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Low cost venom extractor based on Arduino® board for electrical venom extraction from arthropods and other small animals

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ABSTRACT

Extracting venom from small species is usually challenging. We describe here an affordable and versatile electrical venom extractor based on the Arduino® Mega 2560 Board, which is designed to extract venom from arthropods and other small animals. The device includes fine tuning of stimulation time and voltage. It was used to collect venom without apparent deleterious effects, and characterized for the first time the venom of *Zoropsis spinimana*, a common spider in French Mediterranean regions.

1. Introduction

Animal venoms are a rich source of biologically active molecules, but tools to extract and properly investigate them remain inappropriate for many species, and have for instance limited the study of venoms from small animals.

Several manual or electrical venom extraction methods have been already described, which are often associated with differences regarding the quality and/or quantity of venom collected (Li et al., 2013; Oukkache et al., 2013). Electrical stimulation has emerged as the preferred method for most investigators, especially for small animals (Meadows and Russell, 1970), that leads to the development of different techniques in the last 50 years. The choice of the venom extracting method is actually guided by the animal size and how easy it is to access venom glands. For small species, it is difficult to extract venom without removing the venom gland, which could be a problem for scarce and precious animals. It is therefore important to preserve them from injury and keep them alive as far as possible. Electrical extraction methods classically involve the contraction with electrodes of specific muscles located around the venom gland (Lowe and Farrell, 2011 Garb, 2014; Nagaraj et al., 2015). It requires fine, precise and calibrated instrumentation. Among the crucial parameters are the voltage and the current used, which depend on animal size and generally correlate with its resistance. Duration and shape of the electrical pulse are also important, with electrical square waves being less deleterious for the animal.

In essence, venom extraction needs simple and affordable equipment. In this regard, microcontroller boards such as Arduino®, Raspberry pi® and other boards, have recently emerged as interesting tools to control lab equipment in biology (D'Ausilio, 2012 Kornuta et al., 2013). These boards are able to record different types of events associated with electrical (Sheinin et al., 2015), optical (Anzalone et al., 2013) or mechanical signals (Grenez et al., 2013; Schubert et al., 2013). We used here an Arduino® board to create a simple and low cost system for extracting venoms from spiders and other small animals, which includes fine tuning of stimulation time and voltage. This device was exploited to extract the venom of *Zoropsis spinimana* that was subsequently characterized by liquid chromatography coupled with mass spectrometry.

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2. Materials and methods

2.1. Arduino® mega 2560 development board

Arduino® mega 2560 development board is a printed circuit allowing the use of a microcontroller ATMEGA2560 16AU. This microcontroller controls 54 digital Input/Output pins, 15 Pulse-width modulation pins, 16 analog pins, and is able to automate any system. Using an Arduino development board is more expensive compared with other boards, but it guarantees greater stability of electronic components. It's easy to connect many sensors, screen, or other interface through the connector pins on the Arduino® board, which enables a quick prototyping of different projects. Documentation and software are open source and available at the Arduino website. The programming software is based on the C/C++ language; therefore Java programs may be used, allowing to create simple functions quickly and easily. Programs can be adapted to the evolution of the project. The power supply of this development board can be done through USB or main supply from 5 V to 12 V. Choice of the power mode is mainly based on the connected consumer device for mega card, and output voltage is stabilized at 5 V.

2.2. Variable power supply

Use of a Lab Mains Adapter is required to operate the system. The Arduino® venom extractor is able by itself to modulate the frequency of positive or negative impulses, but the current and the voltage are both driven by a BaseTech Lab Mains Adapter. This linear variable power supply can generate both controllable output voltage (0–30 VDC) and controllable output current (0–5 A).

2.3. Venom extractor assembly

A circuit diagram of the Arduino® venom extractor is shown in Fig. 1. The key component of this printed circuit is the Arduino® mega 2560 R3 prototyping board, which coordinates inputs and outputs of the device. Four push buttons are connected in "Pull down", with, for each of them, a 10 kOhm resistor (R1 to R4) to bring the contact to a low logic level. Two of them, "T1+" and "T1−", allow adjustment of the "working time", and two others, "T2+" and "T2−", are used to set the length of the "rest time". An "On/Off" switch, which is also connected in "Pull down" with a 10 kOhm resistor (R5), starts the device. Visualization of the

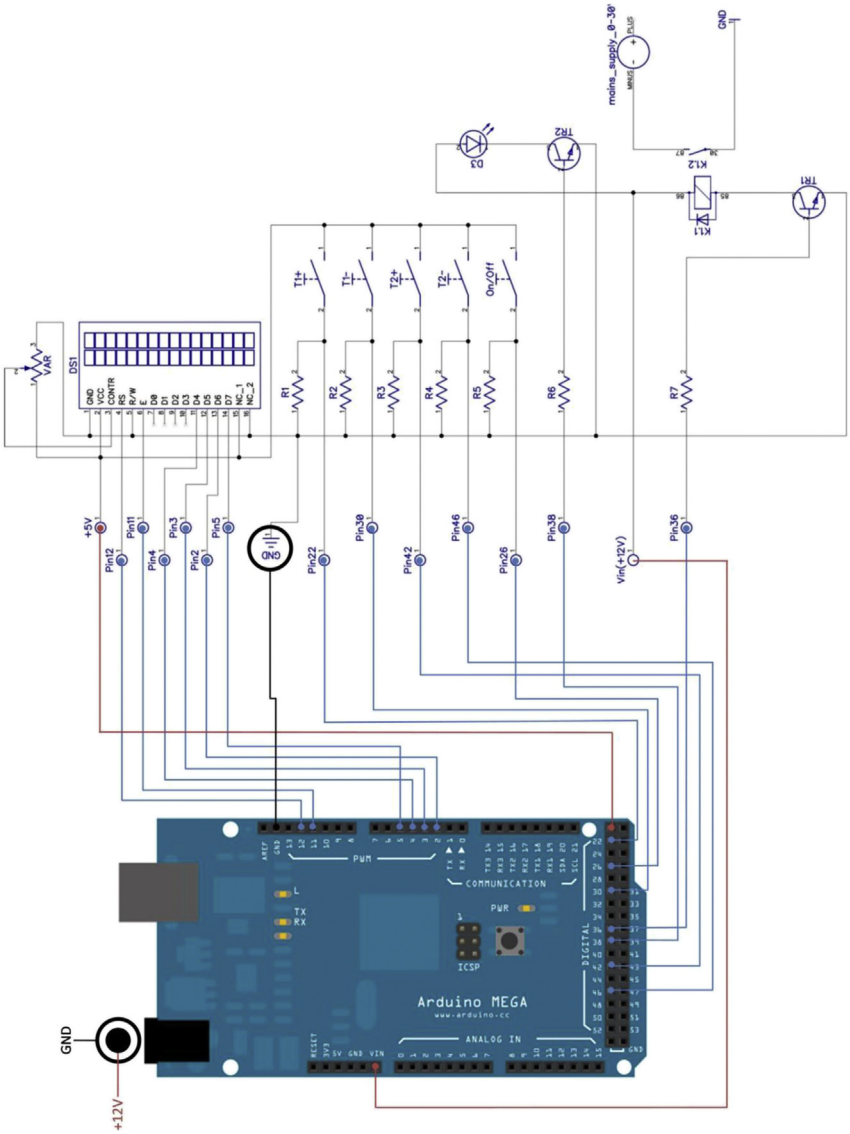

Fig. 1. Schematic electronic circuit of the venom extractor constructed from an Arduino® mega 2560 board.