H(15b)···O(1) = 120 (3)°]. The widening of the exocyclic angle C(9)–N(10)–C(15) = 126·7 (4)° can also be attributed to the above interaction.

Bond distances and angles in the trifluoromethyl group are in good agreement with those found in related structures (Murthy & Vijayan, 1979; Lenstra, Gupta, Vanhoeck & Lemière, 1984). Fig. 1 shows that the trifluoromethyl group may possibly rotate around the C(6)–C(21) bond. This is consistent with the observation of relatively high standard deviations of positional and thermal parameters of F(21*A*), F(21*B*) and F(21*C*), and may result in the relatively high *R* value in the present structure analysis. In the isovaleryl substituent, the N(4)–C(16)–C(17)–C(18)–C(19) chain takes approximately a *trans* zigzag conformation with torsion angles of 170·9 (4) and 170·6 (4)°, while C(20) is in a *gauche* position [−65·4 (6)°] against the C(16)–C(17) bond.

Fig. 2 shows the packing of the molecule. The fluoromethyl group is stacked over the furo[2,3-*b*]-indole ring system of the adjacent molecule, where the closest van der Waals contacts of 3·154 (6) and 3·433 (6) Å are between F(21*A*) and C(8a) and between F(21*C*) and C(8).

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Garuganin-II,* an Antibiotic

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Abstract. $C_{22}H_{24}O_5$, $M_r = 368{\cdot}41$, monoclinic, *Pc*, $a = 17{\cdot}180$ (2), $b = 11{\cdot}180$ (2), $c = 10{\cdot}052$ (1) Å, $\beta = 94{\cdot}08$ (1)°, $V = 1925{\cdot}8$ (5) Å^3, $Z = 4$, D_m(flotation) $= 1{\cdot}25$ (1), $D_x = 1{\cdot}271$ Mg m^{-3}, λ(Cu $K\alpha$) $= 1{\cdot}5418$ Å, $\mu = 0{\cdot}646$ mm^{-1}, $F(000) = 784$, $T \simeq 298$ K, $R = 0{\cdot}027$ for 2647 observed reflections. Garuganin-II exists as two independent molecules which are grossly similar. The biphenyl rings are twisted by dihedral angles of 41·4 (1) and 38·6 (1)° in the two molecules. The carbonyl bond at the aliphatic ansa bridge joining the non-adjacent positions of the biphenyl group is nearly equi-inclined (67–77°) to the biphenyl rings.

Introduction. Garuganin-II is one of a series of compounds extracted from the plant *Garuga pinnata*. The structures of this molecule and its chemical isomer garuganin-I (Pattabhi, Krishnaswamy & Gabe, 1984) resemble the ansamycin antibiotics (Brufani & Cellai, 1984). The ansamycin antibiotics are macrocyclic antibiotics characterized by an aliphatic ansa bridge joining two non-adjacent positions of an aromatic system. The structure determination of garuganin-II is part of a programme of work on the structure–activity relations of antibiotics.

* IUPAC name: 1-hydroxy-4,6,12-trimethoxytricyclo-[12.3.1.1^{3,7}]nonadeca-2(18),3,5,7(19),11,15,17-heptaen-10-one.

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Experimental. Sample from Hindustan Antibiotics Ltd, Pune, India. Crystal size 0·3 × 0·2 × 0·2 mm. Density measured by flotation in aqueous KI solution. Data collected on a Picker four-circle automatic diffractometer. $\theta/2\theta$ scan with line profile analysis (Grant & Gabe, 1978). Three standard reflections measured every 100 reflections did not show appreciable variation in intensity. Unit-cell determination by least-squares refinement of measured angle values of 58 reflections with $45 \le \theta \le 50°$. $\theta_{max} = 60°$, $-19 \le h \le 19$, $0 \le k \le 12$, $0 \le l \le 11$. Data corrected for direct-beam polarization (Le Page, Gabe & Calvert, 1979) and Lorentz effects. No absorption correction. 2647 reflections out of 2841 had $I \ge 2\sigma(I)$. Structure solved using direct methods and the Karle recycling procedure through the program *MULTAN*80 (Main, Fiske, Hull, Lessinger, Germain, Declercq & Woolfson, 1980). H atoms stereochemically fixed, hydroxyl H atom from difference synthesis. Full-matrix anisotropic refinement using *SHELX*76 (Sheldrick, 1976) including H atoms (isotropic). $R = 0·027$, $wR = 0·028$, $S = 1·50$, $w = 0·8276/[\sigma^2(F_o) + 0·0002F_o^2]$, $R = 0·039$ for all reflections. Origin defined by clamping the x and z coordinates of the centre of mass. 679 parameters refined. $(\Delta/\sigma)_{max} = 0·18$, final difference map had no peaks $>0·08$ e Å^{-3}. Atomic scattering factors from *SHELX*76 (Sheldrick, 1976).

Discussion. The coordinates and the equivalent temperature factors of the non-H atoms are listed in Table 1.* The average e.s.d.'s in bond lengths (Fig. 1), bond angles (Fig. 2) and torsion angles are 0·003 Å, 0·2 and 0·2° for molecule 1, and 0·004 Å, 0·2 and 0·3° for molecule 2. The two independent molecules have grossly similar features. The torsion angles of the two molecules differ by about 5–8 e.s.d.'s on average, except for those involving the methoxy groups which have much larger changes. The differences in torsion angles between molecules 1 and 2 and the higher thermal factors of molecule 2 (average $U_{eq} = 0·05$ for molecule 1 and 0·07 Å^2 for molecule 2) may be attributed to the lower number of stabilizing contacts involving molecule 2. Fig. 3 is an *ORTEP* drawing of molecules 1 and 2. Table 2 gives details of the hydrogen bonding.

The rings of the biphenyl group are at an angle of 41·4 (1) (molecule 1) and 38·6 (1)° (molecule 2). This interplanar angle varies from 0 to 90° in biphenyl structures depending on the substituents (Wang, Cheng, Chen & Chen, 1985). The aromatic rings are non-planar and boat-shaped as found in 4,12-dimethyl-(2·2)metacyclophane (Hanson, 1962) and di-*m*-xylene (Brown, 1953). In garuganin-I (Pattabhi *et al.*, 1984), where the hydroxy-substituted biphenyl group is replaced by the diphenyl ether group, the methoxy-substituted ring is planar. The large bond-angle deviations at C(2) and C(3) from the standard C(sp^2) value of 120° are probably due to the effect of the macrocycle on the biphenyl group.

The carbonyl bond C(10)–O(10) is nearly equiinclined to ring I [56·6 (1), 63·0 (2)°] and ring II [76·3 (1), 72·9 (2)°]. The corresponding values in

Table 1. *Fractional coordinates* (×10^4) *and equivalent isotropic thermal parameters* (×10^4) *for non-*H *atoms in garuganin-*II, *with e.s.d.'s in parentheses*

$U_{eq} = \frac{1}{3}\sum_i\sum_j U_{ij} a_i^* a_j^* \mathbf{a}_i.\mathbf{a}_j.$

	x	y	z	U_{eq}(Å^2)
C(1)	5157 (1)	−2394 (2)	844 (2)	463 (7)
O(1)	5434 (1)	−3466 (2)	1340 (2)	603 (6)
C(2)	4383 (1)	−2224 (2)	365 (2)	406 (7)
C(3)	3724 (1)	−3090 (2)	390 (2)	377 (6)
C(4)	3713 (1)	−4255 (2)	−72 (2)	409 (7)
O(4)	4427 (1)	−4735 (1)	−329 (2)	587 (6)
C(5)	3018 (1)	−4880 (2)	−302 (2)	451 (7)
C(6)	2314 (1)	−4315 (2)	−132 (2)	436 (7)
O(6)	1604 (1)	−4848 (2)	−424 (2)	618 (6)
C(7)	2290 (1)	−3145 (2)	345 (2)	391 (7)
C(8)	1528 (1)	−2467 (2)	380 (3)	447 (7)
C(9)	1617 (1)	−1152 (2)	779 (2)	432 (7)
C(10)	2097 (1)	−393 (2)	−113 (2)	392 (7)
O(10)	2128 (1)	−634 (1)	−1298 (2)	507 (5)
C(11)	2491 (1)	640 (2)	537 (2)	385 (6)
C(12)	3076 (1)	1303 (2)	113 (2)	390 (6)
O(12)	3370 (1)	2269 (1)	794 (2)	503 (5)
C(13)	3521 (1)	1153 (2)	−1114 (2)	453 (7)
C(14)	4414 (1)	1008 (2)	−846 (3)	538 (9)
C(15)	4680 (1)	−152 (2)	−201 (2)	468 (7)
C(16)	5436 (1)	−327 (3)	364 (3)	572 (9)
C(17)	5668 (1)	−1421 (3)	861 (2)	564 (9)
C(18)	4182 (1)	−1111 (2)	−177 (2)	416 (7)
C(19)	2995 (1)	−2600 (2)	646 (2)	378 (6)
C(20)	4445 (2)	−5722 (3)	−1179 (4)	777 (13)
C(21)	1583 (2)	−5925 (3)	−1175 (5)	853 (14)
C(22)	2998 (2)	2682 (3)	1938 (3)	633 (10)
C(1*P*)	9642 (1)	1893 (2)	2143 (3)	582 (9)
O(1*P*)	9600 (1)	2057 (3)	3484 (2)	875 (9)
C(2*P*)	8991 (1)	1954 (2)	1239 (2)	487 (7)
C(3*P*)	8179 (1)	2309 (2)	1514 (2)	486 (8)
C(4*P*)	7727 (1)	1892 (2)	2501 (2)	547 (8)
O(4*P*)	8102 (1)	1173 (2)	3466 (2)	711 (7)
C(5*P*)	6932 (1)	2157 (3)	2468 (2)	566 (9)
C(6*P*)	6583 (1)	2818 (3)	1429 (2)	536 (8)
O(6*P*)	5802 (1)	3064 (2)	1288 (2)	704 (7)
C(7*P*)	7019 (1)	3265 (2)	411 (2)	508 (8)
C(8*P*)	6641 (2)	3872 (3)	−811 (3)	668 (10)
C(9*P*)	7210 (2)	4323 (3)	−1793 (3)	753 (12)
C(10*P*)	7722 (2)	3398 (3)	−2410 (3)	677 (11)
O(10*P*)	7501 (1)	2364 (3)	−2557 (2)	834 (9)
C(11*P*)	8476 (2)	3849 (4)	−2779 (3)	746 (12)
C(12*P*)	9121 (2)	3224 (3)	−2997 (3)	685 (10)
O(12*P*)	9803 (1)	3748 (2)	−3282 (3)	906 (9)
C(13*P*)	9242 (2)	1898 (3)	−2979 (3)	683 (11)
C(14*P*)	9927 (2)	1453 (3)	−2054 (3)	620 (10)
C(15*P*)	9837 (1)	1622 (2)	−584 (2)	497 (8)
C(16*P*)	10472 (1)	1629 (2)	345 (3)	580 (9)
C(17*P*)	10374 (1)	1735 (3)	1686 (3)	645 (10)
C(18*P*)	9110 (1)	1768 (2)	−96 (2)	473 (7)
C(19*P*)	7808 (1)	3049 (2)	543 (2)	474 (7)
C(20*P*)	7654 (2)	619 (4)	4432 (4)	797 (13)
C(21*P*)	5341 (2)	2760 (5)	2360 (4)	853 (16)
C(22*P*)	9831 (3)	5030 (5)	−3434 (8)	1386 (27)

Origin defined by clamping the x and z coordinates of the centre of mass.

* Lists of anisotropic thermal factors, H-atom parameters, least-squares planes, torsion angles, intermolecular distances and structure factors have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 43461 (25 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

garuganin-I are 84·7 (3) and 35·8 (3)°. The plane through the ansa bridge makes an angle of [30·6 (1), 25·3 (1)°] with ring I and [60·3 (1), 57·8 (1)°] with ring II. The related angles in garuganin-I are 45·6 (3) and 57·2 (3)°. In the active ansamycin antibiotics the CO bond at the ansa bridge is nearly parallel to the aromatic system and the best plane through the ansa bridge is nearly perpendicular to the aromatic rings (Brufani & Cellai, 1984). On this basis, garuganin-II should be inactive whereas garuganin-I could be of intermediate activity. Biochemical studies are to be carried out to verify the validity of this conclusion from structure–activity considerations.

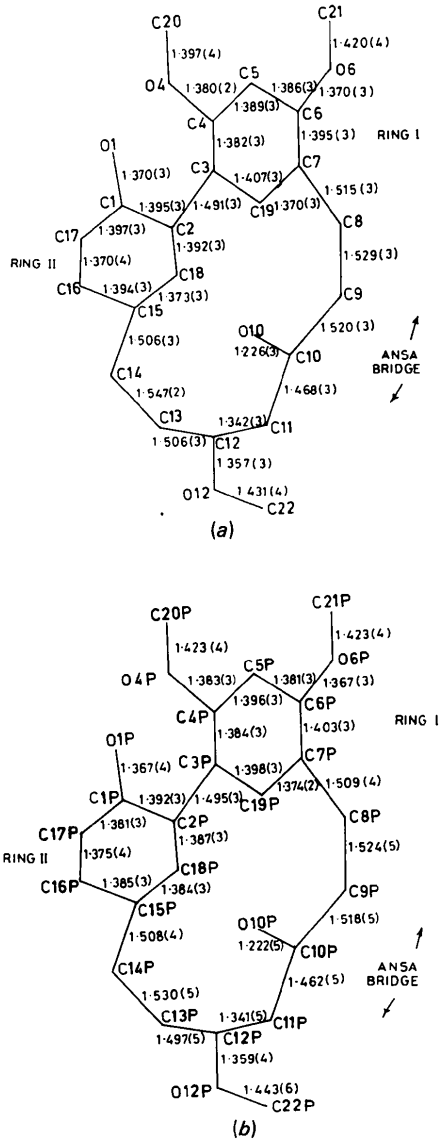

Fig. 1. Bond lengths (Å) for garuganin-II with e.s.d.'s in parentheses: (*a*) molecule 1, (*b*) molecule 2.

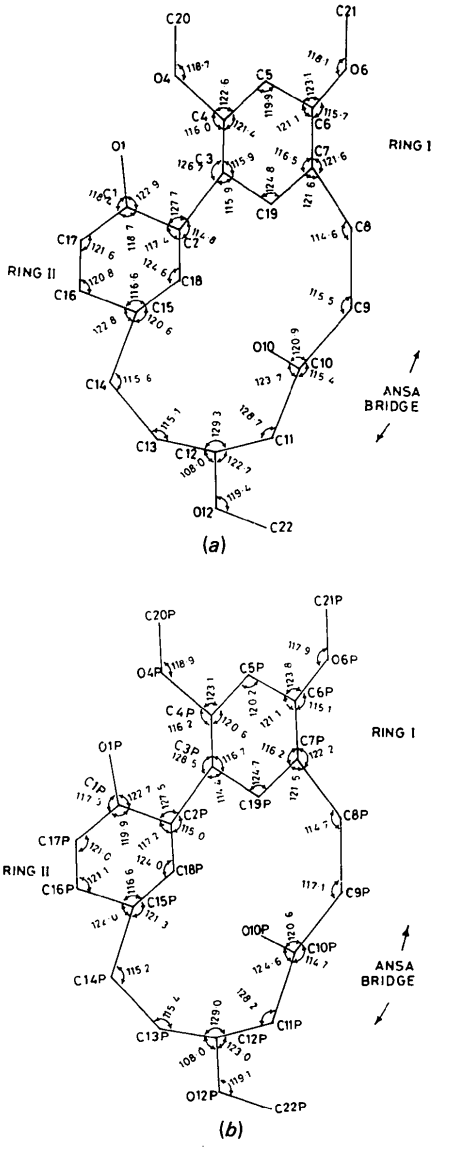

Fig. 2. Bond angles (°) for garuganin-II: (*a*) molecule 1, (*b*) molecule 2. The average e.s.d. is 0·2° for both molecules.

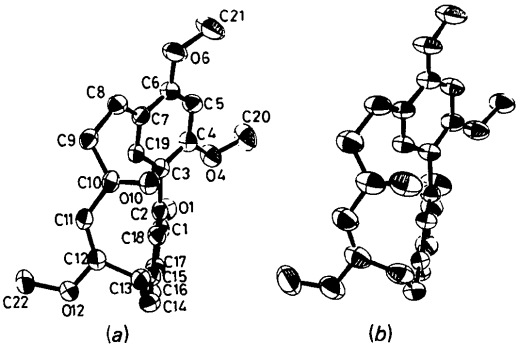

Fig. 3. *ORTEP* diagram (Johnson, 1965) showing thermal ellipsoids at 50% probability level: (*a*) molecule 1, (*b*) molecule 2.

Table 2. *Hydrogen-bond lengths* (Å) *and angles* (°)

D—H···*A*	*D*···*A*	H···*A*	*D*—H···*A*	Symmetry of *A*
Intramolecular				
O(1)—H(O1)···O(4)	2·722 (2)	1·81 (3)	158 (2)	
O(1*P*)—H(O1*P*)···O(4*P*)	2·756 (3)	1·98 (4)	159 (3)	
C(13)—H(131)···O(10)	3·133 (2)	2·44 (3)	126 (2)	
C(13*P*)—H(131*P*)···O(10*P*)	3·095 (4)	2·34 (3)	130 (2)	
Intermolecular				
C(11)—H(C11)···O(10)	3·286 (3)	2·36 (2)	155 (1)	$x,\bar{y},\frac{1}{2}+z$

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Hydrogen Bonding in Andrographolide: 3-{2-[Decahydro-6-hydroxy-5-(hydroxymethyl)-5,8a-dimethyl-2-methylene-1-naphthalenyl]ethylidene}dihydro-4-hydroxy-2(3*H*)-furanone

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Abstract. $C_{20}H_{30}O_5$, $M_r = 350{\cdot}45$, monoclinic, $P2_1$, $a = 6{\cdot}559$ (1), $b = 8{\cdot}017$ (1), $c = 18{\cdot}004$ (2) Å, $\beta = 97{\cdot}38$ (1)°, $U = 938{\cdot}9$ (2) Å^3, $Z = 2$, $D_x = 1{\cdot}240$ g cm^{-3}, λ(Cu $K\alpha$) = 1·5418 Å, $\mu = 6{\cdot}7$ cm^{-1}, $F(000) = 380$, $T = 295$ K, $R = 0{\cdot}044$ for 1894 observed reflections with $I > 2{\cdot}5\sigma(I)$. The present study confirms the results of the previous structure determinations of andrographolide by Smith, Toder, Carroll & Donohue [*J. Cryst. Spectrosc. Res.* (1982), **12**, 309–319] and Fujita, Fujitani, Takeda, Takanishi, Yamada, Kido & Miura [*Chem. Pharm. Bull.* (1984), **32**, 2117–2125], but the present structure is more accurately determined and the hydrogen-bonding scheme clearly defined. The six-membered rings are in chair conformations. The furan ring is slightly puckered. There are two separate systems of infinite chains of hydrogen bonds along the *a* and *b* axes, respectively.

Introduction. *Andrographis paniculata* Nees (Acanthaceae) is an annual herb common in Sri Lanka (Trimen, 1974) and India (Chopra, Nayar & Chopra, 1956). It is extensively used in the Ayurvedic system of medicine in Sri Lanka for fevers, dysentery, general debility, certain forms of dyspepsia and also as a stomachic, anthelmintic and a tonic (Jayaweera, 1981). A preparation of it with pepper is used in the treatment of malarial fever (*Ayurveda Pharmacopoeia*, 1979).

Reported pharmacological studies on the extracts and compounds of the plant indicate that *Andrographis* exhibit antibacterial (*Herbal Pharmacology in the Republic of China*, 1975), anthelmintic (Kaleysa Raj, 1975), male antifertility (Stamsuzzona, Rahman &

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