Synthesis of *Erythrina* and Related Alkaloids. XXIII.[1] Intramolecular Cyclization Approach. (2). Synthesis and Reactions of 1,7-Cyclo-*cis*-erythrinans, Potential Intermediates to Natural *Erythrina* Alkaloids

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Several 2,8-dioxo-1,7-cycloerythrinan drivatives (bearing a 6β-ethoxycarbonyl or 6β-hydrogen substituent) were prepared in good yields from the reported 2,8-dioxo-7β or 7α-hydroxyerythrinan derivatives by a base-catalyzed intramolecular alkylation of the corresponding O-mesylates, and they were shown to be useful intermediates for synthesizing natural erythrinan alkaloids. The C-1 of these compounds has been suitably protected for further manipulation at C-3 and the cyclopropane ring can be readily cleaved in a reductive or a non-reductive manner to give C-1 methylene or C-1 olefin derivatives. The latter process is discussed in detail with reference to several examples of ionic and radical opening. The reactivity of the carboxylate ester group on the cyclopropane ring bearing an electro-negative substituent was unusually high.

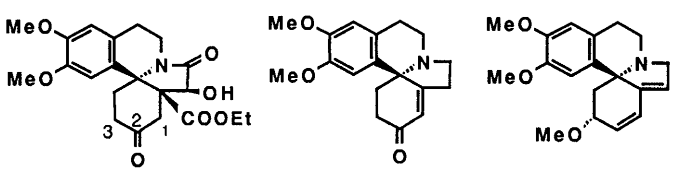
Keywords *Erythrina* alkaloid; synthesis; key intermediate; 1,7-cyclo-*cis*-erythrinan; cyclopropane; reductive opening; radical opening; ionic opening

In the previous paper,[1] we described an efficient method of synthesizing the erythrinan skeleton *via* intramolecular cyclization of dioxopyrroline derivatives. By the use of this method, 6β-ethoxycarbonyl-7β-hydroxy-15,16-dimethoxy-2,8-dioxo-*cis*-erythrinan **1** is readily available from homoveratrylamine and ethyl 4,4-ethylenedioxycyclohexanone-2-carboxylate in five step in 52% overall yield. Removal of the 6-COOEt group from this compound and several requisite modifications lead to (±)-3-demethoxyerythratidinone **2**,[1] proving the usefulness of **1** in the synthesis of natural erythrinan alkaloids.

For synthesis of the dienoid-type alkaloids such as erysotrine **3**, a different transformation, *i.e.*, transposition of the oxygenated function from C-2 to C-3, is necessary. For this purpose, one of the two methylene groups in **1** must be differentiated and one (C-1) has to be selectively protected before manipulation of C-3. This should be conveniently achieved by the formation of a cyclopropane ring between C-1 and C-7 with the aid of the 7β-hydroxy group. The resulting cyclopropane ring, after suitable manipulation at C-3, will readily generate the C-1 methylene or the C-1 olefin by a reductive or non-reductive cleavage, as required. The potential utility of such 1,7-cycloerythrinans in the synthesis of natural alkaloids was demonstrated in the total syntheses of erysotrine,[2] erythristemine,[3] schelhammericine,[4] dihydroschelhammeridine,[5] and comosine.[5] This paper presents a full account of the preparation and the properties of these 1,7-cycloerythrinan derivatives.

Results and Discussion

Synthesis and Properties of 6-Ethoxycarbonyl-1,7-cyclo-*cis*-erythrinans Methanesulfonylation of the hydroxy-



1 2 3

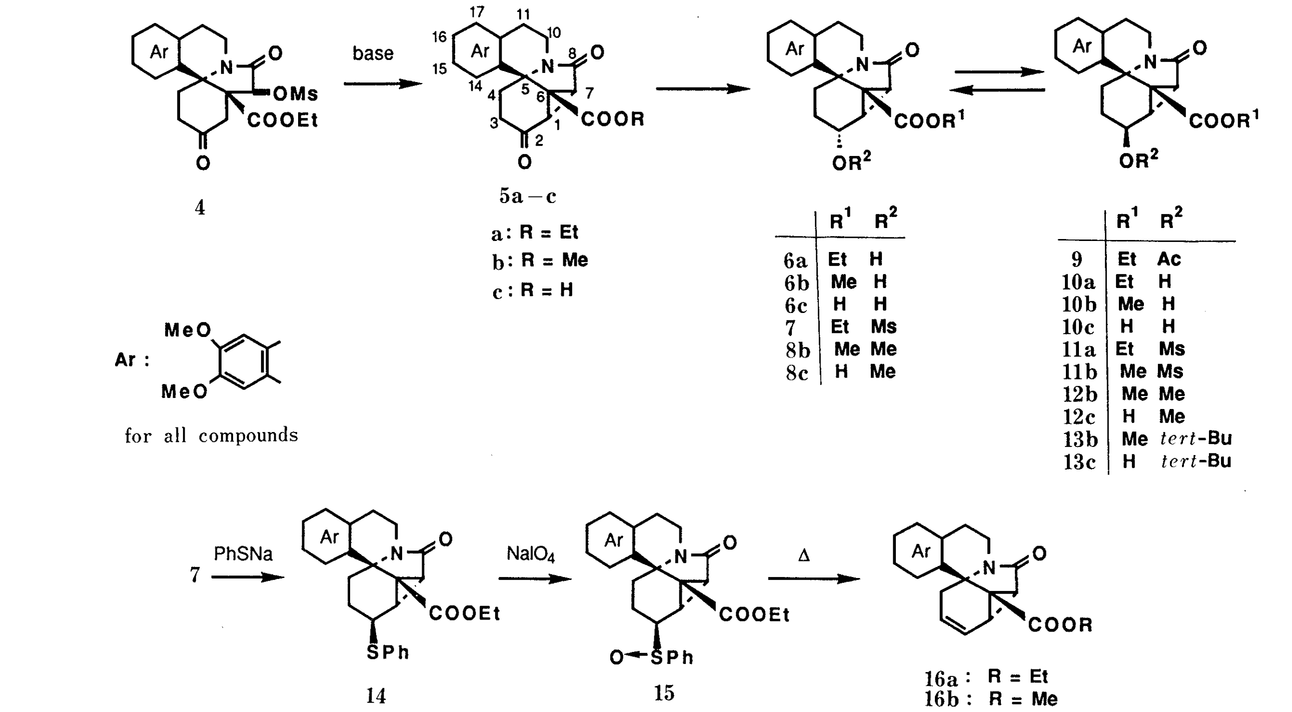
Chart 1

ketone **1** gave the *O*-mesylate **4** which, on heating with 1,8-diazabicyclo[5.4.0]-undec-8-ene (DBU) in benzene, gave the 1,7-cyclo-*cis*-etythrinan **5a** in 83% yield. The structure of **5a** was confirmed by its ^{13}C nuclear magnetic resonance (NMR) spectrum, which exhibited signals at 35.1 (d), 33.6 (d), and 46.5 (s) attributable to the cyclopropane ring.

A remarkable increase of the reactivity of the ester group toward alkaline hydrolysis was observed in this transformation: the carbethoxy group on the cylopropane ring was highly sensitive to alkali. The ethyl group of **5a** was completely hydrolyzed by a short treatment (5 min) with 5% KOH–EtOH at room temperature [or on heating with NaCN in hexamethylphophoric triamide (HMPA)] to give the acid **5c**, which was characterized as the methyl ester **5b** on methylation with diazomethane. In contrast, the ester group in **1** or the deoxy-compound **25** (see below) was highly resistant to alkaline hydrolysis: they were recovered unchanged even on heating with 10% KOH–MeOH under reflux for 7 h. Such a high sensitivity of the tertiary carboxylate ester to bases can be explained by considering that it is on the cyclopropane substituted by an electron-withdrawing group, so that the electron density of the ester carbonyl is reduced, and the steric hindrance of the ester carbonyl is almost removed by the bent nature of the molecule. Both factors facilitate the attack of a nucleophile on the carbonyl carbon of this tertiary carboxylate group. In agreement with the above observation, treatment of **4** with 10% methanolic sodium hydroxide directly gave the cyclo-acid **5c**.

Reduction of **5a** with $NaBH_4$ gave a single alcohol **6a**, which undoubtedly has 2α configuration, since the concave face of **5** is highly hindered and the hydride should have attacked from the convex face. Similarly, **5b** was reduced to the corresponding methyl ester **6b**.

The alcohol **6a** gave the *O*-mesylate **7** on methanesulfonylation. Very high reactivity of this *O*-mesylate in *S*N2 reactions was revealed as follows. Treatment of **7** with Zn–AcOH[6] gave the stereochemically inverted 2β-*O*-acetate **9** in high yield, and this was hydrolyzed to the hydroxy-acid **10c**. Attempted demesylation of **7** with DBU



	R^1	R^2
6a	Et	H
6b	Me	H
6c	H	H
7	Et	Ms
8b	Me	Me
8c	H	Me

	R^1	R^2
9	Et	Ac
10a	Et	H
10b	Me	H
10c	H	H
11a	Et	Ms
11b	Me	Ms
12b	Me	Me
12c	H	Me
13b	Me	*tert*-Bu
13c	H	*tert*-Bu

Chart 2

in dimethyl sulfoxide (DMSO) gave three compounds, 2β-alcohol **10a**, the olefin **16a**, and the ketone **5a**.[7] Treatment of **7** with potassium *tert*-butoxide in *tert*-BuOH produced the 2β-butoxy derivative **13c**, which accompanied with hydrolysis of the ester group, and the product was characterized as the methyl ester **13b**. Similarly, heating of **7** with 10% KOH–MeOH gave the hydroxy-acid **10c** and the methoxy-acid **12c**, which were again characterized as the methyl esters, **10b** and **12b**, respectively.

The 2β-*O*-mesylate **11a** derived from **10a** was also susceptible to *SN*2 reactions. On treatment with 10% KOH–MeOH, it gave the 2α-hydroxy-acid **6c** and 2α-methoxy-acid **8c**, which were characterized as the methyl esters, **6b**, and **8b**, respectively. These correlative transformations clarified the stereochemical assignments of each compound.

The stereochemistries of the 2-OR groups could also be elucidated from the ^{1}H-NMR spectra. The 14-H signal in 2β-OR derivatives always appeared at lower field than that of the corresponding 2α-OR derivatives, while the 17-H signal was almost unchanged. Therefore the differences in chemical shifts between 14-H and 17-H were *ca.* 0.2 ppm for 2β-OR and ≤0.1 ppm for 2α-OR derivatives. This suggests a sterically closer relationship of 2-OR and 14-H in the 2β derivatives.

By application of the above easy *SN*2 displacement reaction of the *O*-mesylates at C-2, the olefin **16a** was prepared as follows. Treatment of **7** with sodium thiophenolate gave the 2β-thiophenoxy derivative **14** which, on periodate oxidation and heating of the resulting sulfoxide **15** in toluene, gave **16a** in 60% overall yield.

Synthesis of 1,7-Cyclo-*cis*-erythrinan 17 There are two reports on the preparation of 15,16-dimethoxy-2,8-dioxo-1,7-cyclo-*cis*-erythrinan **17**. Ito *et al.*[8] obtained **17** in 70% yield on alkaline treatment of the 7β-*O*-mesylate **18b**. Mondon *et al.*[9] obtained the same compound **17** by rather

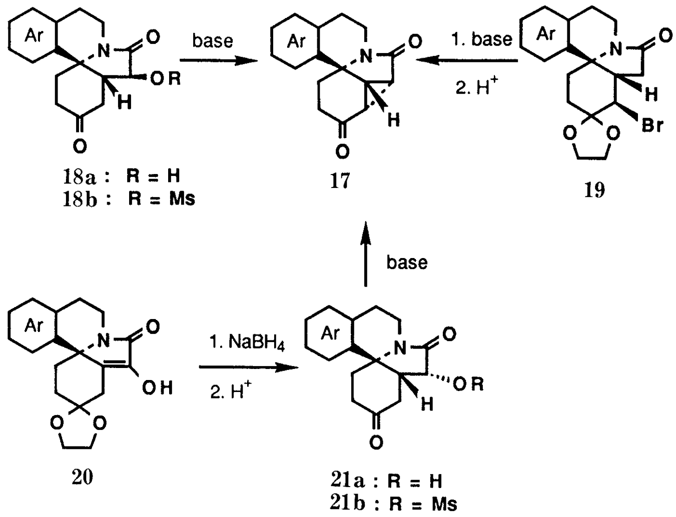


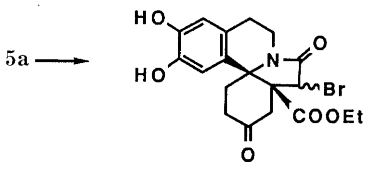
Chart 3

drastic alkaline treatment of the bromoacetal **19** followed by acid hydrolysis. We present here a third method.[10]

Oxidation of the ethylene-acetal of **1** with DMSO/acetic anhydride, decarbethoxylation of the resulting 7,8-dioxo derivative with $MgCl_2$/DMSO, and reduction of the erythrinan-7,8-dione **20** with $NaBH_4$ followed by acid hydrolysis gave the 7α-ol **21a** as a single product.[1] This compound was isomeric to Ito's 7β-ol **18a**[8] as confirmed by the depression of the mixed melting point and comparisons of the spectral data. Methanesulfonylation of **21a** gave the *O*-mesylate **21b** which was again different from Ito's 7β-*O*-mesylate **18b**. Treatment of **21b** with a base (10% KOH–MeOH or 10% K_2CO_3–MeOH) smoothly gave, in 73% yield, the 1,7-cyclo-*cis*-erythrinan **17**, identical with the compound prepared from the 7β-*O*-mesylate **18b** by Ito *et al.*[8] The ^{13}C-NMR spectrum of this compound (δ 30.3 d, 28.8 d, and 33.6 d) again confirmed the formation of the 1,7-cyclo structure.

Since the stereochemical character of the 7α-*O*-mesylate **21b** is not suitable for the concerted intramolecular *S*N2 alkylation to give **17**, the above reaction could proceed through rapid base-catalyzed inversion of the 7α-OMs group to the 7β configuration.

As the cyclizations of 7β-OMs **18b** and 7α-OMs **21b** to the 1,7-cycloerythrinan **17** proceed with comparable ease and the yields are also comparable (*ca.* 70%), we now have in hand a method for the preparation of 1,7-cycloerythrinans from either the 7β or the 7α-hydroxy isomer. This finding has a great synthetic value, particularly when the photochemical approach for the synthesis of erythrinan alkaloids is employed, since in that approach the key intermediates are 7α-hydroxy derivatives.[11)]



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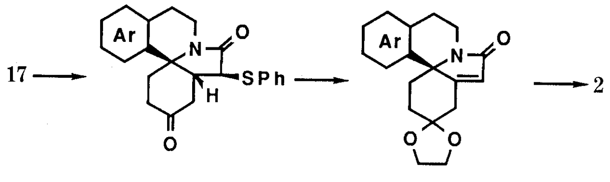


23 24

Chart 4

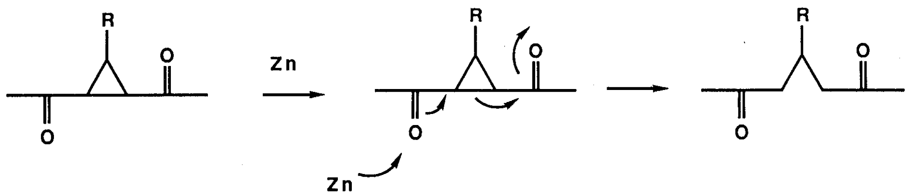
Opening of the Cyclopropane Ring The cyclopropane ring in **5a** was resistant to attempted acidic cleavages. The compound was recovered unchanged on treatment with TsOH–AcOH and $SnCl_4$ in nitromethane, and with HCl–AcOH it gave a complex mixture. The only successful cleavage was that with HBr–AcOH, which gave a compound supposed to be **22**. This stability of the cyclopropane ring toward acids is consistent with its negatively substituted nature.

Cleavage of the cyclopropane ring in **17** with nucleophilic reagents was achieved, though the yield was unsatisfactory. Treatment of **17** with PhSNa in the presence of 18-crown-6 afforded the 7β-thiophenoxy derivative **23**. The structure of **23** was proved by converting it to the known olefin **24**. Oxidation of **23** with $NaIO_4$ and heating of the resulting sulfoxide in benzene with ethylene glycol and a catalytic amount of *p*-TsOH resulted in *syn*-elimination of the sulfoxide group with concomitant ethylene acetalization, giving rise to the previously reported acetal **24**,[1,12)] which has been converted, by reduction and deacetalization, to the natural *Erythrina* alkaloid, (±)-3-demethoxyerythratidinone **2**. Although the yield was low (7% from **17**), this transformation provided an alternative synthesis of the alkaloid.

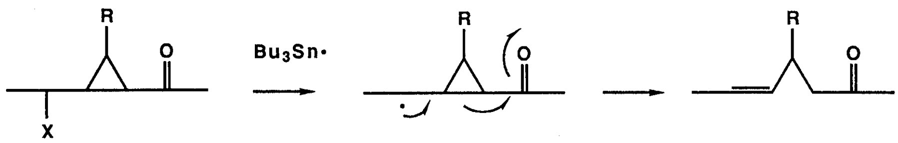
The cyclopropane ring in **5** and **17** was found to be effectively cleaved by one of the three following routes (A—C in Chart 5). Reductive cleavage by route A is realized as follows. Treatment of **5a** with Zn–AcOH gave **25** in a quantitative yield. The reaction should have proceeded in a similar way to Zn reduction of an enedione system. The methyl dithioacetal **26** also gave the same product (**25**) on similar reduction.

A radical cleavage of the ring leading to the olefinic product (route B) was verified as follows. The 2α- and

A : reductive cleavage



B : radical cleavage



C : ionic cleavage

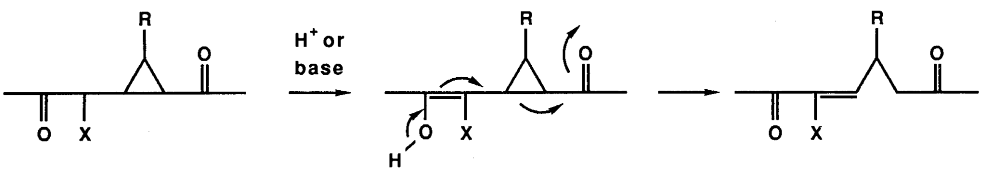


Chart 5. Cleavage of a Conjugated Cyclopropane Ring

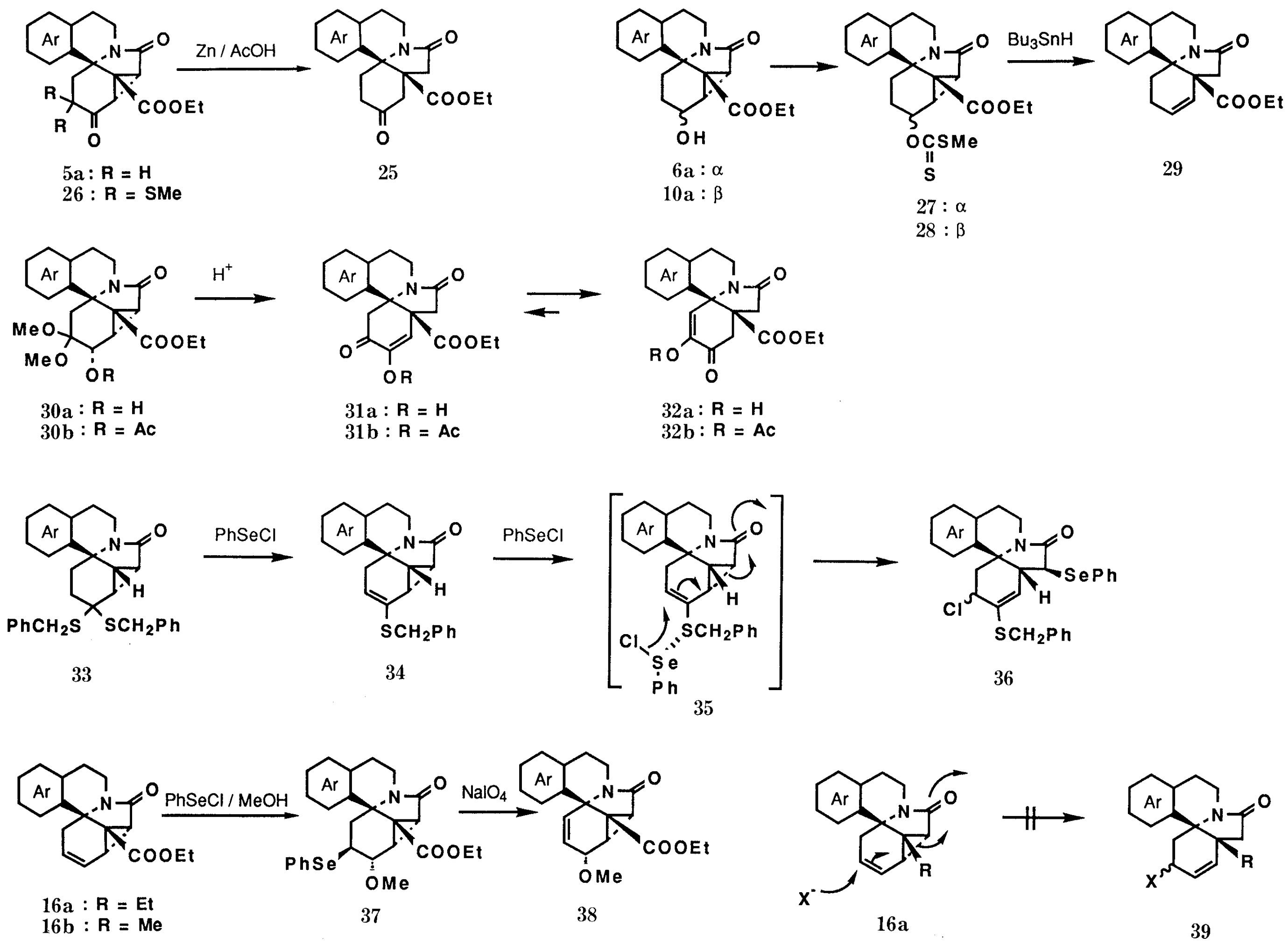


Chart 6

2β-hydroxy derivatives, **6a** and **10a**, were readily converted to the dithiocarbonates, **27** and **28**, respectively, on treatment with NaH/CS_2 followed by CH_3I. Heating of either **27** or **28** with tributyltin hydride in toluene in the presence of a catalytic amount of azobisisobutyronitrile (AIBN) gave the olefin **29** in over 90% yield from the either isomer. The comparable yields of **29** from the two isomers indicated that this elimination reaction proceeded through the same radical intermediate from either stereo-isomer. Since many of the natural erythrinan alkaloids have a double bond at the 1-2 position, this method should be useful in synthesizing them.[13)]

Ionic cleavage by route C was achieved by forming an anion at C-2. We have prepared the dimethoxy-alcohol **30a** through α,α-dimethoxylation[12)] of **5a** followed by hydride reduction. Deacetalization of this with HCl gave, with spontaneous opening of the cyclopropane ring, a mixture of diosphenols, **31a** and **32a**. On the other hand, the acetate **30b** gave, on short treatment with acid, an isomer **31b**, which on further treatment with acid, was changed into a mixture of **31a** and **32a**. Acetylation of this mixture afforded **31b** and **32b**.

Another intriguing ionic cleavage of a 1,7-cycloerythrinan was reported by Ito *et al.*[8)] in their total synthesis of erysotramidine. They obtained the chloro-olefin **36**[14)] on treatment of the benzyl dithioacetal **33** with phenylselenenyl chloride. Reinvestigation of their route clarified that the intermediate of this transformation is the olefin **34**, which undergoes the ring cleavage reaction by attack of Cl^- at C-3 in the presence of phenylselenenyl chloride. However, the similar olefin **16a**, on treatment with PhSeCl in MeOH, yielded a different type of product (**37**), whose structure was proved by converting it, by oxidative elimination of the PhSe group, to the methoxy-olefin **38** which showed two olefinic proton signals in the ^{1}H-NMR spectrum. The stereochemistry of the methoxy group was concluded to be α on the assumption that the phenylselenenylation took place from the less hindered convex face of the molecule. An attempted methoxylation of **16a** with sodium methoxide in MeOH again did not give **39**, but only resulted in trans-esterification to the methyl ester **16b**. Obviously the thio-enolate system in **34** plays a major role in determination of the orientation of phenylselenenylation. These differences in the reactive sites between **34** and **16** on phenylselenenylation must be attributable to the soft-soft interaction of S and Se atoms in the reaction of **34**, which fixes the position of attack of the chloride anion.

Conclusion

2,8-Dioxo-1,7-cyclo-*cis*-erythrinan derivatives are readily obtainable from both 2,8-dioxo-7β- and 7α-hydroxy-erythrinans in comparable yields. The resulting products are suitably protected at C-1 for further manipulation at C-3 of erythrinans. The cyclopropane ring in the compounds is readily cleaved by one of the above three routes (reductive, radical, and ionic) to give the C-1 methylene or C-1 olefinic derivatives, which are potentially useful for the synthesis of natural erythrinan alkaloids.

Experimental

General Unless otherwise stated, the following procedures were adopted. Melting points were determined on a Yanaco micro hot stage melting point apparatus and are uncorrected. Infrared (IR) spectra were taken in KBr disks, recorded on a Jasco IR-G spectrometer, and the data are given in cm^{-1}. ^1H-NMR spectra were taken with a JNM-PMX-60 (60 MHz) or JEOL FX-100 (100 MHz) spectrometer in chloroform-*d* solution with tetramethylsilane as an internal standard, and the chemical shifts are given in δ values (s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; br, broad; dif, diffused). Mass spectra (MS) and high resolution mass spectra (HRMS) were taken with a Hitachi M-80 machine and M^+ and/or major peaks are indicated as *m/z*. Column chromatography was performed on Wakogel C-200 (silica gel). For thin layer chromatography (TLC), Merck precoated plates GF_{254} were used and spots were monitored by measuring ultraviolet (UV) absorbance (254 nm), then developed by spraying 1% $Ce(SO_4)_2$ in 10% H_2SO_4 and heating the plates at 100 °C until coloration took place. All organic extracts were washed with water and dried over anhydrous sodium sulfate before concentration. Identities were confirmed by mixed melting point determination (for crystalline compounds) and also comparisons of TLC behavior, and ^1H-NMR and IR spectra.

The 7β-*O*-Mesylate 4 Compound **1**[1] (810 mg) and methanesulfonyl chloride (360 mg) in pyridine (10 ml) were stirred at room temperature for 50 min. The mixture was poured into water and extracted with $CHCl_3$. Chromatography of the product gave the *O*-mesylate (900 mg, 93%) as colorless prisms from MeOH–ether, mp 234—236 °C. IR: 1715. ^1H-NMR: 6.53, 6.46 (each 1H, s, ArH), 5.05 (1H, s, CHOMs), 3.81, 3.74 (each 3H, s, OMe), 3.56 (2H, q, J=7 Hz, $COOC\underline{H}_2CH_3$), 3.25 (3H, s, Ms), 0.84 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). *Anal.* Calcd for $C_{22}H_{27}NO_9S$: C, 54.88; H, 5.65; N, 2.91. Found: C, 54.72; H, 5.51; N, 2.77.

6β-Ethoxycarbonyl-15,16-dimethoxy-2,8-dioxo-1,7-cyclo-*cis*-erythrinan 5a The *O*-mesylate **4** (1.4 g) and DBU (6 g) in toluene (120 ml) were heated under reflux for 2 h. The mixture was diluted with benzene (100 ml), washed with 1 N HCl and water, dried, and concentrated to give **5a** (0.93 g, 83%) as colorless prisms from MeOH, mp 183—184 °C. IR: 1723, 1693, 1685 (sh). ^1H-NMR: 6.84, 6.65 (each 1H, s, ArH), 3.95 (2H, qd, J=7, 2.5 Hz, $COOC\underline{H}_2CH_3$), 3.88, 3.85 (each 3H, s, OMe), 1.00 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). ^{13}C-NMR: 200.7s, 167.1s (×2), 148.5s, 147.6s, 127.5s, 126.5s, 112.3d, 108.8d, 61.9t, 61.9s, 56.1q, 55.9q, 46.5s, 36.9t, 35.23t, 35.05d, 34.93t, 33.6d, 28.7t, 13.6q. *Anal.* Calcd for $C_{21}H_{23}NO_6$: C, 65.44; H, 6.02; N, 3.63. Found: C, 65.33; H, 5.87; N, 3.76.

The 6β-Carboxylic Acid 5c (1) Compound **5a** (50 mg) in 5% KOH–MeOH (3 ml) was stirred at room temperature for 5 min. The resulting clear solution was passed through a column of Dowex 50 (H^+ form) and the column was eluted with MeOH. Concentration of the combined eluates gave the acid **5c** (45 mg) as a solid, mp > 300 °C. HRMS: Calcd for $C_{19}H_{19}NO_6$ (M^+): 357.1211. Found: 357.1232.

(2) The *O*-mesylate **4** (0.5 g) in 10% NaOH–MeOH (30 ml) was stirred for 1 h at room temperature and worked up as above to give the acid **5c** (0.3 g, 80%).

(3) Compound **5a** (100 mg) and NaCN (28 mg) in HMPA (5 ml) were heated at 155 °C for 40 min. The solvent was evaporated off and the residue was dissolved in $CHCl_3$. This solution was washed with 1 N HCl, dried, and concentrated to give the acid **5c** (45 mg). The acid **5c** obtained by each of the above three methods was characterized as the methyl ester **5b** (see below).

The Methyl Ester 5b The acid **5c** suspended in MeOH was treated with ethereal diazomethane for 30 min at room temperature. Evaporation of the solvent left the methyl ester **5b** as a gum. IR: 1730, 1708, 1683. ^1H-NMR: 6.81, 6.61 (each 1H, s, ArH), 3.88, 3.86 (each 3H, s, OMe), 3.53 (3H, s, COOMe). HRMS Calcd for $C_{20}H_{21}NO_6$ (M^+): 371.1368. Found: 371.1382.

6β-Ethoxycarbonyl-2α-hydroxy-15,16-dimethoxy-8-oxo-1,7-cyclo-erythrinan 6a The 2-oxo compound **5a** (0.5 g) and $NaBH_4$ (15 mg) in EtOH (70 ml) were stirred for 40 min at 0 °C. After evaporation of the solvent and addition of water, the mixture was extracted with $CHCl_3$. Concentration of the extract gave the 2α-hydroxy compound **6a** (503 mg, 100%) as colorless prisms from MeOH, mp 195—196 °C. IR: 3370, 1715, 1670. ^1H-NMR: 6.58, 6.52 (each 1H, s, ArH), 3.81, 3.78 (each 3H, s, OMe), 0.84 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). *Anal.* Calcd for $C_{21}H_{25}NO_6$: C, 65.10; H, 6.50; N, 3.37. Found: C, 65.03; H, 6.44; N, 3.37.

2α-Hydroxy-6β-methoxycarbonyl-15,16-dimethoxy-2,8-dioxo-1,7-cycloerythrinan 6b The methyl ester **5b** (50 mg) in EtOH (20 ml) was reduced as above to give the 2α-hydroxy compound **6b** (50 mg) as colorless prisms from MeOH, mp 217—219 °C. IR: 3400, 1730, 1660. ^1H-NMR: 6.57, 6.51 (each 1H, s, ArH), 3.82 (6H, s, 2×OMe), 3.37 (3H, s, COOMe). *Anal.* Calcd for $C_{20}H_{23}NO_6$: C, 64.33; H, 6.21; N, 3.75. Found. C, 64.03; H, 6.22; N, 3.61.

The 2α-*O*-Mesylate 7 Compound **6a** (1.16 g), methanesulfonyl chloride (1.2 g), and 4-dimethylaminopyridine (36 mg) in pyridine (15 ml) and CH_2Cl_2 (5 ml) were stirred for 1 h at room temperature. The mixture was poured into water, and extracted with $CHCl_3$. The organic layer was washed with 1 N HCl and water, dried, and concentrated to give **7** (1.24 g), which crystallized on trituration with MeOH–ether. Recrystallization from MeOH gave colorless needles, mp 188—189 °C. IR: 1725, 1685. ^1H-NMR: 6.62, 6.57 (each 1H, s, ArH), 5.3—5.8 (1H, CHOMs), 3.84, 3.81 (each 3H, s, OMe), 3.08 (3H, s, Ms), 0.88 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). *Anal.* Calcd for $C_{22}H_{27}NO_8S$: C, 56.76; H, 5.85; N, 3.01. Found: C, 56.67; H, 5.82; N, 3.23.

Reaction of the 2α-*O*-Mesylate 7 with Zn–AcOH Powdered zinc (0.5 g) was added in portions to a stirred solution of **7** (54 mg) in AcOH (6 ml) for 1 h at 100—105 °C, and then the mixture was filtered. The filtrate was diluted with water and extracted with $CHCl_3$. Concentration of the extract gave the 2β-*O*-acetate **9** (40 mg) as a gum. IR ($CHCl_3$): 1725, 1685, 1675. ^1H-NMR 6.68, 6.52 (each 1H, s, ArH), 5.15—5.35 (1H, CHOAc), 3.82 (6H, s, 2×OMe), 2.15 (3H, s, Ac), 0.91 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). HRMS: Calcd for $C_{23}H_{27}NO_7$ (M^+): 429.1786. Found: 429.1768.

This (170 mg) was hydrolyzed with 10% NaOH–MeOH (5 ml) for 1.5 h at room temperature. Acidification and extraction with EtOAc of the mixture gave the 2β-hydroxy acid **10c** (115 mg). Treatment of **10c** (115 mg) in MeOH with ethereal diazoethane for 30 min at room temperature gave the ethyl ester (108 mg) as a gum, which was different from **6a** and identical with the 2β-hydroxy compound **10a** obtained below.

Reaction of the 2α-*O*-Mesylate 7 with DBU in DMSO Compound **7** (540 mg) and DBU (0.5 g) in DMSO (10 ml) were heated for 3 h at 90—110 °C. After evaporation of DMSO, the residue was taken up in $CHCl_3$ and the extract was washed with 1 N HCl and water, dried, and concentrated. Chromatography of the residue gave, from the $CHCl_3$ eluate, a gum (181 mg) whose TLC behavior and ^1H-NMR spectrum revealed that it is a mixture of the ketone **5a** and the olefin **16a**. Further elutions with $CHCl_3$–EtOAc (1 : 1) and AcOEt gave the 2β-hydroxy derivative **10a** (254 mg) as a gum. IR ($CHCl_3$): 3400, 1715, 1670. ^1H-NMR: 6.79, 6.59 (each 1H, s, ArH), 3.86, 3.84 (each 3H, s, OMe), 0.87 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). MS: 387 (M^+).

The 2β-*O*-Mesylate 11a Compound **10a** (193 mg) was mesylated and worked up as described for the preparation of **7** to give **11a** (208 mg, 90%) as a gum. IR ($CHCl_3$): 1720, 1680. ^1H-NMR: 6.65, 6.53 (each 1H, s, ArH), 5.17—5.3 (1H, CHOMs), 3.82 (6H, s, 2×OMe), 3.13 (3H, s, Ms), 0.90 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). HRMS: Calcd for $C_{22}H_{27}NO_8S$ (M^+): 465.1456. Found: 456.1445.

Reaction of the 2α-*O*-Mesylate 7 with *tert*-BuOK Compound **7** (100 mg) in 10% *tert*-BuOK–*tert*-BuOH (10 ml) was heated under reflux for 1 h. The mixture was poured into water, acidified with HCl, and extracted with $CHCl_3$ to give the crude acid **13c** (76 mg) as a gum, which was methylated with ethereal diazomethane and purified by chromatography to give the methyl ester **13b** (40 mg) as colorless prisms from MeOH, mp 163—165 °C. IR: 1720, 1690. ^1H-NMR: 6.92, 6.48 (each 1H, s, ArH), 3.81 (6H, s, 2×OMe), 3.46 (3H, s, COOMe), 1.24 (9H, s, *tert*-Bu). *Anal.* Calcd for $C_{24}H_{31}NO_6$: C, 67.11; H, 7.28; N, 3.26. Found: C, 66.98; H, 7.12; N, 3.25.

Reaction of the 2α-*O*-Mesylate 7 with 10% KOH–MeOH Compound **7** (200 mg) in 10% KOH–MeOH (20 ml) was heated under reflux for 3 h. The mixture was passed through a column of Dowex 50 (H^+ form) and the column was washed with 90% MeOH. Concentration of the combined eluates gave a mixture of **10c** and **12c** (175 mg), a portion (100 mg) of which was methylated with diazomethane. Chromatography of the product gave the methyl ester of the 2β-OMe compound (**12b**, 61 mg) from the $CHCl_3$–EtOAc (2 : 1) eluate and the methyl ester of the 2β-OH compound (**10b**, 48 mg) from the $CHCl_3$–MeOH (20 : 1) eluate.

12b: Colorless prisms from MeOH, mp 167—168 °C. IR ($CHCl_3$): 1725, 1673. ^1H-NMR: 6.72, 6.49 (each 1H, s, ArH), 3.80 (6H, s, 2×OMe), 3.43 (6H, s, OMe and COOMe). *Anal.* Calcd for $C_{21}H_{25}NO_6$: C, 65.10; H, 6.50; N, 3.62. Found; C, 64.94; H, 6.39; N, 3.53.

10b: Colorless gum. IR ($CHCl_3$): 3400, 1725, 1675. ^{1}H-NMR: 6.74, 6.53 (each 1H, s, ArH), 3.82 (6H, s, 2 × OMe), 3.40 (3H, s, COOMe). HRMS: Calcd for $C_{20}H_{23}NO_6$ (M^+): 373.1524. Found: 323.1528. It gave the *O*-mesylate **11b**, as a gum, on methanesulfonylation as described above. ^{1}H-NMR: 6.65, 6.53 (each 1H, s, ArH), 5.0—5.3 (1H, CHOMs), 3.82 (6H, s, 2 × OMe), 3.42 (3H, s, COOMe), 3.13 (3H, s, Ms). MS: 451 (M^+).

Reaction of the 2β-*O*-Mesylate 11a with 10% KOH–MeOH The *O*-mesylate **11a** (179 mg) in 10% KOH–MeOH (20 ml) was heated under reflux for 1 h and worked up as described for the reaction of **7**. A portion (50 mg) of the acidic products (**6c** and **8c**, 135 mg) was methylated with diazomethane and purified by chromatography to give the 2α-methoxy derivative **8b** (30 mg) from the $CHCl_3$–EtOAc (2 : 1) eluate and the 2α-hydroxy derivative **6b** (10 mg), mp 217—219 °C, from the $CHCl_3$–MeOH (20 : 1) eluate. **8b** was a colorless gum. IR ($CHCl_3$): 1720, 1680. ^{1}H-NMR: 6.61, 6.52 (each 1H, s, ArH), 3.82 (6H, s, 2 × OMe), 3.43, 3.38 (each 3H, s, COOMe, OMe). HRMS: Calcd for $C_{21}H_{25}NO_6$ (M^+): 387.1680. Found; 387.1687.

The 2β-Thiophenoxy Derivative 14 Sodium thiophenoxide [prepared from 10 g of thiophenol and 2 g of sodium in dimethylformamide (DMF)] was added to a solution of the 2α-*O*-mesylate **7** (1 g) in DMF (20 ml) and the mixture was stirred for 20 min at 0 °C. The mixture was acidified with AcOH, diluted with water, and extracted with $CHCl_3$. Chromatography of the product gave PhSSPh from the benzene eluate, then the 2β-thiophenoxy derivative **14** from the benzene–$CHCl_3$ eluate; **14** was washed with ether and crystallized from MeOH to give pure **14** (788 mg, 77%), mp 155–157 °C. IR: 1710, 1685. ^{1}H-NMR: 7.1—7.6 (5H, PhH), 6.78, 6.50 (each 1H, s, ArH), 3.84 (6H, s, 2 × OMe), 0.95 (3H, t, J = 7 Hz, $COOCH_2C\underline{H}_3$). *Anal.* Calcd for $C_{27}H_{29}NO_5S$: C, 67.63; H, 6.10; N, 2.92. Found: C, 67.48; H, 6.22; N, 2.90. Elution of the column with $CHCl_3$–EtOAc (1 : 2) gave the starting material **7** (112 mg).

6β-Ethoxycarbonyl-15,16-dimethoxy-8-oxo-Δ^2-1,7-cycloerythrinan 16a The thiophenoxide **14** (0.7 g) and $NaIO_4$ (1 g) in MeOH–H_2O (1 : 1, 120 ml) were stirred for 1 h at room temperature. The mixture was diluted with water and extracted with CH_2Cl_2. Concentration of the extract gave a mixture of sulfoxides **15** as a solid (685 mg, 95%). IR: 1720, 1700. ^{1}H-NMR: 7.1—7.8 (5H, PhH), 6.55, 6.48 (each br s, ArH), 3.78 (6H, s, OMe), 0.97, 0.93 (each 3/2 H, t, J = 7 Hz, $COOCH_2C\underline{H}_3$).

Compound **15** (0.6 g) in toluene (30 ml) was heated under reflux for 2 h, then the solvent was evaporated off. Chromatography of the residue gave, from the $CHCl_3$–benzene (1 : 1) and $CHCl_3$ eluates, the olefin **16a** (368 mg, 82%), as colorless prisms from ether, mp 144—146 °C . IR: 1715, 1685. ^{1}H-NMR: 6.88, 6.51 (each 1H, s, ArH), 5.7—5.9 (2H, CH = CH), 3.81 (6H, s, 2 × OMe), 1.02 (3H, t, J = 7 Hz, $COOCH_2C\underline{H}_3$). *Anal.* Calcd for $C_{21}H_{23}NO_5$: C, 68.28; H, 6.28; N, 3.79. Found: C, 68.51; H, 6.42; N, 3.66.

7α-Hydroxy-15,16-dimethoxy-2,8-dioxo-erythrinan 21a Compound **20** was reduced with $NaBH_4$ as described in the previous paper,[1] and the resulting product (0.3 g) in 2% HCl (30 ml)–acetone (30 ml) was heated for 15 min at 60 °C. After evaporation of the acetone under reduced pressure, the mixture was extracted with $CHCl_3$. Concentration of extract gave **21a** in a quantitative yield as colorless prisms from MeOH, mp 239—241 °C. IR: 3320, 1715, 1655. *Anal.* Calcd for $C_{18}H_{21}NO_5$: C, 65.24; H, 6.39; N, 4.23. Found: C, 65.22; H, 6.21; N, 4.12.

The 7α-*O*-Mesylate 21b Compound **21a** (0.21 g) and methanesulfonyl chloride (0.2 g) in pyridine (10 ml) were stirred for 2 h at room temperature and worked up as usual to give **21b** (0.25 g, 95%), as colorless prisms from MeOH, mp 209—210 °C. IR: 1710, 1690. ^{1}H-NMR: 6.63, 6.53 (each 1H, s, ArH), 5.12 (1H, d, J = 9 Hz, CHOMs), 3.83 (6H, s, 2 × OMe), 3.17 (3H, s, Ms). *Anal.* Calcd for $C_{19}H_{23}NO_7S$: C, 55.74; H, 5.66; N, 3.42. Found: C, 55.59; H, 5.58; N, 3.36.

1,7-Cyclo-*cis*-erythrinan 17 The *O*-mesylate **21b** (55 mg) in 10% KOH–MeOH (5 ml) was heated under reflux for 1.5 h. Addition of water and extraction with $CHCl_3$ of the mixture gave the cyclo-derivative **17**, which was purified by preparative TLC to yield 30 mg (70%) as colorless prisms from MeOH, mp 216—217 °C (lit. mp 205—207 °C).[8] IR: 1700, 1685. ^{1}H-NMR: 6.78, 6.64 (each 1H, s, ArH), 3.86, 3.83 (each 3H, s, OMe). ^{13}C-NMR: 203.0s, 168.8s, 148.2s, 148.0s, 129.8s, 125.3s, 112.0d, 107.3d, 59.1s, 56.0q, 55.7q, 36.2t, 34.7t, 33.6t, 33.6d, 30.3d, 28.8d, 27.5t. *Anal.* Calcd for $C_{18}H_{19}NO_4$: C, 68.99; H, 6.11; N, 4.47. Found: C, 68.76; H, 6.08; N, 4.50. This was identical with the sample (mp 215—217 °C) provided by Dr. M. Haruna, Meijo University.

Reaction of 5a with HBr–AcOH Compound **5a** (100 mg) in AcOH (6 ml) and 48% HBr (0.3 ml) was heated at 90 °C for 9 h, and concentrated. The residue (**22**) was dissolved in MeOH (5 ml) and treated with ethereal diazomethane for 30 min at room temperature. Chromatography of the product gave a mono-methyl ether (50 mg), as a gum, from the $CHCl_3$ eluate. IR ($CHCl_3$): 1705—1720. ^{1}H-NMR: 6.60, 6.48 (each 1H, s, ArH), 4.52 (1H, s, CHBr), 3.82 (3H, s, OMe), 0.83 (3H, t, J = 7 Hz, $COOCH_2C\underline{H}_3$). MS: 415, 417 (1 : 1, M^+).

Reaction of 1,7-Cycloerythrinan 17 with Sodium Thiophenoxide Thiophenol (50 mg), NaOH (18 mg), and 18-crown-6-(40 mg) in benzene (5 ml) were heated under reflux for 2.5 h. Compound **17** (94 mg) was added to this solution and the mixture was heated under reflux for a further 5 h. The mixture was diluted with benzene, washed with water, and concentrated. Chromatography of the residue gave **23** (36 mg) as a gum from the benzene–EtOAc (1 : 1) eluate. This was used for the next step without further purification.

The Olefin-acetal 24 The above obtained **23** (36 mg) and $NaIO_4$ (46 mg) in MeOH–H_2O (1 : 1, 10 ml) were stirred for 22 h at room temperature. The mixture was extracted with CH_2Cl_2 to give the sulfoxide which, without purification, was dissolved in benzene (7 ml) and heated with a catalytic amount of *p*-TsOH and ethylene glycol (5 drops) under reflux for 2 h. The cooled mixture was washed with water, dried, and concentrated, and the residue was purified by preparative TLC to yield **24** (7 mg, 7% from **17**), as colorless needles from ether, mp 128—130 °C (lit. mp 133—135 °C).[1]

Zn–AcOH Reduction of 5a Powdered zinc (0.5 g) was added in portions to a stirred solution of **5a** (99 mg) in AcOH (10 ml) at 120—130 °C for 2 h. The mixture was filtered and the filtrate was diluted with water extracted with $CHCl_3$. Concentration of the extract gave the reduced product **25** (90 mg, 91%) as colorless prisms from MeOH–ether, mp 253—256 °C. IR: 1720, 1685 (sh), 1675. ^{1}H-NMR: 6.55, 6.51 (each 1H, s, ArH), 3.81 (6H, s, 2 × OMe), 0.78 (3H, t, J = 7 Hz), $COOCH_2C\underline{H}_3$). *Anal.* Calcd for $C_{21}H_{25}NO_6$: C, 65.10; H, 6.50; N, 3.62. Found: C, 64.98; H, 6.43; N, 3.58.

The Methyl Dithioacetal 26 Lithium diisopropylamide (2.2 mol eq) was added to a stirred solution of **5a** (50 mg) and methyl 2-nitrophenyl disulfide (60 mg) in tetrahydrofuran (THF) (4 ml), and the mixture was heated in a sealed tube at 100 °C for 2.5 h. After decomposition of excess reagent with a few drops of water, the mixture was diluted with benzene, washed with water, dried, and concentrated. Chromatography of the residue gave the methyl dithioacetal **26** (20 mg, 32%) as colorless prisms from MeOH, mp 190—192 °C. IR: 1720, 1710. ^{1}H-NMR: 7.12, 6.45 (each 1H, s, ArH), 4.05 (2H, q, J = 7 Hz, $COOC\underline{H}_2CH_3$), 3.80 (6H, s, 2 × OMe), 1.95, 1.90 (each 3H, s, SMe), 1.13 (3H, t, J = 7 Hz, $COOCH_2C\underline{H}_3$). MS: 477 (M^+).

Zn–AcOH Reduction of the Methyl Dithioacetal 26 Compound **26** (30 mg) in AcOH (5 ml) was reduced with powdered Zn (50 mg) and worked up as described above. Preparative TLC of the product gave **5a** (15 mg, 62%) and **25** (5 mg, 21%).

The 2α-Dithiocarbonate 27 Compound **6a** (137 mg), NaH (70 mg), and imidazole (3 mg) in THF (7 ml) were heated under reflux for 1 h under an argon atmosphere. Carbon disulfide (2 ml) and methyl iodide (2 ml) were added successively and the mixture was refluxed for a further 20 min. The cooled mixture was poured into water, brought to pH 4 by AcOH, and extracted with $CHCl_3$. Chromatography of the product gave **27** (143 mg, 85%) as a yellowish oil from the benzene–acetone (5 : 1) eluate. IR ($CHCl_3$): 1720, 1685. ^{1}H-NMR: 6.69, 6.60 (each 1H, s, ArH), 6.44 (1H, m, C_2-H), 3.87, 3.84 (each 3H, s, OMe), 2.57 (3H, s, SMe), 0.89 (3H, t, J = 7 Hz, $COOCH_2C\underline{H}_3$). MS: 477 (M^+), 370 (base peak).

The 2β-Dithiocarbonate 28 Compound **10a** (76 mg) was converted to the dithiocarbonate **28** (80 mg, 85%) in a similar manner to that described above to give a yellowish oil. IR ($CHCl_3$): 1720, 1680. ^{1}H-NMR: 6.78, 6.60 (each 1H, s, ArH), 6.08 (1H, m, C_2-H), 3.87 (6H, s, 2 × OMe), 2.63 (3H, s, SMe), 0.93 (3H, t, J = 7 Hz, $COOCH_2C\underline{H}_3$). MS: 477 (M^+), 370 (base peak).

The Olefinic Compound 29 (1) Compound **27** (130 mg), Bu_3SnH (0.35 ml), and AIBN (3 mg) in toluene (20 ml) were heated under reflux for 10 h. The cooled mixture was poured onto a column of silica gel and the column was washed with benzene. Elution of the column with benzene–acetone (2 : 1) gave the olefin **29** (99 mg, 98%) as colorless prisms from CH_2Cl_2–ether, mp 152—153 °C. IR ($CHCl_3$): 1725, 1680. ^{1}H-NMR: 6.71, 6.60 (each 1H, s, ArH), 6.14 (2H, m, CH = CH), 3.84, 3.76 (each 3H, s, OMe), 0.76 (3H, t, J = 7 Hz, $COOCH_2C\underline{H}_3$). MS: 371 (M^+), 298 (base peak). *Anal.* Calcd for $C_{21}H_{25}NO_5$: C, 67.90; H, 6.78; N, 3.77. Found: C, 67.76; H, 6.88; N, 3.77.

(2) Compound **28** (60 mg) was treated with Bu_3SnH (0.17 ml) and AIBN (1 mg) as described above to give the olefin **29** (45 mg, 96%).

Acid Treatment of the Dimethylacetal 30a The dimethylacetal **30a**[13] (48 mg) in 10% HCl (5 ml)–acetone (5 ml) was heated at 50 °C for 1 h. After dilution with water, the mixture was extracted with $CHCl_3$ to give the product, which showed two spots due to **31a** and **32a** on TLC. Preparative TLC of this mixture, however, yielded only the more mobile compound

32a (26 mg, 54%). IR: 1730. 1695, 1665. ^{1}H-NMR: 6.47 (2H, s, ArH), 6.08 (1H, br s, OH, disappeared on addition of D_2O), 5.78 (1H, s, =CH), 3.77, 3.75 (each 3H, s, OMe), 0.88 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). MS: 401 (M^+). It formed the acetate **32b**, mp 218—221 °C, colorless prisms from MeOH, on acetylation with pyridine–acetic anhydride. IR: 1770, 1720, 1695. ^{1}H-NMR: 7.03, 6.50 (each 1H, S, ArH), 6.15 (1H, s, =CH), 3.80 (6H, s, 2×OMe), 2.22 (3H, s, Ac), 0.90 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). MS: 443 (M^+).

Acetylation of the mixture of **31a** and **32a** with pyridine-acetic anhydride gave a gum, which showed two spots on TLC: one was identical with that of **32b** and the other was considered to be due to **31b**.

The Acetate 30b Compound **30a** (130 mg) was acetylated with Ac_2O–pyridine in a usual manner to give the acetate **30b** (128 mg) as colorless needles from MeOH, mp 230—231 °C. IR: 1745, 1730, 1690. ^{1}H-NMR: 6.83, 6.38 (each 1H, s, ArH), 5.35 (1H, m, CHOAc), 3.78 (6H, s, 2×OMe), 3.35, 3.13 (each 3H, s, OMe), 0.97 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). MS: 489 (M^+). *Anal.* Calcd for $C_{25}H_{31}O_9$: C, 61.34; H, 6.38, N, 2.86. Found: C, 61.21; H, 6.44; N, 2.91.

Acid Treatment of the Acetate 30b The acetate **30b** (100 mg) derived from **30a** was heated in 10% HCl (5 ml)–acetone (5 ml) at 50 °C. After 1h, the mixture showed three spots corresponding to **31a**, **32a**, and **31b**, and after 3 h, only the spots of **31a** and **32a** were observed. Work-up of this mixture gave a gum, which was identical on TLC with the mixture of **31a** and **32a** obtained by acid treatment of **30a**. Acetylation of this mixture gave a gum which showed two spots corresponding to **31b** and **32b** on TLC.

Benzyl Thioacetalization of 17 (1) Compound **17** (1 g), $PhCH_2SH$ (1.5 ml), and $BF_3 \cdot Et_2O$ (8 ml) in AcOH (20ml) were stirred for 12 h at room temperature. The precipitated crystals were collected by filtration, washed with water and ether, and dried to give the benzyl dithioacetal **33** (1.57 g, 91%). Recrystallization from MeOH gave colorless needles, mp 175—178 °C. IR: 1670. ^{1}H-NMR 7.20 (10H, br s, 2×PhH), 6.60, 6.55 (each 1H, s, ArH), 3.98, 3.88 (each 2H, s, SCH_2Ph), 3.85, 3.78 (each 3H, s, OMe). *Anal.* Calcd for $C_{32}H_{33}NO_3S_2$: C, 70.70; H, 6.12; N, 2.58. Found: C, 70.56; H, 5.97; N, 2.44.

(2) Compound **17** (50 mg), $PhCH_2SH$ (0.1 ml), and $BF_3 \cdot Et_2O$ (1 ml) in AcOH (5 ml) were stirred for 3 h at room temperature. After concentration to *ca.* 1/2 volume, the mixture was neutralized with aqueous K_2CO_3 and extracted with $CHCl_3$. Chromatography of the product in $CHCl_3$ gave **33** (35 mg, 42%) and **34** (35 mg, 52%). **34** crystallized as colorless needles from benzene, mp 99—102 °C. IR: 1675. ^{1}H-NMR: 7.20 (5H, s, PhH), 6.55, 6.48 (each 1H, s, ArH), 5.58 (1H, dd, J=6, 2 Hz, =CH), 3.95, 3.82 (each 1H, d, J=13 Hz, SCH_2Ph), 3.82, 3.78 (each 3H, s, OMe). MS: 419 (M^+), 328 (base peak). *Anal.* Calcd for $C_{25}H_{25}NO_3S$: C, 71.58; H, 6.01; N, 3.34. Found: C, 71.55; H, 5.89; N, 3.26.

Reaction of Dithioacetal 33 with Phenylselenenyl Chloride (1) With 2.0 eq of PhSeCl: The dithioacetal **33** (10 mg) and PhSeCl (7.2 mg) in THF (6 ml) were heated under reflux for 5 min. The mixture was diluted with $CHCl_3$, washed with water, and concentrated. Chromatography of the product gave **34** (8 mg), mp 104—106 °C, identical with the compound obtained above.

(2) With 3.5 eq of PhSeCl: Compound **33** (0.5 g) and PheSeCl (635 mg) in THF (100 ml) were heated under reflux 30 min. Work-up as above and chromatography of the product gave **36** (368 mg, 63%) as an oil from the $CHCl_3$ eluate. IR ($CHCl_3$): 1685. ^{1}H-NMR: 7.13 (10H, s, 2×Ph), 6.40, 6.37 (each 1H, s, ArH), 5.32 (1H, d with fine splittings, J=5 Hz, =CH), 4.42 (1H, m, CHCl), 3.87 (2H, s, SCH_2Ph), 3.78, 3.73 (each 3H, s, OMe). MS: 611 (M^+).

Reaction of 34 with Phenylselenenyl Chloride Compound **34** (10 mg) and PhSeCl (7 mg) in THF (5 ml) were heated at 80 °C for 30 min. Chromatography of the product gave **36** (7 mg).

Attempted Methoxylation of the Olefin 16a (1) MeONa–MeOH: Compound **16a** (48 mg) in 3.5% MeONa–MeOH (4 ml) was stirred for 50 min at room temperature. The mixture was diluted and extracted with $CHCl_3$. Concentration of the extract gave the methyl ester **16b** (35 mg) as colorless prisms from MeOH, mp 203—205 °C. ^{1}H-NMR: 6.83, 6.49 (each 1H, s, ArH), 5.73—5.9 (2H, CH=CH), 3.79 (6H, s, 2×OMe), 3.49 (3H, s, COOMe). *Anal.* Calcd for $C_{20}H_{21}NO_5$: C, 67.57; H, 5.96; N, 3.94. Found: C, 67.07; H, 5.94; N, 4.08.

(2) $BF_3 \cdot Et_2O$–MeOH: Compound **16a** (48 mg) and $BF_3 \cdot Et_2O$ (300 mg) in MeOH (4 ml) were heated in a sealed tube at 100—105 °C for 2 h. The mixture was diluted with water and extracted with $CHCl_3$. Concentration of the extract left a gum (35 mg), which was a mixture of **16a** and **16b** as evidenced by its TLC behavior and ^{1}H-NMR spectra.

Phenylselenenylation of 16a Compound **16a** (40 mg) and PhSeCl (50 mg) in MeOH (8 ml) were stirred for 18 h at room temperature. The mixture was diluted with water and extracted with EtOAc. The product obtained from the extract was chromatographed to give, from the benzene–$CHCl_3$ eluate, the adduct **37** which was dissolved in MeOH (5 ml) and treated with 5% $NaIO_4$ solution (10 ml) at room temperature for 8 h. The mixture was diluted with water, and extracted with $CHCl_3$. The residue from the extract was heated in toluene (10 ml) under reflux for 1 h. The mixture was washed with water and the toluene layer was dried and concentrated to leave the residue, which was chromatographed to give **38** (13 mg) as colorless prisms from ether, mp 133—136 °C. ^{1}H-NMR: 6.91, 6.59 (each 1H, s, ArH), 6.25 (1H, d, J=10 Hz, =CH), 6.08 (1H, dd, J=10, 2.5 Hz, =CH), 3.68 (1H, m, CHOMe), 3.87, 3.84, 3.55 (each 3H, s, OMe), 2.17 (1H, d, J=9 Hz, C_7-H), 1.02 (3H, t, J=7 Hz, $COOCH_2C\underline{H}_3$). ^{13}C-NMR: 168.3s, 167.7s, 148.3s, 147.7s, 135.4d, 135.2d, 128.6s, 127.3s, 111.6d, 110.3d, 71.3d, 61.4t, 60.9s, 57.2q, 56.0q, 55.8q, 40.0s, 36.2t, 32.2d, 32.1d, 29.0t, 13.7q. *Anal.* Calcd for $C_{22}H_{25}NO_6$: C, 66.15; H, 6.31; N, 3.51. Found: C, 65.98; H, 6.28; N, 3.48.

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11) Details of our photochemical studies will be presented in a separate paper [*e.g.*, T. Sano, J. Toda, Y. Tsuda, and T. Ohshima, *Heterocycles*, **22**, 49 (1984)].
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13) Details of these transformations will be presented in a subsequent paper [see also ref. 3 and Y. Tsuda and S. Hosoi, *Chem. Pharm. Bull.*, **33**, 1745 (1985)].
14) Ito *et al.* assigned the 3β-Cl configuration to this compound, because it gave the 3α-OMe derivative on treatment with silver nitrate in methanol. However, this is still ambiguous, since both the α and β isomers of such an allyl halide system would give the same thermodynamically more stable 3α-OMe derivative. The ^{1}H-NMR spectrum of this compound resembled those of 3α derivatives, but a definitive conclusion could not be reached.