Visualization of the effects of forest bathing: Comparison between Japan and Thailand

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***Abstract*—Recently, health tourism has become popular worldwide. One category of health tourism is Shinrinyoku (Forest Bathing). Shinrinyoku was born in Japan in 1984. There are several benefits of Shinrinyoku, such as relaxing and refreshing. We have been studying the source of the effect of Shinrinyoku in Oku-Nikko. In February 2023, we researched Shinrinyoku in Kaoyai National Park in Thailand. In Oku-Nikko, we found that we can be relaxed near a waterfall or river. In the forest of Thailand, we found that not only near a river and waterfall, walking in a rain forest was also effective for relaxing.**

Keywords—Health tourism, Forest bathing, Relaxing, Brain wave, Default mode network

I. Introduction

Recently, health tourism has been gaining worldwide attention in the tourism industry; according to UNWTO (United Nations World Tourism Organization), ETC (European Travel Commission) [1], "Health tourism is (among other things) medical and wellness-based activities that enhance our ability to function better as individuals in our environment and society," and encompasses wellness tourism and medical tourism. Wellness tourism is "a type of tourism activity that aims to improve and balance all areas of human life, including physical, mental, emotional, vocational, intellectual, and spirituality," and is primarily aimed at "positive lifestyle enhancement" such as relaxation and fitness. On the other hand, medical tourism refers to "tourism activities that utilize evidence-based medical practices and services (both invasive and non-invasive)" with aspects of diagnosis and treatment.

At the Global Wellness Summit in 2020, "Forest Everything" was one of the trends in wellness tourism [2]. This type of forest bathing has been the subject of various studies due to its relaxing and mindful effects. Lee of the Japanese Society of Forest Medicine described the focus on health tourism and forest bathing as due to "nature deficit disorder" (author's translation); the spread of COVID-19 may also have caused people to rethink their health and well-being.

Forest bathing was proposed by the Forestry Agency in Japan in 1984. According to Takayama [3], forest bathing can be divided into two frameworks: forest therapy and forest treatment. Forest therapy is mainly for healthy people [3]. It is based on medical, physiological, and psychological approaches to "visualize the effects of forest bathing and contribute to maintaining the mental and physical health of people who are unwell or suffering from stressful conditions. In other words, the main focus is on relaxation and refreshment. Forest treatment, on the other hand, "attempts to improve the physical and mental conditions of patients with mental illnesses and the disabled through the comprehensive use of the forest environment. In other words, the focus is on the treatment of diseases. This is consistent with the classification by the UNWTO, which divides forest therapy into wellness tourism and medical tourism. Forest bathing, which has attracted worldwide attention in recent years, is wellness tourism-like and similar to forest therapy.

The awareness, reaction, and attention during forest bathing were analyzed in [4]. We have been using an electroencephalogram (EEG) to visualize the effects of forest bathing in the backcountry [5].

In this study, we also used EEG to measure the effects of forest bathing in Khao Yai National Park in Thailand [6] on subjects' relaxation, compare them with the results of our previous experiments in Oku-Nikko (Senjogahara) [7], and analyze which areas in the forest contribute to relaxation and refreshment.

In section II, we mention the scope of this study. Then, in section III, we explain the research method of this study. The result of the analysis of data in the experiment in Thailand is explained in section IV, and we discuss the comparison between the result in forest bathing in Thailand and Oku-Nikko (Senjogahara) in Japan in section V. Section VI concludes this paper.

II. The Scope of This Study

This study has two objectives as follows.

(1) It will be possible to propose activities that can more effectively elicit the relaxation generated by forest bathing.
Here, the classification of tourism activities will follow that by UNWTO, and recommendations will be made regarding forest bathing as wellness tourism with a primary focus on relaxation.

(2) Investigate what causes the effects of forest bathing, which may not be as great as activities in nature but can create a relaxing environment at home, in the office, in the car, etc.

We have been studying the effects of forest bathing on the body and mind. We have been using EEG sensors to measure the effects of forest bathing to verify the degree of stress and

Fig.1 Brainwave Sensor

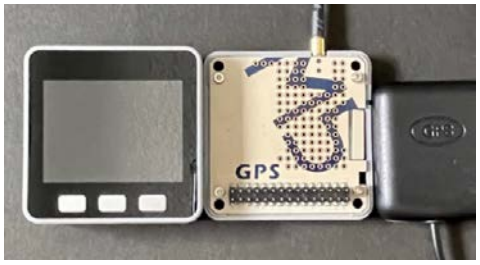


Fig.2 Brainwave logger (M5 stack gray) (left), GPS module (center and right)

relaxation [7]. Our previous research was performed at Oku-Nikko (Senjogahara) in Nikko City, Tochigi Prefecture, Japan. It is shown that the relaxation effect is higher in areas where the sound of water, such as near rivers and waterfalls.

This study compares brain waves in Khao Yai National Park in Thailand. It is very different from Senjogahara, such as temperature, humidity, etc. So, we are also interested in the similarity and effect of forest bathing in Thailand and Japan.

III. The Research Method

To determine where subjects relax, we measure their brain waves. By comparing the results with GPS location measurements, we can verify at what locations subjects relax and identify the attributes of the locations that contribute to relaxation based on their commonalities. EEG was measured using a simple EEG sensor manufactured by Mindsall (Figure 1). Unlike conventional brain sensors, this sensor is a headband type made of cloth and stretchable material. The voltage is measured by aligning the electrodes with the frontal lobe and the two ears, and the difference is recorded as EEG data. The sensor box measures 53 mm x 30 mm x 10 mm. The brain waves measured by the EEG sensor are transmitted to another device using BLE communication, which stands for Bluetooth Low Energy. This standard allows for extremely low-power communication compared to conventional Bluetooth. The elasticity of the EEG sensor, which causes little discomfort, and the power-saving communication makes it possible to record data for long periods. The data is sent to another small terminal with BLE functionality, the M5 stack, and recorded as an EEG log. By connecting a GPS module to the M5 stack, brain wave values, current location, and time can be synchronized and recorded. Also, as shown in Figure 2, the logger module includes a GPS module, and the location information is recorded simultaneously.

As mentioned in section II, the EEG measurements were conducted in Khao Yai National Park, located northeast of Bangkok, which was registered as a World Natural Heritage site in 2005 and is famous as one of the best bird-watching spots in Thailand [6]. Several hiking routes in the park were explored from February 2 to February 3, 2023. A total of nine participants, seven students (two sophomores, two juniors,

(a) Relaxed points of a participant (No.3) (b) Relaxed points of a participant (No.4)

Fig.3. Personal relaxed points on the way to Heunalok falls

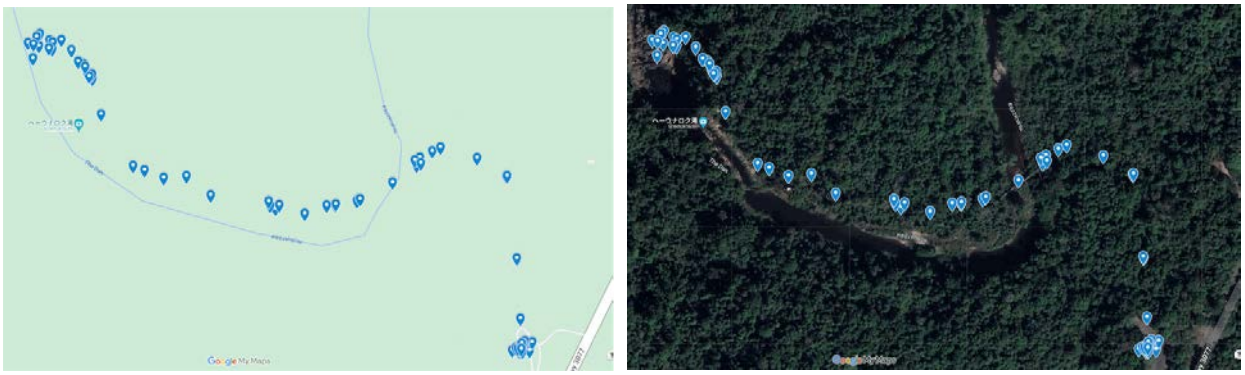


Fig.4 Relaxed points on the way to Heunalok falls (Relaxed data of all participants are plotted)

TABLE 1. THE RESULT OF PANAS ON THE ROUTE TO HEUNALOK FALLS

Start point	Positive	Strong(2) Inspired(5) Active(7) Enthusiastic(2) Interested(5) Excited(4) Alert(3) Determined(2) Attentive(3)
	Negative	Irritable(1) Scared(2) Nervous(1) Distressed(1)
One hour passed	Positive	Strong(5) Inspired(6) Active(7) Enthusiastic(7) Interested(5) Excited(7) Proud(2) Determined(2)
	Negative	Irritable(2) Afraid(1) Upset(2) Scared(1) Distressed(1)
Return to the start point	Positive	Strong(1) Inspired(2) Active(2) Enthusiastic(1) Interested(3) Proud(3) Determined(1) Attentive(2)
	Negative	Irritable(1) Jittery(1) Upset(1) Scared(1) Nervous(1) Distressed(1)

and three seniors) and two teachers measured EEG on three trails: a roughly 3km round-trip walk to Heunalok Falls on February 2, a roughly 1km round-trip walk to Haeuswat Falls on February 3, and a 4km walk through the forest. Weather, temperature, and humidity were also measured prior to the start of each walk.

In addition, as a supplementary measure, the subjects completed a questionnaire based on PANAS [7].

20 keywords were included in the PANAS test sheet. 10 were positive, and 10 were negative as follows.

Positive: Strong, Inspired, Active, Enthusiastic, Interested, Excited, Proud, Alert, Determined, Attentive,

Negative: Afraid, Scared, Upset, Ashamed, Guilty, Nervous, Distressed, Irritable, Jittery, Hostile

The questionnaires were filled out before the start of the walk, during the walk, and after the walk.

IV. EVALUATION OF THE EFFECT OF FOREST BATHING

The following shows the degree to which the subject relaxed on each walking route by mapping GPS and EEG data.

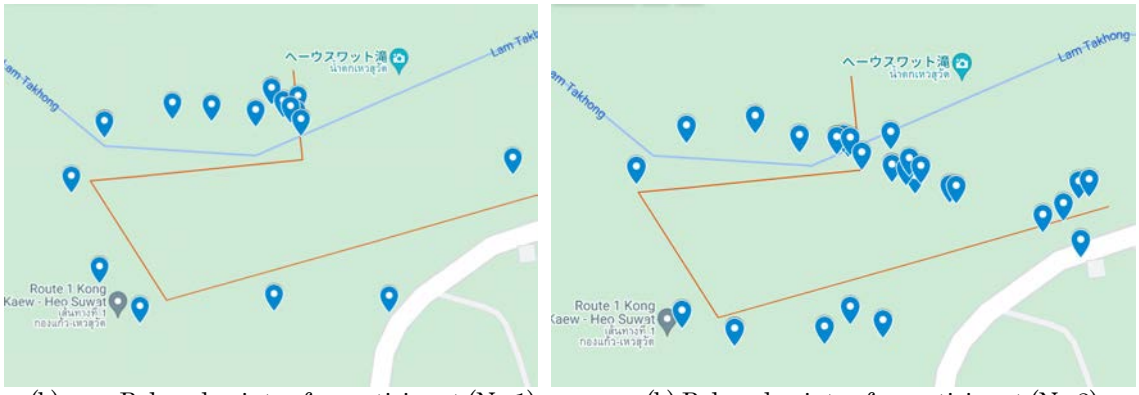
Attention and Meditation are calculated and output every second in SOC. However, since the data during walking is noisy, both Attention and Meditation must be less than 100, and the value of Meditation /(Meditation +Attention) must be greater than 0.6.

A. EEG measurements on the course to Heunalok Falls

On February 2, 2023, the weather at the start of the walk to Heunalok Falls was clear and warm, with 9 participants. The weather did not change significantly during the walk. Figures 3 and 4 show the points at which the participants felt relaxed based on EEG measurements. The orange line represents the walking route. The results of the PANAS questionnaire are shown in Table 1. Here, the number in parentheses indicates the number of people who selected the item, and the items selected by the majority are marked in red.

B. EEG measurements on the course to Haeswat Falls

On February 3, 2023, on the course to Haeuswat Falls, the weather at the start of the walk was cloudy, with a temperature of 28.3°C and humidity of 69%. The weather did not change significantly during the walk.



(b) Relaxed points of a participant (No.1) (b) Relaxed points of a participant (No.2)

Fig.5. Personal relaxed points on the way to Haeuswat falls

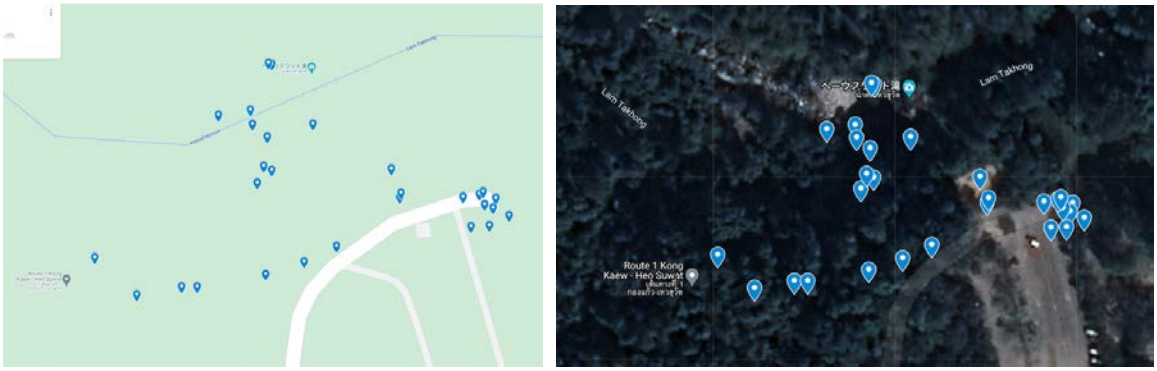


Fig.6 Relaxed points on the way to Haeuswat falls (Relaxed data of all participants are plotted)

TABLE 2. THE RESULT OF PANAS ON THE ROUTE TO HAEUSWAT FALLS

Start point	Positive	Strong(3) Inspired(2) Active(2) Enthusiastic(2) Interested(3) Excited(2) Alert(1) Determined(1) Attentive(1)
	Negative	Irritable(3) Jittery(2) Afraid(2) Upset(3) Scared(1) Nervous(2) Distressed(1)
Half hour passed	Positive	Strong(4) Inspired(5) Active(5) Enthusiastic(5) Interested(4) Excited(5) Proud(5) Determined(3) Attentive(3)
	Negative	Irritable(1) Upset(1) Scared(1) Guilty(1)
Return to the start point	Positive	Strong(4) Inspired(5) Active(6) Enthusiastic(3) Interested(2) Excited(3) Proud(2) Determined(2) Attentive(2)
	Negative	Jittery(1) Afraid(1) Upset(2) Nervous(1)

Figures 5 and 6 show the points at which the subjects felt relaxed based on EEG observations. The results of the questionnaire are shown in Table 2.

C. *EEG measurement on a course through a forest*

On February 3, 2023, the weather at the start of the walk through the forest was clear; the temperature was 28.7°C, and the humidity was 59%. The weather did not change significantly during the walk. Figures 7 and 8 show the points where the subjects felt relaxed, based on EEG observations. The light blue area in the figure shows a lake, which can be seen from the sidewalk on the left side of the figure. After passing by the lake, the subjects walked around the area opened up by the burning of the fields. Around the lower left of the lake on the map, there is a 15-meter-high observatory from which one can see the surrounding area. The results of the survey are shown in Table 3.

V. DISCUSSION

The results from the Heunalok Falls course and the Haeuswat Falls course show that the sound of the water is effective for relaxing. The subjects both began to feel relaxed from the point where they approached the river and relaxed more frequently in front of the waterfall. On the forested trails, subjects are found to be more deeply relaxed in the forest than in areas where the forest is burned, and the surroundings are open. Furthermore, all subjects relax around the waterfall, while many, but not all, relax at the point where the lake is visible. From the above, sound contributes greatly to

(c) Relaxed points of a participant (No.3) (b) Relaxed points of a participant (No.2)

Fig.5. Personal relaxed points on the path in the forest

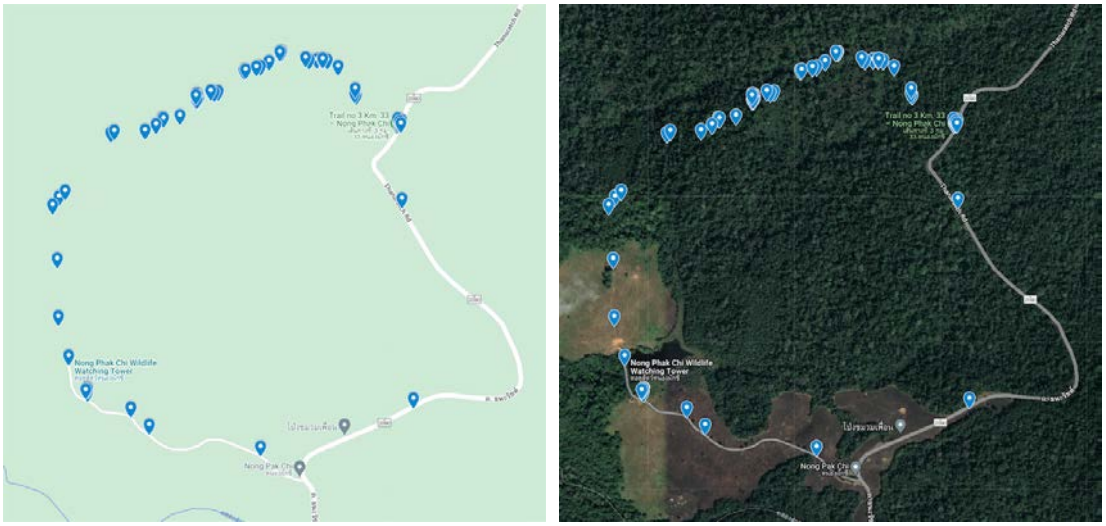


Fig.6. Relaxed points on the path in the forest (Relaxed data of all participants are plotted)

TABLE 3. THE RESULT OF PANAS ON THE PATH IN THE FOREST

Start point	Positive	Strong(2) Inspired(4) Active(3) Enthusiastic(2) Interested(3) Excited(5) Alert(1) Determined(2)
	Negative	Irritable(3) Jittery(1) Afraid(2) Upset(3) Scared(3) Nervous(2) Distressed(2) Hostile(2)
Half hour passed	Positive	Strong(4) Inspired(4) Active(1) Enthusiastic(1) Interested(4) Excited(2) Proud(2) Determined(1) Attentive(2)
	Negative	Irritable(4) Jittery(3) Afraid(2) Upset(3) Scared(1) Nervous(2) Distressed(1)
One hour passed	Positive	Strong(2) Inspired(3) Active(4) Enthusiastic(2) Interested(5) Excited(4) Determined(1) Attentive(3)
	Negative	Irritable(3) Jittery(1) Afraid(1) Upset(3) Scared(1) Guilty(1)
Two hour passed	Positive	Strong(2) Inspired(5) Active(5) Enthusiastic(3) Interested(5) Excited(2) Proud(1) Alert(1) Attentive(3)
	Negative	Irritable(2) Jittery(1) Afraid(1) Upset(2) Scared(1) Nervous(2) Distressed(1)
Arrive at the exit	Positive	Strong(4) Inspired(2) Active(4) Enthusiastic(1) Interested(4) Excited(2) Proud(4) Alert(1) Determined(2) Attentive(1)
	Negative	Irritable(2) Upset(1) Nervous(1) Distressed(2)

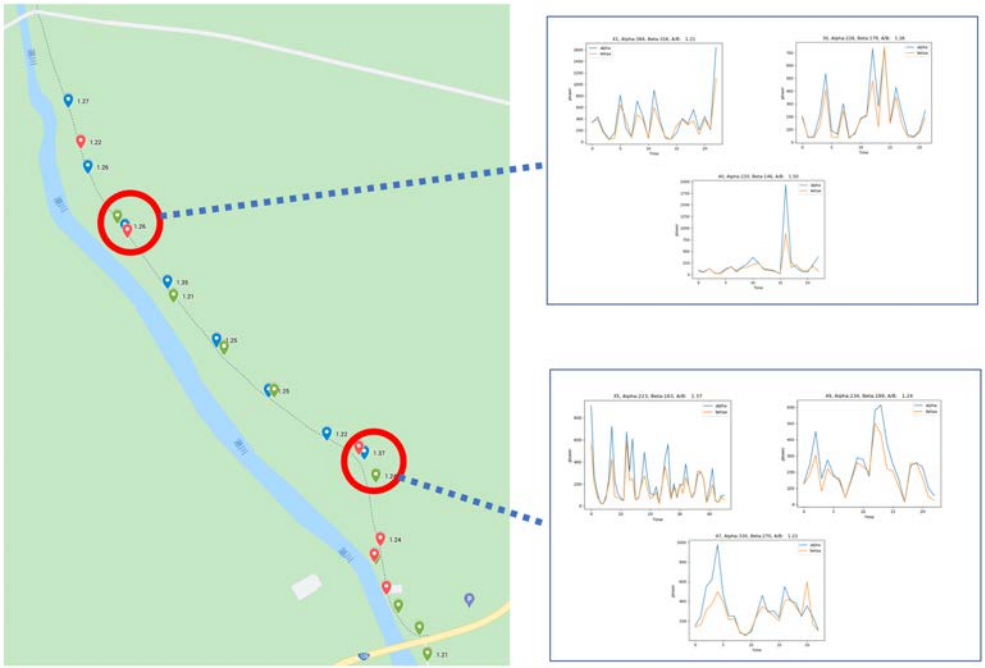


Fig. 7. Two locations where all of them felt relaxed, and EEG (α > β)

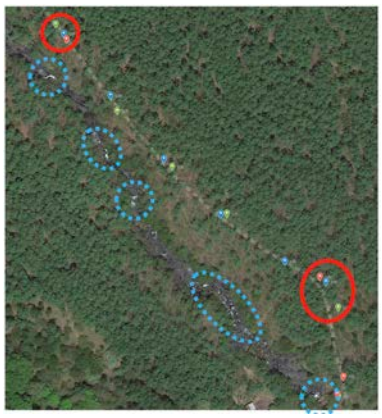


Fig.8. Waterfalls (dotted circles) and two locations where all of them felt relaxed (solid lines)

relaxation during forest bathing and hiking. Subjects were more deeply relaxed at sites where they could hear the loud sound of water, such as a waterfall, than at sites with little sound of water, such as a lake. Similar results were obtained in a study conducted in Oku-Nikko [5]. Figures 7 and 8 show the results of the forest bathing experiment in Oku-Nikko in 2021. Two locations where all of them felt relaxed (= α/β > 1.2), as displayed in Figure 4. Around the left circle of Figure 6, the score of α/β was 1.21, 1.26, 1.50 (average 1.32), and around the right circle, the score of α/β was 1.37, 1.24, 1.22 (average 1.28). They showed a higher α/β ratio at these two points, so we can assume that these points are good for relaxing. Figure 7 shows that along the river, there are some waterfalls. At these two points, we can hear the sound clearly. So, we assume a waterfall may be a good relaxing place. So, experiments A and B in section 3 showed a similar result in Oku-Nikko (Senjogahara) since waterfalls obtained the relaxing effect.

The difference was experiment C in section 3. While walking in the forest in experiment C, the density of relaxing points was greater than near a lookout point with a beautiful view. Some studies have shown that sounds in tropical rainforests contain high frequencies above 100 kHz, which have a relaxing effect [8]. We want to make a detailed comparison and compare the results with other locations in the future.

VI. Conclusion

In this paper, we measured the effects of forest bathing using EEG and considered locations more conducive to relaxation. We found that walking around waterfalls and in forests is more effective for relaxation in forests than good open views. In the future, we plan to test whether listening only to the sound of waterfalls, which is thought to be effective for relaxation, produces the same relaxation effect as strolling around waterfalls. We also plan to investigate the relationship between strolling and the brain's default mode network. It should be added that the criterion for this study is the degree of relaxation of the subjects, not their level of satisfaction.

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References

[1] László Puczkó、Melanie Smith、Keith Pollard, Exploring Health Tourism", World Tourism Organization (UNWTO) and European Travel Commission (ETC) , 2018 (in Japanese)

[2] Global Wellness Summit (https://www.globalwellnesssummit.com/uncategorized/forest-bathing-2-0-the-art-and-science-of-shinrin-yoku/) Accessed at 2023.2.8)

[3] Norimasa Takayama, "Stress and Forest Bathing", JAPANESE SOCIETY OF BIOFEEDBACK RESEAprilARCH, Vol.42, No.1, Apr. 2015, https://doi.org/10.20595/jjbf.42.1_3

[4] Jelena Farkic, Gorana Isailovic, Steve Taylor, "Annals of Tourism Research Empirical Insights", Jan 2021

[5] Ito, A., Hiramatsu, Y., Ueda, K., Harada, Y., Nakayama, H., Hasegawa, M., Morishita, M., Sato, M., Sasaki, A., Chansawang, R. (2022). Development of Tourism Resources Utilizing Healing Effects. In: AHFE (2022) International Conference. AHFE Open Access, vol 41. http://doi.org/10.54941/ahfe1001802

[6] https://www.thailandtravel.or.jp/khao-yai-national-park/ (Accessed at 2023.2.8)

[7] David Watson, Lee Anna Clark(1999), "The PANAS-X: Manual for the Positive and Negative Affect Schedule - Expanded Form"

[8] Tsutomu Oohashi, Emi Nishina, Manabu Honda, Yoshiharu Yonekura, Yoshitaka Fuwamoto, Norie Kawai, Tadao Maekawa, Satoshi Nakamura, Hidenao Fukuyama, and Hiroshi Shibasaki, "Inaudible High-Frequency Sounds Affect Brain Activity: Hypersonic Effect", Journal of Neurophysiology 2000 83:6, 3548-3558