ALKALOIDS FROM *Papaver bracteatum* LINDL.*

Jiří SLAVÍK and Leonora SLAVÍKOVÁ

Department of Medical Chemistry and Biochemistry, Purkyně University, 662 43 Brno

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N-Methylthebainium (as iodide) and corytuberine were isolated from the roots and green aerial parts of *Papaver bracteatum* LINDL., thebaine race Halle III, as significant alkaloids in addition to the predominant alkaloid thebaine (0·61 and 0·23% respectively), as well as the minor alkaloids isothebaine, scoulerine, protopine, epialpinine (O-methylalpinigenine), N-methylisothebainium (as iodide), isoboldine, corydine, rhoeadine, magnoflorine, a mixture of coptisine and palmatine and a new alkaloid PB 1 $C_{18}H_{19}NO_4$. Bracteoline and papaverrubines G, E, D and C were detected chromatographically. From the ripe capsules of the race Halle III N-methylthebainium (as perchlorate), corytuberine and a mixture of coptisine and palmatine were isolated in addition to thebaine (0·67%). From the ripe capsules of *P. bracteatum*, population Demavend (Iran), thebaine (0·56%), epialpinine, alpinigenine, corytuberine, N-methylthebainium (as iodide) and a mixture of coptisine and palmatine were isolated and the presence of papaverrubines G, D and C was detected. In the latex of flowering plants salutaridine was also detected. Fourteen of the mentioned alkaloids were detected in the species *P. bracteatum* for the first time.

Papaver bracteatum LINDL. from the section *Macrantha* ELKAN (*Oxytona* BERNH.) is a perennial plant indigenous to South-west and Central Asia. The alkaloids of this species have been intensively investigated for the last two decades in connection with the importance of thebaine as the starting material for an industrial production of codeine and its derivatives with morphine activity. The races Halle III, Arya I, Arya II and many other Iranian populations (*cf.* the reviews[1,2]) are rich sources of thebaine. The attention of the majority of authors has been concentrated on the determination of thebaine content under various ecological conditions and developmental stages. Less informations can be found in the literature on minor alkaloids. It is known that *P. bracteatum* comprises several chemical races differing in alkaloids accompanying the thebaine. So far more than 20 minor alkaloids from *P. bracteatum* have been described (see also[1,2] and, more recently, for example[3–6]).

A taxonomic revision of the species of the section *Oxytona* was carried out in 1974 by Goldblatt[7]. Conflicting data in older papers published before this date in which isothebaine is indicated as the main alkaloid from *P. bracteatum* (*cf.*[8,9]) were due to erroneous determination of the plant material and confusion with the species

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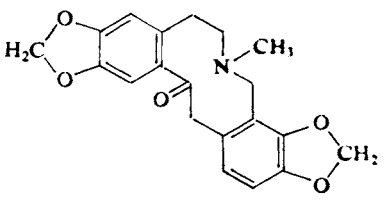
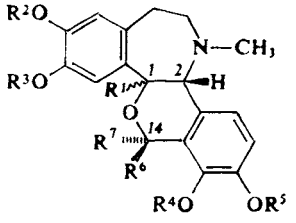
P. pseudo-orientale (FEDDE) MEDW. from the same section[7,10]. The presence of thebaine as the dominant alkaloid is a typical chemical character of *P. bracteatum*[7]; alpinigenine is also a frequent significant alkaloid.

In this paper we describe alkaloids from two chemical races of *P. bracteatum*. The first of them is the so called thebaine race Halle III, also indicated as chemotype e^- (see[10]) which does not contain alpinigenine in contrast to the alpinigenine race E (also e^+). The population of *P. bracteatum* originating from the seeds collected in 1961 from a natural locality at Demavend in Iran represents a different chemical race.

According to the literature data the thebaine race Halle III contains thebaine almost exclusively, with the highest concentration in the root (0·7–1·3%)[11] and the ripe capsules. Little was known so far on the minor alkaloids of this chemical race. In the course of its ontogenetic development a transitory presence of alpinigenine (alkaloid E) as well as isothebaine was observed in the plant, which later dissapear[12], and probably traces of protopine[13] were detected in it. Thebaine methochloride was isolated from the strongly polar fraction[14].

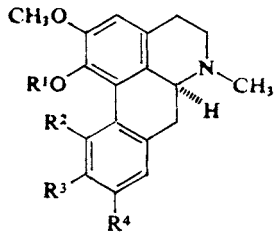


I

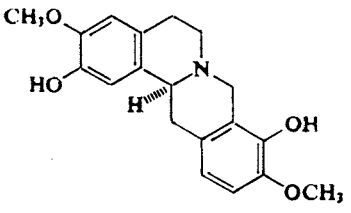


IIa, R^1 = ⁻H, $R^2 + R^3 = R^4 + R^5 = CH_2$, $R^6 = OCH_3$, $R^7 = H$
IIb, R^1 = ‴H, $R^2 = R^3 = R^4 = R^5 = CH_3$, $R^6 = H$, $R^7 = OCH_3$
IIc, R^1 = ‴H, $R^2 = R^3 = R^4 = R^5 = CH_3$, $R^6 = OCH_3$, $R^7 = H$
IId, R^1 = ‴H, $R^2 = R^3 = R^4 = R^5 = CH_3$, $R^6 = H$, $R^7 = OH$

The plant material of the race Halle III used in this study was cultivated by multiplying seeds of two maternal plants which displayed identical composition of the alkaloids on thin-layer chromatograms and which did not contain any alpinigenine. From the homogeneous population obtained in this way the following plant parts were analysed separately: *a*) root, *b*) the whole aerial part at the stage of unripe capsules, and *c*) ripe dry capsules free of seeds. From this material we have identified in addition to thebaine totally nineteen alkaloids of which fourteen were detected in *P. bracteatum* for the first time.

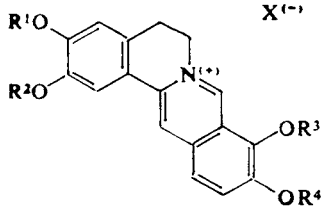


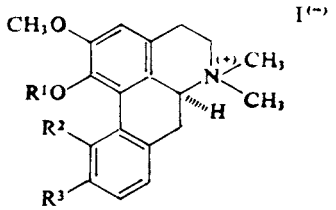
IIIa, $R^1 = R^3 = R^4 = H$, $R^2 = OCH_3$
IIIb, $R^1 = R^4 = H$, $R^2 = OH$, $R^3 = OCH_3$
IIIc, $R^1 = R^4 = H$, $R^2 = R^3 = OCH_3$
IIId, $R^1 = R^2 = H$, $R^3 = OCH_3$, $R^4 = OH$
IIIe, $R^1 = R^2 = H$, $R^3 = OH$, $R^4 = OCH_3$



IV

From the root of this population we isolated thebaine in a 0·61% yield. In accordance with the literature[11] it made at least 97% of the tertiary alkaloids. The bases obtained from the mother liquors after thebaine were separated to a non-phenolic and phenolic fraction. By direct crystallization of the non-phenolic fraction protopine (*I*) and rhoeadine (*IIa*) were obtained while from the phenolic fraction isothebaine (*IIIa*) and scoulerine (*IV*) were isolated. The latter was separated in the form of a poorly soluble hydrochloride. From the fraction of quaternary protoberberines a mixture of coptisine (*Va*) and palmatine (*Vb*) was obtained which was not further separated owing to the scarcity of the material and both alkaloids were identified only by chromatography. In the fraction of strongly polar alkaloids which was obtained in the conventional manner after conversion to iodides (*cf.*[15]) N-methylthebainium iodide and corytuberine hydriodide constituted the main components. It is interesting that the presence of corytuberine (*IIIb*) has not been known in *P. bracteatum* so far, although it is the third significant alkaloid of the plant according to its amount.





Va, $R^1 + R^2 = R^3 + R^4 = CH_2$
Vb, $R^1 = R^2 = R^3 = R^4 = CH_3$

VIa, $R^1 = R^3 = H$, $R^2 = OCH_3$
VIb, $R^1 = H$, $R^2 = OH$, $R^3 = OCH_3$

The evident reason for this is the fact that owing to its strongly polar character it cannot be obtained by the currently used isolation procedures. From the fraction

of iodides N-methylisothebainium iodide (*VIa*) was isolated in small amount, which we isolated earlier from *P. pseudo-orientale*[16], and magnoflorine (*VIb*), widely distributed in *Papaveraceae*.

The green aerial parts of *P. bracteatum* contain the least alkaloids according to literature data. From the material investigated we isolated a sum of tertiary alkaloids in a 0·25% yield, of which thebaine represented 93% of the bases. Of the minor alkaloids protopine, scoulerine, coptisine, palmatine, N-methylthebanium iodide and corytuberine hydriodide were isolated in a similar manner as from the root, and trace amounts of N-methylisothebainium iodide and magnoflorine were identified chromatographically. In addition to this, from the non-phenolic fraction of the tertiary bases a new alkaloid was isolated in a negligible amount, having m.p. 271°C, which was designated PB 1. According to its mass spectrum it had the composition $C_{18}H_{19}NO_4$. When labelled with [O—^{2}H]ethanol only one deuterium atom enters into the molecule of the alkaloid PB 1. Its IR spectrum indicates the presence of a keto group and a hydroxyl, which evidently has a non-phenolic nature. One oxygen atom is probably in the ether cycle. From the chemical shifts in its ^{1}H NMR spectrum and their multiplicity it follows that it contains two pairs of protons bound on the aromatic ring in position *ortho*, which do not visibly interact, one OCH_3 group, a CH—O proton and one CH_2 group (in the spectrum only one half of it is visible). The large geminal coupling constant (J = 18·8 Hz) indicates the probable position vicinal to a carbonyl (—CH_2—CO—). Alkaloid PB 1 is similar to alkaloids of the morphinane or hasubanane type in some of its properties, but the results of the spectral analyses are insufficient for the derivation of its structure.

In the amorphous residues of the tertiary fraction from the root and the aerial part, which had a practically identical composition according to chromatographic analysis, the presence of papaverrubine G (N-demethylalpinine), E (N-demethylrhoeadine), D and C was detected chromatographically. Chromatographic separation of the combined amorphous bases from the roots and the aerial parts on a column of alumina afforded epialpinine (O-methylalpinigenine, *IIb*), corydine (*IIIc*) and isoboldine (*IIId*) in addition to the remains of the above-mentioned alkaloids, and a small amount of bracteoline (*IIIe*) could be identified. The presence of alpinigenine could not be detected even in traces.

Thebaine amounted to 97% of the sum of the tertiary alkaloids (0·69%) isolated from the ripe capsules. In the amorphous residue a small amount of protopine and three further alkaloids were detected in addition to thebaine. Quaternary protoberberines were represented, in trace amounts, by coptisine and palmatine, and from the strongly polar fraction corytuberine as hydriodide was isolated, and after conversion of the remaining iodides to perchlorates also N-methylthebainium perchlorate.

The Iranian population from Demavend displayed only a weak reproductive ability in our climatic conditions, so that the amount of the material obtained suf-

ficed only for the investigation of significant alkaloids. From the dry ripe capsules 0·77% of tertiary alkaloids were isolated, of which thebaine was 73% of the bases. The second main alkaloid was epialpinine present in 26% amount of the tertiary bases. Such a high content of this alkaloid (or alpinine) had not been found in any chemical race of *P. bracteatum* so far. It is accompanied by a small amount of alpinigenine (*IId*). In the amorphous residues of the bases the presence of papaverrubine G, D and C was detected. Coptisine and palmatine were isolated in a negligible yield and from the strongly polar fraction N-methylthebainium iodide and corytuberine hydriodide were obtained after conversion to iodides.

Even though maximally mild isolation procedures were used, the possibility cannot be excluded that epialpinine (O-methylalpinigenine) with the configuration 1*S*, 2*R*, 14*R* (*IIb*, see[16]) isolated from *P. bracteatum* is an artifact formed during the isolation from the less stable $C_{(14)}$ epimer called alpinine (configuration 1*S*, 2*R*, 14*S*, *IIc*, see[16]). As shown by direct comparison the authentic sample of the amorphous "alpinine" of Maturová and coworkers[17] was also identical with O-methylalpinigenine which can be prepared from alpinigenine on reaction with methanol in the presence of hydrochloric acid[17,18]. The "alpinine" of the Soviet authors[3], isolated from *P. bracteatum*, was evidently epialpinine according to its melting point. In the case of "alpinine" found in *P. bracteatum* "Arya I" by Küppers and coworkers[19] no decision can be made, since the authors proved its presence only by a combination of gas chromatography and mass spectrometry. From this it follows that the true alpinine (*IIc*) has not yet been proved in *P. bracteatum* with certainty. It seems that a revision of the data on the occurrence of alpinine (1*S*, 2*R*, 14*S*) is desirable even in species from the circle of *P. alpinum*. Recently we also isolated from *P. kerneri* HAYEK (syn. *P. alpinum* subsp. *kerneri* (HAYEK) FEDDE) only epialpinine[20]. On the other hand the presence of epialpinine as a native alkaloid in *P. bracteatum* can be admitted because we detected an alkaloid with the same chromatographic properties together with alpinigenine in fresh latex of the flowering plants of the Demavend population, where it is the second significant alkaloid after thebaine.* For this reason it also seems very improbable that epialpinine is formed on reaction of methanol with alpinigenine during the extraction. It is known that Küppers and coworkers[19] found "alpinine" in the sum of the bases extracted from the plant material with dilute acetic acid.

In addition to thebaine, epialpinine and alpinigenine, salutaridine was also detected in the latex of the flowering plants of the Demavend population. This morphinane dienone alkaloid was found in one Turkish population together with thebaine as the dominant alkaloid[4].

* Unfortunately a reference sample of authentic alpinine was not available.

EXPERIMENTAL

The melting points were determined on a Mettler FP 51 instrument and they are not corrected. The mass spectra were measured on an AEI MS 902 spectrometer, and the 1H NMR spectra on a Varian XL-200 (200 MHz) spectrometer in deuteriochloroform with tetramethylsilane as internal reference. The IR spectra were measured in nujol (unless stated otherwise) on a Specord 75 IR, Zeiss, Jena instrument and the UV spectra in methanol on a Unicam SP 1 800 spectrophotometer. For thin-layer chromatography (TLC) both silica gel G Merck and Silufol UV 254 sheets (Kavalier) were used. In the first case the following solvent systems were used for tertiary alkaloids: cyclohexane–diethylamine 9 : 1 (S_1), cyclohexane–chloroform–diethylamine 7 : 2 : 1 (S_2) and 6 : 3 : 1, and benzene–acetone–methanol 8 : 1 : 1 with a drop of 25% ammonia. For quaternary alkaloids and corytuberine the systems methanol–water–25% ammonia 15 : 3 : 1 (S3), ethanol–water–25% ammonia 15 : 9 : 1 and 1-propanol–water–85% formic acid 12 : 7 : 1. In the case of the Silufol plates the systems were methanol–diethylamine 4 : 1 and 1 : 1 for quaternary protoberberines. Paper chromatography (PC) was carried out on Whatman paper No 1, descending method, in the systems 1-butanol–water–acetic acid 10 : 3 : 1 and ethanol–water 2 : 1. Fluorescing alkaloids were detected in UV light, while the spots of other alkaloids were visualised with potassium iodoplatinate. Papaverrubines were detected by 20 minute's exposure to conc. hydrochloric acid fumes (formation of purple spots).

Extraction and Isolation of Alkaloids

The plants of *P. bracteatum*, race Halle III, were cultivated at the Centre for the Cultivation of Medicinal Plants, Medical Faculty, Brno (origin of the seeds: German Democratic Republic). The roots and the aerial parts of two and three years old plants were gathered on 30. 6. 1982 at the stage of flowers and unripe capsules and dried at room temperature. The ripe capsules from the plants of the same population were gathered in summer 1981, immediately after ripening and when dried they were emptied of seeds. The plants of the Demavend population were cultivated from seeds obtained in 1961 from the Botanical Garden Bergen (Norway), collected at a natural locality in the Alborz mountains, Demavend, Iran (coll. Mr. K. Olsen). Dry ripe capsules were gathered in 1976.

The extraction of all four samples and the isolation of alkaloids was carried out basically in the same manner. Dry, ground plant material was extracted exhaustively with methanol in the cold. After distillation off of methanol the extract was dissolved in 1% acetic acid and filtered. The acid aqueous filtrate was alkalized with sodium carbonate and extracted several times with ether (fraction A), the aqueous layer was alkalized with sodium hydroxide to pH > 13 and reextracted with ether (fraction B). The aqueous phase was then adjusted to pH 6—7 with 20% sulfuric acid, an excess of an aqueous potassium iodide solution was added and the solution extracted several times with chloroform (fraction I) until reaction with Mayer's reagent was negative.

P. bracteatum race Halle III

Roots: Extraction of 1565 g of roots gave 12 g of raw bases of fraction A. Direct crystallization of the purified bases from ether afforded 9·03 g of thebaine and 1·33 g of less pure bases which were dissolved in 5% acetic acid, the solution was alkalized with sodium hydroxide and extracted with ether (non-phenolic fraction A_1). The aqueous layer was acidified with acetic acid, alkalized with ammonia and again extracted with ether (phenolic bases A_2). Crystallization of the concentrated ethereal solution of fraction A_1 gave thebaine (0·44 g), protopine (22·4 mg) and

rhoeadine (1·3 mg). The remaining amorphous residues (64·2 mg), according to TLC contained isothebaine, epialpinine, papaverrubine G and traces of papaverrubine E in addition to the remains of thebaine and protopine. From the concentrated ethereal solution of fraction A_2 isothebaine (7·0 mg) crystallized out. The amorphous residue of the bases was dissolved in 5% acetic acid and a saturated solution of potassium chloride was added. Scoulerine hydrochloride (5·1 mg) crystallized out and from the mother liquors 235·3 mg of bases were regenerated in which TLC indicated the presence of papaverrubine D and C in addition to a larger number of alkaloids. From fraction B 3·2 mg of golden-yellow bases (0·0002%) were obtained after purification, which according to TLC and PC consisted of palmatine and coptisine. Crystallization of fraction I (3·14 g) from methanol gave 0·67 g of corytuberine hydriodide and the rest of the iodides was separated to a nonphenolic I_1 and a phenolic I_2 fraction[21]. From the fraction I_1 (1·85 g) N-methylthebainium iodide (1·04 g) was separated by crystallization from methanol–ether, and after conversion to perchlorates crystallization from methanol gave 36·6 mg of N-methylthebainium perchlorate. Fraction I_2 (0·52 g) was crystallized from methanol to afford corytuberine hydriodide (17·4 mg), N-methylisothebainium iodide (9·2 mg) and magnoflorine iodide (1·0 mg). In the amorphous residue three additional unidentified alkaloids were detected (R_F 0·42, 0·68, and 0·75 in S_3) in addition to those mentioned.

Aerial parts: From the aerial parts (3·620 g) 9 g of bases of fraction A were obtained which after crystallization from ether gave 7·91 g of thebaine. The impure amorphous residue was separated to a non-phenolic fraction (A_1) and a phenolic fraction (A_2) in the conventional manner. Crystallization of the bases A_1 from ether separated another fraction of thebaine (0·45 g), further protopine (9·1 mg) and alkaloid PB 1 (3·4 mg). According to TLC the amorphous residue (216·0 mg) contained, in addition to the three alkaloids mentioned, isothebaine, epialpinine, papaverrubine G and traces of papaverrubine E. From fraction A_2, which was converted to hydrochlorides in the above-mentioned manner, 24·4 mg of scoulerine hydrochloride could be separated, and from the mother liquors 388·6 mg of amorphous bases were regenerated which according to TLC contained isothebaine, bracteoline, isoboldine, traces of papaverrubine D and C and two unidentified alkaloids (R_F 0·40, 0·46 in S_2) in addition to the residues of non-phenolic alkaloids and scoulerine. The golden-yellow bases of fraction B (6·3 mg, 0·00017%) consisted of coptisine with a small admixture of palmatine (identification by TLC and PC). Fraction I was separated in the conventional manner[21] to I_1 and I_2. Crystallization of fraction I_1 from methanol–ether gave 251·5 mg of N-methylthebainium iodide and in the amorphous residue (45·5 mg) an unidentified alkaloid (R_F 0·70 in S_3) could be detected. The phenolic fraction I_2 was crystallized from methanol to give 27·7 mg of corytuberine hydriodide, and in the amorphous residue (80·7 mg) N-methylisothebainium iodide and magnoflorine could be identified on the basis of TLC, and two additional alkaloids were also detected (R_F 0·42 and 0·75 in S_3) which were also found in the roots.

Separation of the amorphous bases: Since the amorphous residues of the non-phenolic and phenolic bases from the roots and the aerial parts had qualitatively a very similar composition according to TLC, they were combined. The purified bases (0·82 g) were separated chromatographically on a column (115 g) of neutral alumina (Reanal, activity about 2) in benzene solution. Fractions of 40 ml volume were collected and the composition checked by TLC. Fractions 1—21 (elution with benzene) were non-alkaloidal. The following alkaloids were isolated in crystalline state (serial number of the fraction, weight, eluent): epialpinine (22—26, 16·4 mg, benzene–ether 1 : 1), thebaine (27—40, 50·5 mg, benzene–ether 1 : 1 and 2 : 3), isothebaine (33—40, 67·0 mg, benzene–ether 2 : 3), and from the mother liquors after conversion to hydrochlorides corydine hydrochloride (4·0 mg) and a non-alkaloidal substance (9·5 mg), m.p. 150—151°C, protopine (41—44, 8·0 mg, ether), scoulerine (45—49, after conversion to hydrochloride 19·2 mg, ether)

and isoboldine (50—58, after conversion to hydrochloride 7·4 mg, ether–chloroform 1 : 1). In the mother liquor after crystallization of isoboldine hydrochloride bracteoline was identified by TLC. Fractions 59—81 (101·2 mg, chloroform, chloroform–methanol 1 : 1 and 1 : 4) contained non-alkaloidal substances practically exclusively.

Ripe capsules: Extraction of 135 g of dry ripe capsules gave 0·94 g of bases of fraction A which were crystallized from ether to afford 0·91 g of thebaine. In the amorphous residue of the bases (31·5 mg) protopine, trace of isothebaine and two unidentified alkaloids (R_F 0·12 and 0·56 in S_1) were detected by TLC in addition to thebaine. In fraction B (< 1·0 mg) palmatine and coptisine were detected by TLC and PC. From fraction I 1·6 mg of corytuberine hydriodide were isolated by crystallization from methanol, and after conversion of the residue to perchlorates and crystallization from methanol 22·4 mg of N-methylthebainium perchlorate were obtained. The remaining amorphous residue weighed 57·7 mg.

P. bracteatum, Demavend Population

From 64 g of ripe dry capsules 495 mg of bases of fraction A were obtained, which when crystallized from ether gave 349·7 mg of thebaine. The remaining amorphous bases (145 mg) contained a small amount of papaverrubine G and traces of papaverrubine D and C according to TLC. The amorphous bases were then separated on a column of alumina (53 g) under the same conditions as above. Fractions of 20 ml each were collected (the eluent is indicated in brackets): fractions 1—10 (benzene) were non-alkaloidal, from fractions 11—22 (benzene–ether 10 : 1 and 4 : 1) 128·1 mg of epialpinine were obtained by crystallization from methanol, from fractions 28—35 (benzene–ether 1 : 1) 9·9 mg of thebaine and from fractions 39—41 (ether) 2·8 mg of alpinigenine by crystallization from methanol. Further fractions (ether, ether–chloroform, chloroform and chloroform–methanol) remained amorphous. TLC detected in them the presence of protopine, salutaridine and bracteoline. Fraction B (2·5 mg) contained according to TLC and PC coptisine and palmatine. Crystallization of fraction I from methanol afforded 47·0 mg of N-methylthebainium iodide and 5·2 mg of corytuberine hydriodide.

Detection in fresh latex: Latex was taken from a cut of the stalk 3—5 cm below the flower, to which an equal amount of methanol was added in order to precipitate the ballasts. After centrifugation the clear supernatant was chromatographed immediately on a thin layer, parallelly with the reference samples. In the Demavend population thebaine, epialpinine, alpinigenine, salutaridine and another unidentified alkaloid (R_F 0·08 in S_1) were identified.

Characterization of the Alkaloids Isolated

The isolated alkaloids were characterized by their melting points, mixed melting points, optical rotation, mass, ^{1}H NMR, IR and UV spectra and by TLC and PC. The yields of individual alkaloids are given in % of dry plant material of the race Halle III, unless stated otherwise, in the following order: root, aerial part, ripe capsules. The presence of an alkaloid determined chromatographically is indicated by a cross (+).

Thebaine (0·61; 0·23; 0·67; Demavend population 0·56): prisms with m.p. 194—195°C (ether), $[\alpha]_D^{24}$ −219° ± 3° (*c* 0·71, methanol). UV and IR spectra and chromatographic properties were identical with the properties of the reference sample.

Preparation of N-methylthebainium iodide: 107·0 mg of thebaine were dissolved in 3 ml of hot methanol, 5 ml of ether were added, followed by 1 ml of methyl iodide. After 12 h standing 119·2 mg of a product crystallized out in the form of clusters of needles, m.p. 224—225°C, $[\alpha]_D^{24}$ −99° ± 3° (*c* 0·22, methanol), very easily soluble in methanol. The substance is a solvate, with IR spectrum ν(OH) 3 370 and 3 450 cm^{-1}. After drying in a vacuum at 120°C it loses weight

corresponding to a molecule of methanol. Crystallization from methanol gave a product without the solvent of crystallization, large compact prisms, m.p. 227—228°C, poorly soluble in methanol. UV spectrum: λ_{max} (log ε) 208 nm (4·63), 287 nm (4·09), shoulder at 222 nm (4·57), λ_{min} 257 nm (3·73). In the IR spectrum of this preparation the presence of a hydroxyl group could not be detected.

Preparation of N-methylthebainium perchlorate: N-methylthebainium iodide (32·0 mg) was dissolved in hot water and a 20% sodium perchlorate solution was added to it. The precipitate formed was filtered off under suction and crystallized from methanol; colourless clusters (25·6 mg), m.p. 232—233°C.

N-*Methylthebainium iodide* (0·069; 0·007; 0·016; Demavend population 0·073): from methanol–ether needles with m.p. 223—224°C (solvate), $[\alpha]_D^{24}$ −100° ± 3° (*c* 0·37, methanol), or without solvent of crystallization large compact prisms with m.p. 227—228°C (methanol) undepressed in admixture with corresponding preparations obtained by methylation of thebaine with methyl iodide. The UV and IR spectra and the R_F values were identical with those of reference samples. Perchlorate, m.p. 232—233°C (methanol).

Corytuberine (hydriodide 0·044; 0·0008; 0·0012; Demavend population 0·008): hydriodide needles m.p. 213—214°C (methanol), $[\alpha]_D^{24}$ +179° ± 3° (*c* 0·15, methanol). UV spectrum: λ_{max} (log ε) 223 nm (4·79), 270 nm (4·18), 308 nm (3·90), λ_{min} 256 nm (4·10), 292 nm (3·77). IR spectrum, ν(OH) 3 490 cm^{-1}, identical with that of an authentic preparation, the same as the R_F values.

Isothebaine (whole plant 0·0019): prisms from ether, m.p. 205—206°C, undepressed on admixture with a reference sample, $[\alpha]_D^{24}$ +286 ± 3° (*c* 0·10, methanol). UV spectrum, λ_{max} (log ε) 214 nm (4·60), 272 nm (4·16), shoulder at 294 nm (3·82), λ_{min} 248 nm (3·73), as well as the IR spectrum, ν(OH) 3 480 cm^{-1} and the R_F values were identical with the values of an authentic sample.

Scoulerine (whole plant 0·00084): prismatic needles from ether, m.p. 197—198°C, undepressed with an authentic specimen, reddening in air, $[\alpha]_D^{22}$ −346° ± 5° (*c* 0·10, methanol). The UV spectrum, λ_{max} (log ε) 209 nm (4·68), 285 nm (3·91), shoulder 226 nm (4·26), λ_{min} 254 nm (3·46), IR spectrum, ν(OH) 3 440 and 3 540 cm^{-1}, as well as the R_F values were identical with those of an authentic sample. Hydrochloride, m.p. 248—249°C (dilute hydrochloric acid).

Protopine (whole plant 0·00076): prisms from chloroform–methanol, m.p. 209—210°C, undepressed with an authentic specimen. The UV spectrum, λ_{max} (log ε) 209 nm (4·72), 238 nm (4·06), 288 nm (4·01), λ_{min} 232 nm (4·04), 260 nm (3·57), IR spectrum, ν(CO) 1 655 cm^{-1}, and the R_F values were identical with the values of a reference sample.

Epialpinine (whole plant 0·00032; Demavend population 0·20): prisms from methanol, m.p. 104—105°C or 123—124°C, undepressed in admixture with an authentic preparation; the same m.p. is also given in literature[16,18]. Both forms are interconvertible by inoculation; $[\alpha]_D^{22}$ +287° ± 3° (*c* 0·26, methanol). Literature[16,17] gives $[\alpha]_D$ +288° or 302°, respectively, in methanol. Mass spectrum: *m/z* 415 (M^+), 400, 384, 372, 340, 311, 222, 206, 193 (base peak), identical with the literature data[17]. The UV spectrum, λ_{max} (log ε) 208 nm (4·66), 232 nm (4·19), 285 nm (3·92), λ_{min} 226 nm (4·16), 260 nm (3·55), the IR spectrum and the R_F values were identical with those of an authentic sample of epialpinine (O-methylalpinigenine)[16].

Hydrolysis of epialpinine: 32·4 mg of epialpinine were dissolved in 3·2 ml of dilute hydrochloric acid (1 mol l^{-1}) and heated on a water bath for 5 min. On cooling alpinigenine hydrochloride crystallized out, which was dissolved in boiling water, the solution alkalized with ammonia and extracted with ether. The residue (29·0 mg) was crystallized from methanol, giving needle-like prisms with m.p. 186—187°C, $[\alpha]_D^{22}$ +282° ± 3° (*c* 0·19, methanol). UV spectrum:

λ_{max} (log ε) 208 nm (4·64), 232 nm (4·18), 285 nm (3·85), λ_{min} 225 nm (4·15), 261 nm (3·48). IR spectrum: ν(OH) 3 400 cm^{-1}. All these data were in good agreement with the data from literature[16,17,18] and identical with the data of an authentic specimen[16].

Alpinigenine (Demavend population 0·004): m.p. 185—186°C (methanol), UV, IR and TLC identical with those of an authentic preparation[16].

N-*Methylisothebainium iodide* (0·00063; +; —): needles from methanol, m.p. 251—253°C, undepressed on admixture of an authentic sample. UV spectrum, λ_{max} (log ε) 218 nm (4·71), 272 nm (4·14), 299 nm (3·92), λ_{min} 250 nm (3·88), 290 nm (3·89), IR spectrum ν(OH) 3 300 cm^{-1}, and chromatographic properties agreed with those of a reference sample.

Isoboldine (whole plant 0·00042): base from methanol, m.p. 127—128°C, undepressed with an authentic sample. UV spectrum, λ_{max} (log ε) 220 nm (4·76), 281 nm (4·34), 305 nm (4·33), λ_{min} 256 nm (4·00), 292 nm (4·22), identical with the spectrum of a standard. The same is true of R_F values in TLC.

Corydine (whole plant 0·00023): hydrochloride from dilute hydrochloric acid, m.p. 264 to 266°C; the base was amorphous, with UV spectrum: λ_{max} (log ε) 221 nm (4·45), 270 nm (4·02), 306 nm (3·68), λ_{min} 248 nm (3·74), 290 nm (3·63). It agreed with the spectrum of an authentic sample, as also did their R_F values.

Alkaloid PB 1 (—; 0·000094; —): prisms from methanol, m.p. 271—272°C. Mass spectrum *m/z* (composition, intensity) M^+ 313·1324 (for $C_{18}H_{19}NO_4$ calculated 313·1314, 100), 298 (2·9), 285 (1·9), 270 (4·3), 257 ($C_{15}H_{13}O_4$, 3·8), 256 ($C_{15}H_{12}O_4$, 4·8), 229 ($C_{14}H_{15}NO_2$, 35·0), 214 ($C_{13}H_{12}NO_2$, 8·6) 188 (8·0), 179 (4·8), 178 (6·7), 138 (5·2), 115 (5·7), 70 (C_4H_8N, 40·0), 59 (8·0). ^{1}H NMR spectrum: δ 3·85 (s, 3 H, OCH_3), 6·19 (d, J = 10·0), 6·73 (bd, J = 10·0), 6·64 (d, J = 8·2) and 6·72 (bd, J = 8·2; totally 4 Ar—H), 4·75 (bs, 1 H, CH—O), 3·25 (bd, J = 18·8, CH_2; only half is visible). IR spectrum (KBr): ν(CO) 1 670 cm^{-1}, ν(OH) 3 310, 3 420 cm^{-1}. UV spectrum: λ_{max} (log ε) 213 nm (4·56), 283 nm (3·61), λ_{min} 262 nm (3·52). R_F values: 0·26 (S_1) and 0·58 (S_2).

Rhoeadine (0·000083; —; —): needles from methanol, m.p. 255—256°C, undepressed in admixture with an authentic specimen. The UV spectrum, λ_{max} (log ε) 209 nm (4·67), 242 nm (4·13), 288 nm (4·04), λ_{min} 225 nm (3·93), 262 nm (3·52), and the R_F values in TLC were identical with those of a reference sample.

Magnoflorine iodide (0·000064; + —): from methanol m.p. 265—266°C, undepressed in admixture with an authentic sample. The R_F values in TLC were identical with the values of a standard (blue-violet fluorescence in UV light).

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