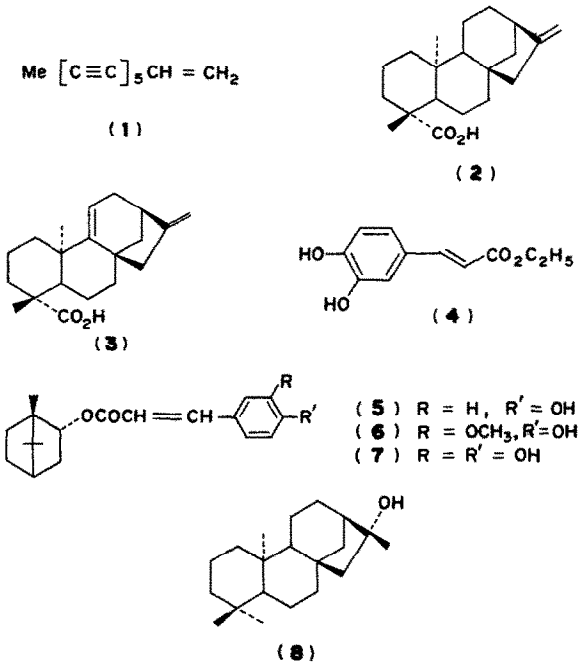
in Mexico gesammelt, Herbar Nr. FB 75–53, 59, 80 identifiziert durch F. Ramos, Herbarium Botanical Institute University of Mexico City.

Bisherige Untersuchungen. Vier Arten enthalten Acetylenverbindungen [1], *V. caahuilensi* [2], *V. rupestris* (Urb.) Blake und *V. virginica* L. Sesquiterpen-Derivate und Borneolester [3], *V. myriocephala* Sch. Bp. ex Klatt. Rhamnocitringlucoronid [4].



Ergebnisse. Die Wurzeln von *V. angustifolia* enthalten das Pentainen (**1**) sowie die Diterpensäuren (**2**) und (**3**), während die oberirdischen Teile neben (**2**) und (**3**) Kaffeesäureäthylester (**4**), der als Naturstoff noch nicht bekannt ist, ergeben. Die Wurzeln von *V. greenmannii* enthalten ebenfalls (**1**) und die Borneolester (**5**) und (**6**) die schon aus *V. rupestris* isoliert wurden [3]. Aus den oberirdischen Teilen erhält man neben (**6**) einen weiteren, bisher nicht beschriebenen Ester, dem die Struktur (**7**) zukommen muss.

Die Wurzeln von *V. oncophora* liefern wiederum (**1**), (**2**) und (**3**) sowie den Diterpenalkohol (**8**), jedoch keine Borneolester. Die bisherigen Ergebnisse lassen keine deutlichen chemotaxonomischen Aspekte erkennen, da das Vorkommen von Kauran-Derivaten sicher nicht sehr charakterisitisch ist und die Borneolester nicht in allen Arten vorkommen.

EXPERIMENTELLES

NMR. Bruker WH 270, TMS als innerer Standard, δ-Werte, $CDCl_3$.

IR. Beckman IR 9, CCl_4.

MS. Varian MAT 711 mit Datenverarbeitung, 70 eV. Die frisch zerkleinerten Wurzeln wurden mit Et_2O extrahiert und die erhaltenen Extrakte zunächst grob an Sigel (Akt. St. II) chromatographiert. Durch PLC (Siegel, GF 254, 1 mm) wurden die einzelnen Fraktionen weiter aufgetrennt. Als Laufmittel dienten Et_2O–Petroläther (= PÄ)-Gemische.

Verbesina angustifolia. 300 g Wurzeln ergaben *ca* 1 mg (**1**), 400 mg (**2**) und 300 mg (**3**). 200 g oberirdische Teile lieferten 100 mg (**2**) und 70 mg (**3**) sowie 5 mg (**4**), identisch mit authentischem Material.

Verbesina greenmannii. 800 g Wurzeln ergaben 3 mg (**1**) und je 300 mg (**5**) und (**6**). 250 g oberirdische Teile lieferten 50 mg (**5**) und 20 mg (**7**) (Et_2O–PÄ 1:1).

Verbesina onocophora. 300 g Wurzeln ergaben *ca* 1 mg (**1**), 500 mg (**2**), 300 mg (**3**) und 100 mg (**8**).

Kaffeesäureborneolester (**7**). Farbloses Öl, *IR.* OH 3540, COOR 1710 cm^{-1}. NMR: *d* 7.60(1) und 6.30(1) (J = 16 Hz); *d* 7.13(1) (J = 1.5 Hz), *dd* 7.03(1) (J = 8, 1.5 Hz), *d* 6.89(1) (J = 8.5 Hz) (Kaffeesäureester); *d(br)* 5.00(1) (J = 9 Hz); *m* 2.41(1), *m* 2.03(1), *m* 1.75(2) *m* 1.30(2), *dd* 1.04(1) (J = 14, 3.5 Hz), *s* 0.94, 0.90, 0.88 (je 3) (Bornylrest). MS: M^+ *m/e* 316.167 (15%) (ber. für $C_{19}H_{24}O_4$ 316.167); $(HO)_2C_6H_3CH{=}CH\,CO^+$ 163(100).

$$[\alpha]_{24^\circ}^{\lambda} = \frac{589 \quad 578 \quad 546 \quad 436\,nm}{-19.8 \quad -19.9 \quad -22.3 \quad -34.4^\circ} \quad (CHCl_3,\ c = 0.6)$$

Anmerkungen—Der Deutschen Forschungsgemeinschaft und dem ERP-Sondervermögen danken wir für die Förderung dieser Arbeit.

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ANTITUMOUR AND ANTIBIOTIC PRINCIPLES OF *ANNONA SENEGALENSIS*

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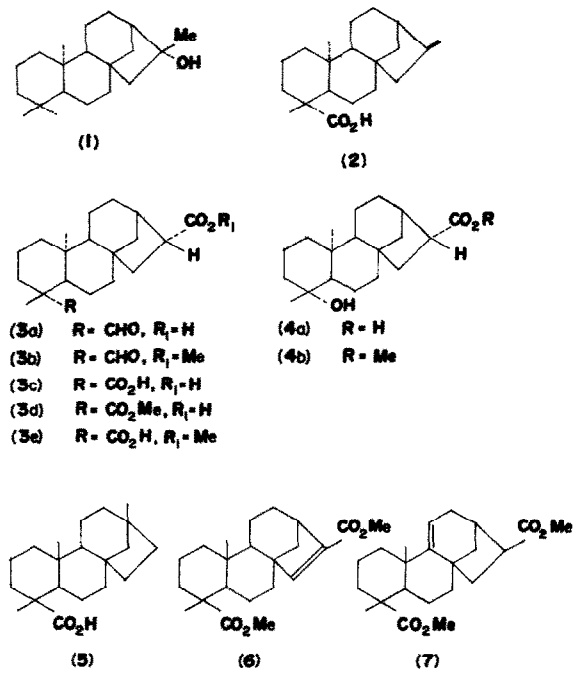
Key Word Index—*Annona senegalensis*; Anonaceae; kaur-16,19-oic acid, kauran-16α-ol, methyl kauran-19-al-17-oate, methyl hydrogen kauran-17,19-oate; methyl 19-norkauran-4α-ol-17-oate.

Annona senegalensis is a shrub common in the savannah regions of West Africa. Chemical studies have been

carried out on the bark, which is used for treatment of convulsions in children, and five diterpenes were isolated [1]. These were kauran-16 α-ol (**1**), kaur-16-en-19-oic acid (**2**), kauran-19-al-17-oic acid (**3a**), 19-norkauran-4α-ol-17-oic acid (**4a**), and kauran-17,19-dioic acid (**3c**).



The root bark of the tree is used by Nigerian herbalists to treat "cancer". In our preliminary work we isolated a white solid, designated C/M_2, which was subsequently shown to be impure. C/M_2 had marked antineoplastic activity measured against sarcoma 180 ascites tumour cells. It showed 100% tumour inhibition and prolongation of survival for 60 days or more with no toxicity to the host. There was a wide margin of safety by the drug, the effective daily dose (ED_{100}) was 100 mg/kg while 200 mg/kg was not toxic to mice. Full details have been reported [2]. In addition C/M_2 was found to contain over 90% kaurenic acid (which has no antitumour properties). MS indicated that C/M_2 contained some monomethyl ester of kaurenic acid (M^+ at *m/e* 348) and a minute quantity of another compound with M^+ at *m/e* 360. Attempts were therefore made to isolate the active principle from both C/M_2 and the root bark.

Chromatography of the petrol extract of the root bark on silica gel afforded 6 crystalline materials. The first two solids were identified as kauran-16α-ol (**1**) and kaur-16-en-19-oic acid (**2**) by comparison with authentic specimens. The third solid was identified as methyl kauran-19-al-17-oate (**3b**) on spectroscopic evidence and because basic hydrolysis gave the known kauran-19-al-17-oic acid (**3a**). The fourth compound, M^+ at *m/e* 320, was a hydroxy ester, and the presence in the NMR spectrum of a characteristic multiplet centred at about δ 2.9 indicative of a proton adjacent to a carboxyl group allowed the identification of the compound as methyl-19-norkauran-4α-ol-17-oate (**4b**), prepared previously from the acid **4a** [1]. Ether eluted a solid, M^+ at *m/e* 304, with three tertiary methyl groups, and a carboxylic acid group. The base peak was at *m/e* 289 (M-Me) and on the basis of all available spectral data, the compound was assigned structure **5**, which is similar to stachanoic acid. Ether also eluted another compound with M^+ at *m/e* 348. IR and NMR spectra indicated the presence of one $-CO_2Me$, one $-CO_2H$ and two tertiary methyl groups. All the data are accounted for by either **3d** or **3e**, however the physical measurements taken did not allow unambiguous differentiation of the two structures. The material with M^+ at *m/e* 348 was accompanied by a very small quantity of another compound with M^+ at *m/e* 360. This compound was presumably the same as that found in C/M_2 and has a probable empirical formula $C_{22}H_{34}O_2$ and could have either structure **6** or **7**. It has so far eluded isolation either from C/M_2 or from the crude root bark extract.

None of the six compounds isolated and purified showed any carcinostatic activity although a very mild antibacterial activity was observed for kaurenic acid. Comparison of the NMR spectrum of C/M_2 and that of kaurenic acid, to which it is very similar, showed a small peak at δ 3.7 and all samples of C/M_2 which showed antitumour activity always possessed this peak. We think the peak at δ 3.7 of C/M_2 is from the compound with M^+ at *m/e* 360, and that the substance is probably responsible for the antitumour activity of C/M_2.

EXPERIMENTAL

Extraction of the root bark. The dried, powdered root bark (0.1 kg) of *Annona senegalensis* Pers (Yoruba-abo) was extracted with petrol (bp 40–60°) at room temp. The oil extract (10 g) was leached with petrol (5 × 10 ml), and the petrol soluble material was chromatographed on alumina (Brockman Grade II). $CHCl_3$–MeOH (3:1) eluted C/M_2 as a white solid (100 mg). The extraction was repeated on a large scale (0.27 kg), and the gum separated on Si gel. Petrol eluted kauran-16-α-ol (0.12 g), mp 220°, M^+ at *m/e* 290; kaur-16-en-19-oic acid (3.32 g), mp 205°, and methyl kauran-19-ol-17-oate (1.0 g) mp 125–126°, M^+ at *m/e* 332 (δ 9.75, –CHO; 3.67, $-CO_2\underline{CH_3}$). Petrol: Et_2O (4:1) eluted methyl-19-norkauran-4α-ol-17-oate (0.037 g) mp 138–140°, M^+ at *m/e* 320, ν_{max} 3460 cm^{-1} (OH), δ 3.67 $-CO_2Me$; 1.1, 1.28 (6H, 2 tertiary Me); which was converted by base hydrolysis to the known acid **4a**. Ether eluted another ester (0.09 g) mp 180–182°, M^+ at *m/e* 348 hydrolysable to kauran-17,19-dioic acid; it also eluted a diterpene acid (**5**) (0.043 g) mp 171–173°, M^+ at *m/e* 304, δ 0.8, 0.83, 1.0, (9H, three tertiary –Me).

Acknowledgement—We thank Professor W. Herz for running the low and high resolution mass spectra of some of the samples.

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