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Efficiency of Bucket Light Traps with Different Light Sources for the National Ecosystem Survey of Korea

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ABSTRACT

Bucket light traps are widely used in nocturnal insect surveys due to their effectiveness in attracting diverse insect taxa. To enhance the efficiency of bucket light traps and reduce survey costs, recent studies have examined various light sources, including conventional black-light UV (BL_UV) and newly introduced LED light sources. This study was conducted to improve the National Ecosystem Survey methodology, aimed at evaluating the efficiency of different light sources in bucket light traps and proposing optimized insect survey methods. We compared the capture efficiency of the current BL_UV light source with those of three LED types (UV [LED_UV], Blue [LED_B], and Green [LED_G]). Field surveys were conducted at six sites under consistent conditions, and samples were analyzed by taxonomic experts specializing in Lepidoptera, Coleoptera, Hymenoptera/Diptera, and Hemiptera/other taxa. In total, 2,036 individuals from 430 species, 92 families, and 11 orders were captured using four light sources. BL_UV and LED_UV showed significantly higher species richness and abundance than LED_B and LED_G. Statistical analyses (one-way analysis of variance and Scheffé tests) indicated no significant differences between BL_UV and LED_UV, but both outperformed LED_B and LED_G. Our results indicate that shorter wavelengths (355-405 nm) are more effective at attracting diverse nocturnal insects. We recommend the continued use of UV-type light sources, particularly LED_UV, for long-term monitoring in the National Ecosystem Survey of Korea. Additionally, the combination of UV and medium wavelengths can further improve the capture efficiency.

Keywords: Bucket light trap, Capture efficiency, Light source, National ecosystem survey, Nocturnal insect survey

Introduction

Insect surveys encompass a wide range of methods that vary according to the ecological characteristics of the diverse taxonomic groups, necessitating the use of suitable collection methods or tools based on the target taxa (Campbell & Hanula, 2007; Noyes, 1989; Shweta & Rajmohana, 2016). Among insects, Lepidoptera, one of the most taxonomically and biologically well-known groups, is considered a good bioindicator of environmental change because of its predominantly phytophagous nature during larval stages (Woiwod & Stewart, 1990; Woiwod & Thomas, 1992). Considering that moths constitute the largest taxonomic group among the insects collected using bucket light traps, it is necessary to use light sources that can be used consistently over long periods. Various designs for trap improvement and development are being pursued to enhance trap efficiency and reduce costs (Russo

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et al., 2011; van Achterberg, 2009). Additionally, in large-scale survey projects, such as the National Ecosystem Survey of Korea, which covers the entire country, it is crucial to select the most efficient survey methods to achieve the best possible outcomes, considering the available manpower and budget (Russo *et al*., 2011). There is a need to move beyond manpower-centered methods by adopting the latest survey techniques and improving insect-trapping methods to ensure the efficient operation of the National Ecosystem Survey of Korea. This approach will help secure quantitative data to provide reliable natural environmental information, thereby laying the foundation for sound environmental policymaking.

Internationally, studies and surveys utilizing bucket light traps have been conducted in various fields. Active research is underway to select the appropriate light sources and develop traps according to specific research objectives. Experiments using various light sources and wavelengths have been conducted to collect specific taxa or determine their taxonomic preferences (Brehm, 2017; Infusino *et al*., 2017; Pan *et al*., 2021). In addition, various light sources and wavelengths tailored for the research purpose are currently being utilized for nocturnal insect diversity surveys and pest monitoring (Pan *et al*., 2021; Ramamurthy *et al*., 2010; Shimoda & Honda, 2013). Furthermore, there is a growing trend towards the development of self-constructing traps that enhance capture efficiency and reduce costs (White *et al*., 2016; Zemel & Houghton, 2017).

As in other countries, research utilizing various light sources and wavelengths to identify taxonomic preferences or attract specific taxa is actively underway in Korea. Instead of conventional black light and mercury lamps, studies have increasingly focused on LED light sources, which are easier to handle and offer greater durability (Jeon *et al*., 2014; Lee, 2013; Song *et al*., 2016). Various light sources and wavelengths have been used in pest surveys and control (Jeon *et al*., 2014; Park *et al*., 2014; Song *et al*., 2016). However, studies on light sources and wavelengths for surveying nocturnal insect diversity in natural ecosystems are limited.

This study aims to propose guidelines for improving the terrestrial insect survey methods of the National Ecosystem Survey of Korea by verifying the efficiency of various light sources used in bucket light traps.

Materials and Methods

Survey date, survey area, and survey method

Field surveys using bucket light traps were conducted in August at six sites selected to meet the same environmental conditions (Table 1). Traps were installed at intervals of 5 m before sunset and were collected the following morning. The lighting period was set from 20:00 to 24:00 using a timer following the guidelines of the National Ecosystem Survey of Korea.

Selection of light sources and wavelengths

To compare the capture efficiency of the black-light UV (BL_UV) source currently used in the terrestrial insect field of the National Ecosystem Survey of Korea, three types of LED light sources (UV [LED_UV], Blue [LED_B], and Green [LED_G]) were selected based on a literature review and preliminary surveys. The wavelength range of the selected light sources is 360-520 nm (Table 2).

Laboratory analysis and statistical analysis

Samples collected from four different light sources at six different sites (24 samples in total) were classified by order and sent to taxonomic experts for species analysis. Classification was performed by experts specializing in Lepidoptera, Coleoptera, Hymenoptera/Diptera, and Hemiptera/other taxa.

To compare the capture efficiency among the four types of light sources, including the BL_UV light source used in the current trap of the National Ecosystem Sur-

Table 1. Survey date, survey area, and survey method of present study

Survey round	Survey date	Coordinates	Survey area	Survey method
1st	August 6, 2022	N 36° 24’28.80” E 126° 51’33.47”	Janggok-ri San 20-1, Daechi-myeon, Cheongyang-gun, Chungcheongnam-do	Installation and collection of bucket light trap
2nd	August 7, 2022	N 36° 24’25.61” E 126° 51’57.81”	Janggok-ri San 20-1, Daechi-myeon, Cheongyang-gun, Chungcheongnam-do	Installation and collection of bucket light trap
3rd	August 12, 2022	N 36° 24’23.65” E 126° 51’52.41”	Janggok-ri San 20-1, Daechi-myeon, Cheongyang-gun, Chungcheongnam-do	Installation and collection of bucket light trap
4th	August 16, 2022	N 36° 24’38.04” E 126° 53’57.89”	Cheonjang-ri San 26-10, Jeongsan-myeon, Cheongyang-gun, Chungcheongnam-do	Installation and collection of bucket light trap
5th	August 17, 2022	N 36° 24’11.76” E 126° 51’03.14”	Janggok-ri 89, Daechi-myeon, Cheongyang-gun, Chungcheongnam-do	Installation and collection of bucket light trap
6th	August 18, 2022	N 36° 26’52.82” E 126° 53’06.86”	Oryong-ri 37, Daechi-myeon, Cheongyang-gun, Chungcheongnam-do	Installation and collection of bucket light trap

vey of Korea and the three LED light sources used as the control group, differences in the average number of species and individuals according to the light source type were analyzed. One-way analysis of variance (ANOVA) was conducted to verify the mean difference, and post-hoc analysis was performed using Scheffé's test. All empirical analyses were conducted at a significance level of $P<0.05$, and statistical processing was performed using SPSSWIN 25.0 (IBM, Armonk, NY, USA).

Table 2. Types and wavelengths of light sources used in present study

Light source	Wavelength (nm)	Remarks
Black-light UV (BL_UV)	360	Current
LED light UV (LED_UV)	365	New
LED light Blue (LED_B)	452	New
LED light Green (LED_G)	520	New

Results

Overall status by light source

Analysis of nocturnal insects captured using four different light sources over six surveys revealed 2,036 individuals from 430 species, 92 families, and 11 orders. The light source results were as follows: BL_UV (current) captured 951 individuals from 284 species, 74 families, and 11 orders; LED_UV captured 848 individuals from 277 species, 64 families, and 9 orders; LED_G captured 125 individu-

Table 3. Overall status by light source

Survey round	Taxa	BL_UV	LED_B	LED_G	LED_UV	Total
1st	Order	7	3	2	6	8
	Family	34	8	8	35	46
	Species	97	11	10	81	143
	Individual	196	23	11	123	353
2nd	Order	10	3	5	3	10
	Family	40	7	13	29	48
	Species	95	11	20	83	156
	Individual	241	15	30	184	470
3rd	Order	7	4	3	5	7
	Family	27	12	6	31	42
	Species	67	15	8	72	117
	Individual	111	30	11	155	307
4th	Order	7	6	5	8	9
	Family	34	14	16	30	49
	Species	83	19	26	70	148
	Individual	161	24	45	120	350
5th	Order	5	3	3	6	6
	Family	29	7	8	33	42
	Species	71	8	9	85	127
	Individual	136	11	13	167	327
6th	Order	5	4	4	4	5
	Family	26	8	10	22	35
	Species	72	8	12	71	123
	Individual	106	9	15	99	229
Total		11 orders, 74 families, 284 species, 951 individuals	6 orders, 30 families, 56 species, 112 individuals	6 orders, 33 families, 71 species, 125 individuals	9 orders, 64 families, 277 species, 848 individuals	11 orders, 92 families, 430 species, 2,036 individuals

BL_UV, black-light UV; LED_B, LED light Blue; LED_G, LED light Green; LED_UV, LED light UV.

als from 71 species, 33 families, and 6 orders; and LED_B captured 112 individuals from 56 species, 30 families, and 6 orders (Table 3).

BL_UV had the highest number of species and individuals in the first (97 species, 196 individuals), second (95 species, 241 individuals), fourth (83 species, 161 individuals), and sixth (72 species, 106 individuals) surveys. In contrast, LED_UV exhibited the highest number of species and individuals in the third (72 species and 155 individuals) and fifth (85 species and 167 individuals) surveys.

The second survey recorded the highest number of species and individuals, with 470 individuals belonging to 156 species, 48 families, and 10 orders. In contrast, the third survey recorded the lowest number of individuals, with 307 individuals from 117 species, 42 families, and 7 orders.

Overall, the number of species and individuals captured by BL_UV and LED_UV were relatively high compared to the significantly lower numbers observed with LED_G and LED_B.

Taxonomic status by light source

Taxonomic analysis of the nocturnal insects captured over the 6 surveys revealed that Lepidoptera accounted for 258 species (60.0% of the total species) and 1,143 individuals (56.1% of the total individuals), representing more than half of the captured specimens. This was followed by Coleoptera with 74 species and 451 individuals, Diptera with 35 species and 60 individuals, Hemiptera with 29 species and 294 individuals, Hymenoptera with 20 species and 23 individuals, and Orthoptera with 4 species and 18 individuals (Table 4).

Among the 284 species and 951 individuals captured in the BL_UV (current) trap, Lepidoptera dominated with 183 species and 545 individuals, followed by Coleoptera (44 species and 199 individuals), Hemiptera (21 species and 143 individuals), Diptera (14 species and 19 individuals), and Hymenoptera (10 species and 11 individuals).

In the LED_UV trap, which captured 277 species and 848 individuals, Lepidoptera showed the highest representation, with 194 species and 495 individuals, followed by Coleoptera (41 species and 189 individuals), Hemiptera (16 species and 103 individuals), Diptera (11 species and 22 individuals), and Hymenoptera (10 species and 10 individuals).

Among the 71 species and 125 individuals captured in the LED_G trap, Lepidoptera accounted for 34 species and 49 individuals, followed by Coleoptera (20 species and 43 individuals), Hemiptera (9 species and 23 individuals), and Diptera (6 species and 8 individuals).

In the LED_B trap, which captured 56 species and 112 individuals, Lepidoptera remained the most abundant with 31 species and 54 individuals, followed by Coleoptera (10 species and 20 individuals), Diptera (10 species

Table 4. Taxonomic status by light source

Orders	BL_UV		LED_B		LED_G		LED_UV		Total	
	No. of species	No. of individuals	No. of species	No. of individuals	No. of species	No. of individuals	No. of species	No. of individuals	No. of species	No. of individuals
Lepidoptera	183	545	31	54	34	49	194	495	258	1,143
Trichoptera	3	20	-	-	-	-	1	18	3	38
Hemiptera	21	143	3	25	9	23	16	103	29	294
Coleoptera	44	199	10	20	20	43	41	189	74	451
Orthoptera	3	8	1	1	1	1	2	8	4	18
Hymenoptera	10	11	1	1	1	1	10	10	20	23
Mantodea	1	1	-	-	-	-	1	2	1	3
Odonata	2	2	-	-	-	-	-	-	2	2
Diptera	14	19	10	11	6	8	11	22	35	60
Neuroptera	1	1	-	-	-	-	-	-	1	1
Ephemeroptera	2	2	-	-	-	-	1	1	3	3

BL_UV, black-light UV; LED_B, LED light Blue; LED_G, LED light Green; LED_UV, LED light UV; -, not available.

Table 5. Main species status by light source

Scientific name	BL_UV	LED_B	LED_G	LED_UV	Total
Ricania sublimata	44	9	2	51	106
Berosus lewisius	52	1	8	41	102
Enochrus simulans	26	-	10	23	59
Sigara substriata	10	14	10	13	47
Katha deplana	25	2	1	13	41
Geotomus pygmaeus	21	-	4	14	39
Cheumatopsyche albofasciata	18	-	-	18	36
Marumba sperchius	19	-	-	14	33

BL_UV, black-light UV; LED_B, LED light Blue; LED_G, LED light Green; LED_UV, LED light UV; -, not available.

Table 6. Number of exclusively captured species by light source

Light source	Order	Family	Species
BL_UV	10	46	108
LED_B	5	9	13
LED_G	5	13	18
LED_UV	7	41	103

BL_UV, black-light UV; LED_B, LED light Blue; LED_G, LED light Green; LED_UV, LED light UV.

Table 7. Comparison of captured species numbers between major light sources (BL_UV, LED_UV)

Light source	Order	Family	Species
BL_UV	11	74	284
LED_UV	9	64	277
BL_UV+LED_UV	11	86	339

BL_UV, black-light UV; LED_UV, LED light UV.

and 11 individuals), and Hemiptera (3 species and 25 individuals).

Main species by light source

Status of main species

The analysis of nocturnal insect species with more than 30 individuals revealed eight main species, including three species from Hemiptera, two species each from Lepidoptera and Coleoptera, and one species from Trichoptera (Table 5).

Regarding the number of individuals of the main species, *Ricania sublimata* had the highest count (106 individuals), followed by *Berosus lewisius* (102 individuals), *Enochrus simulans* (59 individuals), *Sigara substriata* (47 individuals), and *Katha deplana* (41 individuals).

The main species, *R. sublimata*, *B. lewisius*, *S. substriata*, and *K. deplana*, which were found in all light sources, showed a higher proportion in both BL_UV and LED_UV. In contrast, *S. substriata* displayed similar proportions across all light sources. Notably, *Cheumatopsyche albofasciata* and *Marumba sperchius* were observed only in the BL_UV and LED_UV treatments, indicating their tendency to appear specifically under these light conditions.

Number of exclusively captured species by light source

Analysis of the species captured exclusively by light sources revealed that both BL_UV (108 species from 46 families and 10 orders) and LED_UV (103 species from 41 families and 7 orders) showed relatively high numbers of exclusively captured species. In contrast, LED_G (18 species from 13 families and 5 orders) and LED_B (13 species from 9 families and 5 orders) exhibited significantly fewer exclusively captured species. This trend is consistent with the overall capture patterns observed for each light source (Table 6).

Comparison of captured species numbers between major light sources (black-light UV, LED light UV)

In total, there were 339 species from 86 families and 11 orders captured using the BL_UV and LED_UV light sources. Specifically, BL_UV captured 284 species from 74 families and 11 orders, whereas LED_UV captured 277 species from 64 families and 9 orders. These results indicated that the attractiveness of nocturnal insects to both light sources was similar (Table 7).

Comparison of exclusively captured species numbers among major light sources (black-light UV, LED light UV, black-light UV+LED light UV)

A total of 325 species from 76 families and 11 orders were captured exclusively by the three major light sources (BL_UV, LED_UV, and BL_UV+LED_UV). Among them, 108 species were exclusively captured by BL_UV, whereas 103 species were exclusively captured by LED_UV. The combined light source (BL_UV+LED_UV) exclusively captured 114 species. These results indicated that the ratios of exclusively captured species and overlapping captured species between the two light sources were similar (Table 8).

Status of exclusively captured main species among major light sources (black-light UV, LED light UV, black-light UV+LED light UV)

Among the 325 species exclusively captured by the three major light sources (BL_UV, LED_UV, BL_UV+LED_UV), 19 nocturnal insect species with more than 10 individuals were identified. These included 10 species from Lepidoptera, 5 species from Coleoptera, 2 species from Hemiptera, and 1 species each from Trichoptera and Orthoptera (Table 9).

Some species, such as *Halyomorpha halys*, *Spatalia dives*, *Nicrophorus concolor*, and *Dendrolimus spectabilis*, exhibited higher proportions under BL_UV than LED_UV. In contrast, *Laccobius binotatus* appeared exclusively in LED_UV. The other species exhibited similar capture rates between the two light sources.

Verification of capture efficiency by light source

When examining the number of species captured according to the light source type, BL_UV and LED_UV showed similarly high values, with averages of 80.83 and 77.00, respectively. In contrast, LED_B and LED_G had significantly lower values, with averages of 12.00 and 14.17, respectively.

Regarding the number of individuals captured, BL_UV and LED_UV also exhibited similar high values, with averages of 158.50 and 141.33, respectively. In comparison, LED_B and LED_G had relatively low values, with averages of 18.67 and 20.83, respectively (Table 10).

Table 8. Comparison of exclusively captured species numbers among major light sources

Light source	Order	Family	Species
BL_UV (exclusively captured species)	10	46	108
LED_UV (exclusively captured species)	7	41	103
BL_UV+LED_UV (overlapping captured species)	7	35	114
Total	11	76	325

BL_UV, black-light UV; LED_UV, LED light UV.

Table 9. Status of exclusively captured main species among major light sources

Scientific name	BL_UV	LED_B	LED_G	LED_UV	UV (BL+LED)	Total
Cheumatopsyche albofasciata	18	-	-	18	36	36
Marumba sperchius	19	-	-	14	33	33
Halyomorpha halys	20	-	-	6	26	26
Rhamnosa angulata	15	-	-	9	24	24
Notodontidae sp.1	14	-	-	9	23	23
Spatalia dives	16	-	-	4	20	20
Nicrophorus concolor	11	-	-	4	15	15
Dendrolimus spectabilis	12	-	-	3	15	15
Spilarctia seriatopunctata	7	-	-	7	14	14
Isocheilus staphylinoides	6	-	-	7	13	13
Sunesta setigera setigera	5	-	-	8	13	13
Alcis angulifera	7	-	-	6	13	13
Teleogryllus emma	4	-	-	7	11	11
Metcalfa pruinosa	6	-	-	5	11	11
Hydrochara affinis	6	-	-	5	11	11
Laccobius binotatus	-	-	-	11	11	11
Pseudalbara parvula	7	-	-	4	11	11
Noctuidae sp.2	6	-	-	5	11	11
Peridea gigantea	7	-	-	4	11	11

BL_UV, black-light UV; LED_B, LED light Blue; LED_G, LED light Green; LED_UV, LED light UV; -, not available.

Analysis of variance results

The results of the ANOVA revealed significant differences in both the number of species (F=123.081, *P*<0.001) and the number of individuals (F=33.706, *P*<0.001) among the different light sources (Table 11).

The results of the post hoc tests (multiple comparisons, Scheffé) for the number of species and individuals showed significant differences between BL_UV and both LED_B and LED_G (*P*<0.001). However, there was no significant difference between BL_UV and LED_UV (*P*<0.001).

This indicates that the numbers of species and individuals captured by BL_UV and LED_UV were similar, whereas the numbers captured by LED_B and LED_G were comparable. However, both BL_UV and LED_UV showed distinct differences in species and individual counts compared with LED_B and LED_G (Table 12).

Discussion

The results indicated that BL_UV and LED_UV exhibited similarly high numbers of species and individuals, whereas LED_G and LED_B exhibited significantly lower numbers. This suggests that using shorter wavelengths (approximately below 355-405 nm) is more advantageous than using longer wavelengths for attracting a greater number of species and individuals (Bae *et al*., 2015; Pan *et al*., 2021). Furthermore, regardless of the lamp type (e.g., LED light, fluorescent light), species richness remained consistently high within the shorter wavelength range (380 nm, 385 nm, 390 nm, 395 nm, and 403 nm), which included UV, without significant differences (Zemel & Houghton, 2017). This finding suggests that employing a variety of short wavelengths is favorable for capturing diverse nocturnal insects.

In this study, no distinctly captured taxa were observed in the relatively long wavelength ranges of LED_B (452 nm) and LED_G (520 nm) compared with the short wavelengths of UV (BL_UV and LED_UV). However, previous studies have shown that there are preferences for specific taxonomic groups depending on the wavelength range. For example, in a comparative study of green (medium-wavelength) and blue (short-wavelength) light sources ranging from UV-A to mid-wavelengths, aquatic insects and ant species (alate forms) were more commonly captured with green light, whereas moths and beetles were predominantly captured with blue light (Komatsu *et al*.,

Table 10. Descriptive statistics of species number and individual count by light source

Factors		Mean	Standard deviation	Standard error	Minimum	Maximum
No. of species	BL_UV	80.83	12.91	5.27	67.00	97.00
	LED_B	12.00	4.29	1.75	8.00	19.00
	LED_G	14.17	7.22	2.95	8.00	26.00
	LED_UV	77.00	6.72	2.74	70.00	85.00
	Total	46.00	34.56	7.05	8.00	97.00
No. of individuals	BL_UV	158.50	52.42	21.40	106.00	241.00
	LED_B	18.67	8.26	3.37	9.00	30.00
	LED_G	20.83	13.83	5.65	11.00	45.00
	LED_UV	141.33	32.40	13.23	99.00	184.00
	Total	84.83	73.08	14.92	9.00	241.00

BL_UV, black-light UV; LED_B, LED light Blue; LED_G, LED light Green; LED_UV, LED light UV.

Table 11. Analysis of variance for species number and individual count by light source

Source		Sum of squares	df	Mean square	F	*P*-value
No. of species	Between groups	26,062.333	3	8,687.444	123.081	<0.001
	Within groups	1,411.667	20	70.583	-	-
	Total	27,474.000	23	-	-	-
No. of individuals	Between groups	102,558.333	3	34,186.111	33.706	<0.001
	Within groups	20,285.000	20	1,014.250	-	-
	Total	122,843.333	23	-	-	-

-, not available.

Table 12. Post hoc tests (multiple comparisons, Scheffé) for species number and individual count by light source

Dependent variable	(I) Light source	(J) Light source	Mean difference (I–J)	*P*-value	95% Confidence interval	
					Lower bound	Upper bound
No. of species	BL_UV	LED_B	68.83333	<0.001	54.0450	83.6217
		LED_G	66.66667	<0.001	51.8783	81.4550
		LED_UV	3.83333	0.890	–10.9550	18.6217
	LED_B	BL_UV	–68.83333	<0.001	–83.6217	–54.0450
		LED_G	–2.16667	0.977	–16.9550	12.6217
		LED_UV	–65.00000	<0.001	–79.7883	–50.2117
	LED_G	BL_UV	–66.66667	<0.001	–81.4550	–51.8783
		LED_B	2.16667	0.977	–12.6217	16.9550
		LED_UV	–62.83333	<0.001	–77.6217	–48.0450
	LED_UV	BL_UV	–3.83333	0.890	–18.6217	10.9550
		LED_B	65.00000	<0.001	50.2117	79.7883
		LED_G	62.83333	<0.001	48.0450	77.6217
No. of individuals	BL_UV	LED_B	139.83333	<0.001	83.7749	195.8917
		LED_G	137.66667	<0.001	81.6083	193.7251
		LED_UV	17.16667	0.832	–38.8917	73.2251
	LED_B	BL_UV	–139.83333	<0.001	–195.8917	–83.7749
		LED_G	–2.16667	1.000	–58.2251	53.8917
		LED_UV	–122.66667	<0.001	–178.7251	–66.6083
	LED_G	BL_UV	–137.66667	<0.001	–193.7251	–81.6083
		LED_B	2.16667	1.000	–53.8917	58.2251
		LED_UV	–120.50000	<0.001	–176.5584	–64.4416
	LED_UV	BL_UV	–17.16667	0.832	–73.2251	38.8917
		LED_B	122.66667	<0.001	66.6083	178.7251
		LED_G	120.50000	<0.001	64.4416	176.5584

BL_UV, black-light UV; LED_B, LED light Blue; LED_G, LED light Green; LED_UV, LED light UV.

2020). Additionally, in an experiment comparing medium wavelengths (approximately 583 nm) and long wavelengths (656 nm), more species and individuals were attracted to the medium wavelength in both the single and combined setups. Noctuid moths are significantly more attracted to medium wavelengths, whereas geometrid moths are equally attracted to both medium and long wavelengths (Somers-Yeates *et al*., 2013). However, considering the results of this and other studies, it can be inferred that most moth species are more likely to be attracted to UV wavelengths rather than to short wavelengths when UV or short-wavelength light sources are included.

Many studies on the attractiveness of nocturnal insects based on light wavelength vary in their focus, ranging from UV-A wavelengths of approximately 350 nm to longer wavelengths, such as red light at approximately 680 nm, depending on the research objectives or target taxa. However, it is challenging to derive consistent conclusions owing to differences in the wavelengths used and the resulting capture patterns. Nevertheless, the findings of this study, along with numerous others, consistently show that UV or short-wavelength light sources tend to attract a greater variety and number of insects than medium- or long-wavelength light sources. To better understand the taxonomic preferences or attraction levels of specific groups, it would be beneficial to conduct more detailed experiments that subdivide the wavelength range and consider various habitat types.

BL_UV and LED_UV significantly outperformed LED_G and LED_B, which had relatively long wavelengths, in terms of the number of captured species and individuals. Furthermore, statistical analysis confirmed that there were no significant differences between BL_UV and LED_UV, indicating that actively utilizing UV-type light sources would be advantageous for attracting a wide range of species and a large number of individuals. Because the currently used BL_UV lights are mainly imported products and are likely to undergo processes of depletion, sales discontinuation, or production discontinuation, it is time to seek new light sources. Replacing them with LED (UV) lights, which offer durability, ease of procurement, and a reduced risk of breakage, would be a reasonable choice.

Bucket light traps currently in use are imported products that are bulky, heavy, and less portable, posing challenges for field use. In addition, their high costs render them less accessible. Therefore, in addition to replacing lamps, it would be beneficial to develop and manufacture suitable traps domestically. This reduces the dependence on foreign products, lowers costs, and promotes the use of locally manufactured equipment.

Therefore, it would be advantageous to prioritize the installation of multi-wavelength LED_UV light sources in the bucket light traps used for the National Ecosystem Survey of Korea, which primarily aims to identify species. Based on the results of this and previous studies, it would also be worth considering the development of composite light sources that combine short, medium, and long wavelengths, such as LED_B, LED_G, and Cool White LED. However, efficiency testing through preliminary experiments is necessary before practical application.

Author Contributions

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Conflict of Interest

The authors declare that they have no competing interests.

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