TERPENOID DERIVATIVES OF 4-HYDROXYPROPIOPHENONE AS JUVENOIDS AND JUVENOGENS. III.

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Using reactions modifying 4-(3,7-dimethyl-2,6-octadienyloxy)propiophenone and 4-(3,7-dimethyl-2-octenyloxy)propiophenone a series of new potential juvenoids and juvenogens was synthetized.

In this paper, which is a continuation of the study of the relationships between structure and juvenile-hormonal activity in the series of chemically modified 4-(3,7-dimethyl-2,6-octadienyloxy)propiophenone and 4-(3,7-dimethyl-2-octenyloxy)propiophenone[1,2], derivatives of 4-hydroxypropiophenone are described which contain a halogen atom in the terpenoid part of the molecule.

As a reaction for the introduction of a bromine or chlorine atom in the terpenoid part of the molecules the halogen-alkoxylation reaction was used, carried out by means of N-bromosuccinimide or N-chlorosuccinimide in hydroxy compounds as medium[3]. The reaction products (compounds *I*, *IV*–*XI*, *XIII*, *XIV*, *XVI*, *XVII*, Table I) were dependent on the reaction temperature and the type of alcohol. Thus, for example, on reaction of 4-(3,7-dimethyl-2,6-octadienyloxy)propiophenone with N-bromosuccinimide in methanol at 0–5°C 7-bromo-6-methoxy derivative *IV* was formed, while at 15–25°C it was 2,3;6,7-bis(bromomethoxy) derivative *VI*. When 4-(3,7-dimethyl-2,6-octadienyloxy)- or 4-(3,7-dimethyl-2-octenyloxy)propiophenone was reacted with N-bromosuccinimide in the presence of aqueous dimethyl sulfoxide, bromohydrin derivatives *II* and *III* (Table I) were formed, respectively. An identical substance was also obtained on reaction of 4-(6,7-epoxy-3,7-dimethyl-2-octenyloxy)propiophenone with 0·5M-HBr in a mixture of acetic anhydride and acetic acid at room temperature. Hydroxy compound *II* was further etherified using 2,3-dihydro-4*H*-pyran or ethyl vinyl ether, under formation of compounds *XII* and *XV*, while when acetylated with acetic anhydride, derivative *XVIII* (Table I) was formed. Reduction of keto derivatives *II*–*V*, *X* and *XIV* with lithium aluminum hydride gave products *XIX*–*XXIV* (Table II).

Juvenogenic compounds *XXV*–*XXXI* (Table II) were prepared from 7-bromo-6-hydroxy compound *III*, 7-bromo-6-methoxy derivatives *IV* and *V*, 7-bromo-6-isopropoxy compound *X* and 7-bromo-6-(1-methoxyethoxy)derivative *XIII*

TABLE I

Characterization of compounds of the type

$(CH_3)_2CBrCH(R^1)(CH_2)_2C(CH_3)=CHCH_2OC_6H_4$-4-$COC_2H_5$

No	R^1	Yield weight %	Formula (M.w.)	Calculated/Found	
				% C	% H
I[a]	OCH_3	33	$C_{21}H_{32}Cl_2O_4$ (419·4)	60·13 60·16	7·69 7·48
II[b]	OH	65	$C_{19}H_{27}BrO_3$ (383·3)	59·53 59·28	7·10 7·36
III[c,d]	OH	62	$C_{19}H_{29}BrO_3$ (385·3)	59·21 59·23	7·59 7·46
IV[e]	OCH_3	95	$C_{20}H_{29}BrO_3$ (397·3)	60·45 60·18	7·35 7·22
V[c,f]	OCH_3	82	$C_{20}H_{31}BrO_3$ (399·3)	60·14 60·00	7·82 8·06
VI[g]	OCH_3	74	$C_{21}H_{32}Br_2O_4$ (508·3)	49·61 49·48	6·34 6·62
VII	OC_2H_5	50	$C_{21}H_{31}BrO_3$ (411·4)	61·31 61·15	7·59 7·58
VIII[h]	OC_3H_7	48	$C_{22}H_{33}BrO_3$ (425·4)	62·11 62·11	7·82 8·12
IX	Oi-C_3H_7	31	$C_{22}H_{33}BrO_3$ (425·4)	62·11 62·32	7·82 7·80
X[c,i]	Oi-C_3H_7	30	$C_{22}H_{35}BrO_3$ (427·4)	61·82 61·59	8·25 8·03
XI[j]	OC_4H_9	45	$C_{23}H_{35}BrO_3$ (439·4)	62·86 62·56	8·02 8·18
XII	$OCH(CH_3)OC_2H_5$	25	$C_{23}H_{35}BrO_4$ (455·4)	60·65 60·38	7·74 7·85
XIII[k]	$OC_2H_4OCH_3$	50	$C_{22}H_{33}BrO_4$ (441·4)	59·86 59·64	7·53 7·63
XIV[c,l]	$OC_2H_4OCH_3$	45	$C_{22}H_{35}BrO_4$ (443·4)	59·59 59·88	7·96 7·82
XV[m]	O(2-C_5H_9O)	90	$C_{24}H_{35}BrO_4$ (467·4)	61·66 61·66	7·54 7·24
XVI	OC_2H_4Cl	11	$C_{21}H_{30}BrClO_3$ (445·8)	56·57 56·85	6·78 7·07

TABLE I
(*Continued*)

No	R^1	Yield weight %	Formula (M.w.)	Calculated/Found	
				% C	% H
XVII[n]	$OCH_2C_6H_5$	10	$C_{26}H_{33}BrO_3$ (473·4)	65·95 65·92	7·02 6·71
XVIII[o]	$OCOCH_3$	35	$C_{21}H_{29}BrO_4$ (425·4)	59·29 59·04	6·87 6·66

[a] (3,7-Dichloro-2,6-dimethoxy)alkyl compound; calculated: 16·91% Cl; found: 17·40% Cl; mass spectrum: 404/6/8/ ($C_{20}H_{30}Cl_2O_4$), 368/70 ($C_{20}H_{29}ClO_4$), 353/5 ($C_{19}H_{26}ClO_4$), 339/41 ($C_{18}H_{24}ClO_4$), 336/8 ($C_{19}H_{25}ClO_3$), 307/9 ($C_{17}H_{20}ClO_3$), 296/8 ($C_{16}H_{21}ClO_3$), 151 ($C_9H_{11}O_2$), 121 ($C_7H_5O_2$), 107/9 (C_4H_8ClO), 97 (C_6H_9O). [b] B.p. 168—170°C/13 Pa; mass spectrum: 382/4 (M^+), 302 ($C_{19}H_{26}O_3$), 231/3 ($C_{10}H_{16}BrO$), 151 ($C_9H_{11}O_2$), 150 ($C_9H_{10}O_2$), 121 ($C_7H_5O_2$), 93 (C_6H_5O); IR spectrum (5%): 3 615, 3 573 (νOH), 3 473 (ν(OH) assoc.), 1 688 (νCO), 1 670 (ν(C=C)), 1 604, 1 583, 1 514 (ν arom.) cm^{-1}. [c] 2,3-Dihydro compound. [d] B.p. 176—178°C/13 Pa; IR spectrum (3%): 3 616, 3 572 (ν(OH)), 3 500 (ν(OH) assoc.), 1 686 (ν(CO)), 1 603, 1 577, 1 513 (ν arom.), 1 368, 1 379 ($\delta_s(CH_3)$) cm^{-1}; ^{1}H-NMR spectrum, δ (ppm): 0·89 to 1 (m, 3 H), 1·19 (t, 3 H, $J = 7$), 1·31 (s, 3 H), 1·34 (s, 3 H), 1·43—2·04 (m, 6 H), 2·94 (q, 2 H, $J = 7$), 3·32 3·7 (m, H), 3·82—4·18 (m, 3 H), 6·92 (d, 2 H, $J = 9$), 7·96 (d, 2 H, $J = 9$); mass spectrum: 384/6 (M^+), 369/71 ($C_{18}H_{26}BrO_3$), 355/7 ($C_{17}H_{24}BrO_3$), 304 ($C_{19}H_{28}O_3$), 291 ($C_{18}H_{27}O_3$), 275 ($C_{18}H_{27}O_2$), 247 ($C_{16}H_{23}O_2$), 233 ($C_{15}H_{21}O_2$), 219 ($C_{14}H_{19}O_2$), 205 ($C_{13}H_{17}O_2$), 191 ($C_{12}H_{15}O_2$), 177 ($C_{11}H_{13}O_2$), 163 ($C_{10}H_{11}O_2$), 155 ($C_{10}H_{19}O$), 150 ($C_9H_{10}O_2$), 137 ($C_{10}H_{17}$), 121 ($C_7H_5O_2$). [e] B.p. 164—166°C/13 Pa; calculated 20·11% Br, found 20·46% Br; mass spectrum: 396/8 (M^+), 381/3 ($C_{19}H_{26}BrO_3$), 365/7 ($C_{19}H_{26}BrO_2$), 285 ($C_{19}H_{25}O_2$), 247/9 ($C_{11}H_{20}BrO$), 215/7 ($C_{10}H_{16}Br$), 167 ($C_{11}H_{19}O$), 151 ($C_9H_{11}O_2$), 150 ($C_9H_{10}O_2$), 135 ($C_{10}H_{15}$), 121 ($C_7H_5O_2$), 93 (C_6H_5O). [f] B.p. 170—172°C/13 Pa; mass spectrum: 398/400 (M^+), 383/5 ($C_{19}H_{28}BrO_3$), 369/71 ($C_{18}H_{26}BrO_3$), 367 ($C_{19}H_{28}BrO_2$), 318 ($C_{20}H_{30}O_3$), 289 ($C_{18}H_{25}O_2$), 150 ($C_9H_{10}O_2$), 121 ($C_7H_5O_2$); IR spectrum (3%): 1 686 (ν(CO)), 1 604, 1 577, 1 513 (ν arom.), 1 381, 1 367 ($\delta_s(CH_3)$) cm^{-1}; ^{1}H-NMR spectrum; δ (ppm): 0·89—1 (m, 3 H). 1·19 (t, 3H, $J = 7$), 1·26 (s, 3H), 1·31 (s, 3 H), 1·5—2·0 (m, 6 H), 2·94 (q, 2 H, $J = 7$), 3·25 (s, 3 H), 3·25—3·55 (m, H), 3·75—4·20 (m, 3 H), 6·91 (m, 2 H, $J = 9$), 7·95 (m, 2 H, $J = 9$). [g] (3,7-Dibromo-2,6-dimethoxy)alkyl compound; calculated: 31·40% Br; found: 31·31% Br; mass spectrum: 506/8/10 (M^+), 477/9/81 ($C_{19}H_{27}Br_2O_4$), 446/8/50 ($C_{18}H_{24}Br_2O_3$), 426/8 ($C_{21}H_{31}BrO_4$), 277/9 ($C_{12}H_{22}BrO_2$), 251/3 ($C_{10}H_{20}BrO_2$), 245/7 ($C_{11}H_{18}BrO$), 191/3 ($C_7H_{12}BrO$), 151 ($C_9H_{11}O_2$), 150 ($C_9H_{10}O_2$), 121 ($C_7H_5O_2$); ^{1}H-NMR spectrum, δ (ppm): 1·29 (s, 3 H), 1·34 (s, 6 H), 1·20 (t, 3 H, $J = 7$), 2·94 (q, 2 H, $J = 7$), 1·50—2·40 (m, 4 H), 3·92 (m, H), 3·22 (s, 3 H), 3·26 (s, 3 H), 4·32 (m, 2 H), 4·67 (m, H), 6·96 (m, 2 H, $J = 9$), 7·44 (m, 2 H, $J = 9$). [h] ^{1}H-NMR spectrum; δ (ppm): 0·89 (t, 3 H, $J = 7$), 1·21 (t, 3 H, $J = 7$), 1·26 (s, 3 H), 1·31 (s, 3 H), 1·75 (s, 3 H), 1·52 (m, 2 H), 1·82 (m, 2 H), 2—2·5 (m, 2 H), 2·94 (q, 2 H, $J = 7$), 3·28 (m, 2 H), 3·88 (m, H), 4·61 (d, 2 H, $J = 6·5$), 5·56 (t, H, $J = 6·5$), 6·92 (m, 2 H, $J = 9$), 7·93 (m, 2 H, $J = 9$). [i] ^{1}H-NMR spectrum: δ (ppm): 0·85—1·02 (m, 3 H), 1·12 (dd, 6 H, $J = 6$), 1·20 (t, 3 H, $J = 7$), 1·26 (s, 3 H), 1·33 (s, 3 H), 1·45—2·0 (m, 6 H), 2·94 (q, 2 H, $J = 7$), 3·28 to 4·08 (m, 5 H), 6·91 (d, 2 H, $J = 9$), 7·98 (d, 2 H, $J = 9$); mass spectrum: 426/8 (M^+), 411/3

on reduction of the keto group with $LiAlH_4$ and subsequent acylation of the hydroxy compounds *XX–XXIV*. Identical products were also obtained when the reaction sequence was reversed, *i.e.* on reduction of the oxo compound, acylation and subsequent bromomethoxylation of the reaction product. In addition to the above-mentioned derivatives *I–XXXI* 4-(6,7-dibromo-3,7-dimethyl-2-octenyloxy)-, 4-(6,7-dibromo-3,7-dimethyloctyloxy)- and 4-(3,7-dimethyl-2,3,6,7-tetrabromooctyloxy)-propiophenone (compounds *XXXII–XXXIV*, Table III) were prepared by addition of bromine to the double bond of 4-(3,7-dimethyl-2,6-octadienyloxy)- and 4-(3,7-dimethyl-2-octenyloxy)propiophenone.

Using all these modifying reactions a series of juvenoids and juvenogens was prepared from 4-(3,7-dimethyl-2,6-octadienyloxy)- and 4-(3,7-dimethyl-2-octenyloxy)-propiophenone, displaying a promising juvenile hormone activity in insect metabolism. Thus, for example, for the bug *Dysdercus cingulatus* (Hemiptera, *Pyrrhocoridae*) the activity range was 100–0·008 ID-50 morphologic units[4], for *Graphosoma italicum* (Hemiptera, *Pentatomidae*) it was 1 000–0·8 ID-50 morphologic units, and for the beetle *Tenebrio molitor* (Coleoptera, *Tenebrionidae*) it was 500–8 ID-50 morphologic units.

EXPERIMENTAL

The products were purified chromatographically on a silica gel column (60–120 μm, Service laboratory of the Institute), containing 8% (by weight) of water. The homogeneity of the fractions was determined by thin-layer chromatography on silica gel G (Merck) and Silufol with luminescent indicator (Kavalier), using H_2SO_4 or UV light of 254 nm wavelength for detection. The boiling points were not corrected. In some instances the chemical structure of the synthetized compounds

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($C_{21}H_{32}BrO_3$), 397/9 ($C_{20}H_{30}BrO_3$), 366/8 ($C_{19}H_{27}BrO_2$), 337/9 ($C_{17}H_{22}BrO_2$), 305 ($C_{19}H_{29}O_3$), 288 ($C_{19}H_{28}O_2$), 275 ($C_{17}H_{23}O_3$), 259 ($C_{17}H_{23}O_2$), 247 ($C_{16}H_{23}O_2$), 219 ($C_{14}H_{19}O_2$), 203 ($C_{13}H_{15}O_2$), 189 ($C_{12}H_{13}O_2$), 177 ($C_{11}H_{13}O_2$), 163 ($C_{10}H_{11}O_2$), 150 ($C_9H_{10}O_2$), 137 ($C_{10}H_{17}$), 121 ($C_7H_5O_2$). [j] IR spectrum (3%): 1 686 (ν CO), 1 604, 1 578, 1 513 (ν arom.), 1 381, 1 369 ($\delta_s(CH_3)$ cm^{-1}; mass spectrum: 438/40 (M^+), 423/5 ($C_{22}H_{32}BrO_3$), 409/11 ($C_{21}H_{30}BrO_3$), 381/3 ($C_{20}H_{30}BrO_2$), 289/91 ($C_{14}H_{26}BrO$), 215/7 ($C_{10}H_{16}Br$), 151 ($C_9H_{11}O_2$), 135 ($C_{10}H_{15}$); [1]H-NMR spectrum δ(ppm): 0·88 (t, 3 H, $J = 7$), 1·16 (t, 3 H, $J = 7$), 1·23 (s, 3 H) 1·28 (s, 3 H), 1·52 (m, 4 H), 1·73 (s, 3 H), 1·82 (m, 2 H), 2·2 (m, 2 H), 2·91 (q, 2 H, $J = 7$), 3·28 (m, 2 H), 3·88 (m, H), 4·58 (d, 2 H, $J = 6·5$), 5·53 (m, H), 6·91 (m, 2 H, $J = 8·5$), 7·95 (m, 2 H, $J = 8·5$). [k] Mass spectrum: 440/2 (M^+), 425/7 ($C_{21}H_{30}BrO_4$), 411/3 ($C_{20}H_{28}BrO_4$), 365/7 ($C_{19}H_{26}BrO_2$), 335/7 ($C_{17}H_{20}BrO_2$), 291/3 ($C_{13}H_{24}BrO_2$), 285 ($C_{19}H_{25}O_2$), 215/7 ($C_{10}H_{16}Br$), 210 ($C_{13}H_{22}O_2$), 189 ($C_{12}H_{13}O_2$), 159/61 (C_6H_8Br), 151 ($C_9H_{11}O_2$), 135 ($C_8H_7O_2$), 131 ($C_7H_{15}O_2$), 121 ($C_7H_5O_2$). [l] IR spectrum (3%): 1 741 (ν CO ester.), 1 603, 1 577, 1 514 (ν arom), 1 382, 1 368 ($\delta_s(CH_3)$) cm^{-1}. [m] Mass spectrum: 334/6 ($C_{17}H_{19}BrO_2$), 203 ($C_{13}H_{15}O_2$), 151 ($C_9H_{11}O_2$), 121 ($C_7H_5O_2$), 84 (C_5H_8O). [n] Mass spectrum: 364/6 ($C_{19}H_{25}BrO_2$), 322/4 ($C_{17}H_{23}BrO$), 298/300 ($C_{15}H_{23}BrO$), 259 ($C_{17}H_{23}O_2$), 249/51 ($C_{10}H_{18}BrO_2$), 231/3 ($C_{10}H_{16}BrO$), 150 ($C_9H_{10}O_2$), 137 ($C_{10}H_{17}$), 121 ($C_7H_5O_2$), 108 (C_7H_8O). [o] IR spectrum (3%): 1 745 (ν CO), 1 688 (ν (CO)), 1 672 (ν (C=C)), 1 603, 1 581 (ν arom.), 1229 (ν (C—O))cm^{-1}.

was confirmed by IR (UR 20 spectrophotometer), mass (AEI MS-902 spectrometer, 70 eV ionization potential) and ^{1}H-NMR (Varian HA-60 and HA-100, C^2HCl_3, tetramethylsilane, 60 and 100 MHz) spectrometry.

Preparation of Compounds *I*—*V*, *VII*—*XI*, *XIII*, *XIV*, *XVI*, and *XVII*

N-Bromosuccinimide (N-chlorosuccinimide) (0·02 mol) was added at 0—5°C under nitrogen to a solution of 4-(3,7-dimethyl-2,6-octadienyloxy)- or 4-(3,7-dimethyl-2-octenyloxy)propiophenone in anhydrous methanol (ethanol, n-propanol, 2-propanol, n-butanol, 2-methoxyethanol, 2-chloroethanol, benzyl alcohol) or to a solution of these substances (0·01 mol) in 50 ml dimethyl sulfoxide and 0·55 ml of H_2O and the mixture was stirred at this temperature for 15 min. After dilution with water the mixture was extracted with diethyl ether. The ethereal layer was dried over $MgSO_4$ and evaporated under reduced pressure. The residue was separated by column chromatography.

Preparation of Compound *VI*

N-bromosuccinimide (0·02 mol) was added to a solution of 4-(3,7-dimethyl-2,6-octadienyloxy)-propiophenone in methanol at 15—25°C, under nitrogen. The mixture was stirred at this temperature for 1 h and diluted with water and extracted with diethyl ether. Further procedure is described in the preceding experiments.

Preparation of Compounds *XII* and *XV*

A catalytic amount of *p*-toluenesulphonic acid was added to a solution of compound *II* (0·01 mol) in 2,3-dihydro-4*H*-pyrane or ethyl vinyl ether (0·01 mol) at room temperature and under stirring which was continued for another 10 minutes. After dilution with water and extraction with diethyl ether the product was obtained by column chromatography on silica gel.

Preparation of Compounds *XIX*—*XXIV*

A solution of compounds *II*—*V*, *X* or *XIV* (0·01 mol) in diethyl ether was added dropwise at 10—20°C under stirring and exclusion of atmospheric moisture to a suspension of $LiAlH_4$ (5 mmol, 20 wt.% excess) in diethyl ether. The mixture was refluxed for 30 min. After cooling with ice and dilution with diethyl ether the unreacted hydride in the mixture was decomposed by addition of water and dilute H_2SO_4 to the stirred solution. The separated ethereal layer was washed with a saturated NaCl solution, dried over $MgSO_4$ and evaporated under reduced pressure. The residue was purified by column chromatography as above.

Preparation of Compounds *XXV*—*XXX*

Chloride or anhydride of monocarboxylic acid (0·01 mol) was gradually added to a stirred solution of compound *XX*—*XXIV* (0·01 mol) and pyridine (0·01 mol), under addition of dimethylformamide if necessary, kept at room temperature. The mixture was allowed to stand at room temperature for 30 min in the case of acetic anhydride and overnight in the case of acid chloride. The isolation of the product was the same as in the preceding cases. During the preparation of compound *XXIX* the mixture of compound *XXII* (0·01 mol), dicarboxylic acid anhydride (0·01 mol) and pyridine (0·01 mol) was heated at 60°C for 10 h and then allowed to stand at room temperature overnight. The product was isolated as described above.

TABLE II

Characterization of compounds of the type
$(CH_3)_2CBrCH(R^1)(CH_2)_2C(CH_3)=CHCH_2OC_6H_4$-4-$CH(OR^2)C_2H_5$

No	R^1	R^2	Yield weight %	Formula (M.w.)	Calcul./Found % C	% H
XIX[a]	OH	OH	60	$C_{19}H_{29}BrO_3$ (385·3)	59·22 59·42	7·58 7·70
XX[b,c]	OH	OH	70	$C_{19}H_{31}BrO_3$ (387·3)	58·91 58·77	8·07 8·02
XXI[d]	OCH_3	OH	81	$C_{20}H_{31}BrO_3$ (399·4)	60·14 60·31	7·82 7·65
XXII[b,e]	OCH_3	OH	85	$C_{20}H_{33}BrO_3$ (401·4)	59·84 59·57	8·29 7·99
XXIII[b,f]	Oi—C_3H_7	OH	82	$C_{22}H_{37}BrO_3$ (429·4)	61·52 61·30	8·68 8·38
XXIV[b]	$OC_2H_4OCH_3$	OH	80	$C_{22}H_{33}BrO_4$ (441·4)	59·86 59·96	7·54 7·51
XXV[b,g]	OH	$OCOCH_3$	61[h]	$C_{21}H_{33}BrO_4$ (429·4)	58·74 58·63	7·75 7·75
XXVI[i]	OCH_3	$OCOCH_3$	85	$C_{22}H_{33}BrO_4$ (441·4)	59·86 60·20	7·54 7·69
XXVII[b,j]	OCH_3	$OCOCH_3$	79[k]	$C_{22}H_{35}BrO_4$ (443·4)	59·59 59·29	7·96 7·81
XXVIII[b,l]	OCH_3	$OCOCH_2Cl$	80[k]	$C_{22}H_{34}BrClO_4$ (477·9)	55·29 55·00	7·17 7·39
XXIX[b,m]	OCH_3	$OCOC_2H_4COOC_2H_5$	79[k]	$C_{26}H_{41}BrO_6$ (529·5)	58·97 58·80	7·81 7·59
XXX[b,n]	Oi—C_3H_7	$OCOCH_3$	89	$C_{24}H_{39}BrO_4$ (471·5)	61·14 61·29	8·34 8·01
XXXI[b,o]	$OC_2H_4OCH_3$	$OCOCH_3$	84	$C_{24}H_{39}BrO_5$ (487·5)	59·13 58·88	8·06 7·82

[a] B.p. 165—7°C/13 Pa; IR spectrum (5%): 3 616 (ν(OH)), 3 573 (ν(OH)), 3 470 (ν(OH)) assoc. 1 672 (ν(C=C)), 1 611, 1 586, 1 513 (ν arom.) cm^{-1}. [b] 2,3-Dihydro compound. [c] B.p. 173 to 175°C/13 Pa; IR spectrum (5%): 3 617, 3 570 (ν(OH)), 1 614, 1 586, 1 515 (ν arom.), 1 383, 1 371 ($\delta_s(CH_3)$) cm^{-1}; mass spectrum: 386/8 (M^+); 368/70 ($C_{19}H_{29}BrO_2$), 339/41 ($C_{17}H_{24}$·.BrO_2), 288 ($C_{19}H_{28}O_2$), 277 ($C_{17}H_{25}O_3$), 261 ($C_{17}H_{25}O_2$), 231 ($C_{16}H_{23}O$), 175 ($C_{12}H_{15}O$), 161 ($C_{11}H_{13}O$), 155 ($C_{10}H_{19}O$), 134 ($C_{10}H_{14}$), 123 ($C_7H_7O_2$); ^{1}H-NMR spectrum, δ (ppm): 0·87 (t, 3 H, J = 7), 0·90—1·02 (m, 3 H), 1·31 (s, 3 H), 1·33 (s, 3 H), 1·48—2·2 (m, 8 H), 3·3 to 3·5 (m, H), 3·90—4·10 (m, 3 H), 4·52 (t, H, J = 7), 6·85 (m, 2 H, J = 9), 7·13 (m, 2 H, J = 9).

TABLE II
(*Continued*)

[d] B.p. 162–164°C/13 Pa; IR spectrum (5%): 3 621 (ν(OH)), 3 487 (ν(OH) assoc.), 1 741 (ν(CO)), 1 674 (ν(C=C)), 1 614, 1 586, 1 516, 1 506 (ν arom.), 1 382, 1 369 (δ_s(CH$_3$)), 1 240 (ν_{as}(C–O)) cm^{-1}; mass spectrum: 398/400 (M$^+$), 380/2 ($C_{20}H_{29}BrO_2$), 300 ($C_{20}H_{28}O_2$), 247/9 ($C_{11}H_{20}$.BrO), 215/7 ($C_{10}H_{16}Br$), 152 ($C_9H_{12}O_2$), 134 ($C_9H_{10}O$), 123 ($C_7H_7O_2$). [e] B.p. 167–169°C/13 Pa; IR spectrum (5%): 3 620 (ν(OH)), 1 614, 1 586, 1 515 (ν arom.), 1 382, 1 368 (δ_s(CH$_3$)) cm^{-1}; mass spectrum: 400/2 (M$^+$), 382/4 ($C_{20}H_{31}BrO_2$), 367/9 ($C_{19}H_{28}BrO_2$), 339/41 ($C_{17}H_{24}BrO_2$), 289 ($C_{19}H_{29}O_2$), 231 ($C_{16}H_{23}O$), 201/3 ($C_9H_{14}Br$), 175 ($C_{12}H_{15}O$), 161/3 ($C_6H_{10}Br$), 137 ($C_8H_9O_2$), 134 ($C_{10}H_{14}$), 123 ($C_7H_7O_2$); ^{1}H-NMR spectrum, δ (ppm): 0·86 (t, 3 H, J = 7), 0·9–1·1 (m, 3 H), 1·26 (s, 3 H,) 1·31 (s, 3 H), 1·5–2·0 (m, 8 H), 3·20 (s, 3 H), 3·35–3·69 (m, H), 3·8–4·2 (m, 3 H), 4·51 (t, H, J = 7), 6·88 (m, 2 H, J = 9), 7·28 (m, 2 H, J = 9). [f] IR spectrum (5%): 3 620 (ν(OH)), 1 613, 1 586, 1 514 (ν arom.), 1 381, 1 369 (δ_s (CH$_3$)) cm^{-1}; mass spectrum: 428/30 (M$^+$), 410/2 ($C_{22}H_{35}BrO_2$), 368/70 ($C_{19}H_{29}BrO_2$), 339/41 ($C_{17}H_{24}BrO_2$), 290 ($C_{19}H_{30}O_2$), 261 ($C_{17}H_{25}O_2$), 231 ($C_{16}H_{23}O$), 175 ($C_{12}H_{15}O$), 137 ($C_8H_9O_2$), 123 ($C_7H_7O_2$); ^{1}H-NMR spectrum, δ (ppm): 0·89 (t, 3 H, J = 7), 0·9–1·05 (m, 3 H), 1·15 (dd, 6 H, J = 6), 1·27 (s, 3 H,) 1·35 (s, 3 H), 1·4–1·9 (m, 8 H), 3·7–4·1 (m, 5 H), 4·52 (t, H, J = 7), 6·86 (m, 2 H, J = 9), 7·24 (m, 2 H, J = 9). [g] IR spectrum (3%): 3 618, 3 571 (ν(OH)), 3 427 (ν(OH) assoc.), 1 740 (ν(CO)), 1 604, 1 516 (ν arom.), 1 382, 1 370 (δ_s(CH$_3$)), 1 238 (ν(C–O)) cm^{-1}; ^{1}H-NMR spectrum, δ (ppm): 0·84 (t, 3 H, J = 7), 0·88–1·20 (m, 3 H), 1·32 (s, 6 H), 1·5–1·95 (m, 8 H), 2·02 (s, 3 H), 2·6–3·06 (m, H), 3·4–4·15 (m, 3 H), 5·64 (t, H, J = 7), 6·88, 6·91 (m, 2 H, J = 9), 7·27, 7·98 (m, 2 H, J = 9). [h] Yield of bromohydroxylation. [i] IR spectrum (2%): 1 741, 1 730 (ν(CO)), 1 672 (ν(C=C)), 1 615, 1 588, 1 515 (ν arom.), 1 382, 1 369 (δ_s(CH$_3$)), 1 239 (ν(C–O)) cm^{-1}; mass spectrum: 440/2 ($C_{22}H_{33}BrO_4$), 380/2 ($C_{20}H_{29}$.BrO$_2$), 300 ($C_{20}H_{28}O_2$), 247/9 ($C_{11}H_{20}BrO$), 215/7 ($C_{10}H_{16}Br$), 194 ($C_{11}H_{14}O_3$), 134 ($C_9H_{10}O$), 123 ($C_7H_7O_2$); ^{1}H-NMR spectrum, δ (ppm): 0·84 (t, 3 H, J = 7), 1·26 (s, 3 H), 1·31 (s, 3 H), 1·73 (s, 3 H), 1·92–2·52 (m, 6 H), 2·02 (s, 3 H), 3·16 (s, 3 H), 3·75–4·08 (m,H), 4·53 (d, 2 H, J = 6·5), 5·61 (t, 2 H, J = 7), 5·63 (t, 2 H, J = 7), 6·89 (d, 2 H, J = 9), 7·29 (d, 2 H, J = 9). [j] IR spectrum (3%): 1 742 (ν(CO)), 1 614, 1 587, 1 516 (ν arom.), 1 381, 1 370 (δ_s(CH$_3$)), 1 239 (ν(C–O)) cm^{-1}; mass spectrum: 442/4 (M$^+$), 413/5 ($C_{20}H_{30}BrO_4$), 399/401 ($C_{20}H_{32}$.BrO$_3$), 382/4 ($C_{20}H_{31}BrO_2$), 370/2 ($C_{18}H_{27}BrO_3$), 367/9 ($C_{19}H_{28}BrO_2$), 351/3 ($C_{19}H_{28}$.BrO), 339/41 ($C_{17}H_{24}BrO_2$), 331 ($C_{21}H_{31}O_3$), 289 ($C_{19}H_{29}O_2$), 271 ($C_{19}H_{27}O$), 249/51 ($C_{11}H_{22}BrO$), 134 ($C_9H_{10}O$), 123 ($C_7H_7O_2$); ^{1}H-NMR spectrum, δ(ppm): 0·79 (t, 3 H, J = 7), 0·85–0·95 (m, 3 H), 1·21 (s, 3 H), 1·26 (s, 3 H), 1·43–2·0 (m, 8 H), 1·96 (s, 3 H), 3·15 (s, 3 H), 3·23–3·50 (m, H), 3·7–4·05 (m, 3 H), 5·54 (t, H, J = 7), 6·80 (m, 2 H, J =9), 7·18 (m, 2 H, J = 9). [k] Yield of bromomethoxylation. [l] IR spectrum (5%): 1 764, 1 742 (ν(CO)), 1 614, 1 587, 1 521, 1 516 (ν arom.), 1 382, 1 368 (δ_s(CH$_3$)), 1 249 (ν(C–O)) cm^{-1}; mass spectrum: 476/8 (M$^+$), 447/9/51 ($C_{20}H_{29}BrClO_4$), 428/30 ($C_{21}H_{33}BrO_4$), 399/401 ($C_{20}H_{32}BrO_3$), 339/41 ($C_{17}H_{24}BrO_2$), 319 ($C_{20}H_{31}O_3$), 249/51 ($C_{11}H_{22}BrO$), 199/201 ($C_9H_8ClO_3$), 134 ($C_9H_{10}O$), 73 (C_4H_9O); ^{1}H-NMR spectrum, δ (ppm): 0·84 (t, 3 H, J = 7), 0·88 to 1·1 (m, 3 H), 1·25 (s, 3 H), 1·31 (s, 3 H), 1·5–2·05 (m, 8 H), 3·20 (s, 2 H), 3·25–3·7 (m, H), 3·8–4·15 (m, 3 H), 4·02 (s, 3 H), 5·73 (t, H, J = 7), 6·88 (m, 2 H, J = 9), 7·26 (m, 2 H, J = 9). [m] IR spectrum (3%): 1 741, 1 732 (ν(CO)), 1 615, 1 587, 1 521, 1 516 (ν arom.), 1 381, 1 369, (ν arom.), 1 381, 1 369 (δ_s(CH$_3$)), 1 249 (ν(C–O)) cm^{-1}; mass spectrum: 528/30 (M$^+$), 497/9 ($C_{25}H_{38}BrO_5$), 448 ($C_{26}H_{40}O_6$), 417 ($C_{25}H_{37}O_5$), 382/4 ($C_{20}H_{31}BrO_2$), 367/9 ($C_{19}H_{28}BrO_2$), 351/3 ($C_{19}H_{28}$.BrO), 339/41 ($C_{17}H_{24}BrO_2$), 302 ($C_{20}H_{30}O_2$), 289 ($C_{19}H_{29}O_2$), 271 ($C_{19}H_{27}O$), 249/51 (C_{11}.$H_{22}BrO$), 169 ($C_{11}H_{21}O$), 151 ($C_9H_{11}O_2$), 134 ($C_9H_{10}O$), 73 (C_4H_9O); ^{1}H-NMR spectrum, δ (ppm): 0·83 (t, 3 H, J = 7), 0·85–1·2 (m, 6 H), 1·28 (s, 3 H), 1·33 (s, 3 H), 1·45 to 2·2 (m,

TABLE II
(*Continued*)

8 H), 2·61 (m, 4 H), 3·22 (s, 3 H), 3·30—3·50 (m, H), 3·80—4·2 (m, 5 H), 5·63 (t, H, $J = 7$), 6·85 (m, 2 H, $J = 9$), 7·26 (m, 2 H, $J = 9$). [n] IR spectrum (3%): 1 743 (ν(CO)), 1 614, 1 588, 1 516 (ν arom.), 1 381, 1 370 ($\delta_s(CH_3)$), 1 240 (ν(C—O)) cm^{-1}; mass spectrum: 470/2 (M^+), 441/3 ($C_{22}H_{34}BrO_4$), 411/3 ($C_{22}H_{36}BrO_2$), 410/2 ($C_{22}H_{35}BrO_2$), 390 ($C_{24}H_{38}O_4$), 351/3 ($C_{19}H_{28}$·.BrO), 350/2 ($C_{19}H_{27}BrO$), 339/41 ($C_{17}H_{24}BrO_2$), 289 ($C_{18}H_{25}O_3$), 261 ($C_{17}H_{25}O_2$), 231 ($C_{16}H_{23}O$), 194 ($C_{11}H_{14}O_3$), 165 ($C_9H_9O_3$), 135 ($C_9H_{11}O$), 134 ($C_9H_{10}O$), 123 ($C_7H_7O_2$), 107 (C_7H_7O), 101 ($C_6H_{13}O$); ^{1}H-NMR spectrum, δ (ppm): 0·83 (t, 3 H, $J = 7$), 0·9—1·0 (m, 3 H) 1·09 (dd, 6 H, $J = 6$), 1·24 (s, 3 H), 1·33 (s, 3H), 1·4—2·0 (m, 8 H), 2·02 (s, 3 H), 3·65—4·06 (m, 5 H), 5·58 (t, H, $J = 7$), 6·82 (m, 2 H, $J = 9$), 7·21 (m, 2 H, $J = 9$). [o] IR spectrum (3%): 1 741 (ν(CO)), 1 603, 1 577, 1 514 (ν arom.), 1 382, 1 368 ($\delta_s(CH_3)$) cm^{-1}; mass spectrum: 486/8 (M^+), 456/8 ($C_{22}H_{33}BrO_5$), 427/9 ($C_{22}H_{36}BrO_3$), 426/8 ($C_{22}H_{35}BrO_3$), 410/2 ($C_{21}H_{31}$·.BrO_3), 384/6 ($C_{18}H_{25}BrO_4$), 367/9 ($C_{18}H_{24}BrO_3$), 339/41 ($C_{17}H_{24}BrO_2$), 289 ($C_{18}H_{25}O_3$), 151 ($C_9H_{11}O_2$), 137 ($C_8H_9O_2$), 131 ($C_7H_{15}O_2$), 121 (C_8H_9O); ^{1}H-NMR spectrum, δ (ppm): 0·97 (t, 3 H, $J = 7$), 1·0—1·2 (m, 3 H), 1·31 (s, 3 H), 1·35 (s, 3 H), 1·45—2·0 (m, 8 H), 2·02 (s, 3 H), 3·51 (s, 3 H), 3·3—3·7 (m, H), 3·8—4·3 (m, 6 H), 5·65 (t, H, $J = 7$), 6·95 (m, 2 H, $J = 9$), 7·99 (m, 2 H, $J = 9$).

TABLE III
Characterization of Compounds of the type
$(CH_3)_2CBrCHBr(CH_2)_2C(CH_3)R^1CHR^2CH_2OC_6H_4$-4-$COC_2H_5$

No	R^1	R^2	Yield weight, %	Formula M.w.	Calculated/Found	
					% C	% H
XXXII[a]	H	H	80	$C_{19}H_{28}Br_2O_2$ (448·2)	50·91 50·70	6·30 6·58
XXXIII[b]	double	bond	35	$C_{19}H_{26}Br_2O_2$ (446·2)	51·14 50·90	5·87 5·90
XXXIV[c]	Br	Br	12[d]	$C_{19}H_{26}Br_4O_2$ (606·0)	37·65 37·34	4·32 4·01

[a] Calculated: 35·65% Br; found: 35·21% Br; mass spectrum: 445/7/9 ($C_{19}H_{27}Br_2O_2$), 417/9/21 ($C_{17}H_{23}Br_2O_2$), 366/8 ($C_{19}H_{27}BrO_2$), 337/9 ($C_{17}H_{22}BrO_2$), 257 ($C_{17}H_{21}O_2$), 203 ($C_{13}H_{15}$·.O_2), 189 ($C_{12}H_{13}O_2$), 175 ($C_{11}H_{11}O_2$), 161/3 ($C_6H_{10}Br$), 147/9 (C_5H_8Br), 137 ($C_{10}H_{17}$), 121 ($C_7H_5O_2$). [b] Calculated: 35·82% Br; found: 35·40% Br; mass spectrum: 444/6/8 (M^+), 415/7/9 ($C_{17}H_{21}Br_2O_2$), 365/7 ($C_{19}H_{26}BrO_2$), 294/6/8 ($C_{10}H_{16}Br_2$), 215/7 ($C_{10}H_{16}Br$), 150 (C_9H_{10}·.O_2), 135 ($C_8H_7O_2$), 121 ($C_7H_5O_2$). [c] Calculated: 52·74% Br; found: 52·59% Br; mass spectrum: 602/4/6/8/610 (M^+), 573/5/7/9/81 ($C_{17}H_{21}Br_4O_2$), 523/5/7/9 ($C_{19}H_{26}Br_3O_2$), 494/6/8/500 ($C_{17}H_{21}Br_3O_2$), 318/20 ($C_{16}H_{15}BrO_2$), 215/7 ($C_{10}H_{16}Br$), 150 ($C_9H_{10}O_2$), 135 ($C_8H_7O_2$), 121 ($C_7H_5O_2$). [d] Compound *XXXIV* was isolated as a by-product during the preparation of compound *XXXIII*.

Preparation of Compounds *XXXII–XXXIV*

Bromine (0·01 mol) was added dropwise to a solution of 4-(3,7-dimethyl-2,6-octadienyloxy)- or 4-(3,7-dimethyl-2-octenyloxy)propiophenone (0·01 mol) in CCl_4 at 0° and the mixture was stirred at this temperature for 30 min. After evaporation of the solvent under reduced pressure the residue was separated on a 100-fold amount of silica gel, using light petroleum with increasing amounts of diethyl ether for elution.

Elemental analyses were carried out by Mrs A. Froňková, Mrs E. Sýkorová, Mrs J. Konečná and Mrs E. Šípová (head of the department Dr J. Horáček); the mass spectra were measured and interpreted by Dr J. Kohoutová (head of the department Dr L. Dolejš); the IR *spectra were measured and interpreted by Mrs K. Matoušková and Dr P. Fiedler (head of the department Dr J. Smolíková); the* ^{1}H-NMR *spectra were measured and interpreted by † Dr M. Synáčková, Dr M. Masojídková, Mrs J. Jelínková, Mrs M. Snopková and Dr D. Šaman (head of the laboratory † Dr Z. Samek). Biological tests were carried out by Dr K. Sláma, Entomological Institute, Czechoslovak Academy of Sciences, Prague.*

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