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A Review of Some Medicinal and or Hallucinogenic Solanaceous Plants of Botswana: The Genus *Datura* L.

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Abstract: *The economically important potato family, Solanaceae, is represented by six genera in Botswana. These are Datura, Lycium, Nicotiana, Physalis, Solanum and Withania. These are mostly herbs and small shrubs. They usually occur as weeds and in disturbed areas. Members of this family are important foods and medicines. Some, however, are poisonous, and their seeds often contaminate food stuffs. This article reviews the known medicinal uses and or hallucinogenic effects of members of the genus Datura in Botswana.*

Keywords: *Solananceae, Datura, atropine, scopalmine, hyosyamine.*

1. INTRODUCTION

The Solanaceae or potato family is almost world wide in distribution, ranging from about 70°N in the Old World and 51°N in the New World to about 53°S in South America (D'Arcy, 1991). Although the family has many well-known and interesting temperate members, the majority of the genera and species are tropical. The family has about 96 genera and over 2000 species. The main centre of taxonomic diversity of the Solanaceae is South America, where 50 near endemic genera with over 400 species occur, plus many species in the wide ranging genera *Lycium*, *Nicotiana* and *Solanum* (D'Arcy, 1991). The great concentration of the family in South America has led to the hypothesis that it may have originated in that subcontinent. The genus *Solanum* (from which the family is named) is the largest with close to two thousand species. Six genera (three introduced) with about 30 species have been recorded for Botswana (Arnold and De Wet, 1993).

The potato family is characterised by herbs, shrubs and small trees with entire or variously dissected, alternate leaves. The family is closely related to the Scrophulariaceae (foxglove family), from which it can be easily distinguished by its flowers. Flowers of the Scrophulariaceae are typically irregular (zygomorphic), while those of the Solanaceae are regular (actinomorphic). The family also has affinities to the Convolvulaceae (sweet potato family).

The potato family is one of the most important families serving mankind. It contains not only many essential vegetables and fruits such as potatoes, tomatoes, egg plant, paprika, chillies, green and red peppers, but also garden ornamentals such as the petunia, and are a source of important medicines and drugs.

Various species of *Datura*, *Nicotiana* and *Solanum* are cultivated for their showy flowers. Some *Capsicum* and *Solanum* species are widely grown for their colourful fruits, while still certain *Solanum* and *Lycium* species are popular shrubs.

Among the most familiar solanaceous food plants are the potato (*Solanum tuberosum* L.), egg plant (*S. melongena* L.), tomato (*Lycopersicon esculentum* Mill.) and the peppers (various *Capsicum* species which include paprika, chillies, cayenne pepper, green peppers, red peppers).

Tobacco (*Nicotiana tabacum* L.), grown extensively for use for smoking, chewing and snuff manufacture, is one of the most popular yet harmful plants in the world. Many *Nicotiana* species contain the highly toxic alkaloid nicotine, which can also be used to advantage as a powerful insecticide.

Plants that are both poisonous and or of medicinal use are found in most solanaceous genera. For instance, the genus *Datura* has members that are notoriously poisonous.

2. GENUS *DATURA* L.

2.1. Taxonomy and Distribution

This is a well-known genus of drug plants with several weedy species. The species occur mainly on disturbed sites. The taxonomy of the genus *Datura* is very difficult as botanists can not agree on the characteristics of some species or even the exact number. The taxonomic classification of the genus is made more difficult because of its long history of cultivation and selection. There are at least fifteen species of *Datura*. Most of the species of *Datura* are native to the Americas from where they were introduced to the Old World by Europeans at an early date (Symon and Haegi, 1991). Three species of *Datura* have been introduced into Botswana and have naturalised. These are *D. ferox* L., *D. inoxia* Mill. and *D. stramonium* L. Two of the species, *D. ferox* and *D. stramonium* are declared weeds in neighbouring South Africa (Henderson, 2001).

2.2. Medicinal and Hallucinogenic Properties of Datura Species

Several species of *Datura* have been used and are still extensively used in many parts of the world as healing and as hallucinogenic plants. The medicinal and hallucinogenic effects are caused by tropane alkaloids: atropine, hyoscyamine and scopolamine. These are fine and medicinal when taken in small doses but have very harmful effects when taken in large quantities causing delirium, loss of body control, cramps and eventual death. The alkaloids are found in differing quantities in all parts of the plant. They occur in the shoot (leaves and stem), the roots, the flowers and the seeds. Cases of hallucinogenic effects due to species of *Datura* have been reported in Botswana in recent times. The accidental occurrence of seeds of *D. stramonium* found in sorghum flour from a mill in Moshupa village caused temporary memory losses to a number of people in the village in May 1998 (Botswana Daily News No. 92, 1998). Many solanaceous plants contain tropane alkaloids. Other than *Datura*, other infamous solanaceous plants containing these alkaloids with the same effect on humans are the deadly nightshade plant or *Atropa belladonna* L., mandrake or *Mandragora officinarum* L., and henbane or *Hyoscyamus niger* L. (McCloy, 2004). Other genera with equally or even more potent tropane alkaloids are *Brugmansia* and *Solandra*. There are therefore many other sources for these drugs.

Below are properties of the three major alkaloids found in several species of *Datura*. These are atropine, scopolamine and hyoscyamine. All these work in a similar way by inhibiting the action of acetylcholine at nerve synapses. They are classified as anticholinergic drugs.

Atropine is a white solid with melting point of 118°C. It has a molecular formula $C_{17}H_{23}O_3N$. Its chemical structure is shown Figure 1 below:

Fig1. *Chemical structure of Atropine.*

Source: http://www.chm.bris.ac.uk/motm/atropine, accessed on 28th November 2013.

Atropine is a neurotoxin, i.e., a poison that disrupts the workings of the nervous system. It is highly toxic even if ingested in moderate quantities. It is used in medicine as a muscle relaxant.

Scopolamine is a viscous liquid. It is used for the prevention of nausea and vomiting associated with motion sickness and recovery from anaesthesia and surgery.

It has a molecular formula $C_{17}H_{21}NO_4$. Its chemical structure is shown in Figure 2 below:

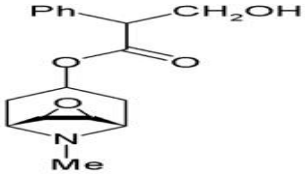

Fig2. *Chemical structure of Scopalmine.*

Source: *http://www.biopsychiatry.com/secobarbital/index.html, accessed on 28th November 2013.*

Hyoscyamine is another tropane alkaloid. It is a levo-isomer of atropine. It is also known as benzeneacetic acid. It is used in medicine under a number of brand names but also as a generic compound. It is available in capsule form and as drops. It has a molecular formula $C_{17}H_{23}NO_3$. Its chemical structure is shown in Figure 3 below:

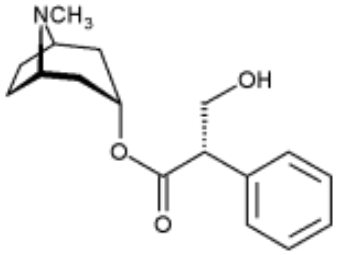

Fig3. *Chemical structure of Hyosyamine*

Source: *http://www.newdruginfo.com/pharmacopeia/usp28/v28230/usp28nf23s0_m39590.htm, accessed on 28th November 2013.*

Hyosyamine is used to control symptoms associated with disorders of the gastrointestinal tract. It works by decreasing the motion of the stomach, intestines and the secretion of stomach fluids. It is also used in the treatment of bladder spasms, and peptic ulcer disease. It may also be used to treat certain heart conditions, to control symptoms of Parkinson's disease, runny nose, and to reduce excess saliva production.

The following treatise discusses the various worldwide medicinal and hallucinogenic uses of the three members of *Datura*, *D. ferox*, *D. innoxia*, and *D. stramonium*. The plants have not been used in Botswana for these purposes largely because of lack of knowledge. The only incidental use was, as mentioned earlier, the chance occurrence of seeds of *D. stramonium* in sorghum in Moshupa in May 1998 which led to hallucinogenic effects in people that had consumed them.

2.3. *Datura ferox* L.; Longspine Thorn Apple, Fierce Thorn Apple, Large Thorn Apple, White Stinkweed

Fierce thorn apple is native to the south western USA and Mexico. This species is often considered to be native to China in literature, but there is doubt on this assertion. It was introduced into Australia as a garden plant, and it is still associated mainly with human settlements in the Northern Territory (Smith, 1998).

This is an erect, branched, herbaceous annual growing to a height of 1.5m tall. The stems are sparsely hairy to smooth. Leaves are dark green above, paler below, lance or oval-shaped, up to 20cm long, with toothed margins and pointed lobes, on long petioles and bad smelling. The trumpet-shaped flowers are erect, have white petals 6 to 10cm long, and are borne singly in the forks of branched stems. Fruits are brown hardened capsules, rounded, 4 to 5cm long with four compartments containing numerous brown to black kidney-shaped seeds. Fruits have 40 to 60 prominent spines approximately 3cm long on an egg-shaped capsule. The spines in the upper half of the capsule are longer than the spines in the lower half and somewhat compressed. Seeds are 4 to 5mm long, 3 to 4mm broad, have a pitted surface and are black in colour.

a. **b.** **c.**

Photo1. *Datura ferox: a. habit, b. leaf, c. fruit*

Fierce thorn apple is a weed of waste ground and disturbed areas in agricultural and pastoral lands. It generally prospers in warmer parts of both hemispheres. The fierce thorn apple is grown from seed in cases where it is used as an ornamental.

The historical use of fierce thorn apple is very similar to that of other *Datura* species. Members of the genus have been used medicinally as an anaesthetic for setting bones, for treating bruises and wounds, skin ulcers, haemorrhoids, dizziness, rheumatism and asthma (Bye et al., 1991; Litzinger, 1994). Many of the uses have been proven to be effective by modern science based on the presence of certain tropane alkaloids, notably scopolamine and atropine (Baker, 1994). The whole plant is poisonous, with seeds particularly so. Therefore seeds contain the highest concentration of these alkaloids.

Fierce thorn apple can be controlled by physical removal, preferably before seed set. For those plants already with seeds, they are collected and destroyed by burning. Registered herbicides are used for large infestations. The most popular way helping the spread of this plant is contaminated stock feed and agricultural seeds.

2.4. *Datura inoxia* Mill.; Downy Thorn Apple, Jimson-Wed, Angel's Trumpet, Indian Apple, Devil's Trumpet

The natural distribution of the devil's trumpet straddles at least three continents. It occurs in central and southern Mexico and south-western USA (Schultes and Hofmann, 1992). It is said to be native to the Americas but has been introduced and naturalised in Africa, Asia and Australia. It occurs mainly in countries with warm climates.

This is a coarse, stout, erect perennial or annual (cultivated forms), growing to a height of 2m. It has green, forked stems covered with dense short hairs. The taproot is stout, branched, extending horizontally or curving downwards to more than 1m deep. Adventitious roots often form at the stem base. Leaves are alternate, densely hairy, about 20cm long, broadly ovate to triangular, lobed, with slightly toothed margins. The leaves have a foul smell. Leaf petioles are 3 to 7cm long. Flowers are trumpet-shaped, short-stalked, erect or nodding and are borne singly in the forks of the branched stems. The calyx is 5-toothed, 5 to 7cm long and the corolla is white, purple, or yellow, 8 to 20cm long (often more in horticultural varieties). Fruits are ovoid, drooping capsules, 2 to 5cm in diameter, covered with stout, soft prickles 2 to 4mm long, and have four compartments containing numerous seeds. The capsules remain on the plant for a very long period. The seeds are 4 to 5mm long, yellow to black or grey to brown in colour, kidney or D-shaped and pitted.

Devil's trumpet flowers at dusk and hence is pollinated by night-flying sphinx moths, which look and act like small hummingbirds. The flowers have a night fragrance (Annie's Annuals, 2002) which is thought to help the moths.

Devil's trumpet is naturally a plant of disturbed areas such as eroded sites, old fields, overgrazed pastures and rangeland, roadsides and abandoned roadbeds. It is drought tolerant and thrives in a wide variety of well -drained soils, but does well in rich, well-manured loams. Disturbance and reduced competition from other plants seems to be required for the plant to become established and grow. The habitats of Daturas presume a close contact with humans, and some have speculated that the plant's success is entirely dependent on dispersal by man.

Tissues of the devil's trumpet and other *Datura* species, particularly the seeds have been used in shamanistic rituals as a path to enlightenment since ancient times (Schultes and Hofmann, 1992). All parts of the plant are anodyne, antispasmodic, hallucinogenic, hypnotic and narcotic (Emboden, 1979; Chopra et al, 1986). It has been used in the past as a painkiller and also in the treatment of insanity, fevers with catarrh, diarrhoea and skin diseases (Chopra et al., 1986). The plant contains several alkaloids, the most active of which is scopolamine (Chopra et al., 1986). This is a potent cholinergic-blocking hallucinogen, which has been used to calm schizoid patients (Weiner, 1980). The leaves contain 0.52% scopolamine, the calices 1.08%, the stems 0.3%, the roots 0.39%, the fruits 0.77%, the capsules 0.33%, the seeds 0.44% and the whole plant 0.52 to 0.62% (Chopra et al., 1986). It also contains hyoscyamine, and atropine. Atropine is used by opticians to dilate the pupils and by doctors to treat heart and urinary problems. Some herbalists also use it to treat birth and menstrual pains. The plant's effects are mainly stupefying. Users feel drowsy, drunk-like and become detached from things around them. They can also hallucinate. Any use of the plant should be with extreme caution and supervision of a qualified practitioner because the toxic and medicinal doses are very close. The doses are very difficult to judge and can easily cause unconsciousness and death. The use of this plant as

food is not recommended because of its toxicity. American Indians are however known to make a stupefying drink from the leaves and roots (Yanovsky, 1936). Alkaloid content varies significantly among species, within a species depending on the season or time of the day, and even within a particular plant (McCloy, 2004). It has also been used as an ornamental in recent times.

It is used in some parts of the world as an ornamental. It is propagated from seed. 3 to 4 seeds are sown in individual pots. The seed usually germinates in 3 to 6 weeks at 15°C. The seeds are sown indoors and the young plants are planted out as soon as the danger of frost has passed. It can not grow in the shade but prefers a sunny position.

Devil's trumpet is susceptible to various viruses that afflict most members of the potato family. Care should therefore be taken not to grow it near potatoes or tomatoes (Huxley, 1992).

The leaves and tops are preferably harvested when the plants are in full bloom, but they may be gathered at any time from the appearance of flowers. They should be stripped from the stem and dried as quickly as possible. Fresh leaves have a fetid odour, which is lost on drying. Seeds harvested for psychoactive purposes are collected by removing the capsules when they are ripe, but are still green and unopened. These are dried in the sun or by low heat.

Various drug products, trading under different names, are developed from devil's trumpet. Method of extraction and drug yield is dependent on the intended use of the alkaloid. All parts of the plant are hallucinogenic and hence they need to be handled carefully.

The devil's trumpet is a species with a wide range of both genotypic and phenotypic expressions. The morphology of both the vegetative and reproductive parts is variable. Genetic studies have revealed that Daturas have a chromosomal nature that is very susceptible to mutation enabling them to adapt almost anywhere, so they are prime candidates for morphological variation and advanced speciation (McCloy, 2004).

2.5. *Datura stramonium* L.; Thorn Apple, Jimson Weed, Devil's Apple, Devil's Trumpet, Stramonium

Datura stramonium is native to the Americas and has been introduced in many tropical, subtropical and even temperate regions. It is a naturalized weed in many African countries, but is probably seriously under-reported.

D. stramonium is an annual or short-lived perennial and erect herb up to 2 m tall, often much-branched. The stem is sparsely hairy to glabrous. The leaves are alternate, simple, and minutely hairy. The leaf petiole is up to 9.5 cm long and the leaf blade is ovate to rhombic-ovate or elliptical, 3–20 cm × 1–15 cm, with cuneate, rounded, truncate or cordate base, and an acute to acuminate or obtuse apex. The leaf margins are sharply toothed with irregular teeth or almost entire, pinnately veined. The flowers are borne on the leaf axils, solitary, rarely paired, bisexual, regular, and 5-merous. The flower pedicel is 5–15 mm long, up to 30 mm long in fruit. The calyx is tubular, 2.5–5 cm long, lobes unequal, 0.5–1 cm long. The corolla is trumpet-shaped to tubular, 6–10 cm long, white or faintly tinged purple, sometimes violet or purplish in the tube. The fruit is an upright, almost globose to ovoid capsule up to 5 cm × 4.5 cm, yellowish to brown, spines few to many, slender, stiff, up to 16 mm long, many-seeded. Seeds almost D-shaped, flattened, 3.5–4.5 mm × 2.5–3.5 mm × c. 1 mm, dark brown to black.

a. **b.**

Photo2. *Datura stramonium flowers.*

Only the basal part of the stem remains vegetative; flowering occurs on the branched part of the plant and branches do not resume vegetative growth after flowering and fruiting. The flowers are closed during the day and open in the evening, and are reported to be pollinated by hawk moths and to be largely self-fertile.

The hyoscyamine/scopolamine ratio in *Datura stramonium* is influenced by the developmental stage reached by the plants. In younger plants scopolamine is the main alkaloid, whereas hyoscyamine mostly becomes the dominant alkaloid when flower development has started. The alkaloids are produced in the roots and transferred to the leaves, flowers and finally the fruits.

Datura stramonium occurs in open locations such as grassland, roadsides, waste places, scrub vegetation and open forest. It tolerates various soil types but prefers clayey or loamy soils. *Datura stramonium* is frost sensitive. In the United States and Australia, *Datura stramonium* is considered a serious weed in crops; elsewhere it is considered a weed in waste land. Control is difficult as *Datura stramonium* is resistant to most commonly used herbicides. Contamination of sorghum, wheat, rye, buckwheat and linseed with seeds of *Datura stramonium* resulting in poisoning has been reported.

The most widely known use of *Datura stramonium* is for relieving asthma, cough, tuberculosis and bronchitis by smoking the dried leaves, roots or flowers. 'Asthma cigarettes' have been shown to be very effective in some cases, but in other cases they had little or no effect. Cigarettes made with the leaves are also used to treat Parkinson's disease. A decoction or infusion of leaves is given as a sedative to mental and schizophrenic patients. The leaves are applied as a dressing to cure rheumatic pain, swellings, wounds, gout, burns, ingrown toe-nails, fungal infections, tumours and ulcers. Dried pulverized leaves are dusted on wounds or applied after mixing the powder with fat or Vaseline.

In DR Congo pounded fresh root and fresh leaves are soaked in water and the liquid is given in enema as an abortifacient. In Zimbabwe a hot poultice of leaves and roots is applied to goitre. A leaf infusion is drunk to treat venereal diseases; to cure ulcers the skin is washed with an infusion of roots and leaves. In Burundi leaf ash is eaten as a cure for whooping cough. In Rwanda a leaf infusion is taken as an antispasmodic and to reduce stomach acidity. In Kenya dried and ground leaves and seeds are eaten mixed with fat to treat ringworm. Headache is relieved by rubbing the scalp with leaves or leaf sap. Hair loss is countered by applying fruit sap or leaf pulp and these also serve to remedy dandruff. In Ethiopia pieces of young fruit are sucked against tonsillitis and sore throat and applied to abscesses and swollen glands. In Kenya the fruit is heated in hot ash and after cooling juice is squeezed and used as ear drops to treat earache. In Zimbabwe an infusion of fruit ash is drunk to treat stomach-ache. In Lesotho the seed oil is used as ear drops to treat headache. In Ethiopia the smoke of burning seeds is inhaled to relieve toothache, while in Kenya fresh green fruit is applied for this purpose. In Namibia a leaf extract is administered to cows to ensure a rapid expulsion of the afterbirth and pulped roots are mixed with water and given to cattle to cure lung diseases. The dried leaves and seeds of *Datura stramonium* are included in the pharmacopoeias of many Western countries as an antispasmodic and for treatment of asthma, whooping cough and Parkinson's disease.

The narcotic use of *Datura stramonium* varies between cultures. In Central and South America hallucinogenic uses are common among native tribes. In Africa, before they enter fighting contests, young men of the Fulfulde people of the border area of Niger and Nigeria are served drinks containing *Datura* seeds. This increases their courage and pain tolerance. The leaves are most commonly used as a narcotic, either smoked or boiled and eaten; seeds are similarly used. Roots, seeds or leaves are added to alcoholic drinks to increase the intoxicating effect. Side effects include dry mouth and throat, eye pain, blurred vision, restlessness, dizziness, arrhythmia, flushing and faintness. An overdose will cause headache, nausea, vomiting and affect the central nervous system causing disorientation, hallucinations, euphoria, inappropriate affect, short-term memory loss and coma. The seeds are also used for criminal purposes. Hospital admissions and fatalities, most often of adolescents, are not uncommon.

Reports on the use of the plant as insecticide vary from good control of aphids in crops in Namibia to no effects in Australia. In East Africa the leaves yield a green dye that is used to dye cloth; in Lesotho the twigs yield a blue-green dye that is used for house decoration. In Ethiopia the plant has been used to tattoo the gums, partly as a treatment of gingivitis or dental decay. The stems are used as firewood. In Kenya the seed oil is used as massage oil.

3. CONCLUSION

The uses of members of *Datura* exemplify the thin line between a plant being medicinal to being psychoactive. Used under the direction of a medical practitioner and in the correct dosage, the Daturas are very useful medicinally. It however is unfortunate that some people exploit the same active principles in the plants to conjure some hallucinogenic effects.

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