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Review article

Psychoactive constituents of the genus *Sceletium* N.E.Br. and other Mesembryanthemaceae: a review

Michael T. Smith*[a], Neil R. Crouch[b], Nigel Gericke[c], Manton Hirst[d]

[a]*Botany Department, University of Natal, Private Bag X01, Scottsville, 3209 Pietermaritzburg, South Africa*
[b]*National Botanical Institute, Ethnobotany Section, Natal Herbarium, Botanic Gardens Road, Durban 4001, South Africa*
[c]*TRAMED, Department of Pharmacology, Medical School, University of Cape Town, Observatory 7925, South Africa*
[d]*Kaffrarian Museum, P.O. Box 1434, Kingwilliam's Town 5600, South Africa*

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Abstract

The use by the Khoisan of South Africa of *Sceletium* plants in psychoactive preparations has often been alluded to in the literature. However, much of it is fragmentary and contradictory. The current review reassembles the historical data recorded over a 300-year period, describes techniques for the preparation and use of 'kougoed' from plants of *Sceletium* and documents the subjective experiences of a number of contemporary users. Apart from chewing the dried product, after 'fermentation', there are reports of uses as tinctures for sedation and analgesia, chewing the material directly and smoking the residue after chewing. The symbolic connections of *Sceletium* with eland antelopes, the 'trance animals' par excellence of the San hunter-gatherers is noted. Observations by Paterson (1789) and reports of contemporary users indicate a synergism and potentiation with smoked *Cannabis*. There is no evidence to support the view that 'kougoed' or *Sceletium* alkaloids are hallucinogenic. The alkaloid distribution in *Sceletium* and other members of the family Mesembryanthemaceae are considered. Chemical studies have indicated as many as nine alkaloids in *Sceletium* which fall into three distinct structural categories. Mesembrine, the alkaloid first isolated and named is not the dominant constituent of plants and is weakly narcotic. Evidence is assembled to suggest that traditional and contemporary methods of preparation serve to reduce levels of potentially harmful oxalates, which are found in *Sceletium* and other Mesembryanthemaceae. It is concluded that there is a need for further pharmacological studies on these alkaloids, based on their narcotic-anxiolytic properties, strong synergism with other psychomimetics, moderate toxicity and anti-cancer activity.

Keywords: Sceletium; Mesembryanthemaceae; Alkaloids; Oxalates; Hallucinogens; Anxiolytic agent

* Corresponding author.

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1. Introduction

It has been observed (Schultes and Hofmann, 1979; Schultes and Farnsworth, 1980) that of the 200 or more psychoactive plants that have been identified world-wide, nearly 90% are native to the Americas. There is little doubt that much of this apparent discrepancy is the result of insufficient study. For instance, Guzman's (1983) monograph indicates an absence of psychoactive species of *Psilocybe* (Fr.) Quél. in sub-Saharan Africa. The recent discovery in KwaZulu-Natal of a new species of hallucinogenic fungus, *Psilocybe natalensis* Gartz and Smith (Gartz et al., 1995), clearly attests to the under-investigation of the southern African flora for psychoactive plants. South Africa is both floristically rich and diverse, and local attention has recently been focused on the use of information from folk medicine as a starting point for pharmaceutical research (Fourie et al., 1992). With few exceptions, the peoples of Africa have exploited psychotropic plants to only a limited degree (Schultes, 1977; Emboden, 1979; Dobkin de Rios, 1990; Weil and Davis, 1994), possibly because of cultural restraints.

Although not mentioned in the classical ethnography of the Khoisan, use of plants of the genus *Sceletium* N.E.Br. has entered the literature (Watt and Breyer-Brandwijk, 1962; Schultes, 1970). Plants were reportedly highly esteemed and sought after by both Khoi pastoralists and San (Bushmen) hunter-gatherers (Watt and Breyer-Brandwijk, 1962; Rood, 1994), yet there is a distinct lack of specific information on details such as preparation, psychoactivity and species used. Furthermore, only limited human pharmacological studies on the active constituent(s) of this plant appear to have been done.

The purpose of this review is threefold. Firstly, we wish to reassemble the data accumulated over some 300 years, thereby highlighting the neglect and uncertainties associated with the genus *Sceletium* in particular, (originally included in *Mesembryanthemum* L.) and the Mesembryanthemaceae Fenzl in general. The second is to record what was probably the original folk method of preparation of *Sceletium*, based on field observations. Thirdly, the psychoactive properties of *Sceletium* are documented by reporting on the experiences of several test subjects.

2. Historical record

Historically, at least as far back as the 17th century, the Little Karoo and Namaqualand, two localities where *Sceletium* species are known to occur, were inhabited by nomadic groups of Khoi and San (see, for example, van der Stel's Journal of the Expedition into Namaqualand; Waterhouse, 1932). Elphick (1977) points out that the Khoi were originally hunter-gatherers who adopted pastoralism and, as a result, effected major changes in the economy, size and social structure of the hunter-gatherer band. This thesis adequately accounts for both the cultural similarities and differences between Khoi and San. The utilisation of *Sceletium* species appears to be one such case of cultural convergence between Khoi and San, as is its symbolic connections with the eland (*Taurotragus oryx* Pallas), indicating a shared history of hunting and gathering. Lewis-Williams (1981) has drawn attention to the symbolic significance of the eland in San thought as the 'trance animal' par excellence. It is a predominant and widely recurring feature of San rock art in southern Africa. Quite apart from its economic importance as one of the major objects of the hunt, the eland was symbolically linked to fertility, marriage, rainmaking, divination, dancing, trance and healing. Whether or not *Sceletium* was chewed or mixed with 'dagga' (*Cannabis sativa* L.) and smoked, there are suggestions that it induced Khoi users to dance (Laidler, 1928). The Khoi of the Little Karoo certainly referred to *Sceletium* and the eland by the same term 'Kanna' (sometimes also spelt 'channa' or 'canna' (c.f. Burchell, 1822). Hence, the derivation of the place-name 'Kannaland' (or 'Canna Land', Raper and Boucher, 1988) which was used by the early white settlers in reference to the Little Karoo, was doubtless a reflection of the fact that *Sceletium* and eland cooccurred in abundance (Nienaber and Raper, 1977). The term 'Kanna' is not to be confused with 'ganna' (*Salsola dealata* Botsch.), which the early settlers used in soap making, nor with 'kamma', the Khoi term for water; there appears to have been a considerable degree of confusion in some of the early writings with respect to the vernacular name given to *Sceletium* by the indigenous peoples. It is recorded that in 1662 van Riebeeck bartered with the local inhabitants, in return receiving sheep and 'kanna'. This plant was prized by the Europeans as a ginseng-like herb (Laidler, 1928), and is unlikely to have been hallucinogenic, although Kolben (1738) noted that the scarce root was the:

> 'greatest Chearer of the Spirits, and the noblest Restorative in the World'. He indicates some uncertainty about the plant, but cites a Father Tachart's commentary: 'tis something like the 'European Mandragora', but much less ... it resembles the 'Mandragora' pretty nearly in its effects too'.

From the labelled illustration presented (*Aureliana canadensis*), it is clear that the rootstock is mandrake-like, but the plant clearly not of the Mesembryanthemaceae. In all probability Kolben's illustration was used for general effect rather than botanical accuracy.

Much of the early confusion in naming of plants appears to result from settlers confusing similar-sounding words of the indigenous languages, aggravated by looseness and inaccuracies. It is easy to corrupt the Dutch colonists 'channa' to 'kanna' or 'canna'. Smith (1966) provides a clear indication of this confusion in his dictionary of common plant names of South Africa. Errors have been perpetuated in some of the more recent literature, where 'kanna' has been used to describe 'kougoed' or 'kauwgoed' prepared from *Sceletium* (e.g. the Merck Index; Jacobsen, 1960). Nevertheless, it is recorded in 1685 by van der Stel, the second colonial governor of the Dutch Cape colony, in his journal:

> 'They chew mostly a certain plant which they call Canna and which they bruise, roots as well as the stem, between the stones and store and preserve in sewn-up sheepskins. When we came to the Coperbergh in October, it was being gathered from the surrounding hills by everybody (to serve as a supply for the whole year). They use it as the Indians use betel or areca, and are of a very cheerful nature'.

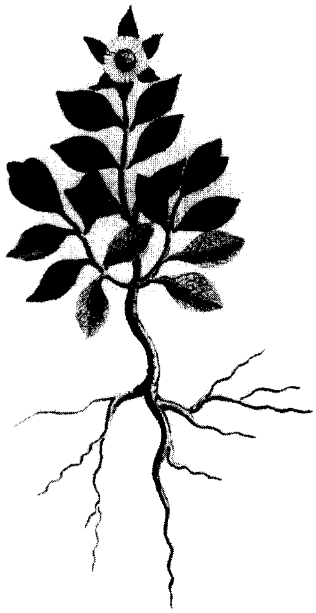

Fig. 1. Illustration from Simon van der Stel's Journal of 1685 of putative mesembryanthemaceous flower and skeletoid leaf typical of *Sceletium*.

Accompanying the illustration (Fig. 1), which leaves little doubt that the plant was a species of *Sceletium*, was the caption:

> 'This plant is found with the Namaquaas and then only on some of their mountains... It is held by them and surrounding tribes in as great esteem as the betel or areca with the Indians. They chew its stem as well as the roots, mostly all day, and become intoxicated by it, so that on account of this effect and its fragrance and hearty taste one can expect some profit from its cultivation' (Waterhouse, 1932; Waterhouse et al., 1979).

This observation is probably the first to attribute intoxicating properties to *Sceletium*. The value of *Sceletium* as a trade item and its value in suppressing hunger and thirst, were noted by Thunberg in his 1773 expedition:

> 'The Hottentots come far and near to fetch this

shrub with the root, leaves and all, which they beat together, and afterwards twist them up like pig-tail tobacco; after which they let the mass ferment and keep it by them for chewing, especially when they are thirsty. If chewed immediately after fermentation, it intoxicates. The word kon, is said to signify the quid; the colonists call it Canna-root... The Hottentots, who live near this spot.. hawke it about, frequently to a great distance, and exchange it for cattle and other commodities.' (Thunberg, 1794).

From these accounts it is apparent that there was a seasonal and almost ritualistic gathering at a specific locality, and that the value of the material warranted such collection, storage, and barter. The reputed intoxicating effects, as well as preparation by fermentation, are noteworthy and will be discussed further (Section 5).

Plants of the genus *Sceletium* were first shown to contain an alkaloid by Meiring (1898) who isolated the, then, unknown mesembrine from *Sceletium tortuosum* (L.) N.E.Br. and demonstrated a rapid physiological response in frogs to subcutaneous injection of a 'few drops' of the alkaloid. His bioassays also included guinea pigs, which were noted as being much more tolerant of the alkaloid. Uneasiness and loss of appetite were the only recorded responses. Meiring also noted that some frogs and guinea pigs died. Some time later, several *Mesembryanthemum* samples were sent by H.W.R. Marloth, a pharmacist, analytical chemist and botanist (Gunn and Codd, 1981) to Professor C. Hartwich in Zurich. E. Zwicky, a student of the latter, produced a dissertation 'Über channa' in 1914 in which *Sceletium expansum* (L.) L. Bolus and *Sceletium tortuosum* (L.) N.E.Br. were reported to contain alkaloids, to which the trivial name mesembrin (now mesembrine) was given.

The impression is given (Herre, 1971) that *Sceletium* is a richer source of alkaloids than other *Mesembryanthemums*, although *Mesembryanthemum crystallinum* L. is also reputedly relatively rich in alkaloids. However, the latter also contains high levels of oxalates, which is a gastric irritant that may cause bladder or kidney stones. The fact that farmers reputedly use this plant to take hair off animal skins (Laidler, 1928) suggests its ingestion would be contra-indicated!

3. Alkaloid distribution within the Mesembryanthemaceae

It is impossible, based on available information to draw any conclusions about the taxonomic implications of alkaloid distribution in the Mesembryanthemaceae. Currently two subfamilies are recognized, the Mesembryanthemoideae and Ruschioideae, and some of the recent taxonomy is in a state of flux (Bittrich, 1986; Hartmann, 1991). It has been suggested, for instance, that *Sceletium* N.E.Br. is a basionym for *Phyllobolus* subgenus *Sceletium* (N.E.Br.) Bittrich, but species names have not been suggested (Bittrich, 1986).

Nevertheless, using the data provided by Watt and Breyer-Brandwijk (1962) and the older classification scheme presented by Herre (1971) it is possible to note some interesting patterns of alkaloid distribution by plant genera. The genus *Sceletium* N.E.Br. is in one of the five subtribes in the subfamily Mesembryanthemoideae and five of the six genera investigated tested positive for alkaloid (*Aptenia* N.E.Br., *Prenia* N.E.Br., *Sceletium* N.E.Br., *Aridaria* N.E.Br., *Psilocaulon* N.E.Br.). Within the larger subfamily Ruschioideae, only five of the twenty-two subtribes of the tribe Ruschieae have been investigated, and that somewhat unrepresentatively. Four out of five species of *Ruschia* Schwantes (subtribe Ruschiinae) were tested positive; *Lampranthus* N.E.Br. (subtribe Lampranthinae) tested both positive and negative. Six out of the nine species investigated in the subtribe Delospermatinae were positive (*Delosperma* N.E.Br., *Drosanthemum* Schwantes, *Trichodiadema* Schwantes, *Mestoklema* N.E.Br. ex Glen). In the subtribes Conophytinae and Malephorinae, the genera *Conophytum* N.E.Br. and *Glottiphyllum* Haw. tested alkaloid-positive. It should be stressed that these were general alkaloid tests and do not necessarily indicate only mesembrine-like alkaloids. For example, Rimington and Roets (1937) isolated piperidine hydrochloride as the toxic alkaloidal constituent of *Psilocaulon absimile* N.E.Br.

Additionally, although the tests were not quantitative, some plants possessed only traces of alkaloid, namely *Delosperma subincanum* (Haw.) Schwantes., *Delosperma ecklonis* Salm-Dyck Schwantes, *Lampranthus deltoides* (L.) Wijnands and *Ruschia rubricalis* (Haw.) L. Bolus.

It should be noted that 116 genera are recognised within the Mesembryanthemaceae (Hartmann, 1991), some of which contain less than ten species (*Aptenia* N.E.Br., *Prenia* N.E.Br. and *Mestoklema* N.E.Br. ex Glen). Whereas there are over one hundred species in each of the genera *Drosanthemum* Schwantes and *Delosperma* N.E.Br., over two hundred and three hundred species are known for *Lampranthus* N.E.Br. and *Ruschia* Schwantes, respectively (Arnold and de Wet, 1993). The extent of under-investigation of the Mesembryanthemaceae with respect to alkaloids is illustrated in Fig. 2 where twelve of the thirteen genera (*Psilocaulon* is excluded, see above) which tested alkaloid-positive by Zwicky are presented graphically, by the number of species. It is a salutatory observation that of the possible number of species, less than 0.04% have been investigated.

Several points warrant further comment and investigation. Levels of secondary plant products, including alkaloids, are strongly influenced by factors such as the age of plants, growing conditions, season and even geographical race. Turnover and degradation of plant alkaloids is a well-established concept and seasonal fluctuations in levels have been documented in many cases (Barz and Köster, 1981). Although many Mesembryanthemums were introduced into cultivation in Europe by early

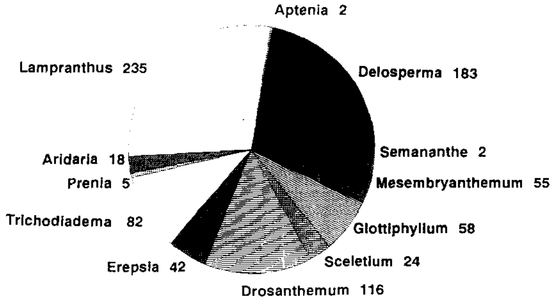

Fig. 2. Species numbers present in the genera of Mesembryanthemaceae investigated for the presence of alkaloids.

plant collectors in the Cape there is a paucity of phytochemical studies. *Sceletium* was apparently grown in England from 1705 (Bolus, 1928). Haworth (1794) recorded that the 'houseleek leav'd fig marygold' (*Sceletium expansum*) flowered abundantly between June and August, while *Sceletium tortuosum*, the 'tortuose fig-marygold' acquired a considerable stem with age. *Sceletium anatomicum* (Haw.) L. Bolus, the 'skeleton-leav'd fig-marygold' was cultivated somewhat later (Aiton, 1811). Herre (1971) reported that plants cultivated in Germany did not form alkaloids, whereas those cultivated in the United States did (further details not given; see below). The precise basis for this discrepancy awaits elucidation. Some twenty-four species of *Sceletium* are recognised, but only *Sceletium joubertii* L. Bolus, *Sceletium namaquense* L. Bolus, *Sceletium strictum* L. Bolus, *Sceletium tortuosum* (L.) N.E.Br. have been investigated chemically and shown to contain mesembrine-like alkaloids. Studies by Jeffs et al. (1971) indicated greater biosynthesis of alkaloids in *Sceletium strictum* L. Bolus during the spring and summer, suggesting that levels may change seasonally. It is significant that within genera of the Mesembryanthemaceae, different species were tested both alkaloid-positive and negative. Alkaloids based on phenylalanine-tyrosine are found in the Cactaceae and the 'mesembrine variant' is formed in the Mesembryanthemaceae (Hegnauer, 1988). Both these families are placed in the superorder Caryophyllidae (Rowley, 1978). Although reference has been made to the alkaloids in *Sceletium* being either cocaine-like (Jacobson, 1960) or hyoscyamine-like (Watt and Breyer-Brandwijk, 1962; Lewis and Elvin-Lewis, 1977), more correctly, they show structural similarity to the Amaryllidaceae alkaloids of the crinane class (Jeffs et al., 1971; Schultes, 1977).

Although there has been support for taxonomically discrete alkaloids and alkaloid pathways at family and order levels its significance may now be questionable. Both amaryllidaceous and mesembrine-type alkaloids share a common biogenetic pathway, although the biosynthetic pathways are fundamentally different (Jeffs et al., 1978). However, the presence of mesembrine alkaloids in *Narcissus pallidulus* (Bastida et al., 1989) may suggest that such discrete chemotaxonomic criteria not be as sharp as previously believed (Hegnauer, 1988).

Sceletium tortuosum (L.) N.E.Br. was reported to contain 0.3% and 0.86% mesembrine in the leaves and stems, respectively (Watt and Breyer-Brandwijk, 1932). Popelak and Lettenbauer (1968) reported that levels of alkaloids in 'kougoed' ranged from 1–1.5%, while mesembrine and mesembrenine levels were 0.7 and 0.2%, respectively. While this suggests that mesembrine may often be the most abundant alkaloid, it is important to note that the phenolic alkaloid constituents of the plant represent a highly complex, multi-component mixture (Jeffs et al., 1974) with as many as nine alkaloidal components (Popelak and Lettenbauer, 1968). Some of these are illustrated in Fig. 3, along with two synthetic analogues which have been patented by the Tanabe Seiyaku Company of Osaka, Japan. These had weak sedative effects on reserpine-induced central inhibition tests (Nabe, personal communication). Jeffs et al. (1974) presented a unified biogenetic scheme of the *Sceletium* alkaloids and distinguished three broad structural categories. One is typified by mesembrine, sceletenone, mesembrenone and mesembranol. A different skeletal type is typified by the dehydrojoubertiamine molecule (Fig. 3), first isolated from *Sceletium joubertii* by Arndt and Kruger (1970). Interestingly, these workers also reported the presence of hordenine in this species. Unidentified species of *Delosperma* have been reported to contain methyltryptamine and dimethyltryptamine (Smith, 1977), although these would not be psychoactive orally without a monoamine oxidase inhibitor (Schultes, 1976; McKenna et al., 1984). *Sceletium tortuosum* was found to contain a third structural variant, *Sceletium* A4 and tortuosamine (Snyckers et al., 1971). Jeffs et al. (1970) found that 3-year-old plants of *Sceletium strictum* grown from seed yielded, from a dry cake

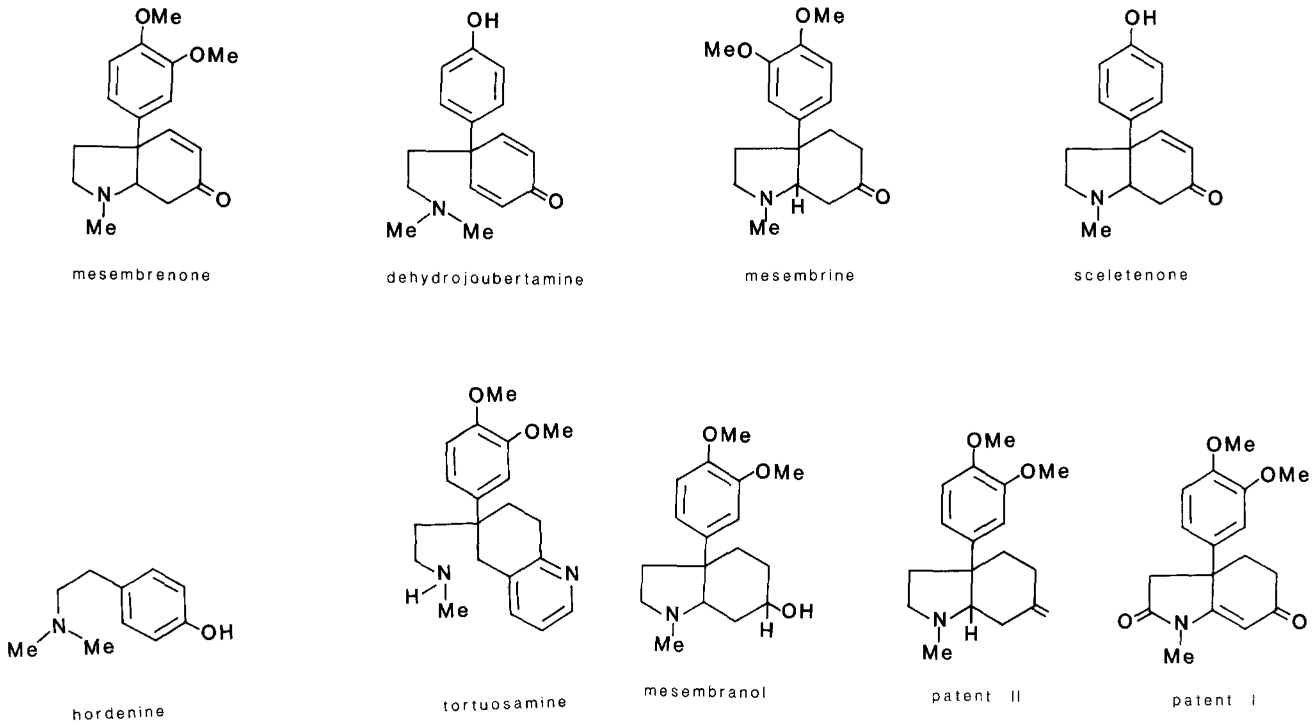

Fig. 3. Some alkaloids present in *Sceletium* along with two patented analogues of weak pharmacological activity.

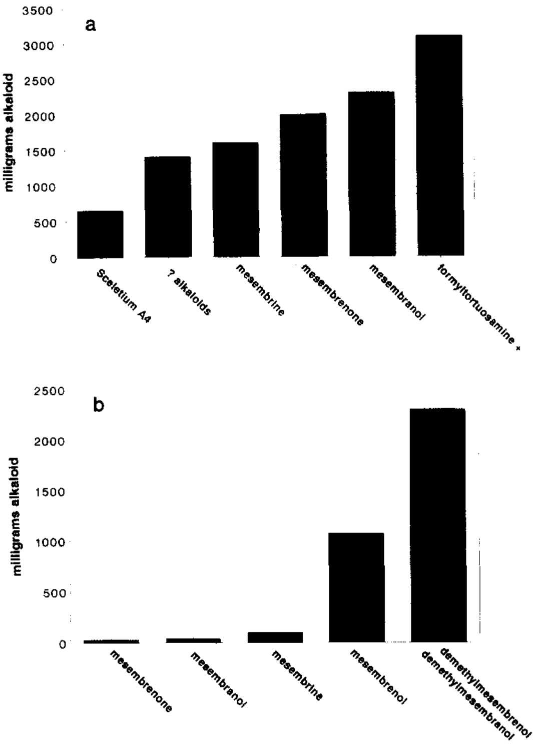

Fig. 4. Varying alkaloid levels identified in (a) *Sceletium namaquense* and (b) *Sceletium strictum*. ?, unknown alkaloids; +, denotes alkaloids additional to that indicated.

weight of 151 g, some 4 g of alkaloid. Over half of this was demethylmesembrenol and demethylmesembranol, followed by mesembrenol, mesembrine, mesembranol, mesembrenone (Fig. 4). Curiously, on one occasion *o*-acetylmesembrenol proved to be the major alkaloid. In a later study (Jeffs et al., 1974) 3.5 kg dry weight *Sceletium namaquense* yielded 50 g of alkaloidal material. When 20 g were subjected to column chromatography, formyltortuosamine and unidentified alkaloids predominated, followed by mesembranol, mesembrenone, mesembrine, unidentified alkaloids and mesembrenone, and *Sceletium* A4 alkaloid.

These vastly different alkaloid levels and types serve to highlight our poor state of knowledge, and suggest that a clear understanding of the psychoactive properties of 'kougoed', and of alkaloid biosynthesis by the plants, has yet to be achieved.

4. Alkaloid activity of *Sceletium* as reported in the literature

There are many reports in the literature concerning the activity and use of 'kougoed' by the indigenous peoples. How many are based on critical observation, as opposed to hearsay is difficult to determine. Laidler (1928) notes that it was:

> 'chewed and retained in the mouth for a while, when their spirits would rise, eyes brighten and faces take on a jovial air, and they would commence to dance. But if indulged in to excess it robbed them of their senses and they became intoxicated.'

Reputed negative side effects include headaches, listlessness, loss of appetite and depression (Marloth, 1913). The narcotic properties of the product are frequently cited in the literature, supposedly only after the 'fermentation' process (Watt and Breyer-Brandwijk 1962; see below). However, tinctures were used by the early white settlers as a sedative, and chewing of the leaves was useful for toothache and stomach pains (Laidler, 1928). Zwicky (1914) reported discomfort, analgesia and a slight headache following ingestion of 'kougoed', swallowing a decoction, or taking the hydrochloride salt of the alkaloid. No stimulatory action was observed. Perhaps the most remarkable claim is to be found in Watt and Breyer-Brandwijk (1962) who cite the observations of a mining engineer (and apparently also a social scientist and moralist!). The Nama peoples had a 'universal addiction' to the use of 'kougoed' which 'produces visions' and led to a 'serious degree of moral degeneration particularly with regard to veracity and sex'. This unsubstantiated notion was later promulgated by Lewis and Elvin-Lewis (1977).

Although 'kougoed' was primarily chewed, there are reports of it being taken as a tea (Jacobsen 1960; Watt and Breyer-Brandwijk, 1962) and also as a snuff (Jacobsen, 1960). This latter mode of administration has also been used for the 'keng-keng' of the Griquas who used another genus of the Mesembryanthemaceae, *Rabaiea albinota* (Haw.) N.E.Br. (= *Nananthus albinotus* N.E.Br.) as an additive to tobacco or snuff (Emboden, 1979). Since the narcotic effect of 'kougoed' can be effectively achieved sublingually, there is little reason to doubt the efficacy of administration by snuff. Smoke-derived volatiles would have a somewhat different chemistry, but could presumably have been just as effective pharmacologically. Of relevance in this regard Thunberg (1794) wrote in his journal of the San: 'These people chew 'Canna' (*Mesembryanthemum*) and afterwards smoke it'. Paterson, a traveller of the same period, recorded in 1789:

> 'We now proceeded...to enter into a country which is, perhaps, one of the most barren in the world. This is called the Channa Land: and derives its name from a species of *Mezembryanthimum* (sic), which is called Channa by the natives, and is exceedingly esteemed among them. They make use of it both in chewing and in smoaking (sic); when mixed with the Dacka (sic) is very intoxicating, and which appeared to be of that species of hemp which is used in the East Indies by the name of Bang'.

5. Field studies and pharmacological investigations

In view of the somewhat contradictory information about *Sceletium* and 'kougoed', one of the authors undertook a field trip to Namaqualand where plants are collected and prepared using traditional methods, for commercial resale. In keeping with literature observations, the plant material is crushed between stones following harvest and allowed to remain in closed containers for several days to 'ferment'. An informant reported that historically, a skin or canvas bag was used as a fermentation vessel, but that these have been replaced by plastic bags. The informant detailed his technique:

> 'Leave the bag of crushed 'kougoed' in the sun to get warm; its not necessary to put it (the bag) in the shade, it gets shade at night, and the sun doesn't harm it. The plant is left to sweat. After 2–3 days the bag is opened, the 'kougoed' is mixed around, and then the bag is tightly closed again. On the 8th day after the crushing, the bag is opened and the 'kougoed' is spread out to dry in the sun, as when you dry raisins. You leave it out until it is dry. If you don't do the whole thing, the plant won't have power. If you eat the fresh plant nothing will happen — it doesn't have power. I learned to prepare it from my father'.

The finished product is stringy, light brown and unattractive in appearance. The informant noted that the season of collection of plants was important; plants collected too early would posses less psychoactivity.

A second informant described an alternative preparation technique, employed when the user seeks to rapidly prepare 'kougoed'. A small fire is made over sand, and when it dies down, the ashes are scraped aside, and a hollow made in the sand. A freshly picked, whole *Sceletium* plant is placed in this excavation, and covered with hot sand. An hour later the baked plant product is recovered, reputedly with acquired properties similar to the conventionally prepared material. Lewis-Williams (1981) describes a similar method for preparing eland fat among the San, the only difference being that it was left to cook overnight. In the Coloured community, to this day, 'ou vet' (old fat) is a colloquial expression for dagga (*Cannabis sativa*).

On one occasion two of the authors took 2 g of conventionally-prepared 'kougoed' by mouth with a small quantity of alcohol, and held the material in the mouth for 10 min. Some of the product was swallowed with saliva during this period. No major discomfort was encountered and after about 30 min both subjects felt a 'tranquil mellowness'. There was no impairment of motor function, and no visual hallucinations were experienced. On a separate occasion, 2 weeks later, the subjects took 1 g of material prepared by another of the co-authors. This material induced the same effects as previously, but appeared to be slightly stronger. This second sample, however, differed from the first in several respects: the preparation included the root, and was prepared in a different season from plants of different origin. When the subjects further attempted to ingest unfermented plant material which had been freeze-dried, by mouth, the acidity was most objectionable and the exercise was discontinued. The discomfort was not unlike that of placing a crystal of oxalic acid under the tongue; the pH of aqueous extracts of freeze-dried material was later determined to be between 5 and 5.5.

An analysis of this material using the technique of Sutikno et al. (1987) indicated levels of 3.6–5.1% oxalate. This is higher than the levels of 1.9% reported for elephant grass by those authors, but falls within the median range for oxalates in crop plants reported by Libert and Franceschi (1987). Our observation, and reports by others of oxalates in *Sceletium* (Watt and Breyer-Brandwijk, 1962; Kellerman et al., 1988) have led us to the view that perhaps the physical crushing of the plant and the fermentation process may, in some way, ameliorate the potentially harmful effects of oxalic acid. Free oxalic acid is likely to complex with cell wall-associated calcium salts and precipitate as calcium oxalate when plant material is crushed.

Hanson et al. (1989) have suggested that a low bioavailability of oxalates in plant tissues may be a function of high ratios of minerals such as calcium and magnesium to oxalate.

Oxalates are degraded by microbial populations in the gastrointestinal tract of humans, ruminants and non-ruminant herbivores (Daniel et al., 1987). There is evidence that adaptive changes in microbial microflora may reduce oxalate absorption and toxicity (Argenzio et al., 1988). Allison et al. (1985) have proposed that these anaerobes be named *Oxalobacter formigenes* and it has been suggested that soils and lake sediments may serve as an inoculum for oxalate degrading organisms in the digestive tract of animals (Smith et al., 1985). We would like to suggest that the crushing process, prior to anaerobic fermentation would introduce oxalate-degrading microbes into the skin or plastic bag and so ameliorate the potential toxic effects of oxalic acid. The use of Mesembryanthemaceae to initiate fermentation for alcohol or breadmaking is well documented (Juritz, 1906; Watt and Breyer-Brandwijk, 1962), so that the microbiology of 'fermentation' in 'kougoed' is likely to be quite complex.

The second preparatory method involving burying plant material in hot sand may also have a scientific basis. Oxalic acid is a simple dicarboxylic acid, and considerable sublimation is likely to occur at temperatures above its melting point of 101–102°C; on the other hand, mesembrine only boils between 186–190°C (Merck Index).

Hence the use of this simple physical technique may achieve the same result as the more traditional 'fermentation' process by removing oxalates, and drying the material while retaining alkaloids.

Additional information on the effect of 'kougoed' has been documented from a dozen individuals who self-experimented with the traditionally prepared material, and provided oral anecdotes of these experiences. Most users found that the 'kougoed' induced a marked anxiolytic effect. One informant used approximately 5 ml of powdered 'kougoed' orally before giving a lecture that he was anxious about. He reported feeling relaxed throughout the lecture, with no cognitive impairment. Many users felt that 'kougoed', in addition to alcohol or on its own, enhanced social intercourse at parties and functions. Users felt considerably less inhibited and self-conscious, and more open than usual in conversation with strangers. One user claimed that she felt that 'kougoed' was a 'truth drug'.

Of 'kougoed', some felt that there was a synergistic effect with alcohol, and with smoked 'dagga' (*Cannabis sativa*). One experimenter, a poly-substance abuser, used 'kougoed' in addition to alcohol (whisky) and smoked 'dagga'. He experienced a traumatic flashback to a violent event he had participated in during a regional armed conflict. Another experimenter, who on two separate occasions smoked 'dagga' after chewing 'kougoed', reported seeing distinct visions of the *Sceletium* flower and was able to accurately describe its form and colour, without ever having seen a specimen of it. The chewing of 'kougoed' was reported to greatly enhance the psychoactivity of an inferior grade of *Cannabis* smoked shortly thereafter (see also 4, above, Paterson's commentary on synergism).

A poly-substance abuser addicted to nicotine and a frequent abuser of alcohol and 'dagga', reported that after using a single dose of 'kougoed', he had felt no craving for alcohol, tobacco or 'dagga' for 4 days.

Some reported euphoria as well as a feeling of meditative tranquillity. Several users felt that the relaxation induced by 'kougoed' enabled one to focus on inner thoughts and feelings, if one wished, or to concentrate on the beauty of nature. Some informants reported heightened sensation of skin to fine touch, as well as sexual arousal. A senior traditional African healer, not previously exposed to 'kougoed', tried it and announced that it 'relaxes the mind' and one's body feels 'light' the following day.

A white Namaqualand farmer, who has observed his shepherds and labourers using 'kougoed', points out that it is not possible to discern that they are intoxicated with it: they walk normally and work as usual. The only sign that they have been using 'kougoed', he says, is 'a sort of faraway look in their eyes'. Three first-time users reported experiencing clouding of consciousness with doses that caused intoxication. A horticulturist reported that he was once stung by a bee while on a field-trip. He chewed on some 'kougoed' (for the first time) in the hope that it would alleviate the pain. The pain subsided rapidly but no intoxication was experienced.

Rood (1994) includes a number of anecdotes on *Sceletium anatomicum*. A Mr. P. van Breda of Worcester reported that if enough is eaten, it anaesthetizes the lower jaw sufficiently to enable a tooth to be extracted painlessly. Mrs. Helena Marincowitz of Prins Albert reported that San mothers used to simply chew the root and spit the juice into the mouth of an infant, who would then sleep soundly for a few hours. Mrs. Lettie van Niekerk of Kamieskroon reported that it is an excellent carminative for stomach ailments and winds. Mr. J.H. Cornelissen stated that Blacks from Queenstown and Khoisan from Namaqualand use an infusion of the leaves of *Sceletium tortuosum* to relieve pain and alleviate hunger.

6. Conclusion

It may be concluded from the evidence presented that 'kougoed' and the *Sceletium* alkaloids show no hallucinogenic properties, but rather are narcotic-anxiolytic. This and their strongly synergistic interaction with other psychomimetics indicates a serious need for thorough pharmacological investigations. Foremost amongst these would be toxicity and mode of action, such as receptor binding. A recent study has shown that although mesembrenone was considerably less toxic to mouse fibroblasts that twenty-one amaryllidaceous alkaloids tested in vitro, it was moderately effective against cancer cells (Weniger et al., 1995).

According to the observations of plant gatherers, plants of *Sceletium tortuosum* and *Sceletium strictum* are becoming increasingly scarce. Dwindling natural populations point to possible over-exploitation. A resurgence of interest in *Sceletium* alkaloids will serve to encourage cultivation of these plants, either in the natural habitat, botanical gardens, or elsewhere, especially as these taxa are reputedly easily grown (Schwantes, 1953).

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