Phytochemistry, Vol. 28, No. 9, pp. 2359–2362, 1989.
Printed in Great Britain.

0031-9422/89 $3.00 + 0.00
Maxwell Pergamon Macmillan plc.

DIARYLHEPTANOIDS AND ISOFLAVONOIDS FROM *CENTROLOBIUM* SPECIES*

LEILA V. ALEGRIO, RAIMUNDO BRAZ-FILHO† and OTTO R. GOTTLIEB‡

†Instituto de Ciências Exatas, Universidade Federal Rural do Rio de Janeiro, 23851 Seropédica, RJ, Brazil; ‡Instituto de Química, Universidade de São Paulo, 05508 São Paulo, SP, Brazil

(*Received* 10 *January* 1989)

Key Word Index—*Centrolobium paraense*; *C. sclerophyllum*; *C. tomentosum*; *C. robustum*; Fabaceae; antipodal diarylheptanoids; isoflavonoids.

Abstract—*Centrolobium paraense*, *C. sclerophyllum* and *C. tomentosum* contain laevorotatory diarylheptanoids, while *C. robustum* contains the dextrorotatory isomers. The presence of a diarylheptanoid diol, of an isoflavone and of three isoflavans is reported for the first time for *Centrolobium*. Two new compounds, 7,4′-dihydroxy-3′,5′-dimethoxyisoflavanone and 7,2′-dihydroxy-8,4′-dimethoxyflavene are described. The presence of antipodal diarylheptanoids in sympatric species is attributed tentatively to an evolutionary trend to diversification.

INTRODUCTION

In a previous paper we reported on the stereochemistry of centrolobol and centrolobines and stated the laevorotatory enantiomers of these diarylheptanoids, i.e. **1a**, **2a** and **2c**, to occur in *Centrolobium robustum* and the dextrorotatory forms **1b**, **2b** and **2d** to occur in *C. tomentosum* [2]. At that time Gonçalves de Lima, Marini-Bettòlo and their collaborators [3–5] had already found (+)-centrolobine (**1b**) in *C. robustum* and we were forced to conclude that the identification and classification of *Centrolobium* species must be considered ambiguous [2]. However more recently Jurd and Wong [6] confirmed the finding of the Brazilian–Italian group [3–5], i.e. presence of the laevorotatory compounds in *C. tomentosum* and reported to have located the dextrorotatory compounds in an additional, unidentified *Centrolobium* species. Recently Haroldo Cavalcante de Lima completed a revision of the genus *Centrolobium* [7] and thus gave us the opportunity to study four of the five species chemically.

RESULTS

The results of the present study are presented in Table 1, section I. Clearly the data of Marini-Bettòlo's group (Table 1, section II) [4, 5] and of Jurd and Wong (Table 1, section III) [6] concerning the optical rotation of centrolobol and the centrolobines are confirmed. Hence the identifications of the species designated *C. robustum* and *C. tomentosum* in our previous work [2] must be interchanged. It is also probable that Jurd and Wong's unidentified species [6] was *C. tomentosum*; this is the reason why the pertinent data are listed tentatively under this heading in Table 1, section III. This arrangement makes sense also with respect to this author's isolation of piceatannol (**3**) which we had isolated previously from what must now also be recognized as *C. tomentosum.*

The most interesting of our new isolates is (−)-hannokinol (**1c**) a compound previously reported, without indication of its specific rotation, for *Alnus japonica* Steud. (Betulaceae) [8]. The three isoflavans **4a**–**c**, as well as the isoflavone **5b**, the occurrence of which in *Centrolobium* is also reported for the first time, have been isolated previously; vestitol (**4a**) as the (+)-isomer from *Machaerium vestitum* [9], the (−)-isomer being a phytoalexin of *Dalbergia sericea* [10], (−)-sativan (**4b**) from *Medicago sativa* [11], mucronulatol (**4c**) from *Machaerium mucronulatum* [12] and 3′-hydroxyformononetin (**5b**) from *Machaerium mucronulatum*, *M. villosum* [12] and *Cyclolobium clausseni* [13].

7,4′-Dihydroxy-3′,5′-dimethoxyisoflavanone (**6**) and 7,2′-dihydroxy-8.4′-dimethoxyisoflavene (**7**) are here described for the first time. Their structural elucidation relied on the straight forward interpretation of mass and NMR spectra. Table 2 registers ^{13}C NMR data of centrolobol (**1a**) and its acetate, reported for the first time, of de-*O*-methylcentrolobine (**2a**) [6] for comparison purposes and of hannokinol (**1c**), its acetate and its dimethylketal (**1d**). The data of **1d** demonstrate the asymmetry of the ketal ring system. Indeed, as already indicated by the optical rotation, **1c** does not occur in the *meso*-form.

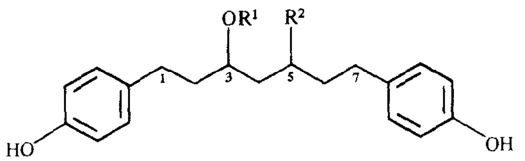
DISCUSSION

As long as the diarylheptanoids remained practically the sole known constituents of *Centrolobium*, it was impossible to perceive chemical affinities of the genus with other genera of the Fabaceae. The present study suggests for the first time similarities with South American *Machaerium* and *Dalbergia*, compatible with the placement of *Centrolobium* in the same tribe Dalbergieae [14].

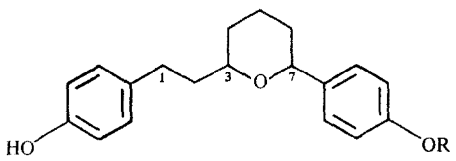
More interesting still is the question of the presence of one stereochemical series of diarylheptanoids in three

---

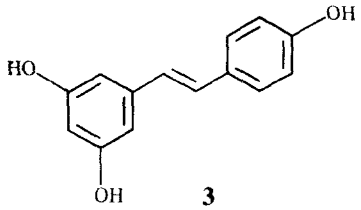
*Part 63 in the series 'The Chemistry of Brazilian Leguminosae'. For Part 62 see ref. [1]. Taken from part of the Doctorate thesis presented by L.V.A. to Universidade de São Paulo (1988).



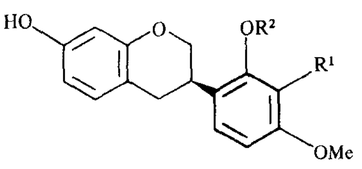
1a (3*S*) R^1 = R^2 = H
1b (3*R*) R^1 = R^2 = H
1c R^1 = H, R^2 = OH
1d R^1–R^2 = CMe$_2$O



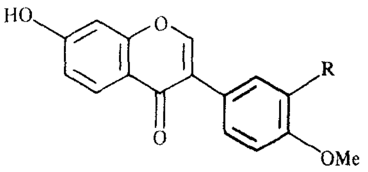
2a (3*S*,7*R*) R = H
2b (3*R*,7*S*) R = H
2c (3*S*,7*R*) R = Me
2d (3*R*,7*S*) R = Me



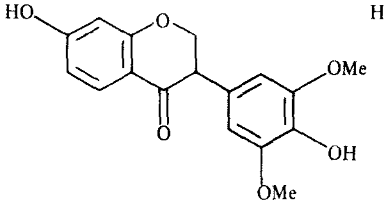
3



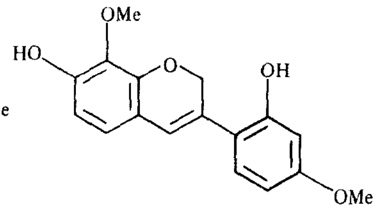
4a R^1 = R^2 = H
4b R^1 = H, R^2 = Me
4c R^1 = OMe, R^2 = H



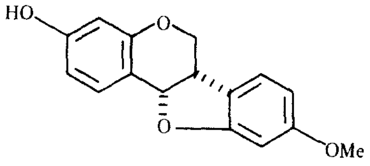
5a R = H
5b R = OH



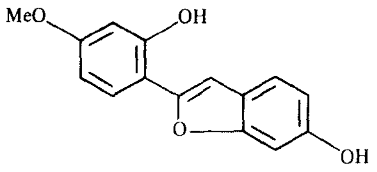
6



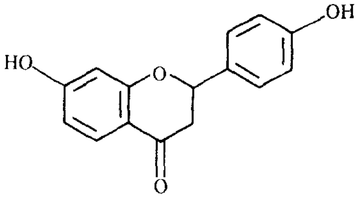
7



8



9



10

species (*C. paraense*, *C. sclerophyllum* and *C. tomentosum*) as opposed to the presence of the antipodal series in a further species (*C. robustum*). If the geographical distribution of these species is taken into account [7], the former species are seen to be allopatric, while *C. robustum* and either *C. sclerophyllum* or *C. tomentosum* show overlapping areas of distribution. Most probably this was the fact which caused the confusion concerning identifications clarified above. We have already called attention to the chemical heterogeneity of closely related sympatric species [15] and the present situation may again indicate a diversificatory trend in chemical composition, this time by configurational inversion of chiral centres. Such a phenomenon would account for several previous observations, e.g. the existence of quasi-enantiomers in *Dalbergia* [16].

EXPERIMENTAL

Isolation of the constituents. For data on collection and identification of plant material see Table 1. Powdered wood samples (1kg each) were extracted at room temp. successively with C_6H_{14}, $CHCl_3$ and MeOH. Yields in extracts *C. paraense* respectively 40, 11 and 24 g; *C. sclerophyllum* respectively 14, 24 and 37 g; *C. tomentosum* respectively 31, 9 and 19 g; *C. robustum* respectively undetermined, 18 g, undetermined. The $CHCl_3$ extracts were submitted to CC (silica gel). *C. paraense*: elution with $CHCl_3$ gradually enriched in MeOH gave five cryst.

Table 1. Compounds (and $[\alpha]_D^{25^\circ}$ values) isolated from four *Centrolobium* species

	Species	*C. paraense* var. *paraense* Tull.	*C. sclerophyllum* Lima sp. nova	*C. tomentosum* Guillem. ex Benth.	*C. robustum* (Vell.) Benth. ex Mart.
I	Voucher	2071 RB	1535 RB	2518 RB	2517 RB
	Collection Site	Botanical Garden Rio de Janeiro, RJ	CURD Reserve Linhares, ES	Botanical Garden Rio de Janeiro, RJ	D. Castorina Street Rio de Janeiro, RJ
	Collection Date	Nov. 23, 1983	Jan. 20, 1985	Jan. 11, 1985	Jan. 9, 1985
	Diarylheptanoids	**1a** (−11°)	**1a** (−11°) **1c** (−19°)	**1a** (−10°)	**1b** (+11°)
		2a (−96°)	**2a** (−96°)	**2a** (−96°) **2c** (−98°)	**2b** (+95°) **2d** (+97°)
	Stilbene [2]			**3**	
	Isoflavans	**4c**	**4c**	**4a** (−22°) **4b** (−18°)	
	Isoflavones	**5b**	**5a, 5b**	**5a**	**5a**
	Isoflavanone	**6**			
	Isoflavene	**7**	**7**		
	Pterocarpane		**8** (−187°)		
II	[3–5]				**2b** (+97°)
III	[6]			**1a**	**1b**
				2a (−95°) **2c**	**2b** (+99°) **2d**
				3, 5a	**5a, 8** (−232°) **9, 10**

Table 2. ^{13}C NMR data of diarylheptanoids in $(CD_3)_2CO$, (**1a**, **1c**, **1d**, **2a**) and in $CDCl_3$ (**1a**-OAc, **1c**-OAc) at 25.5 MHz (**1a**, **1a**-OAc, **1c**-OAc, **2a**) and 20 MHz (**1c**, **1d**)

C	1a	1a-OAc	1c	1c-OAc	1d	2a
1′,1″	133.6	139.0	134.1	138.7	134.6	135.9, 134.0
2′,2″,6′,6″	129.6	129.0	130.1	129.0	129.9	130.0, 127.8
3′,3″,5′,5″	115.5	121.3	115.9	121.3	115.8	115.9, 115.6
4′,4″	155.4	148.7	156.1	148.7	156.0	157.1, 156.1
1	31.5	31.1	31.8	30.9	31.7	34.5
2	40.0	35.7	40.8	36.3	38.7	39.4
3	71.7	73.4	68.7	69.6	66.3	77.7
4	37.6	33.9	44.6	38.5	39.2	32.0
5	25.7	24.7	68.7	69.6	68.2	24.7
6	32.3	31.1	40.8	36.3	40.8	31.4
7	35.3	35.0	31.8	30.9	31.7	79.9
Other		20.9		20.5	25.4	
		169.1		20.7	28.8	
		170.4		169.3	100.4	
				179.5		

fractions A–E. Recryst. from the indicated solvents led from A ($CHCl_3$) to **7** (4 mg) and **4c** (2 mg), from B ($CHCl_3$–C_6H_{14}) to **6** (7 mg), from C (Me_2CO–C_6H_{14}) to **5b** (7 mg), from D (Me_2CO–C_6H_{14}) to **1a** (13 mg) and from E (Me_2CO–C_6H_{14}) to **2a** (9 mg). *C. sclerophyllum*: elution with $CHCl_3$–MeOH mixtures of the indicated composition gave fractions F, G, H (pure $CHCl_3$), I (9:1), J, K (4:1), L (2:3). Recryst. from the indicated solvents led from F ($CHCl_3$) to **8** (5 mg), from G ($CHCl_3$) to **7** (25 mg) and **4c** (5 mg), from H (Me_2CO) to **5a** (27 mg), from I (Me_2CO–C_6H_{14}) to **2a** (6 mg), from J (Me_2CO) to **5b** (4 mg), from K (Me_2CO–C_6H_{14}) to **1a** (400 mg), from L (H_2O) to **1c** (66 mg). *C. tomentosum*: elution with $CHCl_3$–MeOH mixtures of the indicated composition gave fractions M, N (pure $CHCl_3$), O (9:1), P (7:3). Recryst. from the indicated solvents led from M (C_6H_6–C_6H_{14}) to **4b** (3 mg), from N (C_6H_6–C_6H_{14}) to **4a** (23 mg), from P(Me_2CO–C_6H_{14}) to **1a** (10 mg). Fraction O, an oil, was purified by CC (silica gel). Elution with C_6H_6–$CHCl_3$ 1:1 gave two crystalline fractions, recryst. from Me_2CO to **5a** (9 mg) and from Me_2CO–C_6H_{14} to **2a** (5 mg) and to **2c** (10 mg). *C. robustum*: elution with $CHCl_3$ gradually enriched in MeOH gave four cryst. fractions, all recryst, from Me_2CO–C_6H_{14} to **5a** (13 mg), **1b** (20 mg), **2b** (37 mg) and **2d** (12 mg).

7,4′-Dihydroxy-3′,5′-dimethoxyisoflavanone (**6**). Mp 183–185° (C_6H_{14}–$CHCl_3$). ^{1}H NMR (60 MHz, $CDCl_3$ + CD_3OD): 4.2 (*dd*, J = 9, 8 Hz, H-2eq), 4.6 (*dd*, J = 9, 6 Hz, H-2ax), 3.6–4.2 (*m*, H-3), 7.9 (*d*, J = 8.5 Hz, H-5), 6.4–6.7 (*m*, H-6, H-8), 6.7 (*s*, H-2′, H-6′). MS *m/z* (rel. int.): 316 (24, M), 180 (100), 165 (18), 137 (86).

7,2′-Dihydroxy-8,4′-dimethoxiisoflavene (**7**), mp 160–161° ($CHCl_3$). IR ν_{max}^{KCl} cm^{-1}: 3420 (OH), 1625, 1590 (Ar). ^{1}H NMR [300 MHz, $(CD_3)_2CO$] δ: 3.80 (*s*, OMe-8), 3.86 (*s*, OMe-4′), 4.95 (*d*, J = 1.2 Hz, 2H-2), 6.34 (*d*, J = 2.5 Hz, H-3′), 6.42 (*dd*, J = 8.5, 2.5 Hz, H-5′), 6.60 (*br s*, H-4), 6.76 (*d*, J = 8.5 Hz, H-6), 6.80 (*d*, J = 8.5 Hz, H-5), 6.97 (*d*, J = 8.5 Hz, H-6′), 7.60 (*s*, OH), 8.46 (*s*, OH). ^{13}C NMR [25.2 MHz, $(CD_3)_2CO$] δ: 56.5 (OMe-4′), 60.4 (OMe-8), 68.7 (C-2), 103.4 (C-3′), 108.0 (C-5′), 109.4 (C-6), 116.7 (C-4a, C-1′), 122.1 (C-5), 126.1, 128.5, 128.8 (C-4, C-8, C-6′), 140.3

(C-8a), 144.2 (C-7), 155.6 (C-2'), 159.0, 159.1 (C-3, C-4'). MS *m/z* (rel. int.): 300 (100, M), 299 (31), 285 (43), 270 (16), 269 (15), 153 (3), 148 (2), 147 (20), 123 (8).

Acknowledgement—The authors are indebted to CNPq for financial support.

REFERENCES

1. Laux, D. O., Stefani, G. M. and Gottlieb, O. R. (1985) *Phytochemistry* **24**, 1081.
2. Craveiro, A. A., Prado, A. de C., Gottlieb, O. R. and Albuquerque, P. C. W. de (1970) *Phytochemistry* **9**. 1869.
3. Gonçalves de Lima, O., Albuquerque, M. M. de and Maia, M. H. D. (1959) *Rev. Inst. Antibiot. Univ. Recife* **2**, 19.
4. Albuquerque, I. L. de, Galeffi, C., Casinovi, C. G. and Marini-Bettòlo, G. B. (1964) *Gazz. Chim. Ital.* **94**, 287.
5. Galeffi, C., Casinovi, C. G. and Marini-Bettòlo, G. B. (1965) *Gazz. Chim. Ital.* **95**, 95.
6. Jurd, L. and Wong, R. Y. (1984) *Aust. J. Chem.* **37**, 1127.
7. Lima, H. C. de (1983–1985) *Arq. Jard. Bot. Rio de Janeiro* **27**, 177.
8. Nomura, M., Tokoroyama, T. and Kubota, T. (1981) *Phytochemistry* **20**, 1097.
9. Kurosawa, K., Ollis, W. D., Redman, B. T., Sutherland, I. O. and Gottlieb, O. R. (1978) *Phytochemistry* **17**, 1413.
10. Ingham, J. L. (1979) *Z. Naturforsch.* **34c**, 630.
11. Dewick, P. M. and Martin, M. (1979) *Phytochemistry* **18**, 591.
12. Kurosawa, K., Ollis, W. D., Sutherland, I. O., Gottlieb, O. R. and Oliveira, A. B. de (1978) *Phytochemistry* **17**, 1405.
13. Gottlieb, O. R., Oliveira, A. B. de, Gonçalves, T. M. M., Oliveira, G. G. de and Pereira, S. A. (1975) *Phytochemistry* **14**, 2495.
14. Polhill, R. M. (1978) in *Advances in Legume Systematics* (Polhill, P. M. and Raven, R. H., eds), Part I, p. 240. Royal Botanic Gardens, Kew.
15. Gottlieb, O. R. and Kubitzki, K. (1983) *Naturwissenschaften* **70**, 119.
16. Eyton, W. B., Ollis, W. D., Fineberg, M., Gottlieb, O. R., Guimarães, I. S. de S. and Magalhães, M. T. (1965) *Tetrahedron* **21**, 2683.