees 43 minutes north and longitude 100 degrees 45 minutes - 101 degrees 45 minutes east. The total area is 4,363 square kilometers and consists of 11 districts which are Mueang Chon Buri, Ko Si Chang, Bo Thong, Bang Lamung, Ban Bueng, Phan Thong, Phanat Nikhom, Si Racha, Sattahip, Nong Yai, and Ko Chan. Field measurement were collected from August to November 2016, during which 75 plots and grid size is 20 x 20 meters were sampled. In each plot living and non-living land snails were collected by sight and handpicked from the ground, leaves litter, logs, shrub, climber, moss, and rocks.

2.2 Analysis suitable areas for land snail habitat

A Geographic Information System (GIS) are used to study the distribution of the *Hemiplecta* sp. in Chon Buri, Thailand. This research uses Potential Surface Analysis (PSA) method to observe the habitats of the land snails. A literature review and survey of experts were used to select critical habitat factors that will be used for this study. Next, expert discussions estimated the area which is then classified as high, moderate, and low potential. Then, a field survey conducted and specimens were collected in the study areas. The research procedures include 5 steps as follows:

1) Review literature and related theories, and select factors

Review theories and studies that relates to habitats of land snails i.e. a Potential Surface Analysis (PSA) method, collection of field data methods, selection factors which are analyzed areas suitable for living of land snails, the weight and importance of those factors. The physical factors were selected from literature reviews, which are 7 criteria and sub criteria as the following:

- Geology; sub-criteria are Carboniferous rock age, Jurassic rock age, Permian rock age, Quaternary rock age, Silurian-Devonian rock age, and Triassic rock age
- Landform; sub-criteria are Plain, High plain, Hill, and Mountain
- Forest; sub-criteria are Beach Forest, Mangrove Forest, Swamp Forest, Dry Evergreen Forest, Mixed Deciduous Forest, Secondary Growth Forest, Eucalyptus Plantation, and Teak Plantation
- Temperature; sub-criteria are 25^{o}c, 26^{o}c, 27^{o}c, and 28^{o}c
- Relative humidity; sub-criteria are 65 - 70 percent, 71 - 75 percent, 75 - 80 percent, and 80 - 85 percent
- Water resources; sub-criteria are river, ditch/ canal/ stream, marsh/ swamp/ reservoir/ dam, and sea
- Elevation; sub-criteria are 0-1,000 mean sea level (the interval is categorized by 100 meter)

All factors were prepared for spatial data and imported into the Arc GIS program. Basic data, such as administrative boundary, elevation, landform, geology, water, temperature, relative humidity, and forest of Chon Buri in form of raster layer and vector layer, were converted into appropriate scales. Some data layers required additional programs to bring them into a suitable form, i.e. temperature and relative humidity has to alter from 30 years average data and those data would be change to point data in shapefile then interpolated by Inverse Distance Weighting (IDW) technique. While forest type was interpolated form THAICHOTE satellite image in 2014 a 15 meter resolution.

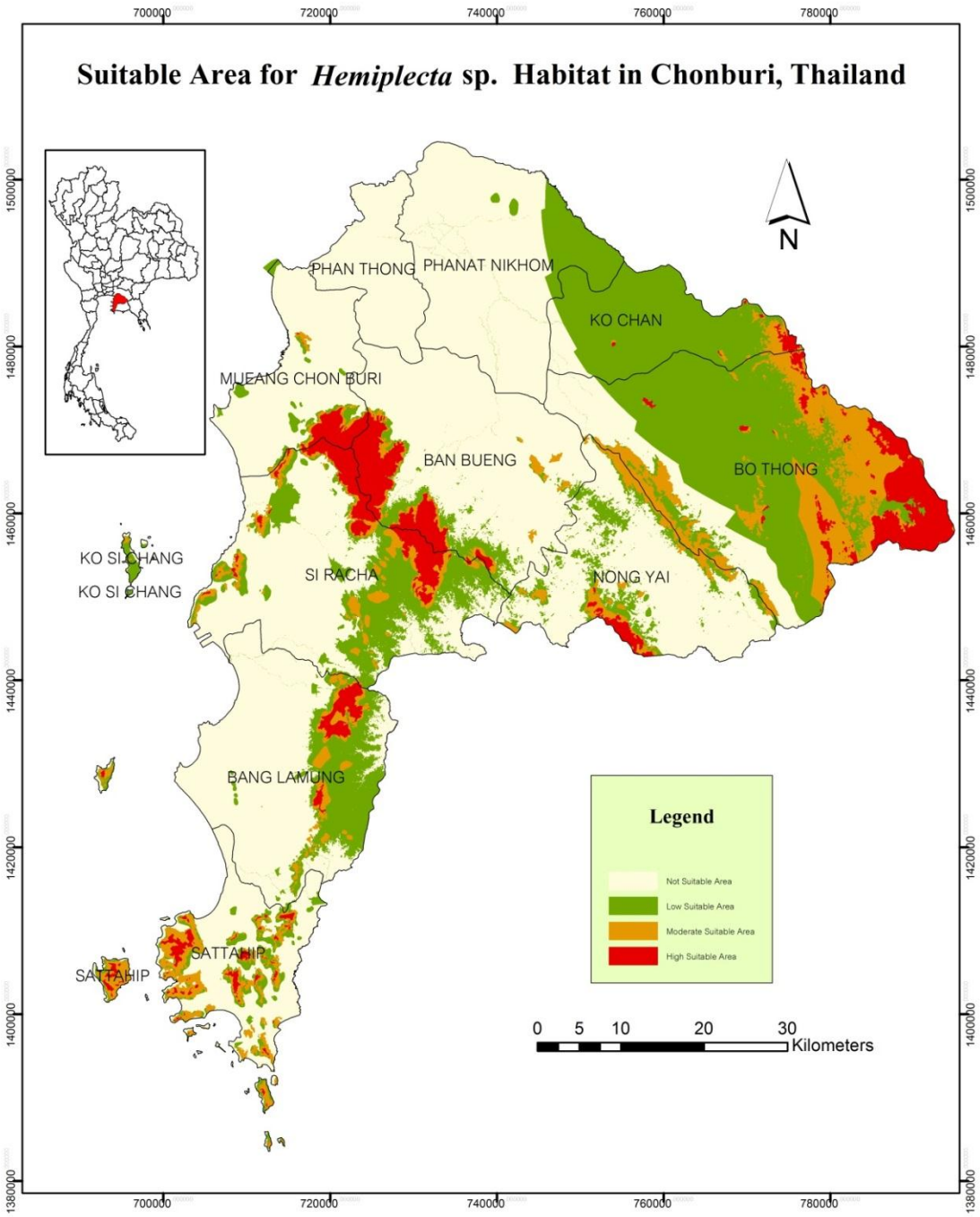

Figure 1 Map of suitable area for *Hemiplecta* sp. habitat in Chon Buri, Thailand

2) Determine weighting score and rating score of factors

Weighting scores and rating scores of habitat factors of land snails are based on expert discussions by using questionnaires. Experts consider ratio of relative in percentage that set the factors that have no relationship or potential. The weighting score ranges zero from the smallest one and growing the relationship to the one hundred percent and the rating score is rated 5 levels (1: no effect, 2: minor affect, 3: neutral, 4: moderate affect, 5: major effect). The selection of experts is considered by the features of poll of people in the profession or others to identify a list of persons that have expertise and positions are acceptable, and studies work appears in books, documents, publications or research [3]. Expert groups are selected by Purposive Sampling, considering a person who has work experience at least 10 years related to field of professional, teaching, and research of biology, ecology, and zoology. Size of expert group in this

research is five people. The expert must be professors or other positions approved by the OCSC.

3) Calculation weighting score of factors

Determine weighting score and range of rating scores, and calculated the important factors in an Excel spreadsheet before entering into Arc GIS program. Then the suitability (S) was calculated using the following equation (1) of Weighted Linear Combination of the different factors and weighting factors [6].

$$\text{Suitability (S)} = (R_1 \times W_1)/100 + (R_2 \times W_2)/100 + \cdots + (R_n \times W_n)/100 \quad (1)$$

where S is suitable area
R is rating score of each factors
W is weighting score of each factors

4) Displaying area from PSA

After calculating the weighting score, the next step is a calculation of range for dividing suitable rank areas. The outcome shows the areas suitable for living of land snails, according to the criteria specified in the appropriate format digital maps. The area is divided into four categories;

- High suitable areas (S_1)
- Moderately suitable areas (S_2)
- Low suitable areas (S_3)
- Not suitable areas (N)

5) Ground truth and snail collection in the field

The accuracy of the spatial model checked with the ground survey, which is a real survey to determine population of land snails (Ground Truth) and the areas from analysis by PSA method. The sampling areas using a combination of probability sampling and non-probability sampling which is determined rectangular areas (Quadrant) to cover all study areas and the grid size (Grid) is 10 x 10 kilometers. The 10 x 10 km grid area is divided into small areas according to A square kilometer in size 1 x 1 km method [5].

The determination sampling areas was done by using Quota Sampling divided into very suitable areas of 25 areas, moderately suitable areas of 25 areas, and low suitable areas of 25 area then divided the grid 1 x 1 km into small size of 20 x 20 meters and randomly selected sampling study areas. Survey and collect the samples of *Hemiplecta* sp. in the study areas by hunting sight and handpicked for both living and non-living of these species in soil, leaves litter, logs, shrub, climber, moss, and rocks.

3. Results and discussion

The results of from this study identify and rank suitable area for land snail using Potential Surface Analysis method from weighting and rating Elevation, Landform, Geology, Water resource, Forest, Temperature, and Relative Humidity factor. The rating point from expert discussion is 10, 10, 20, 5, 25, 15, and 15 respectively. The analysis shows that of the Chon Buri total area of 4,464 km^2, 270.0085 km^2, 411.097 km^2, and 1,166.273 km^2 represent high, moderate, and low suitable area respectively (Figure 1). The most influential factor is forest, which is usually found in dry evergreen forest, dry deciduous dipterocarp forest [7], and mixed deciduous forest [8]. Area is Bo Thong, Ban Bueng, Si Racha, and Sattahip are 234.223 square kilometers of dry evergreen forest, and 167.708 square kilometers of mixed deciduous forest. The study also found Beach Forest, Mangrove Forest, Eucalyptus Plantation, Secondary Growth Forest, Swamp Forest, and Teak Plantation but there is no dry-evergreen-forest area. Second most important factor is geological factors. The series of stone found in the area of Chon Buri varies and consists of conglomerate, sandstone, shale, slate, limestone, chert, mudstone, and sedimentary rock of which the most suitable rock type for land snails is limestone and sandstone [8]. These two rocks are most common in Bo Thong, Nong Yai, Wang Chan, and Sattahip. The third important factor is climatic factor, including temperature and relative humidity. We asked the experts and found that the optimal temperature for land snail is 26 - 27 degree Celsius and relative humidity is 75 - 85 percent. These conditions are found in Bo Thong, Ko Chan, Wang Chan, and some part of Nong Yai because those areas are far from the seas, so the temperature is lower and the relative humidity is higher in other districts. In terms of elevations, the best range is between 100 and 800 meters, while most areas of the Chon Buri are below 100 meters from a flat plain. Generally, land snails usually live in the forests that are highland, hills, and mountains at an altitude of 200-800 meters above mean sea level. The largest area with such conditions is in the central district of Ban Bueng, Sriracha, and Bang Lamung, and to a lesser degree in the east of the province Nong Yai and Bo Thong. Water resources in the area, including rivers, canals, marshes, reservoirs, and four of reservoir (Bang Phra, Nong Kho, Huai Klang Dong, Bang Phai) and the west side of the province, which is next to the Gulf of Thailand.

Surveying the abundance of *Hemiplecta* sp. were collected by 75 grid plots and the plot were divided as quota sampling to 25 plots for high suitable area (S_1), 25 plots for moderate suitable area (S_2) and 25 plots for low suitable area (S_3). During the field survey we

Figure 2 *Hemiplecta* sp. were found in Chon Buri, Thailand

found the total amount of *Hemiplecta* sp. specimen 198 living and 15 shell land snails (Figure 2) of which we found 165 living and 15 non-living in S_1, 25 living in S_2, and 8 living in S_3 (Table 1). The accuracy of model was measured from found specimens in the sample plot. All 75 plots were found specimens from 25 plots of high suitable area, 17 plots of moderately suitable area, and 7 plots of low suitable area, result in the overall of the analysis was 65 percent. The distribution of *Hemiplecta* sp. depends on environment indicator and is found in part of Bo Thong, Ko Chan, Siracha, Bang Lamung, Nong Yai, Ban Bueng, Satthahip, and Mueang Chon Buri respectively. In fact, *Hemiplecta* sp. is a high-rage-niche land snail that can live in a variety of forest types and eat several forms of food. However, snails are less abundant in the low plain which is covered with grass and valleys, which are covered with farm forest because these areas have less or no food for snail, e.g. mushroom. Furthermore, it can be seen that Chon Buri is mostly dry evergreen forest, followed by mixed deciduous forest. However, the study found approximately 2 - 10 *Hemiplecta* sp. in a plot area because this is an area of the forest that is easy to fire, and some people can come and collect land snails for cooking and sale. The movement of land snails with the feet that can stretch and shrink. When they move, mucous glands on their feet and head to help lubricate and mobility yet it takes long time to moves. As a result, it is difficult for *Hemiplecta* sp. to take shelter when there is a threat, like other animals and humans. Another thread is pesticide, which is still widely used today. It affects land snails directly, and it also contaminates the soil surface that snail use as hibernation area. Actually, land snails are seen easily during the rainy season, at night or in the morning time. However, the field trip of this study took place during light rain and in the morning. Furthermore, during the dry season, land snails hide away to avoid the drought of this weather. Pulmonata is often buried under ground, rocks, timber and it gagged tightly with a lid shell to reduce water loss whereas Prosobranchia can make a limestone operculum or thick mucus called epiphrapm to cover the lit. The amount of snails also decrease because they can lay 100 - 200 eggs at a time, from 1 - 2 eggs until hatching, it takes 2 - 4 weeks depending on temperature and humidity [9]. We found that biological and social factors had influence of *Hemiplecta* sp. that these two factors caused of lower amounts or none at all of land snail in this area.

4. Conclusions

Geo-informatics tools can be used to study the abundance of the distribution of the *Hemiplecta* sp. land snail species in Chon Buri, Thailand combining rating and weighting score from elevation, landform, geology, water resource, forest, temperature, and relative humidity factor by Weighted Linear Combination Process. This research uses Potential Surface Analysis (PSA) method to determine the habitats of these species. The result shows four types of suitable with 270.0085, 411.097, and 1,166.273 square kilometers for high (S_1), moderate (S_2), and low suitable area (S_3), respectively. The abundance of *Hemiplecta* sp. was verified by counting individuals inside 20 x 20 meters 75 plots. The research found 198 living land snails and 15 non-living of which S_1 has 165 living land snails and 15 non-living, S_2 has 25 living land snails, and S_3 has 8 living land snails.

Table 1 *Hemiplecta* sp. recorded in the 75 plots in S_1, S_2, and S_3 in Chon Buri

Area type	Coordinate		Amount of specimens	Area type	Coordinate		Amount of specimens
	Longitude	Latitude			Longitude	Latitude	
S_1 (= 165 specimens)	788025.9929	1462207.854	6		722581.0085	1448863.119	3
	789038.4672	1463333.218	7		723000.1093	1448376.962	0
	787348.6582	1464007.025	9		713364.5388	1464540.499	1
	772756.4270	1464493.859	8		713703.2062	1464508.749	1
	779813.3098	1458630.680	7		713601.6060	1464669.616	2
	778924.3080	1458948.181	9		713756.1229	1464860.116	1
	754772.3226	1446621.117	8		713542.3392	1465037.917	2
	754089.6962	1447192.618	6		714141.3570	1464771.216	2
	753121.3193	1447367.244	2		714031.9516	1464803.760	0
	752502.1931	1448430.871	8		714043.9902	1464925.733	1
	751295.6907	1449129.372	9		713978.3734	1465006.167	0
	732250.5842	1460121.490	4		7147920.683	1465964.893	0
	732065.3754	1459579.093	6	S_3 (= 8 specimens)	759103.3925	1465920.158	0
	719950.5157	1433726.234	8		759083.5487	1465723.043	0
	719598.4710	1434396.795	6		759062.0693	1465512.182	0
	720101.3920	1435436.165	8		759035.9236	1465319.553	0
	721226.5640	1472453.453	7		759018.4764	1465105.664	0
	720940.8134	1472336.375	6		769583.6122	1460807.402	1
	720940.8134	1472014.905	5		769773.2659	1460741.723	1
	721139.9128	1471907.087	6		769899.0644	1460687.548	0
	721092.2877	1464508.749	5		770016.8418	1460630.079	0
	713703.2062	1464508.749	6		770137.1957	1460561.086	0
	713601.6060	1464669.616	7		756575.2937	1446536.745	0
	713756.1229	1464860.116	5		756639.8945	1446431.832	2
	714006.8689	1465583.892	7		756710.7125	1446345.462	0
S_2 (= 25 specimens)	786057.4890	1465509.861	1		734046.5071	1458458.292	1
	786269.1561	1464832.526	0		733981.8162	1458615.323	0
	785570.6547	1463541.357	2		733948.3464	1458798.151	0
	785761.1550	1461932.687	1		733908.0635	1458952.402	0
	778458.6404	1457847.512	1		733863.4149	1459091.309	1
	776892.3040	1459075.181	0		721900.0064	1448677.652	0
	777442.6384	1460514.518	1		721798.8030	1448968.033	1
	757233.9685	1450240.625	0		721666.5111	1449237.909	1
	752209.7115	1448860.64	2		714521.3710	1464649.866	0
	753451.3506	1447944.629	2		714482.6782	1464788.973	0
	755073.9482	1447637.119	1		714591.0095	1464751.254	0
	718279.5190	1435369.109	1		715364.1841	1465869.643	0
	718642.9211	1434648.255	0	Total 75 plots			198

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