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ARTICLES

Evaluation of acaricidal efficacy of *Synadenium glaucescens* (Euphorbiaceae) against *boophilus* species 278
Vitus Alberto Nyigo, Robinson Hermmerton Mdegela, Hamisi Massanja Malebo, Faith Philemon Mabiki and Gerda Fouche

*Eleutherine bulbous* (Mill.) Urb.: A review study 286
Carolyana L. L. Couto, Denise F.C. Moraes, Maria do Socorro S. Cartágenes, Flavia M. M. do Amaral and Rosane N. Guerra
Full Length Research Paper

Evaluation of acaricidal efficacy of *Synadenium glaucescens* (Euphorbiaceae) against *boophilus* species

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*Synadenium glaucescens* is a traditional medicinal plant used by some communities in Tanzania for the management of various diseases in animals and human including the use for control of ticks in cattle. The aim of this study was to investigate the ‘acaricidal effect’ of extracts from this plant on *Boophilus decoloratus* and *B. microplus*. The methodology involved the use of larval and adult immersion tests. Results indicated low larvicidal (corrected mortality 37.5%) and adulticidal (corrected mortality 33.33%, LC⁵₀ 666.91) activities respectively for methanol and ethanol extracts from leaves. Other extracts of this plant showed a non-significant activity of mortality. Thus, it is not recommended for field trials, rather additional research is needed to determine its potentials especially using fresh plant material

**Key words:** *Synadenium glaucescens*, Acaricidal activity, ticks, Tanzania.

INTRODUCTION

Records indicated that the number of people relying on agriculture has gone down as from 2001 to 2010, yet still it is the only sector that provides a livelihood for the majority of the communities than any other industry in the world (Upton, 2004; World Bank, 2008; Cervantes-Godoy and Dewbre, 2010). In the agricultural sector, livestock keeping is one among important activities that is practiced by many poor communities in developing world (Randolph et al., 2007). In 2004, Upton reported that livestock keeping provided over half of the value of global agricultural output and one-third being in developing countries. Literature indicates that the number of animals is further experiencing a remarkable increase especially in developing world (Randolph et al., 2007; Thornton, 2010). Despite this amazing increase, livestock keeping is constrained by diseases transmitted by ectoparasites

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(Njoroge et al., 2006). The harmful effects of ectoparasites on the productivity of livestock are well documented (Bagavan et al., 2009, Gazim et al., 2011). Ticks and tick-borne diseases are important causes of losses to the livestock industry, in particular, the production of cattle and small ruminants in tropical and subtropical areas. The diseases are associated with a reduction in productivity, fertility and in some instances may result in the death of an animal (Bagavan et al., 2009; Gazim et al., 2011). A worldwide loss due to diseases transmitted by ticks and the costs of tick control is very high (Minjauw and McLeod, 2003). The economic importance of ticks is principally due to the ability to transmit a wide spectrum of pathogenic microorganisms, such as protozoa, rickettsiae, spirochaetes, and viruses.

In Africa, tick-borne protozoan diseases (e.g. theileriosis and babesiosis) and rickettsial diseases e.g. anaplasmosis and heartwater (cowdriosis) are the main health and management problems of domestic ruminants. Tick-borne diseases that are reported to affect livestock productivity in the East African Region include East Coast Fever, anaplasmosis, babesiosis and cowdriosis (McCosker et al., 1993; Kagaruki et al., 1996). In Tanzania, tick-borne diseases contribute to over 72% of the annual cattle mortality (Mtei and Msami, 1996; Kivaria, 2007). Ticks from the genus Boophilus are important due to their ability to transmit pathogens in cattle such as Anaplasma marginale, Babesia bigemina, Brucella ovis, Babesia trautmanni and Borrelia theileri.

Control of ticks aims at either eradication or prevention and has for a long time depended much on chemical control mainly synthetic chemicals. Main methods of applications include regular dipping of animals and sprays. Despite these novel efforts of control means, ticks control experiences many challenges, which include a rampant development of resistance against common control chemicals such as synthetic pyrethroids, organophosphates, and amitraz. The building and maintenance of dipping tanks or sprays and the purchasing of acaricides for tick control and therapeutic agents hike farmer’s production costs.

This situation is pressing for concerted efforts to search for novel effective and eco-friendly anti-tick natural products. Natural sources especially plants are believed to be arsenals of such control agents and due to their versatile application; they are currently the main target. A study from Korea for example with a detailed analysis of ethnovegetarian plants revealed 143 medicinal plants in use for treatment of cattle diseases (Song and Kim, 2010). While some laboratory tests results report moderate toxic effects of herbal plants on adult ticks and larvae (Bagavan et al., 2009). Some plants reveal significant activity against economically important tick species including species resistant to acaricides (Borges et al., 2003; Sunil et al., 2013; Ghosh et al., 2013; Nawaz et al., 2015).

This study was therefore conceived to assess the activity of crude plant extracts from S. glaucescens against cattle ticks of the genus Boophilus. This plant has been reported to possess various pharmacological and insecticidal activities especially on its use as anti-ticks and in the post-harvest grain storage by local communities. However, there are no scientific reports regarding its acaricidal potentials against ticks. Nonetheless, other species of this genus have indicated good pesticidal activities against various ectoparasites (Bagavan et al., 2009; Hassan et al., 2012), thus building a base for investigating this plant species.

**MATERIALS AND METHODS**

**Plant materials**

Plant materials (leaves and root barks) of *S. glaucescens* Pax were harvested from Mufindi District in Tanzania during May and August 2012. The World Health Organization (WHO, 2003) guideline on Good Agricultural and Collection Practices (GACP) for medicinal plants was used. Thus, roots were dried at room temperature while some minor modifications were considered for leaves in which drying was effected in place with half day shade and half day sun because leaves of this plant contain a large amount of latex (Nyigo et al., 2015). The dried plant materials were pulverized and then subjected to extraction using solvents with different polarities sequentially in ascending order starting with hexane, dichloromethane, ethyl acetate, methanol and ultimately water. After filtration, the extracts were dried in vacuum and in a freeze dryer to obtain different organic and water extracts, respectively (Table 1).

**Ticks collection for adulticidal testing**

Tests of plant extracts against adult ticks were conducted at the Faculty of Veterinary Medicine, Department of Veterinary Medicines and Public Health of the Sokoine University of Agriculture (SUA). Engorged adult ticks (*Boophilus decoloratus*) were collected from naturally infested cattle pastured on local freelance grazing from different areas of Morogoro and Coast regions in Tanzania. During collection, the researchers first enquired information on the application of acaricides to ensure that none has been applied 45 days before tick collection (Rosado-Aguilar et al., 2010, Gazim et al., 2011). Ticks were then washed with water and dried with a paper towel and were subjected into different groups for testing and control.

**Adult ticks for larva production**

Test of extracts against larvae was conducted at the University of Free State, South Africa. Fully engorged female ticks *B. microplus* and *B. decoloratus* were received from Clinvet International on 7 July, 2014. They were washed with tap water, dried and distributed into 5 conical flasks containing 20 females each. The flasks were incubated at 26 ±2°C at a Relative Humidity of >70% for oviposition and hatching, and the hatch date was determined to be the 26th of August 2014. Testing was performed between 17 and 25 days post hatching.

**Sample preparation**

Required weights of extract were prepared and dissolved using appropriate solvents. For organic extracts, the decision of solvent to
use was reached after trials between DMSO and Tween 80. Since the solubility of extracts in DMSO was very low (Figure 1a), Tween 80 was chosen to be the dissolution solvent for organic extracts due its relatively better solubility (Figure 1b). Aqueous extracts were dissolved in distilled water while organic extracts were dissolved in 2% tween in distilled water. With aqueous extracts, the required amount of distilled water was measured and directly poured in the sample while for organic extract samples, the process involved first dissolving an extract in a known amount of tween 80 and diluted with distilled water to make the required volume of a solvent and in both cases, dilutions were assisted by warming in a water bath. The controls composed of two solvents; 2% tween 80 in distilled water for organic extracts and 100% distilled water for aqueous extracts.

Larval immersion test (LIT)

Larvae obtained from the engorged female ticks of B. microplus, and B. decoloratus were rested unfed for 16 to 25 days after hatchability (Gazim et al., 2011). Approximately 200 larvae were placed between two round Whatman no 1 filter papers (diameter 120 mm) to form a larvae sandwich, placed in a pie plate. Ten milliliters of 1% solution from plant extracts was then poured over the larvae sandwich to expose them to the solution. Each run also included a positive control (300 ppm -Field concentration of Chlorfenenvphos- Supadip 30% m/v) and a negative control (diluent). After 30 min, excess solution was drained from the filter paper sandwich, then approximately 100 larvae were transferred to a clean filter paper (Whatman no 1, diameter 250 mm) envelope which was crimped closed as well as taped with masking tape over the crimped area to ensure that larvae cannot escape. The envelopes were then placed in an incubator at a temperature of 26 ± 2°C and RH ≥70% for 72 h. After 72 h each envelope was opened and turned over to allow dead larvae to fall onto a clean filter paper circle (Whatman no 1, diameter 250 mm). Live larvae still clinging to the filter paper envelope were counted by squashing each larva counted onto the filter paper envelope. Then the filter paper containing dead larvae was inspected for any possible live larvae, which were also counted as live and picked up with a masking tape strip. The remaining larvae were then considered dead. Both counts were documented on a datasheet and transferred to a spreadsheet. Efficacy of extract to kill the larvae was determined against a negative control (diluent) by calculating corrected mortality Abbott’s formula (Abbott, 1925).

**Adulcticidal tests through adult immersion test**

The adult immersion tests (AIT) as described by Drummond et al. (1976) and Holdsworth et al. (2006) was adopted with some modification for acaricidal activity tests of crude extracts of plant materials from S. glaucescens against B. decoloratus adult ticks. Ticks were grouped into four groups each with 12 engorged female ticks, three treated with different concentrations (triplicates) and one negative control. Both treatment and control groups were place in perforated cloth specially made to be able to hold the ticks while allowing them to be in contact with solvents (Figure 2). The ticks were then immersed for five minutes in 20 ml of the diluted crude extract with tween 80 and the control group immersed in tween with distilled water (Rosado-Aguilar et al., 2010) and distilled water alone. The ticks were then transferred into Petri dishes and observed for mortality for a maximum of three days at the condition of temperature and humidity described previously. The criteria used to diagnose dead ticks included the lack of movement of legs and change of cuticle color (Pirali-Kheirabadi and Teixeira da Silva, 2011). Efficacy of extract to kill the adult ticks was determined against negative controls, that is, distilled water for aqueous extracts and 2% tween 80 in distilled water for organic extracts by calculating Corrected mortalities

**Definition of test scores for crude extracts**

Definition of test scores was adopted from those reported by Rosado-Aguilar et al. (2010) as follows. Activity of crude plant extracts were classified in mean % of mortality of adult ticks and larvae at 24, 48 and 72 h as; high mortality (86-100%); relatively high mortality (71-85%); moderate mortality (56-70%); low mortality 31-55%; and non-significant activity of mortality (0-30%) (Rosado-Aguilar et al., 2010).

**Statistical analysis**

All data were recorded in an excel sheet and used it to perform descriptive statistics such as arithmetic means of triplicate tests and percentage mortalities of adult ticks and larvae in test and control groups. Efficacy of extract to kill the adult ticks and larvae for all extracts concentrations was calculated using Abbott’s formula (Abbott, 1925).

**Table 1. Types of extracts of S. glaucescens and their codes.**

<table>
<thead>
<tr>
<th>Codes</th>
<th>Plant part</th>
<th>Extract type</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDCM</td>
<td>Root</td>
<td>Dichloromethane (DCM) extract of root prepared by extracting plant with DCM, after the plant materials extracted by Hexane</td>
</tr>
<tr>
<td>Rwater</td>
<td>Root</td>
<td>Water extract of the root after sequential extraction with Hexane, DCM, EtOAc, MeOH; and plant residue extracted with water (H₂O)</td>
</tr>
<tr>
<td>LDCM</td>
<td>Leaves</td>
<td>DCM extract of the leaves prepared by extracting plant with DCM, after the plant materials having been extracted by Hexane</td>
</tr>
<tr>
<td>LMeOH</td>
<td>Leaves</td>
<td>MeOH extract of leaves prepared after sequential extraction with DCM, EtOAc, and plant residue extracted with MeOH</td>
</tr>
<tr>
<td>Lwater</td>
<td>Leaves</td>
<td>Water extract of the leaves after sequentially extracted with hexane, DCM, ethyl acetate and MeOH</td>
</tr>
<tr>
<td>LETOH</td>
<td>Leaf</td>
<td>Ethanol Extract; fresh ground dried leaves extracted with ethanol</td>
</tr>
<tr>
<td>RETOH</td>
<td>Root</td>
<td>Ethanol Extract; fresh ground root barks extracted with ethanol</td>
</tr>
</tbody>
</table>

**Definition of test scores for crude extracts**

Definition of test scores was adopted from those reported by Rosado-Aguilar et al. (2010) as follows. Activity of crude plant extracts were classified in mean % of mortality of adult ticks and larvae at 24, 48 and 72 h as; high mortality (86-100%); relatively high mortality (71-85%); moderate mortality (56-70%); low mortality 31-55%; and non-significant activity of mortality (0-30%) (Rosado-Aguilar et al., 2010).

**Statistical analysis**

All data were recorded in an excel sheet and used it to perform descriptive statistics such as arithmetic means of triplicate tests and percentage mortalities of adult ticks and larvae in test and control groups. Efficacy of extract to kill the adult ticks and larvae for all extracts concentrations was calculated using Abbott’s formula (Abbott, 1925).
Table 2. Corrected Mortalities (%) of ticks from Root extracts of S. glaucescens.

<table>
<thead>
<tr>
<th>Extract type</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>100</th>
<th>200</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>REtoH</td>
<td>2.86</td>
<td>8.57</td>
<td>9.57</td>
<td>3.06</td>
<td>8.57</td>
<td>12.11</td>
<td>9.57</td>
<td>13.3</td>
<td>16.56</td>
</tr>
<tr>
<td>RDCM</td>
<td>5.56</td>
<td>5.56</td>
<td>8.57</td>
<td>5.56</td>
<td>8.57</td>
<td>12.11</td>
<td>8.57</td>
<td>9.97</td>
<td>16.56</td>
</tr>
<tr>
<td>Rwate</td>
<td>2.78</td>
<td>5.56</td>
<td>5.56</td>
<td>2.78</td>
<td>2.78</td>
<td>5.56</td>
<td>2.78</td>
<td>5.56</td>
<td>5.56</td>
</tr>
<tr>
<td>LEtoH</td>
<td>9.16</td>
<td>9.16</td>
<td>16.7</td>
<td>16.7</td>
<td>16.67</td>
<td>25</td>
<td>25</td>
<td>33.3</td>
<td>33.33</td>
</tr>
<tr>
<td>LDCM</td>
<td>0</td>
<td>0</td>
<td>8.33</td>
<td>8.33</td>
<td>16.67</td>
<td>18.21</td>
<td>16.67</td>
<td>18.2</td>
<td>18.21</td>
</tr>
<tr>
<td>Lwater</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9.05</td>
<td>9.05</td>
<td>16.67</td>
<td></td>
</tr>
</tbody>
</table>

(Mortality in test bottles [%] - Mortality in control bottle [%]) 
Corrected mortality = \( \frac{100\% - \text{mortality in control bottle} \%}{100\%} \times 100 \)

The corrected mortality results of adult ticks were then used to calculate lethal concentrations LC\(_{50}\) and LC\(_{90}\) for each extract using a graph pad Software version 5.0.

RESULTS

Adulcicidal tests

Table 2 shows corrected percentage mortalities of adult ticks against different dried extracts of root barks and leaves of S. glaucescens. The minimum and highest mortalities in the last day of observation were 2.78 and 33.33%, respectively. These activities are regarded low especially when the highest mortality recorded below 50%, which appeared on the third day of the observation. However, among the extracts, the ethanol extracts from leaves was the most active (33.33%) while water extracts showed the least activity (2.78%).

Figure 3 shows the trend of mortality from day one to the third day of observation. It is evident that despite the low activity of extracts yet the tendency showed that the percentage mortality slightly increased with number of days and with increase in concentrations.

Table 3 shows the lethal concentrations LC\(_{50}\) and LC\(_{90}\) of the different extracts. The high values are an indication of less effectiveness of the extracts. After 72 h, the LC\(_{50}\) of almost all of extracts are in terms of thousands except for LEtoH (666.91). This further indicates that the activities of the extracts were low including the most active amongst them.

Larvicidal activities

The larvicidal activity was tested only using two extracts. Table 4 shows the larvicidal activity of methanol and water extracts from the leaves of S. glaucescens. Similar results are observed in the larvicidal test as indicated in the adultcicidal tests. Despite their higher susceptibility than adults (Williams et al., 2015), yet the activity of the extract against larvae was low with the highest and least mortality being 37.5 and 3.2% respectively (Table 4) with B. decololoratus larvae exhibiting higher resistance as compared to B. microplus.

DISCUSSION

Synadenium glaucescens is known for many traditional uses including use as pesticides agent in post harvests storage. Apart from traditional utilization, no any systematic study on acaricidal activity of the crude extracts from this plant had previously been reported. The existing reports are on pesticidal activities of other species in the genus (Afonso-Cardoso et al., 2011, Hassan et al., 2012). Thus, the evaluation of this plant on its effect in ticks is being reported for the first time and was based on these traditional values of the plant species and the existing pesticidal information in the genus. The study doses in this study are high and appear different from many studies that have been done on an acaricidal activity of various plant extracts (Bagavan et al., 2009; Rosado-Aguilar et al., 2010).

This is because during trials for an establishment of concentrations, the lower doses (25 and 50 mg/ml) could not perform well thus, necessitating trials of higher concentrations. Despite high test concentrations, yet extracts showed to exhibit very low activities on the adult ticks at 24, 48 and 72 h (Table 2). This is also indicated by high values of lethal concentrations (Table 3), which imply that the extracts exhibits low acaricidal effects. Therefore, most of the extracts have been grouped to bear non-significant activities while only one extract (LEtoH) exhibit low activity on adult ticks. Though only two extracts were tested for larvae efficacy, similar results have been observed where one extract exhibited low activity and the other exhibiting non-significant activity. This low activity against larvae further justifies the low effectiveness of the extracts as acaricide because larvae have relatively high susceptibility as compared to...
Table 3. Lethal concentrations of Adult ticks after immersion in Root extract of *S. glaucescens*.

<table>
<thead>
<tr>
<th>Extract type</th>
<th>LC$_{50}$ 24 h</th>
<th>LC$_{90}$ 24 h</th>
<th>LC$_{50}$ 48 h</th>
<th>LC$_{90}$ 48 h</th>
<th>LC$_{50}$ 72 h</th>
<th>LC$_{90}$ 72 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>REtoH</td>
<td>1481.67</td>
<td>2673.92</td>
<td>1130.09</td>
<td>2014.07</td>
<td>1264.26</td>
<td>2418.66</td>
</tr>
<tr>
<td>RDCM</td>
<td>3086.16</td>
<td>5741.96</td>
<td>1459.64</td>
<td>2681.02</td>
<td>1158.7</td>
<td>2159.95</td>
</tr>
<tr>
<td>Rwater</td>
<td>3463.79</td>
<td>6141.49</td>
<td>3530.46</td>
<td>6408.15</td>
<td>3463.79</td>
<td>6341.49</td>
</tr>
<tr>
<td>LEtoH</td>
<td>1220.95</td>
<td>2286.2</td>
<td>933.57</td>
<td>1893.93</td>
<td>666.91</td>
<td>1627.29</td>
</tr>
<tr>
<td>LDCM</td>
<td>-</td>
<td>-</td>
<td>920.58</td>
<td>1730.3</td>
<td>4395.24</td>
<td>9590.04</td>
</tr>
<tr>
<td>Lwater</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1208.14</td>
<td>2258.01</td>
</tr>
</tbody>
</table>

Table 4. Corrected percentage mortalities of larvae against leaf extracts of methanol and water.

<table>
<thead>
<tr>
<th>Extract type</th>
<th>Conc (%)</th>
<th>Total Alive</th>
<th>Dead</th>
<th>Total Alive</th>
<th>Dead</th>
<th>Mortality CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larva species: <em>B. microplus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMeOH</td>
<td>1</td>
<td>139</td>
<td>76</td>
<td>63</td>
<td>127</td>
<td>47.4</td>
</tr>
<tr>
<td>LWater</td>
<td>1</td>
<td>137</td>
<td>104</td>
<td>33</td>
<td>127</td>
<td>87</td>
</tr>
</tbody>
</table>

| Larva species: *B. decoloratus* |
| LMeOH        | 1        | 54          | 41   | 13          | 95   | 14.8          | 5.1            |
| LWater       | 1        | 104         | 92   | 12          | 119  | 17            | 13             | 3.2            |

Conc = Concentration; CM = Corrected mortality.

Figure 1. Extract dissolves in DMSO (a) and Tween 80 (b).
adult ticks (Williams et al., 2015). These results are quite different from researchers’ expectations and the claimed traditional efficacy on post-harvest storage protections. The reason for this difference is not well understood. However, it could probably be associated with conditions at which the test materials were used. In the traditional utilization, it is common that people use the fresh plant materials, but in this case, plant materials were dried for the purpose of standardization. Some changes may have happened on the constituents during processing that resulted from operational conditions such as temperature and pH (Durairaj et al., 2009). Since the current results were observed within 72 h, the duration of observation could also have affected the results especially if the
product has a slow onset of acaricidal actions (Holdsworth et al., 2006). Maybe longer time observations, which have also been the case for some studies could have a different result from the current observation (Holdsworth et al., 2006; Righi et al., 2013). None of the tested extracts could kill even 50% of the test subjects despite the high dosages used. Thus, none of the plant extracts is considered effective against tested ticks species. We, therefore, suggest further research on the plant by using fresh plant materials especially leaves as the fresh leaf latex has also shown to have activities on pest (Afonso-Cardoso et al., 2011).

Conclusion

Since the activity of extracts in adults and larvae were less than 50%, the extracts are concluded to exhibit low to non-significant activity against ticks under the conditions of the test described. Thus, it is not recommended for field trials, rather additional research is needed to determine its potential using fresh plant material especially those with latex.

Conflict of Interests

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors acknowledge the following; Carnegie Regional Initiative in Science and Education (RISE) and African Natural Products Training Network (CR-AFNNET) for funding the study. They also acknowledge the laboratory technologists at the Faculty of Science, Sokoine University of Agriculture (SUA) for assisting in the extraction of plant materials and Mtulinga village community for their assistance in harvesting the plant materials. Authors also acknowledge Adriano Kindamba for identification of tick species, Daudi Mwangoka for assisting in the collection of ticks from the fields and Dr. Shaban Mshamu, for assisting in the identification and counting of dead ticks.


**Eleutherine bulbous** (Mill.) Urb.: A review study

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**Eleutherine bulbous** (Mill.) Urb., Iridaceae, is a native plant and quite common in several regions of America, commonly known as “coquinho” being widely used in the folk medicine for the treatment of giardiasis, amoebiasis and diarrhea. This paper presents a literature review of studies about **Eleutherine bulbous** including aspects of taxonomy, synonymies, geographical distribution, ethnopharmacology, chemistry and pharmacology studies from several databases (Biological Abstracts, Chemical Abstracts, Medline, Lilacs, Web of Science, Science Direct, PubMed, Food and Drugs Administration) and data bank of patents. The research was also carried on some thesis, dissertations, books and also in some whole articles covering the period from 1950 to 2015, using as key works **Eleutherine**, **Eleutherine bulbous** and its botanical synonymies. The studies indicated several works in the field of ethnopharmacology, prevailing employment in gastrointestinal disorders, especially diarrhea and giardiasis, proving the potential of the species for investments in research and development of new therapies.

**Key words:** Eleutherine bulbous (Mill.) Urb., coquinho, review, diarrhea, giardiasis.

**INTRODUCTION**

Natural products with therapeutic properties are important sources of new biologically active compounds and have been used in many parts of the world for decades, attracting the interest of many researchers (Araújo, 2011). Numerous studies show that some natural products are the main source of chemical diversity while new discoveries in the pharmaceutical field are emerging (Mishra and Tiwari, 2011). The plant selection to

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pharmacological study is a very important step. The choice can be done by one of several ways, such as the traditional, by the chemical components, random selection or combination of more than one criterion (Albuquerque and Hanazaki, 2006). The evaluation of isolated substances, fractions or extracts obtained from the vegetable drug can occur through the characterization of their biological activity, research of the mechanisms assigned to constituents and parts of the plant, determination of their active concentration and their toxic potential (Toledo et al., 2003).

For any approach chosen, the search of new plant-derived active products must be begun with a bibliographical and documentary research (Camargo, 2003). Data obtained from literature reviews, making a list of the plant species, extracts, semi-purified fractions and chemically defined molecules with biological activity as research target, have provided important subsidies, which contribute effectively to the definition of criteria inclusion and or exclusion of plant species selected for development of the validation studies (Barbosa-Filho et al., 2006; Amaral et al., 2006).

The contribution of the review works has been found not only by the increase in publications on this subject, but also by increasing its citations in national and international journals. Thus, various approaches for selection of plant species have been presented, among which are the three most investigated: (a) Random approach, where the choice is done based on the availability of the plant; (b) Chemotaxonomic or phylogenetic approach, in which the selection is done by the interest in a given class of substances in a genus or family; (c) Ethnopharmacological approach, in which the plant is selected according to the therapeutic use evidenced by a particular ethnic group (Albuquerque and Hanazaki, 2006). In these segments, these studies contribute effectively in the selection of vegetable material to be investigated, at the collection place, experimental delineating and analysis of results among others.

*Eleutherine bulbous* (Mill.) Urb. an important medicinal plant belonging to Iridaceae family and distributed in Amazon region. This plant species has been included in the list of medicinal plants of interest in National Health System at Brazil (RENISUS) (Brazil, 2009). This work presents a literature review of studies showing the potential of *E. bulbous* to advance the stages of the production chain and to include it in herbal medicine to generate the products of interest for better healthcare.

**MATERIALS AND METHODS**

Surveys were done to collect information in database (Biological Abstracts, Chemical Abstracts, Medline, Lilacs, Web of Science, Science Direct, PubMed, Food and Drugs Administration) and bases of patents, employing also research to theses, dissertations and books; covering a period from 1950 to 2015; using as descriptors, Iridaceae *E. bulbous* and its botanical synonyms. The references obtained were consulted for details of the studies on the botany, ethnopharmacology, plant geography, chemistry, biology and pharmacology area.

**RESULTS AND DISCUSSION**

In the analysis of the works that make up this review has been shown that, in several studies, the authors employ various scientific names to designate the *E. bulbous* species (Mill.) Urb., mainly *Eleutherine american* (Aubl.) Merr. ex K. Heyne and *Eleutherine plicata* Herb. ex Klett. The first is considered in Plant List (2015) of the Royal Botanical Garden (Kew) and the second is cited as a synonym in the two bases of the main botanical institutes (Plant List, 2015: Tropic, 2015). Thus, to keep the nomenclatures adopted by the authors in this study we chose to use the scientific names originally employed in the work referred in this review, presented in the sections and tables that make up this study. Thus, the initial citation of the accepted nomenclature was standardized, that is, bulbous Eleutherine, and in the sequence jobs with the two most commonly used synonyms.

**Taxonomic**

*E. bulbous* has the following taxonomic according to Angiosperm Phylogeny Group III system (2009) (Tropics, 2015).

Kingdom: Plantae  
Class: Equisetopsida  
Subclass: Magnoliidae  
Suborder: lilianae  
Order: Asparagales  
Family: Iridaceae  
Genus: *Eleutherine*  
Species: *Eleutherine bulbous*

**Scientific and vernacular synonyms**

*E. bulbous* (Mill.) Urb has as botanical synonyms: *Bermudiana bulbous* (Mill.) Molina; *Bermudiana congesta* (Klett) Kurtze; *Cipura plicata* (Sw.) Griseb.; *Eleutherine american* (Aubl.) Merr. ex K. Heyne; *Eleutherine anomala* Herb.; *Eleutherine longifolia* Gagnep.; *Eleutherine plicata* (Sw.) Herb.; *Eleutherine plicata* Herb. ex Klett; *Eleutherine subaphylla* Gagnep.; *Ferraria parviflora* Salisb.; *Galatea american* (Aubl.) Kurtze; *Galatea bulbosa* (Mill.) Britton; *Galatea plicata* (Sw.) Baker; *Ixia american* Aubl.; *Sisyrinchium altissimum* Ten.; *Sisyrinchium americanum* (Aubl.) Lemée; *Sisyrinchium bulbosum* Mill.; *Sisyrinchium capitatum* Pers.; *Sisyrinchium congestum* Klett; *Sisyrinchium elatum* Seub. ex Klett; *Sisyrinchium intihuanense* (Vargas) Ravenna; *Sisyrinchium latifolium* Sw.; *Sisyrinchium palmifolium* var. *Intihuatanense* Vargas;
*Sisyrinchium plicatum* (Sw.) Spreng.; *Sisyrinchium racemosum* Pers. (Kew, 2015).

E. *bulbosus* is the currently accepted scientific name for this species, according to databases of Kew (Plant List, 2015) and the Missouri Botanic Garden (Tropicos, 2015). The vernacular names are marupari, marupazinho (Schultes and Raffauf, 1990; Project..., 2015), marupapiranga (Schultes and Raffauf, 1990), coquinho, lily-leaf-of-palm, marupá, marupaí-piranga, Palmeirinha (Project ..., 2015) and Rhubarb-of-field (Brasilheiro et al.; 2006). In other countries it is known as Jasin huaste, pacahuasten, Pacha huaste, pacahuasten, piri-piri, yagua Piripiri, Yahuar piri piri and WA-ro (Project ..., 2015).

For synonym *Eleutherine plicata*, have been assigned the following vernacular names: marupazinho (Baraúna and Rock, 2006; Oliveira Neto et al., 2007; Lorenzi and Matos, 2008; Menezes et al., 2009; Nascimento et al., 2012), coquinho (Souza et al., 2005; Oliveira Neto et al., 2007), marupari (Oliveira Neto et al., 2007; Nascimento et al., 2012), marupá-piranga, Palmeirinha, Marupa-ú and nambu marrow (Oliveira Neto et al., 2007).

Geographical distribution

The *E. bulbous* species is native of Americas, frequent in this area (Saralamp et al., 1996; Afanas'ev et al., 1999; Johnson, 1999; Lorenzi and Matos, 2002; Paramapojojn et al., 2008; Nascimento et al., 2012). In Brazil, it occurs in the Amazon region, mainly in the state of Roraima (Revilla, 2001; 2002a).

For the *E. american* synonym, the studies indicate your origin in the tropical America, being found in plantations around the world mainly in South Africa, China, Indonesia and Thailandia (Chen et al., 1986; Hara et al., 1997).

Already by the synonymy *E. plicata* several studies indicate this species as widely found in the Amazon region (Baraúna and Rock, 2006; Oliveira Neto et al., 2007; Lorenzi and Matos, 2008).

Morphological description

The species of Eleutherine genus are herbaceous, perennial, rhizomatous and bulbous, predominantly red bulbs or wine color with scales similar to the onion, medium with 20 to 30 cm (Revilla, 2001; Lorenzi and Matos, 2002; Revilla, 2002b; Baraúna and Rocha, 2006).

Goldblatt and Le Thomas (1992) showed that the Eleutherine genus has monosulcado pollen grain with heterogeneous exine in different parts of the grain, almost perforated proximal surfaces.

Jobs reported that *E. bulbous* presents features simple leaves, whole, along pleated, with 25 cm average length; the flowers are white or pink, arranged in a large panicle at the apex of a long hard scape above the foliage, with 5 to 6 petals soldered on the base (Revilla, 2001, 2002b; Lorenzi and Matos, 2002).

Studies developed by Lorenzi and Matos (2002) and Baraúna and Rocha (2006) with *E. plicata* also identified the presence of whole leaves, pleated, simple, verticillate, linear-lanceolate, with longitudinal ribs; the inflorescence is in panicles of white flowers or roses, at the height of an escapement.

Kuntorini and Nugroho (2010) described the changes of the anatomical characteristics that occur in the leaves and the bulb of the *E. american* species during the plant growth cycle, showing that the specie leaf has homogenous mesophyll suffering change in thickness during growth of the plant. Prismatic crystals of calcium oxalate were observed in the mesophyll of this leaf.

There is the presence of stomata on both sides of the leaf epidermis, with difference in number according to the development stage, however, on the average, the lower surface has a higher concentration of these. The thickness of the lower and upper epidermis layers also varied in the growth stage of the plant, and in general, the upper epidermis consists of smaller cells than the cells of the upper face. On the bulb, an increase in diameter and length with the growth of the plant was demonstrated. Anatomically, the bulb has difference in the size and number of parenchymal cells in which was observed the presence of calcium oxalate crystals of different shapes, with predominance of styloid. In the bulb was also verified increase in the vascular bundles structures.

These authors also evaluated the concentration of naphthoquinones during the growth sategs of the plant. In the bulb, there was an increase in the amount of this active ingredient, with the growth of the parenchyma; however the leaves, the concentration of naphthoquinones remained constant evaluated in phases, despite the increase in thickness of the mesophyll (Kuntorini and Nugroho, 2010).

Use of the specie

Some studies have shown the predominance of the popular employment of leaves and *E. bulbous* bulbs for medical purposes, for gastrointestinal disorders (Table 1); being also employee as contraceptives, equimóticos healing by healers of Peru and abortive by the population of Haiti (Project ..., 2015; Weninger et al., 1982) and in indigenous communities of Guyana (Lorenzi and Matos, 2002) and Brazil (Ribeiro, 2008). Kainer and Duryea (1992) refer to representation of *E. bulbous* in extractive activities of women reservation communities in the state of Acre, Northern Brazil.

Study developed by Nascimento et al. (2012) refers potential *E. plicata* as therapeutic option in primary health care in the Amazon region.

Employment in Asian cuisine (Zhengxiong et al., 1984), in the treatment of cellulite (Revilla, 2002b) and as an
Table 1. Indications of popular therapeutic use of *E. bulbous* (Mill.) Urb. and its botanical synonyms.

<table>
<thead>
<tr>
<th>Nomenclature of plant species</th>
<th>Use indication</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Eleutherine american</em> (Aubl.) Merr. ex K.Heyne *</td>
<td>Stroke</td>
<td>Ieyama et al., 2011</td>
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<tr>
<td></td>
<td>Anti-inflammatory</td>
<td>Saptowalyono, 2007</td>
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<td></td>
<td>Anti-platelet</td>
<td>Saptowalyono, 2007</td>
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<td></td>
<td>Anti-Tumor</td>
<td>Saptowalyono, 2007</td>
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<td></td>
<td>Increase the production of milk</td>
<td>Ieyama et al., 2011</td>
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<td></td>
<td>Breast cancer</td>
<td>Saptowalyono, 2007</td>
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<td></td>
<td>Nasal congestion</td>
<td>Saralamp et al., 1996</td>
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<td></td>
<td>Sexual disorders</td>
<td>Ieyama et al., 2011</td>
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<td></td>
<td>Diuretic</td>
<td>Afanas'ev et al., 1999; Johnson, 1999</td>
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<td></td>
<td>Heart disease</td>
<td>Afanas'ev et al., 1999; Saptowalyono, 2007</td>
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<td></td>
<td>Cold diseases **</td>
<td>Saralamp et al., 1996</td>
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<td></td>
<td>Hypertension</td>
<td>Ieyama et al., 2011</td>
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<td></td>
<td>Laxative</td>
<td>Afanas'ev et al., 1999</td>
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<td></td>
<td>Hypoglycemic</td>
<td>Ieyama et al., 2011</td>
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<td></td>
<td>Intestinal disorders</td>
<td>Duke and Vasquez, 1994; Revilla, 2001</td>
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<td></td>
<td>Amebiasis</td>
<td>Duke and Vasquez, 1994; Project..., 2015</td>
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<td></td>
<td>Amenorrhea and menopause</td>
<td>Duke and Vasquez, 1994</td>
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<td></td>
<td>Anti carcinogenic</td>
<td>Brasileiro et al., 2006</td>
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<tr>
<td></td>
<td>Antiparasitic</td>
<td>Schultes and Raffauf 1990; Revilla, 2001; Lorenzi &amp; Matos, 2002</td>
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<td></td>
<td>Healing</td>
<td>Revilla, 2001; Lorenzi &amp; Matos, 2002</td>
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<td></td>
<td>Colic;</td>
<td>Hodge and Taylor 1956; Revilla, 2001</td>
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<td></td>
<td>Conjunctivitis</td>
<td>Revilla, 2001</td>
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<td></td>
<td>Contraceptive</td>
<td>Weniger et al. 1982; Lorenzi and Matos, 2002</td>
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<td></td>
<td>Contraction In muscle fibers</td>
<td>Duke and Vasquez, 1994; Delgado et al. 1997</td>
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<td></td>
<td>Diarrhea</td>
<td>Schultes and Raffauf 1990; Duke and Vasquez, 1994; Delgado and Sifuentes, 1995; Revilla, 2001, Project..., 2015, Lorenzi and Matos, 2002</td>
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<tr>
<td></td>
<td>Dysentery</td>
<td>Revilla, 2001; Project..., 2015</td>
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<td></td>
<td>Stomachache</td>
<td>Duke and Vasquez, 1994</td>
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<td></td>
<td>Epilepsy</td>
<td>Duke and Vasquez, 1994</td>
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<td></td>
<td>Spasm</td>
<td>Delgado and Sifuentes, 1995; Revilla, 2001</td>
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<td>Gastralgia</td>
<td>Schultes and Raffauf 1990; Lorenzi &amp; Matos, 2002</td>
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<td></td>
<td>Bleeding</td>
<td>Revilla, 2001; Revilla, 2002a</td>
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<td></td>
<td>Irregular periods</td>
<td>Hodge and Taylor 1956</td>
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<tr>
<td></td>
<td>Purgative</td>
<td>Brasileiro et al., 2006</td>
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<tr>
<td></td>
<td>Treating cough</td>
<td>Revilla, 2001; Revilla, 2002a</td>
</tr>
<tr>
<td></td>
<td>Treatment Of Cellulite</td>
<td>Revilla, 2002b</td>
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</table>
ornamental (Revilla, 2001) represent the only indications of non-medicinal popular use for the species of the genus Eleutherine.

**Chemical constituents**

In chemical studies of *E. bulbosa* predominates analysis with bulbs, indicating the presence of secondary metabolites, proving the presence of naphthoquinones and anthraquinones, especially the eleuterina (Table 2). Chemical constituents of the aerial parts were studied by Paramapoja et al. (2008); and the underground parts were identified metabolites in study of Xijing et al. (2009).

Phytochemical screening revealed the presence of alkaloids, catechins, flavanones and coumarins in leaves and stem; Fixed acids, flavanones, steroids and condensed tannins in the leaves and triterpenoid (Sousa et al., 2005). The presence of alkaloids was confirmed by Baraúna and Rocha (2006). Phenolic compounds, coumarin derivatives, and Depsides depsidonas, reducing sugars and organic acids were cited by Baraúna and Rocha (2006).

**Pharmacological studies**

Naphthoquinones (eleuterinona) isolated of dichloromethane extract *E. bulbosa* bulbs demonstrated strong activity against the fungus Cladosporium sphaerospermum (Xu et al, 2006).

Antimicrobial properties and coronary dilating action, potentially useful in treating heart disease have been attributed to species rhizomes extract (Lorenzi and Matos, 2002). Zhengxiong et al. (1984) indicate that eleuterol and eleuterina isoeleuterina isolated of rhizomes extracts of the specie have antifungal activity and enhances the flow of the bloodstream, including coronary artery.

Eleuterina, isoeleuterina, elecanacina and isolated isoeleuterol bulbs of bulbous Eleutherine showed inhibitory activity against HIV replication (Hara et al., 1997).

Voravuthikunchai et al. (2007) showed antibacterial activity of *E. bulbous* on Streptococcus pyogenes. Ifesan and Voravuthikunchai (2009) demonstrate that the extract ethnogenic species bulbs can be used as an additive in the pork meat; indicating mild anti-bacterial effect and significant antioxidant activity.

In vitro assays performed with Eleutherine leaf extracts bulbous giardioicidal showing activity against Giardia lamblia (Amaral, 2007) and amebicide against Entamoeba histolytica / Entamoeba dispar (Nascimento et al., 2012) represent the only biological studies to validate the ethnopharmacological use.

Oliveira Neto et al. (2007) in biomonitored study indicate a steroidal sapogenin with peripheral analgesic properties and anti-dematogénica, as active ingredient in *E. plicata* bulbs extract.

*E. plicata* crude lyophilized extract has shown anti-edema and peripheral analgesic activity, but not central (Baraúna and Rock, 2006); and
<table>
<thead>
<tr>
<th>Nomenclature of plant species</th>
<th>Chemical compound</th>
<th>Chemical nomenclature**</th>
<th>Structure **</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Eleutherine american</em> (Aubl.) Merr. ex K. Heyne</td>
<td>Eleuterina</td>
<td>1(H)-Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl-(1R,3S)-, 1(H)-Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl-, (1R-cis)-; 1(H)Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl- (8CI)</td>
<td><img src="image1" alt="Structure 1" /></td>
<td>Hara et al., 1997; Paramapoja et al., 2008; Xijing et al., 2009; Phoem &amp; Voravuthikunchai, 2012</td>
</tr>
<tr>
<td>Eleuterol</td>
<td>Naphtho[2,3-c]furan-1(3(H))-one, 4-hydroxy-5-methoxy-3-methyl-, (3(R))-Naphtho[2,3-c]furan-1(3(H))-one, 4-hydroxy-5-methoxy-3-methyl- (8CI); Naphtho[2,3-c]furan-1(3(H))-one, 4-hydroxy-5-methoxy-3-methyl- (R)</td>
<td><img src="image2" alt="Structure 2" /></td>
<td>Weniger et al., 1982; Hara et al., 1997; Jinzhong et al., 2006; Paramapoja et al., 2008; Cavalcante et al., 2009</td>
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<tr>
<td><em>Eleutherine american</em> (Aubl.) Merr. ex K. Heyne</td>
<td>Eleuterinona</td>
<td>Naphtho[2,3-c]furan-4,9-dione, 1,3-dihydro-8-methoxy-1-methyl-, (1(S))- (+)</td>
<td><img src="image3" alt="Structure 3" /></td>
<td>Xijing et al., 2009</td>
</tr>
<tr>
<td>Elecanacina</td>
<td>10(H)Naphtho[2',3':2,3]cyclobuta[1,2-b]furan-5,10(3(a)(H))-dione, 1,2,4,4a-tetrahydro-6-methoxy-2-methyl-, (2(S),3(a)S,4(a)S,10(a)S)- (+)</td>
<td><img src="image4" alt="Structure 4" /></td>
<td>Hara et al., 1997</td>
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<tr>
<td>Compound</td>
<td>Structure Description</td>
<td>References</td>
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<tr>
<td>Isoeleuterol</td>
<td>Naphtho[2,3-c]furan-1(3H)-one, 5-hydroxy-4-methoxy-3-methyl-, (3R)-Naphtho[2,3-c]furan-1(3H)-one, 5-hydroxy-4-methoxy-3-methyl-, (R)-</td>
<td>Hara et al., 1997; Jinzhong et al., 2006; Xijing et al., 2009</td>
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<tr>
<td>Eleutherine americana (Aubl.) Merr. ex K.Heyne</td>
<td>Hara et al., 1997; Paramapojn et al 2008; Xijing et al., 2009; Nascimento et al., 2012; Phoem &amp; Voravuthikunchai, 2012</td>
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<tr>
<td>Hongconina</td>
<td>1H-Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl-, (1R,3R)-1H-Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl-, (1R-trans)-</td>
<td>Zhengxiong et al., 1981; Xijing et al 2009</td>
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<tr>
<td>Eleutherine americana (Aubl.) Merr. ex K.Heyne</td>
<td>Hara et al., 1997; Jinzhong et al., 2006; Xijing et al., 2009</td>
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<tr>
<td>Eleutherinoside A</td>
<td>4H-Naphtho[1,2-b]pyran-4-one, 8-(β-D-glucopyranosyloxy)-10-hydroxy-2,5-dimethyl-</td>
<td>Ganzera et al., 2009</td>
<td></td>
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Table 2. Cont’d.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
<th>Source</th>
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<tbody>
<tr>
<td><strong>Eleuthoside B</strong></td>
<td>Naphtho[2,3-c]furan-1(3H)-one, 4-[(6-O-β-D-glucopyranosyl-β-D-glucopyranosyl)oxy]-5-methoxy-3-methyl-(3R)-</td>
<td>Ganzera et al., 2009</td>
</tr>
<tr>
<td></td>
<td><img src="image1.jpg" alt="Structure Image" /></td>
<td></td>
</tr>
<tr>
<td><strong>Eleutherine american</strong> (Aubl.) Merr. ex K. Heyne *</td>
<td>Beta-Sitosterol (6CI); Stigmast-5-en-3β-ol (8CI); (-)-β-Sitosterol; (24R)-Ethylcholesterol-5-en-3β-ol; (24R)-Stigmast-5-en-3β-ol; 22,23-Dihydrostigmasterol; 24α-Ethylcholesterol</td>
<td>Xijing et al., 2009</td>
</tr>
<tr>
<td></td>
<td><img src="image2.jpg" alt="Structure Image" /></td>
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</tr>
<tr>
<td>Ni</td>
<td>8-hydroxy-3, 4-Dimethoxy-1-methylanthra-9, 10-quinone-2-carboxylic acid methyl ester</td>
<td>Ni</td>
</tr>
<tr>
<td>Ni</td>
<td>4,8-Dihydroxy-3-Methoxy-1-methylanthra-9,10-quinone-2-carboxylic acid methyl ester</td>
<td>Ni</td>
</tr>
<tr>
<td>Kadsuric Acid</td>
<td>1H-Benz[e]indene-6-propanoic acid, 3-[(1R,4Z)-5-carboxy-1-methyl-4-hexenyl]-2,3,3a,4,6,7,8,9,9a,9b-decahydro-3a,6,9b-trimethyl-7-(1-methylthienyl) - (3R,3aR, 6S,7S, 9aR,9bS) - (9CI); 3,4- Secolanost-4(28),9(11),24-triene-3,26-dioic acid, (24Z)-; 1H-Benz[e]indene-6-propanoic acid, 3-(5-carboxy-1-methyl-4-hexenyl)-2,3,3a,4,6,7,8,9,9a,9b-decahydro-3a,6,9b-trimethyl-7-(1methylene thienyl)-[3R-[3α(1R*,4Z), 3αa,6β,7α,9αa,9ββ]]-</td>
<td>Xijing et al., 2009</td>
</tr>
<tr>
<td></td>
<td><img src="image3.jpg" alt="Structure Image" /></td>
<td></td>
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</tbody>
</table>
Table 2. Cont’d.

<table>
<thead>
<tr>
<th>Species</th>
<th>Compound Description</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Eleutherine american</em> (Aubl.) Merr. ex K.Heyne *</td>
<td>(_)-3-[2-(acetyloxy)propyl]-2-hydroxy-8-methoxy-1,4-naphthoquinone</td>
<td>Malheiros, 2008</td>
</tr>
<tr>
<td></td>
<td>2,5-Dimethyl-10-hydroxy-naphthopyrone 8-O_d-glucopyranoside</td>
<td>Paramapojoja et al., 2008</td>
</tr>
<tr>
<td></td>
<td>3-methoxy-1-methylan-thraquinone-2-carboxylic acid methyl ester</td>
<td>Phoem and Voravuthikunchai, 2012</td>
</tr>
<tr>
<td></td>
<td>methyl ethers of 3,4,8-trihydroxy-1-methyl-anthracene-9,10-quinone-2-carboxylic acid methyl ester</td>
<td>Komura et al., 1983</td>
</tr>
<tr>
<td><em>Eleutherine bulbous</em> (Mill.) Urb.</td>
<td>anthracene-9,10-dione-1,5-diol-4-methoxy-3-methyl-2-carboxylic acid methyl ester</td>
<td>Weniger et al., 1982</td>
</tr>
<tr>
<td></td>
<td>Naphtho[2,3-c]furan-4,9-dione, 1,3-dihydro-8-methoxy-1-methyl-,(1S)-(+)</td>
<td>Xijing et al., 2009</td>
</tr>
<tr>
<td><em>Eleutherine bulbous</em> (Mill.) Urb.</td>
<td>1H-Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl-,(1R,3S)-(1H-</td>
<td>Hara et al., 1997; Paramapojoja et al., 2008; Xijing et al., 2009; Phoem &amp; Voravuthikunchai, 2012</td>
</tr>
<tr>
<td></td>
<td>Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl-,(1R-cis)-; 1H-Naphtho[2,3-c]pyran-5,10-dione,3,4-dihydro-9-methoxy-1\β,3\β-dimethyl- (8CI)</td>
<td></td>
</tr>
<tr>
<td><em>Isoeleuterina</em></td>
<td>1H-Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl-,(1R,3R)-(1H-</td>
<td>Hara et al., 1997; Paramapojoja et al, 2008; Xijing et al., 2009; Phoem &amp; Voravuthikunchai, 2012</td>
</tr>
<tr>
<td></td>
<td>Naphtho[2,3-c]pyran-5,10-dione, 3,4-dihydro-9-methoxy-1,3-dimethyl-,(1R- trans)-; 1H-Naphtho[2,3-c]pyran-5,10-dione,3,4-dihydro-9-methoxy-1\β,3\β-dimethyl- (8CI)</td>
<td></td>
</tr>
<tr>
<td><em>Eleuteron</em></td>
<td>Naphtho[2,3-c]furan-1(3H)-one, 4-hydroxy-5-methoxy-3-methyl-,(3R)-Naphtho[2,3-c]furan-1(3H)-one,4-hydroxy-5-methoxy-3-methyl- (8CI); Naphtho[2,3-c]furan-1(3H)-one, 4-hydroxy-5-methoxy-3-methyl-,(R)-</td>
<td>Weniger et al., 1982; Hara et al., 1997; Jinzhong et al., 2006; Paramapojoja et al., 2008; Cavalcante et al., 2009</td>
</tr>
</tbody>
</table>
Table 2. Cont’d.

| **Eleutherine bulbous** (Mill.) | Isoeleuterol | Naphtho[2,3-c]furan-1(3H)-one, 5-hydroxy-4-methoxy-3-methyl-, (3R)-Naphtho[2,3-c]furan-1(3H)-one, 5-hydroxy-4-methoxy-3-methyl-, (R)-10H-Naphtho[2′,3′:2,3]cyclobuta[1,2-b]furan-5,10(3aH)-dione, 1,2,4,4a-tetrahydro-6-methoxy-2-methyl-, (2S,3aS,4aS,10aS)-(+) | 5 | Hara et al., 1997; Jinzhong et al., 2006; Xijing et al., 2009 |
| **Elecanacina** |  |  |  |  |
| **Hongconina** |  |  |  |  |
| **Crisofanol** |  |  |  |  |
| **Eleutherine plicata** (Sw.) Herb. * | Eleuterol | Naphtho[2,3-c]furan-1(3H)-one, 4-hydroxy-5-methoxy-3-methyl-, (3R)-Naphtho[2,3-c]furan-1(3H)-one, 4-hydroxy-5-methoxy-3-methyl-(8Cl); Naphtho[2,3-c]furan-1(3H)-one, 4-hydroxy-5-methoxy-3-methyl-(8Cl); Naphtho[2,3-c]furan-1(3H)-one, 4-hydroxy-5-methoxy-3-methyl-, (R)- | 2 | Weniger et al., 1982; Hara et al., 1997; Jinzhong et al., 2006; Paramapoja et al., 2008; Cavalcante et al., 2009 |
| **Eleutherine plicata** Herb. ex Klatt * |  |  |  |  |
| **Isoeleuterina** |  |  |  |  |

*Nomenclature adopted by the authors representing botanical synonyms of the species *E. bulbous* (Mill.) Urb, official name currently defined in the databases and botanical institutes; ** Chemical nomenclature and structure of the Chemical Abstract; NI: no information.*
moderate anti-fungal activity (Menezes et al., 2009). Study of hydroalcoholic extract of your bulbs has shown anticholinesterase action (Cavalcante et al., 2009).

Crude extract E. american bulbs inhibit protease and lipase enzymes and may be used in the food industry as an additive, aiming to combat the growth of Staphylococcus aureus (Ifeasan and Voravuthikunchai, 2009).

Study Mahabusarakam et al. (2010) with E. american bulbs has shown antibacterial activity against S. aureus (ATCC25923 and ATCC27664). Study of ethanol extract of kind of bulbs has shown antibacterial activity against Campylobacter spp (Sirirak and Voravuthikunchai, 2011).

In a study of bioprospecting, Brazilian et al. (2006) showed that the ethanol extracts of the aerial parts of E. bulbous have toxicity to larvae of Artemia salina (LD50 <1000 ppm) without evidence of antimicrobial activity assay with Escherichia coli, but showing activity against S. aureus, which is the only evaluation job of toxicity developed with the species under study.

**Patents**

In databases it was found patent deposit, predominating registration based in the E. plicata terminology, where the evaluated patent corresponds to the process for obtaining of an extract and a vegetable fraction, pharmaceutical compositions and their use for the treatment of malaria (WO 2013166576 A1); use of E. plicata to decreased levels of blood cholesterol triglicerideos (CN103127319-A); use of E. bulbous for the treatment of neuro-degenerative disease, heart disease and diabetes (VN31660-A); use of E. plicata for cure of diseases rheumatoid arthritis, arthralgia and myalgia (CN1813986-A), use of leaves of E. bulbous (Mill.) Urb. giardicial for therapeutic use (BR 1020150161930).

**Conclusion**

E. bulbous (Mill.) Urb., which is native and of high occurrence in various regions of the Americas, is a vegetable specie with potential for investments in research and development of herbal products, given the broad therapeutic use in popular practice. The analysis of botanical institutions databases have demonstrated a high number of scientific synonyms for this species and, further, various publications employing scientific names E. plicata and us Eleutherine, which do not represent the official name for the species currently accepted. In this review we noted that the ethnopharmacological studies indicate broad popular job E. bulbous in the gastrointestinal disorders, but there are few validation studies of popular use; noting the need for more study of plant anatomy, for the determination of authenticity parameters. Thus, research in these areas, as well as evaluation of toxicity, should be encouraged aiming at setting security parameters.

**Conflict of Interests**

The authors have not declared any conflict of interests.

**ACKNOWLEDGMENTS**

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**REFERENCES**


Delgado HS, Herrera JEH, Sifuentes TC, Ruiz JG, Dávila MM, Isem FR.


Journal of Medicinal Plant Research

Related Journals Published by Academic Journals

- African Journal of Pharmacy and Pharmacology
- Journal of Dentistry and Oral Hygiene
- International Journal of Nursing and Midwifery
- Journal of Parasitology and Vector Biology
- Journal of Pharmacognosy and Phytotherapy
- Journal of Toxicology and Environmental Health Sciences