Nagwa E. Awad¹, Mostafa A. Abdelkawy², Enas H. Abdelrahman², Manal A. Hamed³,* and Nehal S. Ramadan¹

¹Pharmacognosy Department, National Research Centre, 33 El-Bohouth St., Dokki, Cairo, Egypt; ²Pharmacognosy Department, Faculty of Pharmacy, Cairo University, Cairo, Egypt; ³Therapeutic Chemistry Department, National Research Centre, 33 El-Bohouth St., Dokki, Cairo, Egypt

Abstract: Background: Chemotherapy of schistosomiasis by certain drugs is impractical due to the resistance of Schistosoma larvae to schistosomiasis drugs after long treatment period. The aim of this work is to monitor Schistosoma mansoni infection on mice livers after treatment with the ethanolic extract of Justicia spicigera areal parts and the herbal antischistosomal drug (Mirazid); the oleo-resin extract from Commiphora molmol tree.

Methods: Liver function enzymes; Aspartate Aminotransferase (AST); Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP), Gamma Glutamyl Trans- Peptidase (GGT) and serum total protein content were estimated. Oxidative stress markers; Malondialdehyde (MDA), Glutathione (GSH) and Super Oxide Dismutase (SOD) were also evaluated. Parasitological and histopathological studies through numbers of worm burden and liver pathology pattern were done.

Results: The results showed obvious decreases in AST, ALT, ALP, GGT, total protein, MDA and SOD after treatment with plant extract or the selected drug, while GSH recorded significant increase after treatment. A noticeable decrease in worm count and an improvement in histopathological picture of the infected mice liver were detected.

Conclusion: The ethanolic extract of Justicia spicigera areal parts recorded antioxidants and antischistosomal effects. Further work is needed to validate its safety and for considering it as anti-schistosomal drug.

Keywords: Justicia spicigera, Mirazid, schistosomiasis, oxidative stress, enzymes, worm burden.

1. INTRODUCTION

Schistosomiasis is a chronic parasitic disease affecting millions of people in developing countries and considered a serious public health and economic problem in spite of the continuous control efforts [1].

Disease control by certain chemical drugs is un-useful because of the resistance of Schistosoma mansoni larvae to schistosomicide drugs after repeated infection [1].

The currently used drug, praziquantel, was reported to induce lung hemorrhage as well as diarrhea and abdominal pain [2]. Therefore, the oleo-resin extract from Commiphora molmol tree Myrrh (Mirazid) as a new herbal antischistosomal drug is widely used regarding its safety [3]. The effect of Mirazid is through worm disruption, collapse of tubercles, and reduction of worm burden as well as reduction in ova count in urine and stool [3].

Recently, most researchers use natural plant extracts as safe and effective drugs. Justicia spicigera (JS) (Acanthaceae) is a green shrub with tubular orange flowers in Mexico to South America [4, 5].

Ortiz-Andrade et al. [6] mentioned that Justicia spicigera is used against head aach, hypertension and epilepsy, stomach pain, diarrhea, and dysentery. In addition, it is used in skin infection caused by the itch mite, syphilis and tumors. Moreover, it is also used against fever, kidney infection, anemia, inflammation, cough and bronchitis.
The present study is aimed to evaluate *Justicia spicigera* aerial parts ethanolic extract as antioxidant and antischistosomal agent comparing with Mirazid as a reference herbal drug. The evaluation was done through detecting number of male, female, coupled and total worms in *S. mansoni* infected mice liver. The liver function enzymes, the oxidative stress markers and the liver histopathological architecture were also evaluated.

### 2. MATERIALS AND METHODS

#### 2.1. Chemicals

All chemicals used in the present study were of high analytical grade. Mirazid is a product of Pharco- Pharmaceutical Company, Egypt.

#### 2.2. Plant Material

Fresh aerial parts of *Justicia spicigera* were collected (March 2013-2014) from Giza Zoo, Giza, Egypt. Specimen of the plant was identified by Mrs. Trease Labib Consultant of Plant Taxonomy at the Ministry of Agriculture and director of Orman Botanical Garden, Giza, Egypt. The aerial parts were air-dried, powdered and kept in closed containers until used. Voucher specimen (JSAP-2014) was deposited in Pharmacognosy Dept., National Research Center, Cairo, Egypt.

#### 2.3. Plant Extractions

Three kilograms of dried aerial part of *Justicia spicigera* were extracted with ethanol (95%) till complete exhaustion (538 g) [7] The extract was concentrated to dryness by rotary evaporator under vacuum at temperature 40- 50°C, lyophilized. The extract was kept in refrigerator till further investigation.

#### 2.3.1. Phytochemical Screening Tests

The aerial part of *Justicia spicigera* ethanolic extract was tested for the presence of carbohydrates and/or glycosides [8], anthocyanins [9], coumarins [10], tannins [11], lignans [12], tannins [13], free and compound flavonoids [14], saponins [15], Sterols and/or triterpenes [10], alkaloids and/or nitrogenous compounds [16], free and compound anthraquinones [15, 17].

#### 2.3.2. Determination of Total Phenolic Content (TPC) Assay

Total phenolic content (TPC) was determined by the Folin-Ciocalteu method [18]. The reaction mixture was composed of 0.1 ml extract (1 or 10 mg/ml, 7.9 ml distilled water, 0.5 ml of Folin-Ciocalteu reagent and 1.5 ml of 20% sodium carbonate anhydrous solution. After mixing, the opaque flasks were allowed to stand for 1 h. The optical density of the blue-coloured samples was measured at 765nm. The total phenolic content was determined as gallic acid equivalents (GAE) and values are expressed as mg of gallic acid/g of extract.

#### 2.4. In vitro Antioxidant Assay

The plant ethanolic extract was examined for its *in vitro* antioxidant activity by the method of Chen *et al.* [19] using vitamin C as a slandered. Serial concentrations (10:100μg) for each tested sample were estimated, where 2 ml of 2,2-diphenyl-1-picrylhydrazyl (DPPH) dissolved in ethanol (100 μM) and mixed with 2 ml of the plant extract dissolved in bi-distilled water. The DPPH free radicals react with plant antioxidants and the decrease in absorbance (A) of DPPH at 517 nm was calculated in relation to absorbance of control as follows:

\[
\text{% IP} = \frac{(A \text{ control} - A \text{ sample})}{A \text{ control}} \times 100
\]

#### 2.5. In vivo Antischistosomal Effect

##### 2.5.1. Animals and Ethics

Swiss male albino mice of CDI strain (20-25g) were obtained from Theodor Bilharz Research Institute, Cairo, Egypt and maintained on water and food *ad libitum*.

Anesthetic procedures and handling with animals were complied with the ethical guidelines of Medical Ethical Committee of the National Research Centre, Egypt (Approval no: 11148; on 24 April, 2014).

##### 2.5.2. Scercarial Infection

Mice were subcutaneously injected with 60 cercariae of Egyptian *S. mansoni* strain according to Oliver and Stirewalt [20] and left for 8 weeks. Cercarial suspensions were obtained from at least ten infected *Biomphalaria alexandrina* snails for being sure of bisexual infection.

##### 2.5.3. Experimental Design

Thirty two mice were divided equally into four groups. The first group was normal control mice. The second group consisted of the *S. mansoni* infected mice for 8 weeks. The third group was the *S. mansoni* infected mice treated orally with the ethanolic extract of *Justicia spicigera* aerial parts dissolved in bi-distilled water (500mg/kg body weight) [21], daily for 8 weeks after the 8 weeks of infection. The fourth group was *S. mansoni* infected mice treated orally with the reference drug; Mirazid (600 mg/kg body weight) [3, 22] daily for six days after the schistosomal infection period and sacrificed 24 hours after the last injection.

##### 2.5.4. Recovery of Adult Worm (Liver Perfusion)

Worms were collected after liver perfusion [23], where, the percent of reduction in worm number after challenge was calculated as follows:

\[
P = \frac{C - V}{C} \times 100
\]

Where, \(P\) = % of worm reduction, \(C\) = mean number of parasite collected from infected animals and \(V\) = meanumber of parasite collected from treated animals.

##### 2.5.5. Sample Preparations

Serum sample: Blood collected from each animal by puncture the sublingual vein in a clean and dry test tube and left 10 minutes for clotting. It centrifuged at 3000 r.p.m for serum separation and the separated serum was stored at -80°C for further determinations of liver function enzymes and serum total protein content.

Liver homogenates: Liver tissue was homogenized in normal physiological saline solution (0.9% NaCl) (1:9 w/v).
The homogenate was centrifuged at 4°C for 5 min at 3000 rpm and the supernatant was stored at -80°C for further estimation of hepatic oxidative stress markers; glutathione (GSH), malondialdehyde (MDA) and superoxide dismutase (SOD).

2.5.6. Biochemical Assays

2.5.6.1. Hepatic Oxidative Stress Parameters

Malondialdehyde (MDA) was assayed according to the method of Buege and Aust [24]. MDA is the product of polyunsaturated fatty acids oxidation and calculated using the extinction coefficient value $1.56 \times 105$ M$^{-1}$ cm$^{-1}$ and read at 535 nm. Glutathione (GSH) was assayed according to the method of Moron et al. [25] using dithiobis-2-nitrobenzoic acid (DTNB) in PBS. The reaction colour was read at 412 nm. Total superoxide dismutase was assayed according to Nishikimi et al. [26], where the increase in NADH oxidation was measured at 560 nm using its molar extinction coefficient $6.22 \times 103$ M$^{-1}$ cm$^{-1}$.

2.5.6.2. Serum Biomarkers for Liver Function Tests and Total Protein Level

Aspartate and alanine aminotransferases were estimated by the method of Reitman and Frankel [27] using Diagnostic kit (Biodiagnostic, Egypt) at 520 nm. Alkaline phosphatase was measured by the method of Belfield and Goldberg [28] using Diagnostic kit (Biodiagnostic, Egypt) at 510 nm. GGT was estimated by the method of Szasz [29] at 450 nm. Total protein was assayed by the method of Bradford [30] at 595 nm.

2.5.7. Histopathological Study

Liver slices were fixed in 10% paraformaldehyde and embedded in paraffin wax blocks. Sections of 4μm thick were stained with hematoxylin & eosin (H&E) and Masson’s trichrome, then examined under light microscope for determination of pathological changes [31].

2.5.8. Statistical Analysis and Calculations

All data were expressed as mean ± SD of eight mice in each group. Statistical analysis was carried out by one way analysis of variance (ANOVA), Costat Software Computer Program. Significance difference between groups was at $P<0.05$.

% change = $[(\text{control mean} - \text{treated mean})/\text{control mean}] \times 100$.

% improvement = $[(\text{treated mean} - \text{injured mean})/\text{control mean}] \times 100$.

3. RESULTS

The ethanolic extract of Justicia spicigera aerial parts revealed the high presence of glycosides, anthocyanins and saponins. Coumarins, lignans, flavonoids, sterols and triterpenes were present in moderate concentrations (Table 1). The extract also contained total phenols by 26.54±0.58 mg/g (Table 2).

Concerning the in vitro antioxidant effects of the total ethanolic extract of Justicia spicigera areal parts recorded inhibition of DPPH free radicals by 85.00% at the concentration of 10μg of the extract. Vitamin C; as a standard recorded an inhibition by 43.47 for the same concentration. At a concentration of 50μg, the inhibition percentage reached to 92.50%, while vitamin C showed inhibition by 80.85% for the same concentration (Fig. 1).

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Present/Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile constituents</td>
<td>+</td>
</tr>
<tr>
<td>Carbohydrates and/or glycosides</td>
<td>++</td>
</tr>
<tr>
<td>Anthocyanins</td>
<td>++</td>
</tr>
<tr>
<td>Coumarins</td>
<td>+</td>
</tr>
<tr>
<td>Tannins</td>
<td>-</td>
</tr>
<tr>
<td>Lignans</td>
<td>+</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+</td>
</tr>
<tr>
<td>a-Free</td>
<td>+</td>
</tr>
<tr>
<td>b-Combined</td>
<td>+</td>
</tr>
<tr>
<td>Saponins</td>
<td>++</td>
</tr>
<tr>
<td>Sterols and/or triterpenes</td>
<td>+</td>
</tr>
<tr>
<td>Alkaloids and/or nitrogenous compounds</td>
<td>-</td>
</tr>
<tr>
<td>Anthraquinones</td>
<td>-</td>
</tr>
<tr>
<td>a-Free</td>
<td>-</td>
</tr>
<tr>
<td>b-Combined</td>
<td>-</td>
</tr>
</tbody>
</table>

++: High concentration; +: Moderate concentration.; -: Absent.

Table 2. Total phenolic contents of ethanolic extract of Justicia spicigera aerial parts.

<table>
<thead>
<tr>
<th>Extract</th>
<th>Phenolic Content (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>26.54±0.58</td>
</tr>
</tbody>
</table>

Regarding to worms number in the liver of S. mansoni infected mice, the male worms reached to 23, while the female worms’ number was 4 and the coupled worms were 3. Treatment with Justicia spicige ethanolic leaves extract and Mirazid recorded significant decrease in male worms by 56.52 and 82.60%, respectively. Female worms were decreased after treatment by 50.00 and 75.00%, respectively, while the worms in the coupled state were decreased by 33.33 and 66.66%, respectively (Table 3). We observed the total worm numbers in S. mansoni infected mice was 33 worms, while treated rats with plant extract and Mirazid showed total worm count of 16 and 7%, respectively. Therefore, treated mice with plant extracts and Mirazid decreased the total worm counts by 51.51 and 78.78%, respectively.
In the present study, *Schistosoma mansoni* infected mice showed significant increase in liver function indices as compared to the control group. AST, ALT, ALP, GGT and total serum protein recorded significant increase by 36.19, 75.65, 104.16, 137.48 and 34.97%, respectively (Table 4).

---

Table 3. Number of worms in *Schistosoma mansoni* infected mice liver.

<table>
<thead>
<tr>
<th>Worm Numbers</th>
<th><em>S. mansoni</em> Infected Mice</th>
<th>Treatment with Ethanolic Extract</th>
<th>Treatment with Mirazid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male worms</td>
<td>23.00±5.05</td>
<td>10.00±2.38</td>
<td>4.00±0.82</td>
</tr>
<tr>
<td></td>
<td>(-56.52)</td>
<td>(-50.00)</td>
<td>(-82.60)</td>
</tr>
<tr>
<td>Female worms</td>
<td>4.00±0.95</td>
<td>2.00±0.50</td>
<td>1.00±0.81</td>
</tr>
<tr>
<td></td>
<td>(-50.00)</td>
<td>(-33.33)</td>
<td>(-66.66)</td>
</tr>
<tr>
<td>Coupled worms</td>
<td>3.00±0.81</td>
<td>2.00±0.50</td>
<td>1.00±0.81</td>
</tr>
<tr>
<td></td>
<td>(-50.00)</td>
<td>(-33.33)</td>
<td>(-66.66)</td>
</tr>
<tr>
<td>Total worms</td>
<td>33.00±0.82</td>
<td>16.00±0.52</td>
<td>7.00±0.78</td>
</tr>
<tr>
<td></td>
<td>(-51.51)</td>
<td>(-78.78)</td>
<td></td>
</tr>
</tbody>
</table>

- Values are mean ± SD of eight mice in each group.
- Statistical analysis are done using one way analysis of variance (ANOVA) using Co Stat Computer program accompanied with least significance level (LSD) between groups at p<0.05.
- Unshared superscript letters are significant values between groups at p<0.0001.
- Values between brackets are % changes over infected group.

Table 4. Effect of treatment with plant extract on liver function indices and total protein in *S. mansoni* infected mice.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>Infected with <em>S. mansoni</em></th>
<th>Infected Treated with Plant Extract</th>
<th>Infected Treated with Mirazid</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a</td>
</tr>
<tr>
<td>AST (Unit/L)</td>
<td>2.68±0.04</td>
<td>3.65±0.09</td>
<td>2.92±0.35</td>
<td>2.77±0.07</td>
<td>27.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(+36.19)</td>
<td>[-20.00]</td>
<td>[-24.10]</td>
<td></td>
</tr>
<tr>
<td>ALT (Unit/L)</td>
<td>1.52±0.02</td>
<td>2.67±0.24</td>
<td>2.20±0.10</td>
<td>2.07±0.03</td>
<td>30.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(+75.65)</td>
<td>[-17.60]</td>
<td>[-22.47]</td>
<td></td>
</tr>
<tr>
<td>ALP (Unit/L)</td>
<td>30.00±5.19</td>
<td>61.25±2.59</td>
<td>44.13±2.01</td>
<td>49.00±2.73</td>
<td>57.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(+104.16)</td>
<td>[-27.95]</td>
<td>[-20.00]</td>
<td></td>
</tr>
<tr>
<td>GGT (Unit/L)</td>
<td>24.81±2.78</td>
<td>58.92±9.67</td>
<td>34.66±7.14</td>
<td>33.55±5.28</td>
<td>97.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(+137.48)</td>
<td>[-41.17]</td>
<td>[-43.05]</td>
<td></td>
</tr>
<tr>
<td>Total protein (mg/ml)</td>
<td>17.30±2.12</td>
<td>23.35±3.59</td>
<td>18.00±1.63</td>
<td>17.45±1.26</td>
<td>30.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(+34.97)</td>
<td>[-22.91]</td>
<td>[-25.26]</td>
<td></td>
</tr>
</tbody>
</table>

- Values are mean ± SD of eight mice in each group.
- Statistical analysis are done using one way analysis of variance (ANOVA) using Co Stat Computer program accompanied with least significance level (LSD) between groups at p<0.05.
- Unshared superscript letters are significant values between groups at p<0.0001.
- Values between brackets are % changes over control group.
- Values between parentheses are % changes over infected group.

---

Fig. (1). *In vitro* antioxidant effects of *Justicia spicige* extract. Data are inhibition percentages (IP) of DPPH free radicals at different concentrations. % IP = mean of control (3 reading) - mean of sample (3 reading) x 100 Mean of control.
In case of AST, treatment of infected mice with Justicia spicigera ethanol extract and Mirazid recorded significant decrease by 20.00 and 24.10%, respectively as compared with the infected group. Regarding to ALT, treatment of infected mice with plant extract and the selected drug showed significant decrease by 17.60 and 22.47%, respectively, while ALP enzyme activity showed significant decrease by 27.95 and 20.00%, respectively. In addition, treatment of the infected mice with Justicia spicigera ethanolic extract and Mirazid showed significant decrease in GGT activity by 41.17 and 43.05%, respectively. Moreover, serum total protein showed significant decrease in GGT activity by 102.25, 50.00 and 19.61% for GSH, MDA and SOD, respectively (Table 5).

In summary, the results revealed that treatment with Justicia spicigera ethanolic extract improved the liver function indices; AST, ALT, ALP, GGT and total protein levels by 27.23, 30.92, 57.06, 97.78 and 30.92%, respectively, while treatment by Mirazid improved the selected parameters by 32.83, 39.47, 40.83, 102.25 and 34.10%, respectively (Table 4).

Concerning oxidative stress markers in S. mansoni infected mice, glutathione showed significant decrease by 44.62%, while MDA and SOD recorded significant increase by 87.55 and 32.43%, respectively as compared with the control group (Table 5).

Infected mice treated with the ethanolic extract of Justicia spicigera showed that the GSH level significantly increased by 55.66%, while MDA and SOD decreased by 20.00 and 16.71%, respectively. Mirazid treatment increased GSH by 13.78% and decreased MDA and SOD by 26.66 and 14.81%, respectively. In conclusion, we recorded improvement level of GSH, MDA and SOD after schistosomal infection to the release of the enzyme from the hepatocytes to the circulation as a result of cell membrane fragility and permeability. Variations in the release of both enzymes, destruction, excretion or an unknown metabolic disturbance are probably important contributory mechanisms due to infection [33-35]. Mansy et al. [36] attributed the increase in ALP enzyme activity to the bile ductules proliferation as a result of schistosomiasis.

### Table 5. Effect of treatment with plant extract on oxidative stress markers in S. mansoni infected mice.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>Infected with S. mansoni</th>
<th>Infected Treated with Plant Extract</th>
<th>Infected Treated with Mirazid</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSH (μg/mg protein)</td>
<td>17.68±2.10</td>
<td>9.79±0.74</td>
<td>15.24±1.59</td>
<td>11.14±1.01</td>
<td>30.82 ± 7.63</td>
</tr>
<tr>
<td>MDA (μg/mg protein)</td>
<td>0.16±0.01</td>
<td>0.30±0.02</td>
<td>0.24±0.04</td>
<td>0.22±0.02</td>
<td>37.50 ± 50.00</td>
</tr>
<tr>
<td>SOD (μmol/mg protein)</td>
<td>97.42±22.43</td>
<td>129.02±6.06</td>
<td>107.46±4.34</td>
<td>109.91±6.06</td>
<td>22.13 ± 19.61</td>
</tr>
</tbody>
</table>

- Values are mean ± SD of five mice in each group.
- Statistical analysis are done using one way analysis of variance (ANOVA) using Co Stat Computer program accompanied with least significance level (LSD) between groups at p<0.05.
- Unshared superscript letters are significant values between groups at p<0.0001.
- Values between brackets are % changes over control group.
- Values between parentheses are % changes over infected group.
Leonard et al. [37] observed an increase in GGT after stress and confirmed GGT as indicator of bile duct lesions.

In addition and in agreement with the present study, Romero et al. [38] and Motawi et al. [39] recorded increase in total protein content in liver diseases which can be clearly used as a useful index of cellular dysfunction.

Oxidative stress is well documented due to schistosomiasis where ROS is generated and increment of endogenous antioxidant enzymes is associated with the disease [40]. Our results showed that the malondialdehyde (MDA); the end product of lipid peroxidation process was elevated in *S. mansoni* infected liver. In agreement with the present finding, several authors reported that oxidative stress due to schistosomiasis causes an elevation in lipid peroxides [34-35]. Elevation of MDA as a result of infection with *S. mansoni* has been suggested to be due to release of significant amount of O$_2^-$ from macrophages of hepatic granulomas. At the same time, liver GSH was significantly decreased in infected mice. This decrease leads to increase in H$_2$O$_2$ cytotoxicity as a re-
sult of inhibition of glutathione reductase that keeps glutathione in its reduced state [40].

It obviously indicated that, the number of worm burden increases the degree of liver fibrosis and granulomatous reactions in S. mansoni infected mice [3, 33-35]. These were in agreement with the present histopathological findings of increased number and size of granulomatous, increased lymphocytes infiltrations, and increase of intact ova and sever fibrous deposition.

The present results recorded improvement levels of all enzymes under investigation after treatment of S. mansoni infected mice with plant extract and Mirazid.

This amelioration was confirmed by a significant reduction of male and female worms. Our data is confirmed by the previous reports indicated that Mirazid is an effective drug for treatment of Fasciola hepatica, S. mansoni, and S. haematobium through reduction of worm burden as well as reduction in ova count [22, 41]. In addition, Justicia spicigera contain high concentration of flavonoid, glycosides, coumarins and saponins which recorded an antioxidant properties, acts as free radical scavenger and has anti-inflammatory activity [42, 43]. In addition, Maghraby et al. [44] postulated the role of saponin as immunomodulator against S. mansoni infection. Haridas et al. [45] added that saponin was maintaining liver architecture that in turn preventing the development of malignancies. Lee et al. [46] and Saeed et al. [47] also postulated the hepatoprotective action of saponin by enhancing the level of liver enzymes, enhancing the enzymes responsible for antioxidant activity; scavenging free radicals responsible for cell damage and induction of regeneration of the liver cells. Moreover the root, flower, fruit and leaf of plant have been used in the treatment of helminthic, diarrhea and dysentery [48].

CONCLUSION

In conclusion, Justicia spicigera and Mirazid succeeded to reduce the hazardous effect of S. mansoni through reduction of worm burden, improvement of liver enzymes, ameliorated oxidative stress indices and enhanced the histopathological pattern of the infected liver. Further studies are needed to validate plant safety as well as the suitable recommended dose of the extract and the drug for complete eradication of worm and to preserve normal liver function parameters.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Anesthetic procedures and handling with animals were complied with the ethical guidelines of Medical Ethical Committee of the National Research Centre, Egypt (Approval no: 11148; on 24 April, 2014).

HUMAN AND ANIMAL RIGHTS

No humans were used in this study and the reported experiments in accordance with the standards set forth in the 8th Edition of Guide for the Care and Use of Laboratory Animals (http://grants.nih.gov/grants/olaw/Guide-for-the-care-and-use-of-laboratory-animals.pdf) published by the National Academy of Sciences, The National Academies Press, Washington DC, United States of America.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

zymol cercariae of Smithers, S.R.; Terry, R.J. The infection of laboratory hosts with lung and liver.

Moron, M.S.; Depierre, J.W.; Mannervik, B. Level of glutathione, glutathione reductase and glutathione-S-transferase activities in rat.


