

IDENTIFICATION OF ERGOLINE ALKALOIDS IN THE GENUS *ARGYREIA* AND RELATED GENERA AND THEIR CHEMOTAXONOMIC IMPLICATIONS IN THE CONVULVULACEAE

JEW-MING CHAO* and ARA H. DERMARDEROSIAN

Philadelphia College of Pharmacy and Science, Philadelphia, PA 19104, U.S.A.

(Received 23 March 1973. Accepted 18 April 1973)

Key Word Index—*Argyrea*; Convolvulaceae; ergoline alkaloids; chemotaxonomy.

Abstract—The results of the identification of 21 ergoline alkaloids of 14 species of *Argyrea*; viz.: *A. barnesii*, *A. capitata*, *A. cuneata*, *A. luzonensis*, *A. mollis*, *A. maingayi*, *A. nervosa*, *A. obtusifolia*, *A. philippinensis*, *A. reticulata*, *A. ridleyi*, *A. rubicunda*, *A. splendens* and *A. sp.* and 2 closely related genera; *Stictocardia tiliifolia* and *Rivea corymbosa*, by using 2-D TLC procedures are given. A brief discussion of the implications of the ergoline alkaloids and the chemotaxonomy of the Convolvulaceae is also presented.

INTRODUCTION

SINCE Aztec times in the uplands of southern Oaxaca in Mexico, the seeds of *Rivea corymbosa* (Ololiuqui) and *Ipomoea violacea* (morning glory or 'badoh negro') have been used for divinatory and hallucinatory purposes during religious ceremonies. The native use of these seeds for ceremonial purposes has been extensively reported by Schultes¹⁻³ and Wasson.⁴ Following these publications, there occurred a rash of use of morning glory seeds for hallucinatory purposes in the United States.

Prior to 1960, ergoline-type alkaloids were known to occur only in certain lower fungi, particularly the genus *Claviceps*. Hofmann and Tschertter⁵ were the first to find and isolate these ergoline alkaloids from higher plants. Later, Hofmann,^{6,7} Der Marderosian *et al.*,⁸⁻¹¹ and several other groups¹²⁻²⁹ showed a wider distribution of the ergoline-type alkaloids

* Present address. New Jersey State Police, Forensic Science Bureau, West Trenton, NJ 08625, U.S.A.

¹ SCHULTES, R. E. (1960) Univ. Texas, Third Lecture Series, Pharm. Sci. Part V, 138.

² SCHULTES, R. E. (1963) *Harvard Rev.* **1**, 18.

³ SCHULTES, R. E. (1963) *Psychedelic Rev.* **1**, 145.

⁴ WASSON, R. G. (1963) *Bot. Mus. Leaflet. Harvard Univ.* **20**, 161.

⁵ HOFMANN, A. and TSCHERTTER, H. (1960) *Experientia* **16**, 414.

⁶ HOFMANN, A. (1961) *Planta Med.* **9**, 354.

⁷ HOFMANN, A. (1963) *Bot. Mus. Leaflet. Harvard Univ.* **20**, 194.

⁸ DERMARDEROSIAN, A. H. and LOCKWOOD, R. H. (1967) paper presented at the 8th Annual Meeting of A.S.P., Ann Arbor, Michigan.

⁹ DERMARDEROSIAN, A. H. (1966) *Lloydia* **29**, 35.

¹⁰ DERMARDEROSIAN, A. H. (1967) *Lloydia* **30**, 23.

¹¹ DERMARDEROSIAN, A. H. (1967) *Am. J. Pharm.* **193**, 19.

¹² TABER, W. A., VINING, L. C. and HEACOCK, R. A. (1963) *Phytochemistry* **2**, 65.

¹³ TABER, W. A., HEACOCK, R. A. and MAHON, M. E. (1963) *Phytochemistry* **2**, 99.

¹⁴ GRÖGER, D. (1963) *Flora* **153**, 373.

¹⁵ GRÖGER, D. (1963) *Planta Med.* **11**, 444.

¹⁶ GENEST, K. (1965) *J. Chromatog.* **19**, 531.

¹⁷ GENEST, K. (1966) *J. Pharm. Sci.* **55**, 1284.

¹⁸ GENEST, K. and SAHASRABUDHE, M. R. (1966) *Econ. Bot.* **20**, 416.

¹⁹ HYLIN, J. W. and WATSON, D. P. (1965) *Science* **148**, 499.

in the Convolvulaceae. These currently include the genera, *Rivea*, *Ipomoea*, *Argyreia*, *Cuscuta* and *Stictocardia*.

The unique occurrence of ergoline-type alkaloids in the Convolvulaceae represents a very interesting chemotaxonomic problem. To date, the ergoline alkaloids have been reported in 28 species representing 6 different genera of the morning glory family. These include, ergine, isoergine, chanoclavine-I, elymoclavine, lysergol, agroclavine, festuclavine, penniclavine, cycloclavine, ergometrine (ergonovine), ergometrinine, lysergic acid α -hydroxyethylamide (lysergic acid methylcarbinolamide), isolysergic acid α -hydroxyethylamide (isolysergic acid methylcarbinolamide), ergosine, and ergosinine.

RESULTS

The results of the identification of several ergoline alkaloids of fourteen *Argyreia* species and two closely related genera, *Stictocardia tiliifolia* and *Rivea corymbosa* (Table 1) are summarized in Table 2. Limited availability of seeds (2–10 seeds) from the herbarium specimens restricted analysis to 2-D TLC.

TABLE 1. SPECIES IN THE CONVOLVULACEAE SCREENED FOR ERGOLINE-TYPE ALKALOIDS BY 2-D TLC

Species	Collector	Locality
<i>Argyreia barnesii</i> (Merr.) Ooststr.	M. Ramos	Luzon, Philippines
Same	M. Ramos and G. Edano	Luzon, Philippines
<i>A. capitata</i> (Vahl) Choisy	N. K. Chun and C. L. Tso 44532	Yaichow, Hainan, China
<i>A. cuneata</i> (Wild) Ker-Gawl	G. V. Narayana 1929	S. India
<i>A. luzonensis</i> (Hallier f.) Ooststr.	M. S. Clemens 177236, Dec. 1926	Luzon, Philippines
<i>A. mollis</i> (Burm. f.) Choisy	H. S. Yates 1948	East Coast of Sumatra
<i>A. maingayi</i> (Clark) Hoogl.	Henderson 10727	Pahang
<i>A. nervosa</i> (Burm. f.) Bojer	Commercial	Hawaii
<i>A. obtusifolia</i> Lour.	Y. K. Wang 536	Ying-tak, Kwantung, China
<i>A. philippinensis</i> (Merr.) Ooststr.	G. Edano 75961	Luzon, Philippines
<i>A. reticulata</i> (Prain) Hoogl. var. <i>reticulata</i> Ooststr.	Buckill and Holttum	Pahang
<i>A. ridleyi</i> (Prain) Prain ex Ooststr.	Sinclair 40514 Dec. 1954	Singapore
<i>A. rubicunda</i> (Wall) Choisy	Vnalvis 831 Feb. 1885	Sembilam
<i>A. splendens</i> (Hornem) Sweet	H. T. Tsai 54534	China
<i>A. sp.</i>	A. Henry 12511A	Yunnan, China
<i>Stictocardia tiliifolia</i> (Desr.) Hallier f.	I. M. Johnston 1011	Panama
<i>Rivea corymbosa</i> (L.) Hallier f.		Mexico
<i>Ipomoea violacea</i> L.	Commercial	U.S.A.

The majority of *Argyreia* species contained the same alkaloids found in *Argyreia nervosa*, viz. agroclavine, chanoclavine-I, chanoclavine-II, racemic chanoclavine-II, elymoclavine,

²⁰ ABOU-CHARR, C. I. and DIGENIS, G. A. (1966) *Nature* **212**, 618.

²¹ STAUFFACHER, D., TSCHERTER, H. and HOFMANN, A. (1965) *Helv. Chim. Acta* **48**, 1879.

²² STAUFFACHER, D., NIKLAUS, P., TSCHERTER, H., WEBER, H. P. and HOFMANN, A. (1969) *Tetrahedron* **25**, 5879.

²³ GARDINER, M. R., ROYCE, R. and OIDROYD, B. (1965) *Br. Vet. J.* **121**, 272.

²⁴ IKAN, R., RAPAPORT, E. and BERGMAN, E. D. (1968) *Israel J. Chem.* **6**, 65.

²⁵ MCJUNKINS, S. P., THORNTON, J. I. and DILLON, D. J. (1968) *J. Forensic Sci. Soc.* **8**, 121.

²⁶ NIWAGUCHI, T. and INOUE, T. (1969) *J. Chromatog.* **43**, 510.

²⁷ MILLER, M. D. (1970) *J.A.O.A.C.* **53**, 123.

²⁸ CRAWFORD, K. W. (1970) *J. Forensic Sci.* **15**, 588.

²⁹ CHAO, J. and DERMARDEROSIAN, A. H. (1973) *J. Pharm. Sci.* **62**, 588

festuclavine, lysergene, lysergol, isolysergol, molliclavine, penniclavine, setoclavine, isosetoclavine, ergine, isoergine, ergometrine, ergometrinine, lysergic acid α -hydroxyethylamide and isolysergic acid α -hydroxyethylamide. Some species, however, contained several unknown indole alkaloids (Table 2).

Stictocardia tiliafolia contained chanoclavine-I, chanoclavine-II, festuclavine, lysergol, ergine, ergometrine, ergometrinine, lysergic acid α -hydroxyethylamide, and six unidentified indole alkaloids. Lysergol was the major compound in this species (Table 2).

The 2-D TLC procedure detected several previously unreported alkaloids in *Rivea corymbosa* which include agroclavine, chanoclavine-II, lysergene, setoclavine, isosetoclavine, isolysergic acid α -hydroxyethylamide and nine unidentified indole alkaloids (Table 2).

DISCUSSION

Table 2 also shows the occurrence of ergoline-type alkaloids in other species of the Convolvulaceae. It may be noted that chanoclavine-I is one of the major compounds present and is widely distributed throughout the family. The significance of this tricyclic indole alkaloid in the Convolvulaceae will become apparent later in this discussion.

Lysergene, setoclavine, and isosetoclavine are not common in the family and usually occur in minor concentration, but the most interesting fact is that they are present in *Argyreia nervosa*, *Argyreia cuneata*, and *Rivea corymbosa*. These three compounds are probably biosynthetically controlled by the same or similar genes.

Ergine and isoergine constitute an isomeric pair and are the two major compounds in most of the species of the family examined. The results also show that there are no two species possessing exactly the same alkaloid pattern. Therefore, ergoline-type alkaloids can be useful in chemotaxonomic studies of the Convolvulaceae, particularly for distinguishing between certain species. However, it seems at present that there is no uniform pattern of indole alkaloids within the genus. For example, the unique compounds lysergene, setoclavine, and isosetoclavine exist in both of the genera *Argyreia* and *Rivea*, while ergosine and ergosinine are present in both genera of *Argyreia* and *Ipomoea*. Therefore, until further studies are carried out these chemotaxonomic characters are not apparently useful in inter-generic differentiation.

As indicated in Table 3, *Cuscuta monogyna* is the only member of the parasitic sub-family Cuscutoidae reported to contain ergoline compounds, viz. agroclavine. Three species of *Convolvulus* have been reported to contain 'van Urk reacting substances', however, this has not been confirmed. Another 15 species of *Convolvulus* have been confirmed to be negative.^{8,9,11,24} Of all species containing ergoline alkaloids thus far reported, most are in Tribe III, Ipomoeae. Specifically, the genera *Ipomoea* and *Argyreia* contain 11 and 20 species respectively. *Stictocardia* and *Turbina* (synonymous with *Rivea*) include one species each which contain ergoline alkaloids while representatives of *Mina* and *Lepistemon* have not yet been shown to contain ergoline alkaloids.²⁴

This short summary by no means exhausts the possibilities for continued studies in the Convolvulaceae which has at least 55 genera and 1650 species. For example, continued investigations on the Convolvulaceae are needed to clarify the classical taxonomy, e.g. morphology, anatomy and cytogenetics. More studies are indicated in the chemotaxonomy of the Convolvulaceae, e.g. ergoline alkaloid distribution, non-indole alkaloid constituents, resins, sterols, seed coat pigments, volatile principles, fatty acid patterns in lipids, glycosides, and so on.^{9,18} Pharmacological investigations are needed on the purgative resins; psycho-

TABLE 2. SPECIES OF THE CONVULVULACEAE

Species	Alkaloids										
	1. Agroclavine	2. Chanoclavine-I	3. Chanoclavine-II	4. Rac. Chanoclavine-II	5. Elymodavine	6. Festuclavine	7. Lysergene	8. Lysergol	9. Isolysergol	10. Molliclavine	11. Penniclavine
<i>Argyreia acuta</i>		×									
<i>A. aggregata</i>											
<i>A. barnesii</i>	×	×	×	×	×	×			×		
<i>A. capitata</i>											
<i>A. cuneata</i>	×	×	×	×	×	×	×	×	×		×
<i>A. hainanensis</i>		×									
<i>A. luzonensis</i>	×	×	×	×	×	×		×	×		×
<i>A. mollis</i>	×	×	×	×	×	×			×		×
<i>A. maingayi</i>											
<i>A. nervosa</i>	×	×	×	×	×	×	×	×	×	×	×
<i>A. obtusifolia</i>	×	×	×	×	×	×					×
<i>A. osyrendis</i>											
<i>A. philippinensis</i>		×		×		×		×	×		×
<i>A. pseudorubicunda</i>											
<i>A. reticulata</i>											
var. <i>reticulata</i>											
<i>A. ridleyi</i>											
<i>A. rubicunda</i>								×			
<i>A. splendens</i>		×	×		×	×		×			
<i>A. wallichii</i>		×				×			×		
<i>A. sp.</i>			×								
<i>Stictocardia tiliifolia</i>		×	×			×		×			
<i>Rivea corymbosa</i>	×	×	×		×		×	×		×	
<i>Cuscuta monogyna</i>	×										
<i>Ipomoea argyrophylla</i>	×										
<i>I. cardiophylla</i>											
<i>I. coccinea</i>					×						
<i>I. hederacea</i>		×						×			
<i>I. hildebrandtii</i>						×					
<i>I. hybrida</i>											
<i>I. leptophylla</i>		×									
<i>I. mulleri</i>											
<i>I. rubra</i>											
<i>I. tamnifera</i>											
<i>I. violacea</i>	×	×	×	×	×	×		×	×		×

* This work: see Table 1.

† Number in brackets is number of unknowns found by TLC.

CONTAINING ERGOLINE-TYPE ALKALOIDS

12. Setoclavine	13. Isosetoclavine	14. Ergine	15. Isoergine	16. Ergometrine	17. Ergometrine	18. Lysergic acid α -hydroxyethylamide	19. Isolysergic acid α -hydroxyethylamide	20. Ergosine	21. Ergosinine	22. Cycloclavine	23. Unidentified†	Ref.
		×		×							×	8
			×		×	×					×	8
											×	*
×	×		×	×	×	×					×	(1) *
		×	×	×	×	×	×	×	×		×	(7) *
		×	×	×	×	×						8
		×	×	×	×	×	×	×	×		×	(10) *
		×	×	×	×	×		×	×		×	(8) *
											×	(5) *
×	×	×	×	×	×	×	×				×	(11) * 8, 19, 25, 27, 29
		×	×	×	×	×		×	×		×	(5) *
											×	8
		×	×		×	×					×	(2) *
											×	8
											×	(2) 8
								×	×		×	(1) *
												*
		×	×	×	×	×		×	×		×	(1) *
		×	×	×								8
		×	×									*
×	×	×	×	×	×	×	×				×	(6) *
											×	(9) * 5, 7, 9
								×	×			24
											×	21
												8
												14
										×		20
												22
		×	×	×							×	12
			×	×							×	8
												23
											×	8
											×	10
		×	×	×	×	×	×				×	(6) *, 7, 9, 12, 14, 15, 16

tomimetic, sedative and uterotonic ergolines,⁹ antihistaminic principles³¹ and hypotensive substances.³² All of these avenues have only been opened by various research efforts and more thorough studies are needed along all these lines to fully comprehend the botanical, chemical and pharmacological spectrum of the family.

TABLE 3. CHEMOTAXONOMIC DISTRIBUTION OF ERGOLINE ALKALOIDS IN THE CONVULVULACEAE*

Convolvulaceae	
Subfamily Cuscutoidae	
Tribe I Cuscutae	
Mostly parasitic, leafless	
1 species (<i>Cuscuta monogyna</i>) here with indole alkaloid positive	
Subfamily Convolvuloideae	
Tribe II Convolvuleae (pollen non spinulose)	
3 species of <i>Convolvulus</i> reported as 'van Urk reacting substances', not confirmed	
Tribe III Ipomoeae (pollen spinulose)	
<i>Ipomoea</i>	11 species ergoline alkaloid positive
<i>Argyreia</i>	20 species ergoline alkaloid positive
<i>Stictocardia</i>	1 species ergoline alkaloid positive
<i>Turbina</i> (syn. <i>Rivea</i>)	1 species ergoline alkaloid positive
<i>Mina</i>	Few species examined, none ergoline alkaloid positive
<i>Lepistemon</i>	Not reported

* Taxonomic arrangement based on S. J. Van Ooststroom.³⁰

To date, a total of 22 ergoline-type alkaloids have been described in the Convolvulaceae. Most of the alkaloids are found in various species and strains of ergot and related fungi. The exception is cycloclavine (an isomer of agroclavine with the carbon atoms 8, 9 and 10 forming a 3-membered ring in place of the 8, 9 double bond) which is an alkaloid isolated by Stauffacher *et al.*²² from *Ipomoea hildebrandtii*. The absence of reports on the occurrence of the other commonly encountered ergoline alkaloids may be attributed to the fact that in many instances, surveys were conducted on very small amounts of seed obtained from herbarium specimens.⁸ It can reasonably be predicted that more ergoline-type alkaloids, including certain new indole alkaloids, will be found when more species and larger quantities of convolvulaceous materials become available.

EXPERIMENTAL

The detailed procedures of the alkaloid extraction and the 2-D TLC [solvent systems: MeOH-CHCl₃ (1:4), followed by diethylamine-CHCl₃ (1:9)] were described in previous paper.²⁹

Acknowledgements—This work was supported by a fund from the Philadelphia College of Pharmacy and Science. The authors wish to thank Dr. Albert Hofmann of Sandoz Limited, Basel, Switzerland for his provision of reference compounds, and to Drs. Richard Howard and Richard Schultes of Harvard University and Dr. Hseun Keng of Singapore University for their help in procuring herbarium material used in a part of this study.

³⁰ VAN OOSTSTROOM, S. J. (1953) *Flora Malesiana* **4**, 494.

³¹ WASUWAT, S. (1970) *Nature* **225**, 758.

³² MATIN, M. A., TEWARI, J. P. and KALANI, D. K. (1969) *J. Pharm. Sci.* **58**, 757.