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SHORT COMMUNICATION

Equipment based on high power UV and white light LEDs to collect and observe scorpions (Arachnida: Scorpiones) and other fluorescent organisms

Eduardo N. Ramires[1,4], Luiz F. Peracetta[2], Cláudio Nogas[3], Mário A. Navarro-Silva[1] & Edson P. Paladini[3]

[1] *Departamento de Zoologia, Universidade Federal do Paraná. Caixa Postal 19020, 81531-980 Curitiba, PR, Brazil.*
[2] *Holostech Soluções em Eletrônica. Avenida Visconde de Guarapuava 770, 80045-200 Curitiba, PR, Brazil.*
[3] *Centro Tecnológico, Universidade Federal de Santa Catarina. Campus Universitário Trindade, 88040-900 Florianópolis, SC, Brazil.*
[4] *Corresponding author. E-mail: contato@aranhamarrom.net*

ABSTRACT. We introduce a new, high quality, low cost and versatile LEDs-based handset device that emits high power UV and white light, which can be used interchangeably. It offers power control and has long battery life. Even though it is optimized to detect and collect scorpions under low light conditions, it can also be used with other groups of fluorescent organisms. The device achieved superior performance in field and laboratory trials when compared with a 12 LEDs low power UV flashlight, and a 46 W black fluorescent light lamp, to locate *Tityus serrulatus* Lutz & Mello, 1922.

KEY WORDS. Buthidae; fluorescence; invertebrate collecting methods; pest control.

The fact that scorpions are strongly fluorescent when illuminated with long ultraviolet light (320-400 nm) has been known for decades (Lawrence 1954). Scorpions (and their exuviae) that do not fluoresce under UV have are yet to be found, although first instar nymphs are not generally visibly fluorescent. The fluorescence exhibited by scorpions and the intensity range of the light emitted by them may vary among species, and is affected by the time elapsed since the last molt (Stahnke 1972). The UV light generally does not noticeably affect the behavior of scorpions (Williams 1968; Stahnke 1972). Molecules associated with the cuticular fluorescence of scorpions have been identified as the beta-carboline (Stachel *et al.* 1999) and 4-methyl, 7-hydroxycoumarin (Frost *et al.* 2001). However, the biological function of fluorescence has not been definitively demonstrated (Kloock *et al.* 2010). Some specialists have hypothesized that fluorescence has no function. For them, fluorescence, is either a relict trait (Frost *et al.* 2001) or is correlated with some other aspect of the functional molecules responsible for it (Stachel *et al.* 1999). In experiments, scorpions continuously exposed to UV light for several weeks showed significant reduction in cuticular fluorescence (Kloock 2009). UV light can be also used to study the external morphology of a scorpion's epicuticle (Volschenk 2005).

Distinct invertebrate taxa, such as spiders (Andrews *et al.* 2007), harvestmen (Acosta 1983), insects (Wiesenborn 2001) and other groups (Lawrence 1954) may also fluoresce under UV light. Various body fluids released by mammals, such as urine and semen, are fluorescent and for that reason UV lamps are used in forensics (Carter-Snell & Soltys 2005).

In the field of pest control, the use of UV lamps is widely recommended to collect scorpions and also for locating rodent urine. In the past, mobile fluorescent lamps were used to collect scorpions (Williams 1968, Stahnke 1972) and, more recently, low power LEDs (Lowe *et al.* 2003) have been used. Those, however, in order to be efficiently employed in the field, require a configuration with many LEDs – 168 in the device described by Lowe *et al.* (2003). Our goal in this paper is to present a new device based on high power UV and white light LEDs, which can be interchanged. This new, versatile, and low cost device has long battery life. Even though it is optimized to detect and collect scorpions in low light situations, it can also be used with other groups of organisms.

The device (Figs 1 and 2) employs, as illumination sources, two 3 W UV LEDs (model EDEV-SLC1-R, light emission 395 nm-410 nm ± 0.5 nm at 25°C), and two 3 W "white light" LEDs (model EDEW-3LS5-FR, light emission 455-470 nm ± 0.5 nm at 25°C), manufactured by Opto Edison®. We used collimator lenses with an aperture angle of 25°, model LL1ED-CV25-L-M1, manufactured by Led Link®. We chose not to apply a current exceeding 500 mA on the LEDs (below the nominal current of 750 mA), in order to prolong the lifespan of both the LEDs and the battery. As a further measure to increase the lifetime of the LEDs, the voltage on them is increased from 0 V to 7 V (3.5 V to each LED) by applying a tension ramp through pulse width modula-

tion. The intensity control of the UV or white lights, the choice between white or UV light, and turning the device on and off are accomplished by four push buttons located on the front of the apparatus. There are two 20 mA LEDs on the front of the device to indicate whether the battery is connected or not, and when the battery charge becomes low. The entire process control unit is implemented through an algorithm written in "C" programming language that runs on an ATMEL® AVR ATMEGA88P microcontroller. The generation, compilation, debugging and recording of the program onto the microcontroller was carried out using the ATMEL® AVR Studio4 microcontroller development environment. The ATMEGA88P was programmed in the ISP mode, using a circuit board specially manufactured for the purpose, coupled with the recording tool (ATMEL®AVR DRAGON). The equipment's power supply is a rechargeable 12 V 7A/h lead-acid battery. The battery run time is about 8 h of uninterrupted use. The electrical connection between the battery and the circuit is through a spring-shaped contact made of stainless steel. To dissipate the heat produced by the LEDs we used a finned heat sink, in aluminum (10 x 10 x 2.5 cm) (Fig. 1). Two circuit boards are glued with epoxy resin on the heat sink, as a substrate for soldering the LEDs. A layer of thermal grease was applied between the rear of the LEDs and the heat sink to improve the dissipation of heat produced by the LEDs. The body of the device was constructed with a 1.5 mm thick aluminum plate, but standardized boxes may be used. The battery is introduced into the device by sliding it from the rear, and its contacts are pressed against the contacts of the circuit. This loading method make it possible to rapidly replace the battery, while also preventing a polarity reversal, since the battery can only be introduced into the device in one way. The amount paid for all components used to build the device was estimated on $ 90, quoted in June 2012. The weight of the device with the battery is 3.5 Kg. The voltage and current measurements were made with the ICEL Meter® Model MD-6400. Measurements of the waveform and frequency were made with the MINIPA® model MO1225 oscilloscope.

Figure 1. View of the device with the movable head upright and UV LEDs on. Scale: 10 cm.

In order to conduct field comparisons, we evaluated the device described in this article against a 12 LEDs (720 mW) flashlight (peak emission of 400 nm) powered by three AAA batteries, and a 46 W black light fluorescent lamp (Golden® model 1453), powered by AC 127 V. The latter is similar to the model that has been used in collecting activities conducted by public health staff in the city of Americana, SP, Brazil. The test was performed on a moonless night, on a lawn away from artificial light sources. Five adult specimens of *Tityus serrulatus* Lutz & Mello, 1922 (Buthidae) preserved in 70% alcohol for less than seven days were placed on a 20 cm X 10 cm and 2 cm thick dark wood plate at ground level. Our previous observations had not shown a noticeable difference between the fluorescence of living and fresh (seven days maximum) alcohol-preserved specimens. Two observers attempted to visualize the scorpions at a distance. Each observer moved slowly on a straight line towards the scorpions, guided by a stretched rope, while holding the UV light-emitting equipment tested about 1 m above the ground, directed forward. As soon as the fluorescence emitted by the scorpions could be distinguished, the observer stopped moving, and the distance to them was measured. When our high power LEDs device was used, the scorpions were visible to the observers at 12.90 m and 10.90 m, respectively. When the 46 W black light lamp was used, scorpion visualization occurred at 9.8 and 7.2 m, respectively. Using the 12 LEDs flashlight, scorpions were first sighted at 6 m and 5.20 m, respectively. In the laboratory tests five adult specimens of *T. serrulatus* used in the field observations were placed on a piece of dark rubber at 80 cm from the lighting sources, those kept at 45° inclination to the plane of the substrate. A Nikon D5100 digital camera on a tripod and with the outer surface of the lens placed on the same plane and distance from the light sources was used to record images (aperture of f/5.6, 1/4 s shutter speed, ISO 100). The images obtained were not post-processed. The highest light intensity was recorded with the high power LEDs device, followed by the 12 LEDs flashlight and the 46 W black light fluorescent lamp (Figs 3-5).

The device described in this study performed comparatively better as an aid to locate scorpions in the field and in the laboratory. The difference between the results obtained with the black light lamp and the low power LEDs flashlight in the laboratory and the field may be due to the fact that the flashlight lacks a collimating lens, which results in significant scattering of light at greater distances in the field, but in the 80 cm distances used in the lab test this effect was not significant, caus-

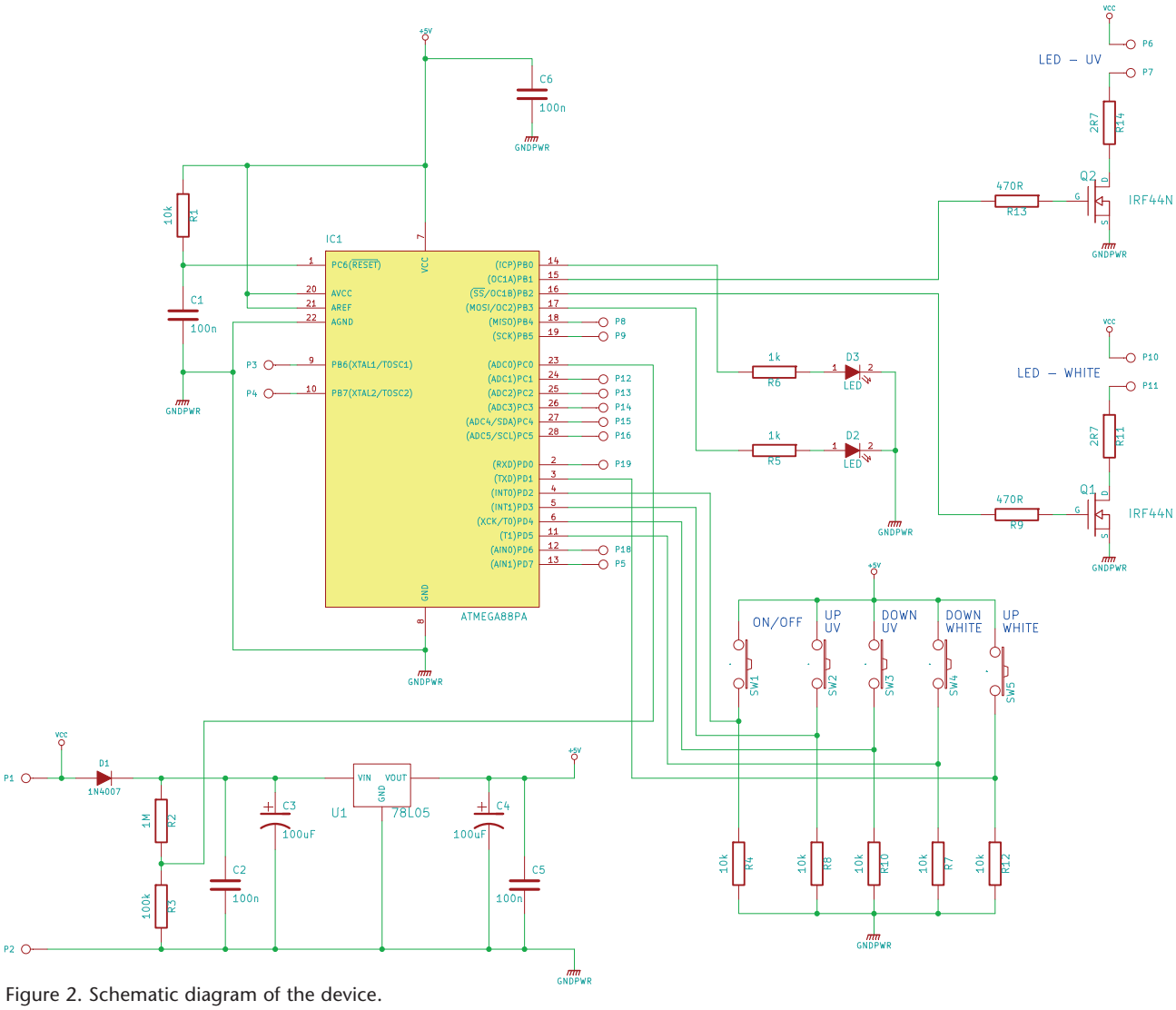
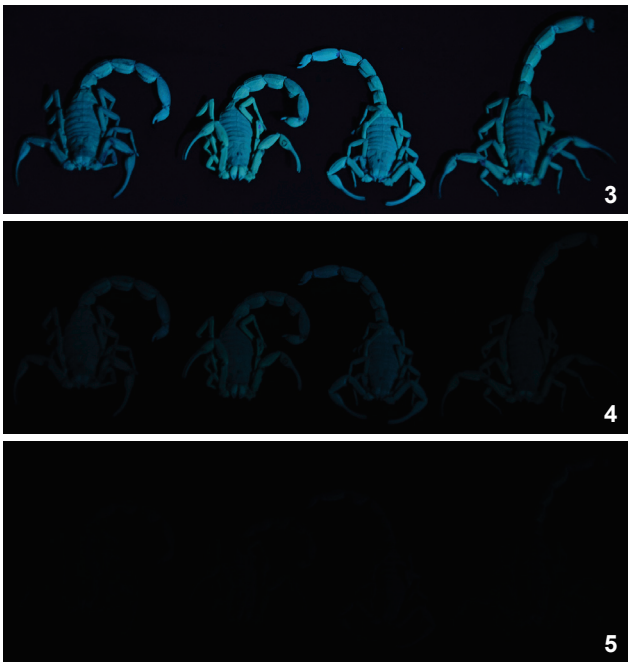


Figure 2. Schematic diagram of the device.

ing the scorpions to fluoresce more intensely compared to the 46 W black light lamp. We particularly suggest the use of our equipment by pest control teams, because it will allow them to optimize scorpion collecting. The easy use and the possibility of alternating UV light and white light in the same device facilitate its use of the field in various situations. The Brazilian Scorpions Control Manual from the Ministry of Health (Brazil 2009) does not recommend collecting scorpions during the night, and the fact that scorpions fluoresce under UV light is not mentioned in it. In this respect, this manual contrasts with most sources on scorpion capture worldwide. Despite the need to adjust the workload of employees and the allocation of public health staff teams, collecting scorpions in the evening with UV light devices is an alternative to be considered, because during this period scorpions are generally most active, and their fluorescence greatly facilitates their localization (Stanhke 1972, Lowe *et al.* 2003). As an exception, when inspecting and collecting in low light conditions such as found on gutters and pluvial water systems, which are frequently colonized by *T. serrulatus*, the day hours are appropriate. The Scorpions Control Program of Americana (SP) has successfully established routine evening capture of scorpions using 47 W black light fluorescent lamps (Brites Neto & Galassi 2012), which has the drawback of requiring an AC electricity current source and long extension cords, up to hundreds of meters. The low power LEDs flashlights, despite their convenient portability, performed worse than our device in the field. According to Lowe *et al.* (2003), many LEDs are necessary for the effective use of the former. Flashlights with up to 100 low power LEDs are commercially available. The high efficiency, low cost involved in constructing the device described



Figures 3-5. Preserved specimens of *Tityus serrulatus* photographed with a reflex digital camera, ISO 100, f/5.6, shutter speed 1/4s. Sources of illumination: (3) device described in this article; (4) 12 LEDs low power UV flashlight; (5) 46 W fluorescent black light lamp.

in this article, its versatility and the many possibilities to enhance its portability, such as the use of a transport strap or the use of longer wires separating the LEDs from the body of the device, adapting the lights on helmets, for example, are advantages of its use in collecting and observation of scorpions and other groups of animals. New high power LEDs models, of increasing power, are being released on the market and the prices will likely be significantly reduced in the near future. Our device has the potential to increase the quality (Paladini 2011) of public services to the population, as for instance in education and scorpion control and monitoring.

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