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Biodiversity in the alkaloids of Turkish *Papaver* species*

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Abstract: There are about 35 *Papaver* species growing in Turkey, which are grouped into eight sections, namely Argemonidium, Carinata, Glauca, Miltantha, Oxytona, Papaver, Pilosa, and Rhoeadium.

As a result of our extensive work on the alkaloids of Turkish *Papaver* species the presence of several chemotypes has been shown. Among these chemotypes, medicinally important alkaloids such as noscapine (=narcotine), papaverine- and thebaine-containing samples have been found as new sources for the production of them.

The infraspecific variation encountered within the *Papaver* species has been demonstrated mainly in two sections of the genus, Miltantha and Oxytona. The alkaloids of seven species (*Papaver armeniacum*, *P. curviscapum*, *P. cylindricum*, *P. fugax*, *P. persicum*, *P. polychaetum*, and *P. triniifolium*) of the section Miltantha have been studied, and the existence of chemical strains has been shown mainly in *P. fugax*, *P. persicum*, and *P. triniifolium*.

Investigations on the species of the section Oxytona indicated that there is a relationship between the major alkaloid content and the chromosome numbers of the samples.

Isolation of new secoberbine-type alkaloids as well as promorphinane- and morphinane-types has revealed the biosynthetic relationship between the alkaloids of Miltantha and Oxytona species. Chemical races are also known for species of *Papaver* within other sections of the genus.

P. lateritium of Turkish origin from section Pilosa yielded some secoberbine and protoberberine types, whereas *P. rhopalothece* of the section Rhoeadium contained narcotine as a major alkaloid. Isolation of spirobenzylisoquinoline type from *P. argemone* (sect. Argemonidium) was the first report of the occurrence of this type in the Papaveraceae.

INTRODUCTION

Species of the genus *Papaver* are grouped together on the basis of their morphological characteristics into ten sections namely, Argemonidium, Carinata, Glauca, Horrida, Meconella, Miltantha, Oxytona, Papaver, Pilosa, and Rhoeadium [1–4]. With the exception of Horrida and Scapiflorae about 35 *Papaver* species exist in Turkey, that belong to eight sections.

Opium poppy, *P. somniferum* from section *Papaver*, has been cultivated since the Hittites in Turkey, and the production of opium, a latex obtained by incising the unripe capsules of the plant has been known for more than 2000 years. Isolation of medicinally important alkaloids, morphine, codeine, papaverine, and narcotine (=noscapine) has been of considerable interest in the alkaloids of opium.

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The illicit use of opium and its major alkaloid morphine as a drug of abuse led the Turkish government to ban the cultivation of *P. somniferum* in 1972. But increasing demand for morphine in the pharmaceutical industry was reconsidered by our government to start the cultivation again. Today, the plant is cultivated to obtain capsules for the production of morphine and its derivatives in the alkaloid factory located at Bolvadin in Central Turkey. The demand for codeine is much bigger than morphine, and this alkaloid has largely been prepared from codeine by methylization.

The increasing abuse of opiates has stimulated the search for raw materials other than *P. somniferum* which would meet the requirements of the pharmaceutical industry. Thus, plants containing nonaddictive thebaine as principal alkaloid could be used for the manufacture of codeine.

When the Turkish government banned the cultivation of *P. somniferum* in 1972, we decided to investigate the alkaloids of *Papaver* species growing wild in Turkey to find alternative sources for the medicinally important alkaloids as well as to evaluate the alkaloid contents of Turkish *Papaver* species. The location of the specimen collected in Turkey are shown in Figs. 1–4.

REVIEW

Alkaloids from section Oxytona

In *Flora of Turkey*, Cullen reported the existence of the following four species within the section [3].

P. bracteatum Lindl.
P. lasiothrix Fedde
P. orientale L.
P. paucifoliatum (Trautv.) Fedde

Revision of section Oxytona by Goldblatt resulted in the recognition of three species [5]. In this review, it was reported that each species could be characterized morphologically (e.g., by petal coloring and markings and by capsule shape). Furthermore, the three species were distinguished by cytological and chemical techniques:

a) *P. bracteatum*, 2n = 14, major alkaloid thebaine **7b**
b) *P. orientale*, 2n = 28, major alkaloid oripavine **7a**
c) *P. pseudo-orientale*, 2n = 42, major alkaloid, isothebaine **5c**

In this review, although the specimens from the locations where *P. bracteatum* and *P. lasiothrix* grow have not been obtained and the field observations have not been made, these samples have been accepted as synonyms of *P. pseudo-orientale*. *P. paucifoliatum* is treated as a synonym of *P. orientale* in this review.

Many specimens from this section were investigated, and the results were published [6–12]. Some confusing results have led us to extend the investigation on this section with careful field observation. Tables l and 2 summarize the type of the alkaloids obtained from 18 samples of *P. pseudo-orientale* and 5 samples of *P.orientale*. The samples of *P. pseudo-orientale* (P4–P16) having a chromosome number of 2n = 42 and containing aporphine **5** type, isothebaine **5c** as the major alkaloid should be considered as pure species. Three samples (P1, P3, and P17) have been found to contain either promorphinane **6** type, salutaridine **6d** and secoberbine **8** type, macrantaline **8a** or salutaridine **6d** and morphinane **7** type, thebaine **7a** as the major alkaloids and have a chromosome number of 2n = l4. As a result of field observations, these samples may better be treated as varieties of *P. bracteatum* having two chemical strains.

Two samples of *P. pseudo-orientale* from Northeastern Turkey (P2 and P18) contain either salutaridine **6d** and mecambridine **9d** (protoberberine **9** type) or salutaridine **6d** and papaveroxine **8e** (secoberberine **8** type). The chromosome number of P2 was determined as 2n = 28. This sample has spreading hairs on the peduncle and was previously identified as *P. lasiothrix* by Cullen. The field observations suggest that both samples could be intermediates between *P. bracteatum* and *P. pseudo-orientale*.

Table 1 Major alkaloids from *Papaver* species of the section Oxytona in Turkey.

Species		Major alkaloid	Diploid chromosome number (2n)	Locality
*P. bracteatum**	P3	salutaridine, thebaine	14	B7 TUNCELİ
"	P1	salutaridine, thebaine	14	B5 NİĞDE
*P. lasiothrix***	P2	mecambridine, salutaridine	28	A7 GÜMÜŞHANE
P. orientale	01	oripavine		A9 KARS
	02	oripavine		A9 KARS
	03	mecambridine		A8 ERZURUM
	04	oripavine	28	B9 AĞRI
	05	oripavine		A9 KARS
P. pseudo-orientale	P4	isothebaine, mecambridine, orientalidine		A7 GÜMÜŞHANE
"	P5	isothebaine, mecambridine, orientalidine		A8 ERZURUM
"	P6	isothebaine, mecambridine, orientalidine		A9 KARS
"	P7	isothebaine, mecambridine, orientalidine		A9 KARS
"	P8	isothebaine, mecambridine, orientalidine		A9 KARS
"	P9	isothebaine, mecambridine, orientalidine		A9 KARS
"	P10	isothebaine, mecambridine	42	A9 KARS
"	P11	isothebaine, mecambridine		B9 AĞRI
"	P12	isothebaine, mecambridine		A9 AĞRI
"	P13	isothebaine, mecambridine	42	A9 KARS
"	P14	isothebaine, mecambridine	42	B9 VAN
"	P15	isothebaine, mecambridine		B9 VAN
"	P16	isothebaine	42	C10 HAKKARİ
"	P17**	salutaridine, macranthaline***, macrantaldehyde***	14	B7 SİVAS
"	P18	salutaridine, papaveroxine***		A7 GİRESUN

* *P. pseudo-orientale*, Goldblatt 1974.
**This species may better be treated as a variety of *P. bracteatum* or of *P. orientale.*
*** Novel alkaloids

Table 2 Types of alkaloids in the section Oxytona.

	P. bracteatum	*P. lasiothrix*	*P. orientale*	*P. pseudo-orientale*
Simple isoquinoline 1				
Cotarnine **1a**				+
Cotarnoline **1b**				+
Proaporphine 4				
Orientalinone				+
Aporphine 5				
Bracteoline				+
Isothebaine **5c**	+		+	+
Promorphinane 6				
Salutadimerine* **6e**		+		+

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Table 2 (*Continued*)

	P. bracteatum	*P. lasiothrix*	*P. orientale*	*P. pseudo-orientale*
Salutaridine **6d**	+	+	+	+
Salutaridine-*N*-oxide*	+	+		
Norsalutaridine		+		
Morphinane 7				
Oripavine **7a**	+		+	
Neopine	+			
Thebaine **7b**	+	+	+	
Thebaine-N-oxide	+	+		
Secoberbine 8				
Macrantaline* **8a**				+
Macrantaldehyde* **8b**				+
Macrantoridine* **8c**				+
Narcotindiol* **8g**				+
Papaveroxine* **8e**				+
Papaveroxinoline* **8d**				+
Papaveroxidine* **8f**				+
Protoberberine 9				
Mecambridine **9d**		+	+	+
Orientalidine **9e**		+	+	+
N-methopapaverberbine* **9c**				
Phthalideisoquinoline 11				
Narcotine **11b**				+
Narcotinhemiacetale* **11a**				+
Narcotolinol* **11c**				+
Rhoeadine 13				
Alpinigenine			+	+
Alpinine				+

*****Novel alkaloids

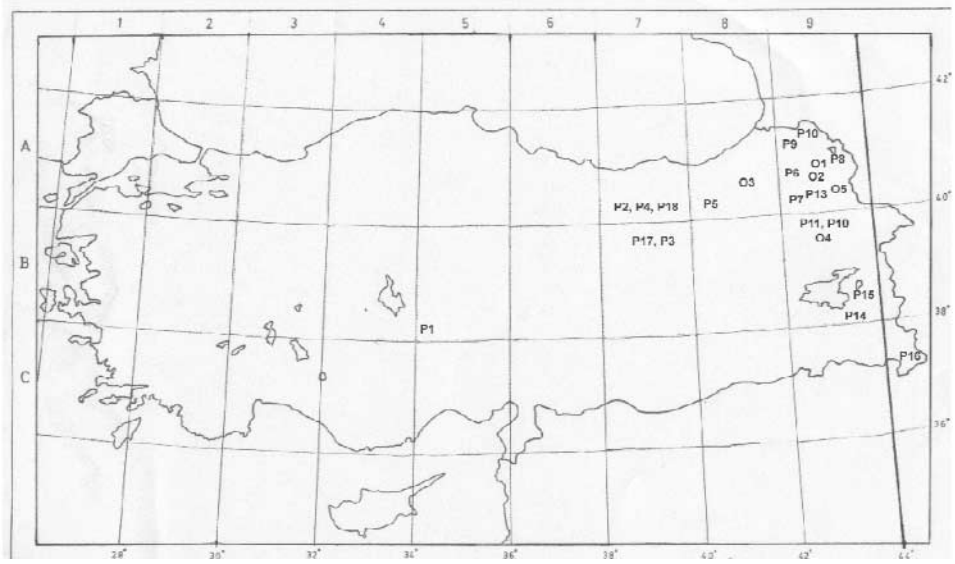

Fig. 1 Distribution of *Papaver pseudo-orientale* (P1–P18) and *Papaver orientale* (O1–O5).

Four samples of *P. orientale* (01, 02, 04, and 05) yielded oripavine **7a**, whereas one sample (03) was found to contain mecambridine **9d** as the major alkaloid. The chromosome number of 01 and 02 was determined as 2n = 28. Although the chromosome number of 03 has not been reported, there was no difference between 03 and other samples of *P. orientale* morphologically. Hence, we accept 03 as a chemical strain of *P. orientale*.

Alkaloids of *P. paucifoliatum* of Turkish origin accepted as a synonym of *P. orientale* by Goldblatt have not been investigated yet.

Alkaloids from section Miltantha

According to Cullen, the following species exist in Turkey [3].

P. acrochaetum Bornm.
P. armeniacum (L.) DC.
P. curviscapum Nabelek
P. cylindricum Cullen
P. fugax Poir.
P. persicum Lindl. (syn.: *P. tauricola.* Boiss.)
P. polychaetum Schott & Kotschy
P. triniifolium Boiss.

With the exception of *P. acrochaetum*, the alkaloids of seven species have extensively been investigated [10,12–20]. Tables 3 and 4 summarize the alkaloid content of the species with their types.

Two samples of *P. armeniacum* (Al and A2) were investigated and found to contain either rhoeadine **13** or proaporphine **4** –aporphine **5** –benzylisoquinoline **2** types as the major alkaloid that indicated the presence of two chemotypes.

Table 3 Major alkaloids from *Papaver* species of the section Miltantha in Turkey.

Species		Major alkaloid	Locality
P. armeniacum	A1	oreodine, rhoeadine	C9 HAKKARİ
"	A2	floripavidine, mecambrine, papaverine	B9 VAN
P. cylindricum		narcotine, oripavine, rhoeadine, thebaine	B9 VAN
"		narcotine	B9 AĞRI
P. curviscapum		berberine, protopine	C9 HAKKARİ
P. fugax	F1	theabine, narcotine	B8 BİNGÖL
"	F2	floripavidine, mecambrine	A8 GÜMÜŞHANE
"	F3	armepavine, oreodine, rhoeadine	A9 KARS
"	F4	floripavidine, salutaridine	A9 KARS
"	F5	narcotine, narcotinehemiacetale, papaveroxine	C9 HAKKARİ
"	F6	oreodine, rhoeadine	C9 HAKKARİ
*P. persicum**	P1	oreodine, oreogenine	B7 MALATYA
"	P2	glaucamine, glaudine	B5 KAYSERİ
"	P3	rhoeagenine	C5 ADANA
"	P4	mecambridine, salutaridine	B7 ERZİNCAN
"	P5	oreodine, rhoeadine	B7 SİVAS
"	P6	salutaridine, floripavidine	A8 GÜMÜŞHANE
"	P7	armepavine, floripavidine	C9 HAKKARİ
P. polychaetum	Po	berberine	MERSİN

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Table 3 (*Continued*)

Species		Major alkaloid	Locality
P. triniifolium	T1	floripavidine, rhoeadine	B5 NİĞDE
"	T2	oreodine, rhoeadine, thebaine	B8 ERZURUM
"	T3	mecambrine, narcotine, papaverine	B7 ERZİNCAN
"	T4	oreodine, thebaine	B7 ERZİNCAN
"	T5	mecambrine, oreodine, rhoeadine	B7 TUNCELİ
"	T6	oreodine,rhoeadine	B7 TUNCELİ
"	T7	oreodine	B7 MALATYA
"	T8	oreogenine, rhoeagenine	B4 ANKARA

*This species is previously treated as *P. tauricola*

Table 4 Types of alkaloids in the section Miltantha.

	P. armeniacum	*P. curviscapum*	*P. cylindricum*	*P. fugax*	*P. persicum*	*P. polychaetum*	*P. triniifolium*
Benzylisoquinoline 2							
Armepavine **2a**			+	+	+		
Crykonisine							+
Miltanthaline* **2b**							+
Papaverine **2c**	+		+				+
Isopavine 3							
Amurensinine **3a**					+		
Proaporphine 4							
Mecambrine **4a**	+			+	+		+
N-methylcrotonosine							+
Aporphine 5							
Floripavidine **5b**	+		+	+	+		+
N-methylasimilobine	+		+	+	+		
Promorphinane 6							
Amurine							+
Salutaridine **6d**			+	+	+		+
Morphinane 7							
Oripavine **7a**			+				
Thebaine **7b**			+	+			+
N-methylthebaine			+				
Secoberbine 8							
Papaveroxine **8e**				+			
Protoberberine (with Tetrahydroproto-berberine) 9							
Berberine **9a**		+				+	
Cheilantifoline			+				+
Isocorypalmine							+
N-methylsinactine							+
Sinanctine					+		+
Scoulerine			+		+		
Protopine 10							
Allocryptopine **10b**		+					
l-Methoxy-allocryptopine* **10c**		+					
l-Methoxy-13-oxo-allocryptopine		+					
Protopine **10a**		+					
Phthalideisoquinoline 11							

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Table 4 (*Continued*)

	P. armeniacum	*P. curviscapum*	*P. cylindricum*	*P. fugax*	*P. persicum*	*P. polychaetum*	*P. triniifolium*
Narceine							+
Narcotine **11b**	+		+	+			+
Narcotinhemiacetale* **11a**				+			
N-Methylnarcotine* **11d**			+				
Rhoeadine 13							
Epiglaudine					+		
Glaucamine **13e**					+		
Glaudine					+		
Oreodine **13b**	+			+	+		+
Oreogenine **13d**					+		+
O-Ethylrhoeagenine							+
O-Ethyloreogenine							+
O-Ethyltriniifoline							+
Rhoeadine **13a**	+		+	+	+		+
Rhoeagenine **13c**					+		+
Triniifoline* **13f**							+

*Novel alkaloids

The samples of *P. fugax* (F1–F6) and *P. persicum* (P1–P7) have been found to contain either proaporphine **4**-aporphine **5**, proaporhine **4**-aporphine **5**- benzylisoquinoline **2**, aporphine **5**, benzyltetrahydroisoquinoline **2**-aporphine **5**, proaporphine **4**-promorphinane **6**, aporphine **5**-promorphinane **6**, secoberbine **8** phthalideisoquinoline **11**, benzyl-tetrahydroisoquinoline **2**-rhoeadine **13**, or rhoeadine **13** types as the major alkaloids. As a result, *P. fugax* and *P. persicum* of Turkish origin have been shown to exist in six and four different chemical strains, respectively.

The alkaloids of *P. triniifolium*, an endemic species of the section have been isolated from eight samples (T1-T8). Five different chemical strains have been found in this species containing either aporphine **5**-rhoeadine **13**, aporphine **5**-phthalideisoquinoline **14**-benzlisoquinoline **2**, proaporphine **4**-rhoeadine **13**, rhoeadine **13**-morphinane **7**, or rhoeadine **13** types.

Distribution of this species extends from Central to East Turkey (Fig. 2).

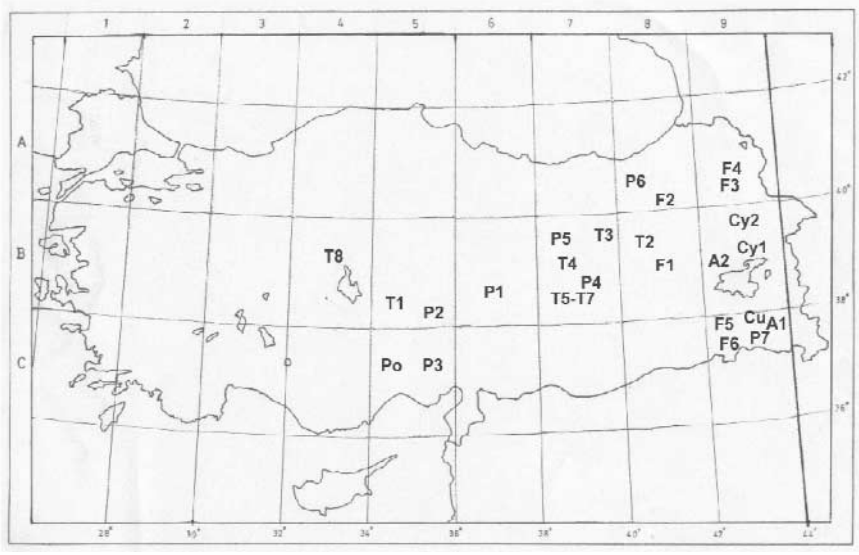

Fig. 2 Distribution of *P. armeniacum* (A1–A2), *P. curviscapum* (Cu), *P. cylindricum* (Cy), *P. fugax* (F1–F6), *P. persicum* (P1–P7), *P. polychaetum* (Po), *P. triniifolium* (T1–T8).

Two samples of *P. cylindricum* contained morphinane **7** (oripavine **7a**) together with phthalideisoquinoline **11** (narcotine **11b**) and rhoeadine **13** (rhoeadine **13a**) types.

The remaining two species of the section Miltantha, *P. polychaetum* and *P. curviscapum*, both yielded berberine **9a** as the major alkaloid. They also have morphologically similarities being subscapose plants bearing solitary flowers on long peduncles.

The existence of secoberbine **8** type (papaveroxine **8e**) has been reported from Miltantha section for the first time.

The presence of promorphinane **6**, morphinane **7**, phthalideisoquinoline **11**, and secoberbine **8** types as the major alkaloid in section Miltantha indicates the close relationship between Oxytona and Miltantha.

Chromosome numbers of some species have been determined, however, there was no relationship between the chromosome number and the major alkaloid content in section Miltantha.

The results of our recent investigations on sections Miltantha and Oxytona are the contributions to the review article published by J. D. Phillipson, who indicated the infraspecific variations in two sections of the genus *Papaver* [20].

Alkaloids from section Pilosa

Section Pilosa contains five species that are endemic to Turkey [3].

P. apokrinomenon Fedde
P. lateritium Koch
P. pilosum Sibth. & Sm.
P. spicatum Boiss. & Bal.
P. strictum Boiss. & Bal.

Of these species, *P. lateritium* is in a different subgroup than the other four species having different morphological characters and different type of major alkaloids. The alkaloids of this section were investigated in detail [21–23] and the results have been summarized in Tables 5 and 6. The species in this section have no chemotypes. The new alkaloids of promorphinane **6** type (amurinine **6b** and epiamurinine **6c**) alkaloids have been found in this section.

Table 5 Major alkaloids from *Papaver* species of the section Pilosa in Turkey.

Species	Major alkaloid	Diploid chromosome number (2n)	Locality
P. apokrinomenon	amurine, roemerine, *n*-methyllaurotetanine		B4 KONYA
P. lateritium	protopine, rhoeadine, rhoeagenine	14	A8 RİZE
P. pilosum	amurine, glaucine, roemerine	28	A2 BURSA
P. spicatum var. *luschanii*	glaucine, roemerine		C3 ANTALYA
var. *spicatum*	glaucine, roemerine		C3 ANTALYA
P. strictum	amurine	14	B2 KÜTAHYA

Table 6 Types of alkaloids in the section Pilosa.

	P. apokrinomenon	*P. lateritium*	*P. pilosum*	*P. spicatum*	*P. strictum*
Aporphine 5					
Dehydroglaucine	+		+	+	+
Dehydroroemerine	+		+	+	+

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Table 6 (*Continued*)

	P. apokrinomenon	*P. lateritium*	*P. pilosum*	*P. spicatum*	*P. strictum*
Glaucine **5f**	+		+	+	+
N-methylglaucine					+
N-methyllaurotetanin **5g**	+				+
N-methylroemerine					+
Roemerine **5a**	+		+	+	+
Promorphinane 6					
Amurine **6a**			+	+	+
Amurinine* **6b**			+	+	+
Dihydronudaurine			+	+	+
Epiamurinine* **6c**			+	+	+
Secoberbine 8					
Macranthaline **8a**		+			
Protoberberine 9					
Mecambridine **9d**		+			
N-Methyltetrahydropalmatine		+			
Protopine 10					
Protopine **10a**		+			
Cryptopine		+			
Rhoeadine 13					
Rhoeadine **13a**		+			
Rhoeagenine		+			

*New alkaloids

The existence of secoberbine **8** alkaloid macranthaline **8a** has been shown in this section for the first time.

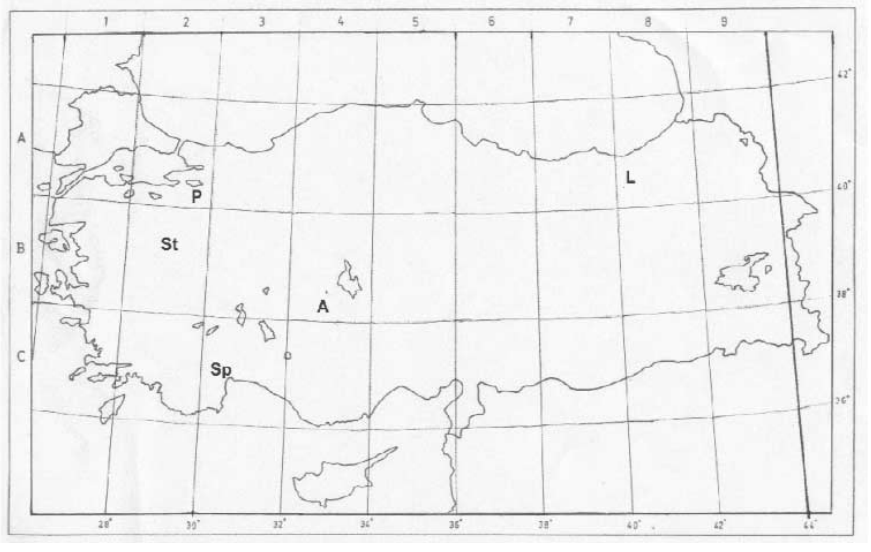

Fig. 3 Distribution of *P. apokrinomenon* (A), *P. lateritium* (L), *P. pilosum* (P), *P. spicatum* (Sp), and *P. strictum* (St).

Alkaloids from section Rhoeadium

According to Cullen and Kadereit, the following species exist in Turkey [3,24]:

Cullen 1965	Kadereit 1988
P. arenarium Bieb.	*P. purpureamarginatum* Kadereit
P. clavatum Boiss. & Hausskn. ex Boiss.	*P. dubium* L. ssp. *dubium*
	ssp. *laevigatum* (syn.: *P. lacerum*)
	ssp. *lecoquii*
P. commutatum Fisher & Meyer	*P. arachnoideum* Kadereit
P. dubium L.	*P. arenarium* M. Bieb
P. lacerum Popov	*P. commutatum* Fisher & C. Meyer ssp. *euxinum* Kadereit
P. postii Fedde	*P. guerlekense* Stapf. (syn.: *P. rhopalothece*)
P. rhoeas L.	*P. stylatum* Boiss. & Bal.
P. rhopalothece Stapf.	*P. clavatum* Boiss. & Hausskn. ex Boiss.
P. stylatum Boiss. & Bal.	*P. rhoeas* L.
P. syriacum Boiss.	

The alkaloids isolated from this section have been summarized in Table 7. Two major alkaloids aporphine **5** (isocorydine **5c**) and phthalideisoquinoline **11** (narcotine **11b**), types have been isolated from *P. guerlekense* (syn.: *P. rhopalothece*). The presence of narcotine as the major alkaloid in this species explains the traditional use of the plant as antitussive [25].

Table 7 Major alkaloids from *Papaver* species of the section Rhoeadium.

Species		Major alkaloid	Locality
P. commutatum ssp. *euxinum*	C1*	isocorydine	A6 ORDU
	C2*	isocorydine	A4 ZONGULDAK
P. dubium ssp. *dubium*		berberine, thalifendine	A3 BOLU
ssp. *laevigatum*		berberine	A3 BOLU
ssp. *lecoqii*		allocrytopine, protopine	C1 MUĞLA
*P. lacerum***		roemerine	B5 KAYSERİ
P. rhoeas		rhoeadine	A6 ORDU
*P. rhopalothece****		isocorydine, narcotine	C2 MUĞLA

*Different minor alkaloids
**This species is treated as a subspecies, *P. dubium* ssp. *laevigatum* (Kadareit 1988)
***Synonym of *P. guerlekense*

Table 8 Types of alkaloids isolated from Turkish *Papaver* species, section Rhoeadium.

	P. commutatum ssp. *commutatum*	*P. dubium* ssp. *dubium*	*P. dubium* ssp. *laevigatum*	*P. lacerum*	*P. rhoeas*	*P. rhopalothece*
Isopavine 3						
Amurensinine **3a**	+					
Proaporphine 4						
Mecambrine **4a**			+	+		
Pronuciferine				+		
Aporphine 5						
Corydine		+				
Isocorydine **5d**	+	+			+	

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Table 8 (*Continued*)

	P. commutatum ssp. *commutatum*	*P. dubium* ssp. *dubium*	*P. dubium* ssp. *laevigatum*	*P. lacerum*	*P. rhoeas*	*P. rhopalothece*
N-Methylasimilobine				+		
Roemerine **5a**		+	+		+	+
Rhopalotine* **5e**						+
Protoberberine 9 (with tetrahydro-protoberberine)						
Berberine **9a**		+			+	+
Cheilantifoline	+				+	
Coptisine						+
Sinactine					+	
Stylopine		+				
Tetrahydro pseudocoptisine		+				
Thalifendine **9b**		+				
Protopine 10						
Allocryptopine **10b**			+		+	
Couteropine						+
Cryptopine						+
Protopine **10a**					+	+
Phthalideisoquinoline 11						
Narceine						+
Narcotine **11b**						+
Rhoeadine and Papaverrubine 13						
Papaverrubine A	+					
Rhoeagenine **13c**	+					
Rhoeadine **13a**				+		

* Novel alkaloids

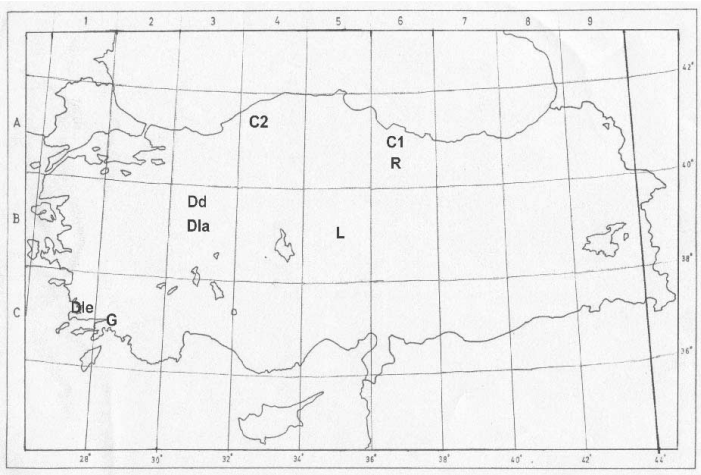

Fig. 4 Distribution of *P. commutatum* ssp. *euxinum* (C1–C2), *P. dubium* subsp. *dubium* (Dd), -ssp. *laevigatum* (Dla), -ssp. *lecoqii* (Dle), *P. lacerum* (L), *P. rhoeas* (R), *P. rhopalothece* (syn. *P. guerlekense*) (G).

Three subspecies of *P. dubium*, ssp. *dubium*, ssp. *Laevigatum*, and ssp. *lecoqii* have been found to contain different major alkaloids [26].

Alkaloids from sections Argemonidium and Carinatae

Cullen and Kadereit have reported the existence of the following species in the section Argemonidium in Turkey [3,28]. Section Carinatae is represented by only one species named as *P. macrostomum* Boiss. & Huet ex Boiss. The alkaloids isolated from sections Argemonidium and Carinatae are shown in Table 9.

Cullen 1965	Kadereit 1986
P. argemone L.	*P. argemone* L. ssp. *davisii* Kadereit
P. hybridum L.	ssp. *minus* (Boiv.) Kadereit
	ssp. *nigrotinctum* (Fedde) Kadereit
P. virchowii Aschers & Sin. ex Boiss.	*P. hybridum* L.

Table 9 Alkaloids from *Papaver* species of the sections Argemonidium and Carinatae.

Species	Major alkaloid	Locality
P. argemone	protopine, fumariline, fumarophycine	A1 ÇANAKKALE
P. macrostomum	isocorydine, amurensine	A4 ZONGULDAK

Fumariline **12a** and fumarophycine **12b** (spirobenzylisoquinoline **12** type) isolated from *P. argemone* have been found for the first time in the Papaveraceae.

As a result of our investigations on Turkish *Papaver* species, the infraspecific variation has been demonstrated in Turkish sections Oxytona, Miltantha, and Rhoeadium. However, further investigations are necessary on some sections.

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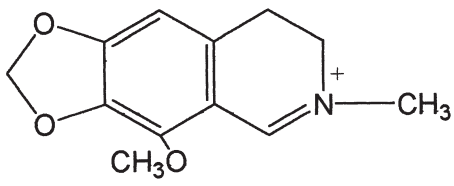
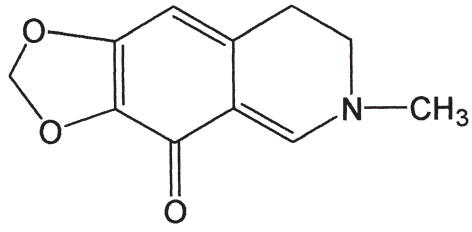
SIMPLE ISOQUINOLINE 1

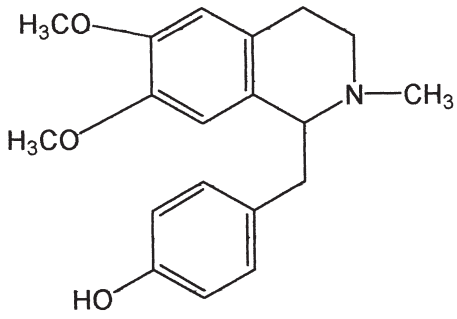


1a



1b

BENZYLISOQUINOLINE 2



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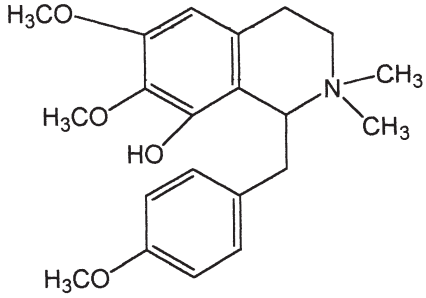

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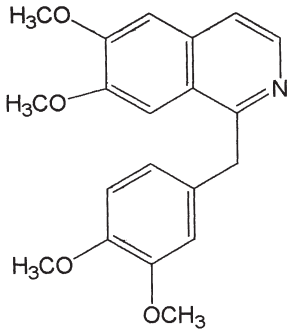

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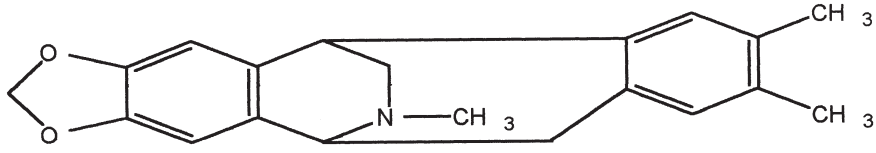
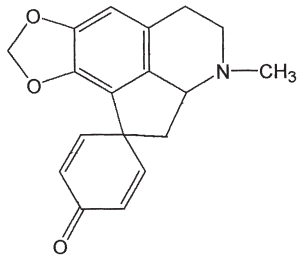
ISOPAVINE 3



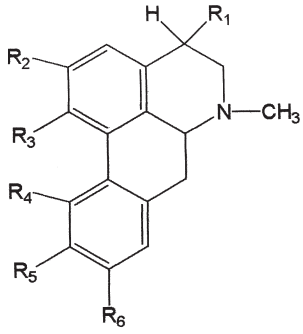
3 a

PROPAPORPHINE 4



4a

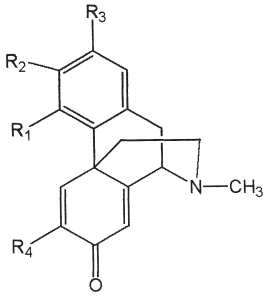
APORPHINE 5



5

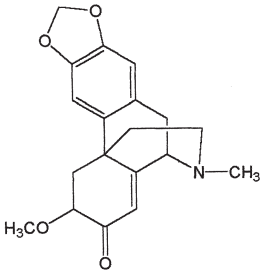
	R_1	R_2	R_3	R_4	R_5	R_6
5a	H	O-CH_2-O		OH	H	H
5b	H	O-Glu.	OMe	H	H	H
5c	H	OMe	OH	OMe	H	H
5d	H	OMe	OH	OMe	OMe	H
5e	OH	OMe	OH	OMe	OMe	OH
5f	H	OMe	OMe	H	OMe	OMe
5g	H	OMe	OMe	H	OMe	OH

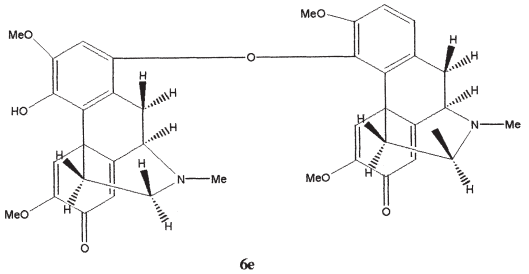
PROMORPHINANE 6



6

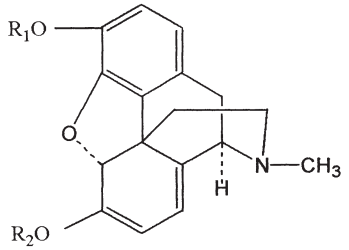
	R_1	R_2	R_3	R_4
6a	H	O-CH_2-O		OMe
6d	OH	OMe	H	OMe





6e

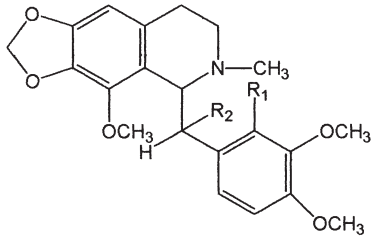
MORPHINANE 7



7

	R_1	R_2
7a	OH	Me
7b	Me	Me

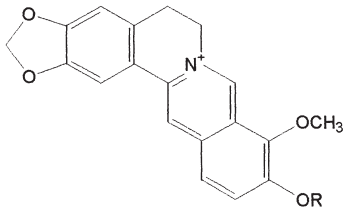
SECOBERBINE 8



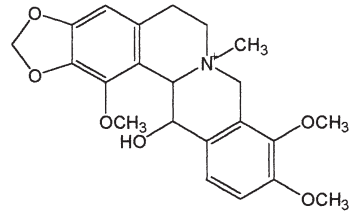
8

	R_1	R_2
8a	CH_2OH	H
8b	CHO	H
8c	COOH	H
8d	CH_2OH	$OCOCH_3$
8e	CHO	$OCOCH_3$
8f	COOH	$OCOCH_3$
8g	CH_2OH	OH

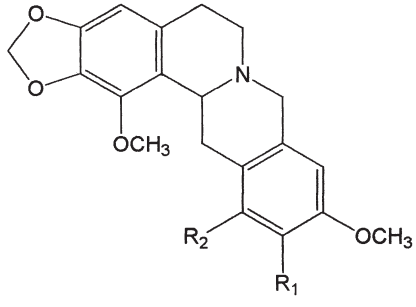
PROTOBERBERINE 9



	R
9a	OCH_3
9b	H

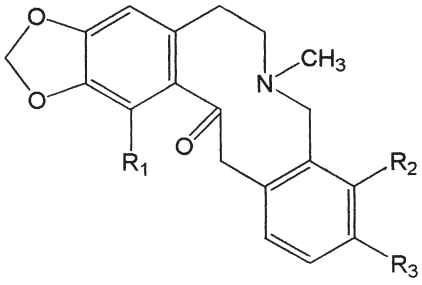


9c



	R_1	R_2
9d	OMe	CH_2OH
9e	CH_2-O-CH_2	

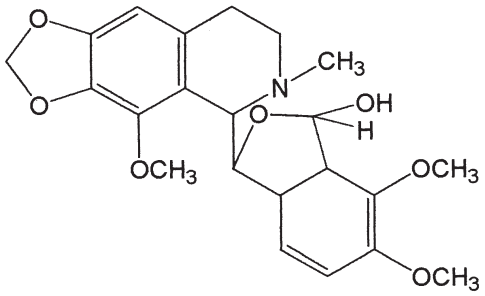
PROTOPINE 10



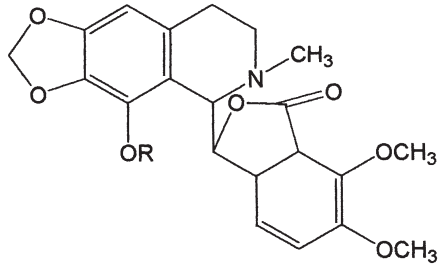
	R_1	R_2	R_3
10a	H	O- CH_2-O	
10b	H	OMe	OMe
10c	OMe	OMe	OMe

10

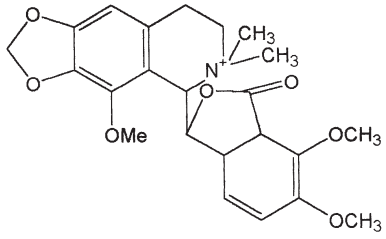
PHTHALIDEISOQUINOLINE 11



11a

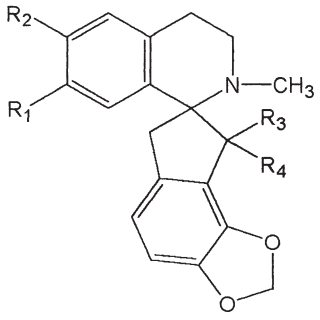


	R
11b	OMe
11c	OH



11d

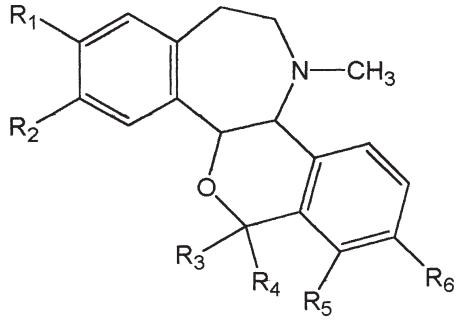
SPIROBENZYLISOQUINOLINE 12



12

	R_1	R_2	R_3	R_4
12a	O- CH_2-O			-O-
12b	OH	OMe	H	OCOMe

RHOEADINES 13



13

	R_1	R_2	R_3	R_4	R_5	R_6
13a	O- CH_2-O		H	OMe	O- CH_2-O	
13b	OMe	OMe	H	OMe	O- CH_2-O	
13c	O- CH_2-O		H	OH	O- CH_2-O	
13d	OMe	OMe	H	OH	O- CH_2-O	
13e	OMe	OMe	OH	H	O- CH_2-O	
13f	O- CH_2-O		H	OH	OMe	OMe