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Chemical Constituents of the Soft Coral Species of *Sarcophyton* Genus : A Review

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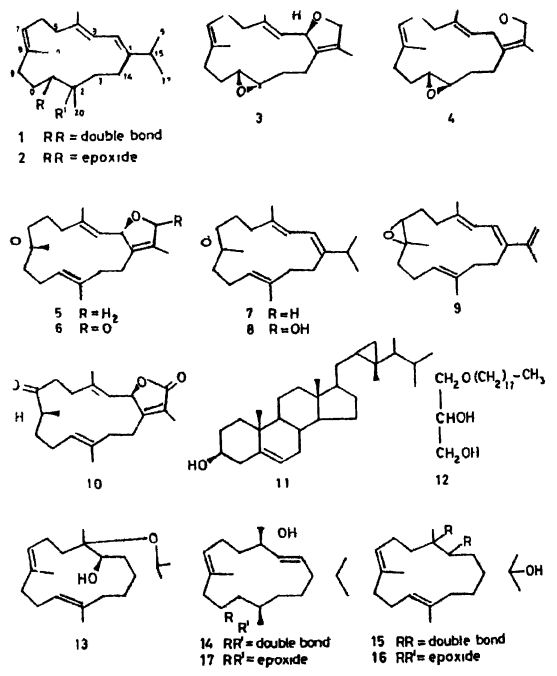
In recent years there has been much interest in the metabolites of marine invertebrates such as soft corals, sponges, sea cucumbers etc. The chemistry and biology of these compounds in general have been reviewed[1-8]. Soft corals (Phylum : Coelenterata) form a significant group of marine organisms occurring widely in the coral reefs of the world over. Of these, the corals of the genera *Sinularia*, *Lobophytum* and *Sacophyton* are the most prolific. A large number of these species have been chemically examined resulting in the accumulation of extensive information. It was felt appropriate to review the chemical constituents of the soft corals on genus basis, which has not been attempted earlier. With this in view the chemical constituents of soft coral species of *Sinularia* genus have earlier been reviewed by us[9]. The present review pertains to the chemical constituents of the soft corals of *Sarcophyton* genus. Nearly 25 species of this genus occurring in different sea waters have been examined chemically so far.

Chemical constituents from *Sarcophyton* genus

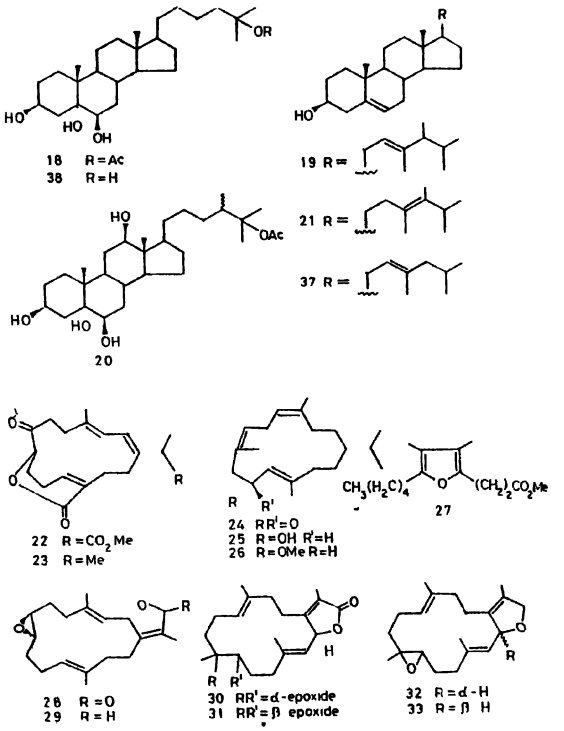
Sarcophyton species contain upto 10% of their dry weight as a single diterpene and this large quantity of secondary metabolites play functional roles in the survival of Octocorals such as defensive, competitive, reproductive and possibly pheromonal roles[6] Soft corals lacking physical defence thus appear to be protected from predation by the presence of diterpene toxins in their tissue. Chemical examination of *Sarcophyton birkilandi*[10] collected off near Peloris Island, Australia, resulted in the isolation of five cembranoid diterpenes (**1-5**). These are cembra-1,3,7,11-tetraene (**1**), 11,12-expoxycembra-1,3,7-triene (**2**), (2*R*, 11*R*,12*R*)-isosarcophytoxide (**4**) and its epimers (2*S*,11*R*, 12*R*)-isosarcophytoxide (**4**) and (–)-sarcophytoxide (**5**). The structure and absolute stereochemistry of **4** was determined by *X*-ray analysis. Compound **5** showed ichthyotoxic activity to *Gambusia affinis*[10a]. Two new cembranoid diterpenes, sarcophine (**6**) and (–)-sarcophytoxide (**5**) along with three known compounds (**7-9**) were reported from an Australian species of *S. crassocaule*[11]. Compounds **5** and **6** released by *S. crassocaule* into the sea water[12] were regarded as allelochemicals. The crude extract of *S. craussum* (1.0 mg ml^{-1}) was found to immediately arrest the farword mobility of rat cauda epidiglymal sperm without apparent suppression of their trial movement. Incubation at concentration of 0.5 or 0.25 mg ml^{-1} resulted in a reduction of sperm farword velocity after 10 min of incubation[13]



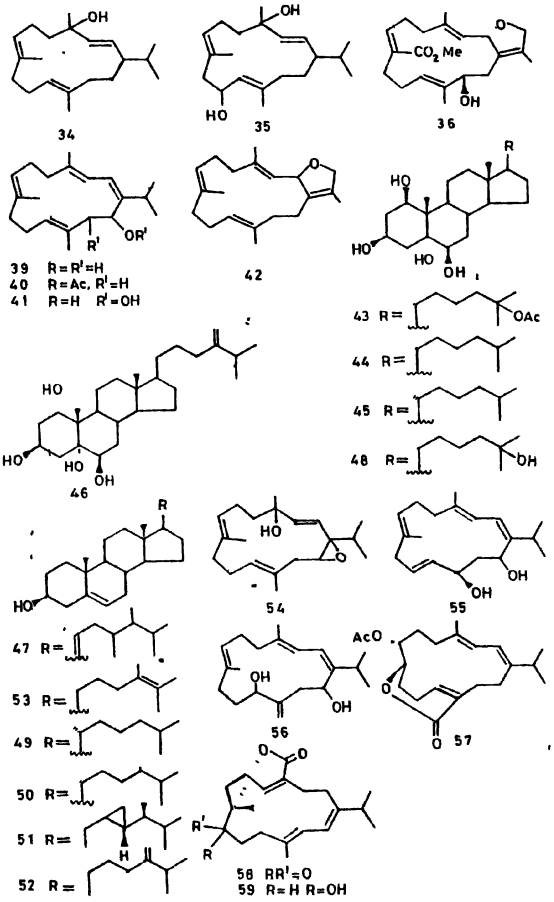
Sarcophinone (**10**) was reported from the Chinese species *S. decaryi*[14] and its structure was determined by 1D-nmr spectral data and confirmed by *X*-ray analysis. The same species yielded sarcophine (**6**), gorgosterol (**11**) and batylalcohol (**12**) along with three other lipid compounds[15]. The same species[16] collected from the Pacific Ocean was reported to yield five diterpenoids, decaryiol (**13**), thunbergol (**14**), 3,4-epoxynephthenol (**16**) and nephthenol (**15**), of which decaryiol (**13**) was found to be new. Their structures were determined on the basis of spectral data and by chemical correlations. The same species yielded trocheliophorol (**17**)[17]. Two diterpenoid derivatives, sarcophytoxide (**5**) and cembrene-C (**1**) were reported from an Australian species S. *ehrenbergi*[18].

Several polyhydroxysteroids have been reported from soft corals. They all had hydroxy functions at 3β,5α,6β-positions. A tetrahydroxysteroid, 24*S*-methylcholestane-3β,

5α,6β,25-tetrol-25-monoacetate (**18**) was isolated from *S. elegans* collected from the Pacefic Ocean[19]. Three new sterols, 23,24-dimethylcholesta-5,22-diene-3β-ol (**19**)[20], 24*S*-methylcholestane-3β,5α,6β,12β,25-pentol-25-monoacetate (**20**)[21] and 23,24-dimethylcholesta-5,23-dien-3β-ol (**21**)[22] were reported from the same species. Twelve cembranoid diterpenes were isolated from *S. elegans* and two other *Sarcophyton* species[23]. An unidentified Japanese species[24] of the same genus yielded two more cembranoids, keteoemblide (**22**) and sarcophytolide (**23**), both having seven membered lactone (ε-lacone) systems. Their structures were elucidated on the basis of spectral data and chemical correlations. Another Japanese species[25] was reported to yield three cembranoid derivatives; 10-oxocembrene (**24**), 10-hydroxycembrene (**25**) and 10-methoxycembrene (**26**). A new furanoid fatty acid (**27**) had been obtained from *Sarcophyton gemmatum*[26]

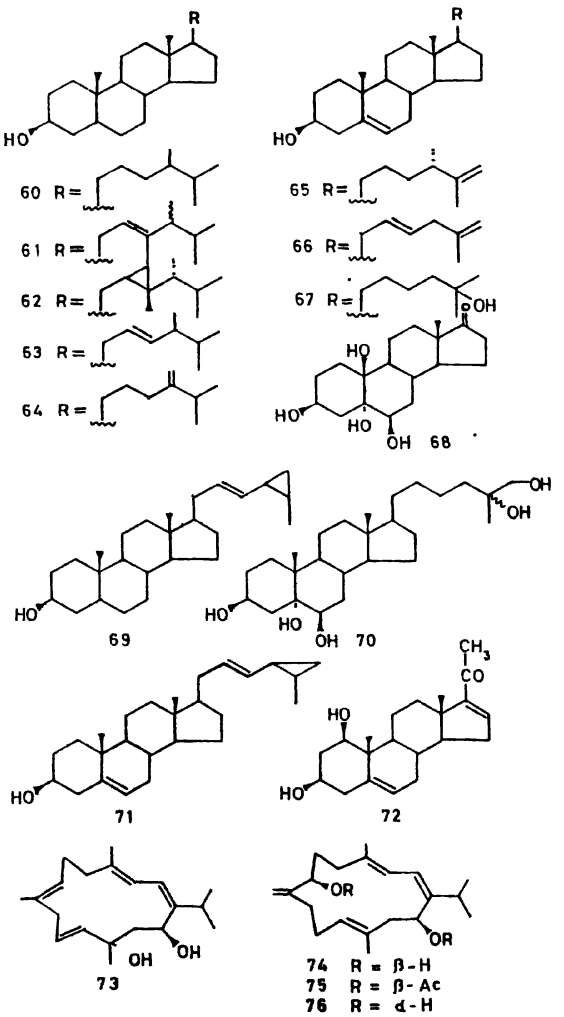


Sarcophyton glaucum occurring in different sea waters had been chemically examined by several workers. (+)-Sarcophine (**28**), the first new epoxycembranolide (from the marine origin) was isolated from this species[28]. It showed toxicity against *Gambusia affinis* and toxic to mice, rats and guinea pigs. It also exhibited strong anti-acetylcholine action on the isolated guinea pig ileum and was also a competitive inhibitor of cholinesterase *in vitro*[29]. Sarcoglaucol (**36**), a novel ichthytoxic cembranoid was reported from the same species. Its structure and relative stereochemistry was determined by *X*-ray analysis[30]. The same species collected from the Pacific Ocean coast furnished a furanoid fatty acid (**27**)[26]. Kobayashi *et al.*[31] isolated a new sterol, (22*E*)-23-methylcholesta-5,22-dien-3β-ol (**37**) along with the known sterol, 23,24-dimethylcholesta-5,22-dien-3β-ol (**19**)[31] from the Japanese species. The lipid extract of the same species[32] yielded four more cembranoids, sarcophytol-A (**39**), sarcophytol-A acetate (**40**), sarcophytol-B (**41**) and sarcophytonin-A (**42**). Another Japanese species[33] furnished some polyhydroxysteroids. 24*S*-Methylcholestane-1β,3β,5α,6β,25-pentol-25-monoacetate (**43**), cholestane-1β,3β,5α,6β-tetrol (**44**) and its 24-methyl derivative (**48**) and numersterol-A (**46**).



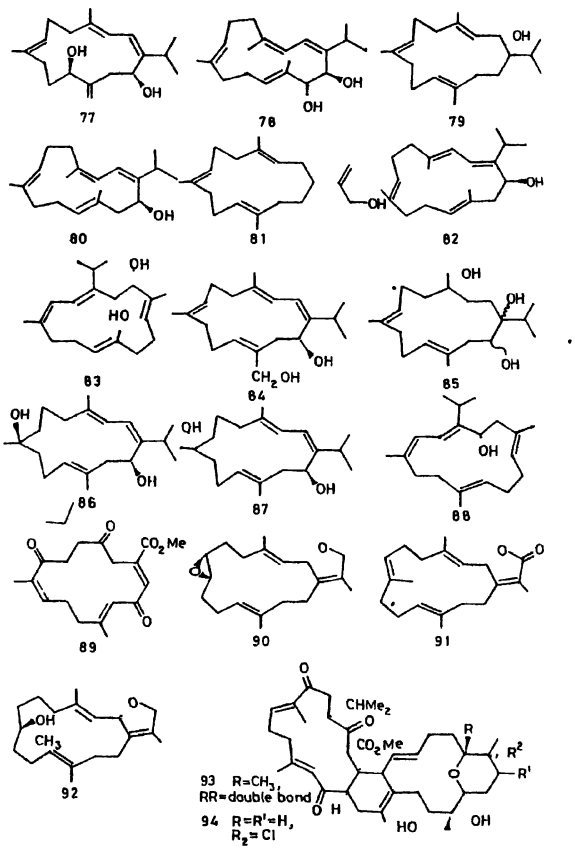
Two new sterols (**47** and **19**) along with six known (**11**, **49-53**) were reported from the Southern Japan species[34]. The same species[35] also gave three new cembranoids; sacrophytol-C (**54**), sarcophytol-D (**55**) and sarcophytol-E (**56**) along with three known cembranoids (**39-41**). Their structures were elaborated on the basis of spectral evidence and degradative studies. A new polyfunctional cembranolide, emblide (**57**) was reported from the Pacific Ocean species[36], whose structure was established from spectral data and by *X*-ray analysis. An antileukemic compound, sarcophytol-B (**41**) was obtained along with two known compounds (**39** and **42**) from *S. glaucum*[37-39]. Another Australian species[40] gave two seven-membered cembranoid lactones : (1*E*,3*E*,8*S*,11*Z*)-4,8-dimethyl-1-isopropyl-7-oxocyclotetradeca-1,3,11-triene (**58**) and its 7*R*-hydroxy

derivative (**59**). Their structures were deduced spectroscopically and confirmed by chemical conversions.



Five 4α-methylsterols (**60-64**) and three 4α-demethylsterols (**52**, **65** and **66**) were reported from the Japanese species[41]. One new sterol, 5α-cholestane-1β,3β,5,6β-tetrol (**69**) along with five known sterols, numersterol-A (**46**), ergostane-1β,3β,5α,6β,25-pentol (**48**), ergostane-1β,3β,5α,6β,25-pentol-25-monoacetate (**43**) and ergost-5-ene-3β,25-pentol (**67**) were reported from the Japanese species[42] A new nor steroid having cyclopropane unit, 5β,6-dihydroglaucasterol (**69**)[43] and glaucasterol (**71**) were isolated from another Japanese species. (24*S*)-24-Methylcholestane-3β,5α,6β,25ζ,26-pentol (**70**) was reported by Kobayashi and Mitsuhashi[44] and its structure was confirmed by synthesis. A new polyhydroxysteroid, androstane-1β,3β,5α,6β-tetrahydroxy-17-one (**68**) was isolated together with four polyhydroxysteroids (**20**, **44**, **45** and **48**). The structure of **68** was confirmed by synthesis[45] starting from 1β,3β-dihydroxy-5,16-pregnadien-20-one (**72**). The same species also yielded glaucasterol (**71**)[46]

Eight new cembranoids, sarcophytol-G (**73**), sarcophytol-H (**74**) and its acetate (**75**), sarcophytol-I (**77**), sarcophytol-J (**78**), sarcophytol-M (**79**), sarcophytol-N (**80**) and sarcophytol-O (**76**) in addition to two known cembranoids, (–)-nephthenol (**15**) and sinulariol-D (**81**) were reported from the soft coral *S. glaucum*[47]. All the structures were determined by spectroscopic data and chemical conversions; sarcophytol-M (**79**) was found to be the enantiomer of the known compound cembrenol. Six new cembranoids sarcophytol-F,K,P,Q,R,S (**82-87**) together with sarcophytols-B,C,D,E,G,H,I,J,M,N,O were reported

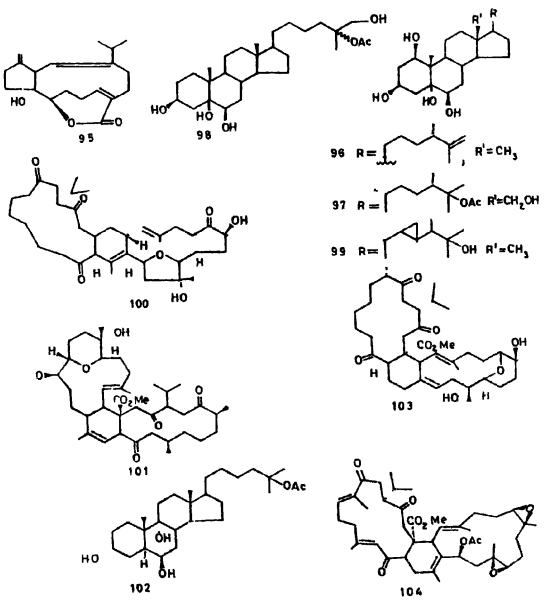


from a Japanese species[48]. Sarcophytol-P (**84**) was shown to be the 20-hydroxy derivative of sarcophytol-A; sarcophytols-R, S were correlated with sarcophytol-A by conversion of its 7*R*,8*R* and 7*S*,8*S*-epoxide derivatives. Sarcophytol-Q (**85**) was shown to be a 1,4,14-trihydroxycembranoid, and sarcophytol-K (**83**) is a 13,14-dihydroxycembranoid having a 1*E*,3*Z*-diene moiety. Sarcophytol-F (**82**) was a 1*E* isomer of sarcophytol-A (**39**) An antitumor promotion active compound sarcophytol-A (**39**) was

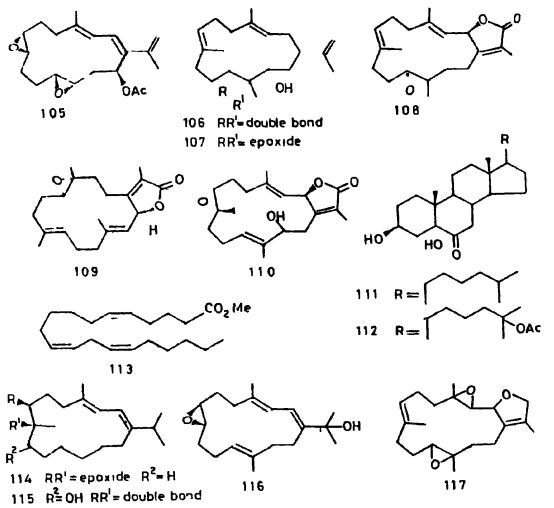
reported from the same species[49]. Several cembranoids were reported[50] from a Japanese species and their chemical reactions studied.

A new cembranoid derivative sarcophytol-T (**88**) in addition to sarcophytol-A (**39**), sarcophytol-N (**80**) and sarcophytol-F (**82**) was reported from the same species[51] and **81** was shown to be geometrical isomer of the potent antitumor compound sarcophytol-A (**39**); sarcophytol-T (**88**) and its isomer sarcophytol-N (**80**) and sarcophytol-F (**82**) were converted by autooxidation to bicyclo-(9.3.0)tetradecane derivatives, when kept in $CHCl_3$ solution at room temperature. Kobayashi *et al.*[52] reported on the transannular cyclisation of cembranoids, sarcophytols-F,N,T and also reported ten new cembranoids[53] (**73, 74, 76, 77, 79, 82-85, 87**). The structures of these compounds were elucidated by spectroscopic data and confirmed by chemical correlations. A new triketocembranoid, methylsaroate (**89**) was reported from the same species[54]. An Okinawan species[55] yielded cembrane-C (**1**), sarcophytonin-A (**42**) and deoxysarcophine (**90**) along with two lactonic cembranoids, sarcophytonin-B (**91**) and sarcophytonin-C (**92**). The total synthesis of (±)-sarcophytol-M (**79**)[56], (±)-sarcophytonin-B (**91**)[57], sarcophytol-A (**39**)[58] and sarcophytol-Q (**85**)[59] were also reported. Two new and novel cytotoxic tetraterpenes, methylsarcophytotate (**93**) and methylchlorosarcophytoate (**94**) were isolated from the species of Japanese waters[61]. (–)-Sarcophytoxide (**5**) was reported from *Sarcophyton pauciplicatum*[17].

A new and novel diterpenoid, sarsolilide-A (**95**) was



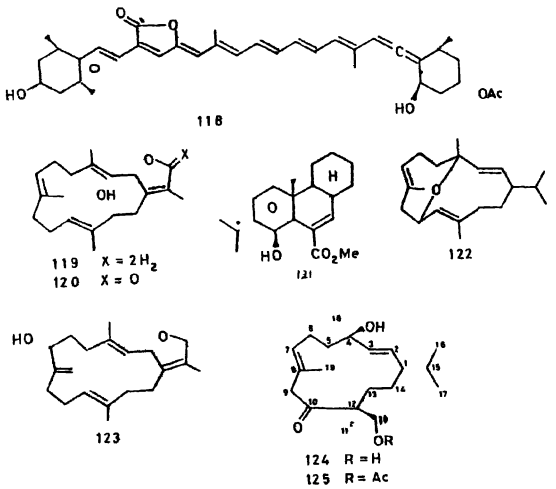
reported from the south China species *Sarcophyton solidun*[62]. Its structure was established by spectral data and stereochemistry by *X*-ray crystallography. Four new polyhydroxysteroids (24*S*)-ergostane-25-ene-1β,3β,5α,6β-tetrol (**96**), (24*S*)-ergostane-1β,3β,5α,6β,18,25-hexol-25-monoacetate (**97**), (24*S*)-ergostane-3β,5α,6β,25ζ,26-pentol-25-monoacetate (**98**) and gorgostane-1β,3β,5α,6β, 25-pentol (**99**) along with five known steroids (**18, 38, 44, 45** and **48**) were reported from the species *Sarcophyton subviride*[63] collected off Katchal Island, A & N coast. India.



A novel tetracyclic tetraterpenoid, methylisosartortuate (**100**) was reported from *S. tortuosum*[64], whose structure was determined by spectral data and confirmed by *X*-ray studies. The same species yielded one more unique tetracyclic tetraterpenoid, methylsartortuate (**101**)[65] and its structure was confirmed by *X*-ray diffraction. A novel polyoxygenated steroid sartartuosterol-A (**102**) having 3α-hydroxyl group was reported from the Chinese species, *S tortuosum*[66,67] and its structure was established by comparison of its spectral data with its derivatives. A unique new tetraterpenoid (**103**) was also reported from the same species[68]. This compound showed contraction of mouse uteri and inhibited S_{180} tumor cells. One new biscembranoid, methylneosartotuate (**104**), one novel bisepoxide (**105**) along with one known compound, methylsarcoate (**89**) were isolated from an Australian species of *S. tortuosum*[69], whose structures were elucidated by 1D- and 2D-nmr spectral data.

Trocheliophorol (**17**) was reported from *S. trocheliophorum* collected off the Pacific Ocean[17]. Two new cembranoids, (1*S*,3*E*,7*E*,11*E*,13*S*)-cembra-3,7,11,15-tetraen-13-ol (**106**) and (1*S*,3*E*,7*E*,13*S*)-11,12-epoxyembra-3,7,15-trien-13-ol (**107**) were reported from the hexane extract of the same species[70] and their structures were identified by 1D-nmr spectral data. Two cembranoid derivatives (**106** and **107**) were reported from the same species[71] which showed cytotoxic activity on ehrlichacities tumor cells. Two cytotoxic cembranoid diterpenes, (+)-isosarcophytoxide (**4**) and (+)-isosarcophine (**108**) were isolated from the Chinese species[72]. A new macrocyclic diterpenoid

lactone, (–)-sartrochine (**109**) was reported from the same species[73], which showed cytotoxic activity against S_{180} cells and antibiotic effect on *Streptococus*. Its structure was determined by *X*-ray analysis and the absolute configuration was assigned by CD method An Andaman species *S. trocheliophorum*[60] yielded three new compounds, 13-hydroxysarcophine (**110**), (24*S*)-24-methylcholestane-3β,5α-diol-6-one (**111**) and its 25-acetate (**112**) along with



ethylarachidonate (**113**), batyl alcohol (**12**), cembrene-C (**1**), 3,4-epoxycembrane-C (**2**), nephthenol (**15**), sarcophine (**6**), (24*S*)-24-methylcholestane-3β,5α,6β,25-tetrol (**38**) and its 25-acetate (**18**) in addition to seven monhydroxysterols. Very recently the Australian workers[74] reported two new compounds (7*R*,8*R*,14*S*,1*E*,3*E*,11*E*)-7,8-epoxycembra-1,3,11-trien-14-ol(**114**), (7*R*,14*S*,1*E*,3*E*,8*E*,11*E*)-cembra-1,3,8,11-tetraen-7,14-diol (**115**) together with the known dihydrofuran sarcophytoxide which showed mild cytotoxicity

A large number of unidentified species have been worked out by different workers. Coll *et al.*[75] reported a new cembranoid diterpene 7,8-epoxy-4,8,12-trimethylcyclotetradeca-1,3,11-trien-15-ol (**116**) from an Australian species. A Red Sea species[76] yielded nephthenol (**15**) and 16-deoxysarcophine (**5**). Two new cembranoids, isosarcophytoxide-C (**3**) and the diepoxide (**117**) were isolated from the same species[77] and their structures determined on the basis of their spectral data and chemical transformations. Peridinin (**118**) was isolated from another species[78]. Several sesquiterpenes were identified by gas liquid chromatography from another specimen[79] Two new cembranoid diterpenes (**119** and **120**) related to sarcophine were reported from an Australian species of the same genus[80]. Compound **120** showed convulsant activity. A cytotoxic stetroid, gorgosterol (**11**) together with batyl alcohol (**12**), stearic acid and octadecyl sterate were reported from a species of South China Sea water[81]. A diterpenoid (**29**) was reported[82] from another *Sarcophyton* species which showed Ca^{2+}-antagonist activity, inhibited the KCl-induced contraction of rabbit aorta smooth muscle. Two known cembranoid diterpenes (**39** and **40**) were reported from a soft coral of the genus *Sarcophyton*[82]. An unidentified Japanese species[83] was reported to yield 16-deoxysarcophine (**5**), which was found to be useful as a calcium antogonist vasodilator and antispasmodic Latyshev *et al*[84] reported the composition and seasonal variations of phospholipids content on *Sarcophyton* genus Tenet *et al.*[85] described a method for isolation of high molecular weight DNA from somatic tissue of soft corals A platelet activity factor (PAF) antogonist, chatancin (**121**) was reported from an unidendified soft coral of the same genus[86,87]. Its structure was determined on the basis of 1D-nmr spectral data and *X*-ray analysis.

A new epoxy-bridged cembranoid diterpene (**122**) possessing antifouling activity was reported from a Thai soft coral of unidentified species of the *Sarcophyton* genus[88], whose structure was assigned by ^1H and ^{13}C nmr experiments. Fujiki *et al.*[89] reported experiments on the tumor antipromoter activity of sarcophytols-A, B, (–)-epidallocatechin gallate and morusin The total synthesis of sarcophytol-A (**39**) was achieved in six steps starting from acetone[90]. A new dihydrofurn cembranoid, sarcophytonin-E (**123**) was reported from another species[91]. Its structure was derived by spectroscopic data and confirmed by correlation with the known compound, 16-deoxysarcophine. A stereoselective synthesis of both the half-segments for (–)-sarcophytonin-A (**42**) and (–)-sarcophytoxide (**5**) were reported[92]. The total synthesis of cytotoxic and antitumor compound, sarcophine (**6**) was reported from geraniol[93]. The stereoselective synthesis of (±)-sarcophytol-A (**39**) and a discussion of the stereoselectivity in the β-elimination of alkoxy group of the macrocyclic enolate were reported[94] Two novel irregular cembranoids possessing a 13-membered carbocyclic skeleton, sarcotol (**124**) and sarcotol acetate (**125**) were reported from another unidentified *Sarcophyton* species[95], whose structures were determined by *X*-ray analysis.

References

1 P J SCHEUER, "Chemistry of Marine Natural Products", Academic, New York, 1973

2 P J SCHEUER, "Marine Natural Products Chemical and Biological Perspectives", Academic, New York, 1978-83, Vols I-V

3 P J SCHEUER, "Bioorganic Marine Chemistry", Springer-Verlag, Berlin, 1987-92, Vols I-VI

4 D J FAULKNER, *Nat Prod Rep*, 1995, **12**, 223, and references therein

5 A J WEINHEIMER, C W J CHANG and J A MATSON, *Forschr Chem Org Naturst*, 1979, **36**, 285

6 J C COLL, *Chem Rev*, 1992, **92**, 613

6a J C COLL, *Chem Rev*, 1993, 1693

7 D S BHAKUNI, *J Sci Ind Res*, 1990, **49**, 330, 1994, **53**, 340

8 F PIETRA, *Gazz Chim Ital*, 1985, **115**, 1985

9 A S R ANJANEYULU and G V RAO, *J Sci Ind Res*, in press

10 C M IRELAND, B R COPP, M P FOSTER, L A MCDONALD, D C RADISKY and J C SWERSEY, "Pharmaceutical and Bioactive Natural Product Marine Biotechnology", eds O R ZABORSKY and A

ATAWAY, Plenum Press, New York, 1986.

10a. B. F. BOWDEN, J. C. COLL, A. HEATON, G. KONIG, M. A. BRUCK, R. E. CRAMER, D. M. KLEIN and P. J. SCHEUER, *J. Nat. Prod.*, 1987, **50**, 650.

11. B. F. BOWDEN, J. C. COLL and S. J. MITCHELL, *Aust. J. Chem.*, 1980, **33**, 879.

12. J. C. COLL, B. F. BOWDEN, D. M. TAPIOLAS and W. C. DUNLOP, *J. Exp. Mar. Biol. Ecol.*, 1982, **60**, 293.

13. G. K. LIYANAGE, W. D. RATNASOORIYA, L. M. V. TILLEKERATNE, M. MAHENDRAN and E. D. DE SILVA, *IRES Med. Sci.*, 1986, **14**, 721.

14. Z. YAN, C. CHEN and L. ZENG, *Redai Haiyang*, 1985, **4**, 80.

15. Z. YAN, C. CHEN and L. ZENG, *Redai Haiyang*, 1984, **3**, 78.

16. S. CARMELY, A. GROWEISS and Y. KASHMAN, *J. Org. Chem.*, 1981, **46**, 4279.

17. A. GROWEISS, Y. KASHMAN, D. J. VANDERAH, B. TURSCH, P. CORNET, J. C. BREAKMAN and D. DALOZE, *Bull. Soc. Chim. Belg.*, 1978, **87**, 277.

18. B. F. BOWDEN, J. C. COLL, W. HICKS, R. KAZLAUSKAS and S. J. MITCHELL, *Aust. J. Chem.*, 1978, **31**, 2707.

19. J. M. MALDOWAN, B. TURSCH and C. DJERASSI, *Steroids*, 1974, **24**, 387.

20. A. KANOZAWA, S. TESHIMA, T. ANDO and S. TOMITA, *Nippon Suisan Gakkaishi*, 1974, **40**, 729.

21. J. M. MALDOWAN, W. L. TAN and C. DJERASSI, *Steroids*, 1975, **26**, 107.

22. A. KANAZAWA, T. ANDO and S. TESHIMA, *Nippon Suisan Gakkaishi*, 1977, **43**, 83.

23. Y. UCHIO, M. NITTA, J. TOYATA, M. NAKAYAMA, Y. NISHIZONA, T. IWAGAWA and T. HASE, *Tennen Yuki Kagobutsu Torankai Koen Yoshishu*, 1981, **24**, 63.

24. Y. UCHIO, M. NITTA, H. NOZAKI, M. NAKAYAMA, T. IWAGAWA and T. HASE, *Chem. Lett.*, 1983, 613.

25. Y. UCHIO, M. NITTA, H. NAZAKI, M. NAKAYAMA, T. IWAGAWA and T. HASE, *Chem. Lett.*, 1983, 1719.

26. A. GROWEISS and Y. KASHMAN, *Experientia*, 1978, **34**, 299.

27. J. BERNSTAIN, U. SHMEULI, E. ZADOCK, Y. KASHMAN and I. NEEMAN, *Tetrahedron*, 1974, **30**, 2817.

28. Y. KASHMAN, E. ZADOCK and I. NEEMAN, *Tetrahedron*, 1974, **30**, 3615.

29. I. NEEMAN, L. TISHELSON and Y. KASHMAN, *Toxicon*, 1974, **12**, 593.

30. M. ALBERICCI, J. C. BREAKMAN, D. DALOZE, B. TURSCH, J. P. DECLERCK, G. GERMAIN and M. V. MEERSCHE, *Bull. Soc. Chim. Belg.*, 1987, **87**, 487.

31. M. KOBAYASHI, A. TOMIOKA, T. HAYASHI and H. MITSUHASHI, *Chem. Pharm. Bull.*, 1979, **27**, 1951.

32. M. KOBAYASHI, T. NAKAGAWA and H. MITSUHASHI, *Chem. Pharm. Bull.*, 1979, **27**, 2382.

33. M. KOBAYASHI, T. HAYASHI, F. NAKAJIMA and H. MITSUHASHI, *Steroids*, 1979, **34**, 285.

34. M. KOBAYASHI, A. TOMIKA, and H. MITSUHASHI, *Steroids*, 1979, **34**, 273.

35. T. NAKAGAWA, M. KOBAYASHI, K. HAYASHI and H. MITSUHASHI, *Chem. Pharm. Bull.*, 1981, **29**, 82.

36. J. A. TOTH, B. J. BURRESON, P. J. SCHEUER, J. FINER-MOOR and J. CLARDY, *Tetrahedron*, 1980, **36**, 1307.

37. Mitsubishi Chemical Industries Company Ltd., Jap. Pat. JP 137 981 25/1979.

38. Mitsubishi Chemical Industries Company Ltd., Jap. Pat. JP 138 430 25/1979.

39. Mitsubishi Chemical Industries Company Ltd., Jap. Pat. JP 138 429/1979.

40. B. F. BOWDEN, J. C. COLL and R. H. WILLS, *Aust. J. Chem.*, 1982, **35**, 621.

41. M. KOBAYASHI, T. ISHIZAKA and H. MITSUHASHI, *Steroids*, 1982, **40**, 201.

42. M. KOBAYASHI, T. HAYASHI, K. HAYASHI, M. TANABE, T. NAKAGAWA and H. MITSUHASHI, *Chem. Phrm. Bull.*, 1983, **31**, 1848.

43. M. KOBAYASHI, T. ISHIZAKA and H. MITSUHASHI, *Chem. Pharm. Bull.*, 1983, **31**, 1803.

44. M. KOBAYASHI and H. MITSUHASHI, *Chem. Pharm. Bull.*, 1983, **31**, 4127.

45. M. KOBAYASHI and H. MITSUHASHI, *Steroids*, 1982, **40**, 473.

46. M. KOBAYASHI and H. MITSUHASHI, *Steroids*, 1982, **40**, 665.

47. M. KOBAYASHI and K. OSABE, *Chem. Pharm. Bull.*, 1989, **37**, 631.

48. M. KOBAYASHI, T. IESAKA and E. NAKANO, *Chem. Pharm. Bull.*, 1989, **37**, 2053.

49. H. FUJIKI and M. SUGANUMA, *Farmashia*, 1989, **25**, 702.

50. M. KOBAYASHI and K. OSABE, *Chem. Pharm. Bull.*, 1989, **37**, 1192.

51. M. KOBAYASHI and E. NAKANO, *J. Org. Chem.*, 1990, **55**, 1947.

52. M. KOBAYASHI, T. IESAKA, M. NAKANO and K. HIRAYAMA, *Tennen Yuki Kagobutsu Torankai Koen Yoshishu*, 1989, **31**, 540.

53. M. KOBAYASHI and K. OSABE, *Tennen Yuki Kogobutsu Torankaai Koen Yoshishu*, 1988, **30**, 212.

54. M. O. ISHITSUKA, T. KUSUMI and H. KAKISAWA, *Tetrahedron Lett.*, 1991, 2917.

55. M. KOBAYASHI and T. HIRASE, *Chem. Pharm. Bull.*, 1990, **38**, 2442.

56. X. YUE and Y. LIE, *Bull. Soc. Chem. Belg.*, 1994, **103**, 35.

57. K. NISHITANI, T. KONOMI, K. OKADA and K. YAMADA, *Heterocycles*, 1994, **37**, 679.

58. H. TAKAYANGI, Y. KITANO and Y. MORINAKA, *J. Org. Chem.*, 1994, **59**, 2700.

59. Y. LI and Y. LI, *Chin. Chem. Lett.*, 1994, **5**, 11.

60. S. M. D. KUMAR, Ph.D. Thesis, Andhra University, 1992.

61. T. KUSUMI, M. IGARI, M. O. ISHITSUKA, A. ICHIKAWA, Y. ITAZONE, N. NAKAYAMA and H. KAKISAWA, *J. Org. Chem.*, 1990, **55**, 6268.

62. M. ZHANG, K. LONG, S. HUANG, K. SHI and C. W. T. MAK, *J. Nat. Prod.*, 1992, **55**, 1672.

63. B. L. RAJU, G. V. SUBBARAJU, M. C. REDDY, D. V. RAO, C. B. RAO and V. S. RAJU, *J. Nat. Prod.*, 1992, **55**, 904.

64. J. SU, K. LONG, T. PENG, C. HE and J. CLARDY, *J. Am. Chem. Soc.*, 1986, **108**, 177.

65. J. SU, K. LONG, T. PENG, Q. ZHENG and X. LIN, *Huaxue Xhebao*, 1985, **43**, 796.

66. J. SU, L. ZENG, T. PENG and K. LONG, *Zhonggshan Daxue Xuebao, Ziran Kexueban*, 1987, 71.

67. J. SU, T. PENG, K. LONG and L. ZENG, *Steroids*, 1986, **48**, 233.

68. J. SU, K. LONG, T. PENG, L. ZENG, Q. ZHENG and X. LIN, *Sci. Sin., Ser. B*, 1988, **31**, 1172.

69. P. A. LEONE, B. F. BOWDEN, A. R. CARROLL, J. C. COLL and G. V. MEEHAN, *J. Nat. Prod.*, 1993, **56**, 521.

70. A. M. SULEIMENOVA, A. I. KALINOVSKII, A. I. RALDUGIN, S. A. SHEVTSOV, I. Y. BAGRYANSKAYA, Y. V. GATILOV, T. V. KUZNETSOVA and G. B. ELYAKOV, *Khim. Prir. Soedin*, 1988, 535.

71. T. A. KUZNETSOVA, A. M. POPOV, I. G. AGAFONOVA, A. M. SULEIMONOVA and G. B. ELAYAKOV. *Khim. Prir. Soedin*, 1989, 137.

72. Y. C. WU, P. W. HSIECH, C. Y. DUH, S. K. WANG, K. SOONG and L. FANG, *J. Chin. Chem. Soc.*, 1992, **39**, 355.

73. J. SU, Y. ZHONG, G. LOU, X. LI, L. ZENG, Y. HUNAG and S. HU, *Huaxue Xuebao*, 1994, **52**, 813.

74. G. L. GREENLAND and B. F. BOWDEN, *Aust. J. Chem.*, 1994, **47**, 2013.

75. J. C. COLL, G. B. HAWES, N. LIYANAGE, W. OBERHANSHI and R. J. WELLS, *Aust. J. Chem.*, 1977, **30**, 1305.

76. Y. KASHMAN, M. BODNER, Y. LOYA and Y. BENAYAHU, *Isr. J. Chem.*, 1977, **16**, 1.

77. B. F. BOWDEN, J. C. COLL, S. J. MITCHELL and G. J. STOKIE, *Aust.*,

J. Chem., 1979, **32**, 653.

78. M. HALLENSTVET and S. LIAAEN-JENSEN, *Biochem. Syst. Ecol.*, 1979, **7**, 171.
79. Y. KASHMAN, Y. LOYA, M. BODNER, A. GROWEISS, Y. BENAYAHU and N. NAVEH, *Mar. Biol. (Berlin)*, 1980, **55**, 255.
80. R. KAZLAUSKAS, J. A. BIARD-LAMBARD, P. T. MURPHY and R. J. WELLS, *Aust. J. Chem.*, 1982, **35**, 61.
81. R. LI, Z. LAI and K. LONG, *Zhongshan Daxue Xuebao, Ziran Kexueban*, 1982, 78.
82. A. J. BLACKMAN, B. F. BOWDEN, J. C. COLL, B. FRICK, M. MAHENDRAN and S. J. MITCHELL, *Aust. J. Chem.*, 1982, **35**, 1873.
83. Mitsubishi Chemical Industries Company Ltd., Jap. Pat. JP 150 596/1958.
84. N. A. LATYSHEV, K. H. NGUYEN, T. N. DO and V. I. SVETASHEV, *Biol. Morya (Vladivostok)*, 1986, 52.
85. L. M. TEN, P. ALDERSLADE and D. J. MILLER, *Mar. Biol. (Berlin)*, 1990, **104**, 489.
86. M. SUGANO, T. SHINDO, A. SATO, Y. IIJISNA, T. OSHIMA, N. KUWANO and T. HATA, *J. Org. Chem.*, 1990, **55**, 5803.
87. A. SATO, T. SHINDO, M. SUGANO, T. OSHIMA and H. KUWANO, Jap. Pat. JP 2 141 580/1990.
88. U. ANTHONI, K. BOCK, C. CHRISTOPHERSEN, J. O. DUÚS, E. B. KJAER and P. H. NIELSEN, *Tetrahedron Lett.*, 1991, **32**, 2825.
89. H. FUJIKI, M. SUGANUMA, K. TAKAGI, S. YOSHIZAWA, H. SUGURI-FURIYA, S. NISHIWAKI, M. KOBAYASHI and T. OKUDA, *Anticarcinog. Radiat. Prod.*, 1989, **3**, 357.
90. J. MAO, W. LI, Y. LI and X. LIANG, *Chem. Res. Chin. Univ.*, 1991, **7**, 247.
91. M. KOBAYASHI and T. HIRASE, *Chem. Pharm. Bull.*, 1991, **39**, 3055.
92. K. NISHITANI, K. HARADA, N. SANO, K. SATO and K. YAMAKAWA, *Chem. Pharm. Bull.*, 1991, **39**, 2514.
93. Q. ZHENG, J. SU and L. ZENG, *Chin. Sci. Bull.*, 1992, **37**, 86.
94. T. TAKAHASHI, H. YOKOYAMA, T. HAINO and H. YAMADA, *J Org. Chem.*, 1992, **57**, 3521.
95. T. IWAGAWA, Y. SHIBATA, H. OKAMURA, M. NAKATANI and M. SHIRO, *Tetrahedron Lett.*, 1994, **35**, 8415.