

## BIOSTRATIGRAPHICAL AND PALEOECOLOGICAL ANALYSIS OF THE NEOGENE DEPOSITS OF KALAMOS ISLAND, IONIAN SEA, WEST GREECE

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### ABSTRACT

The aim of this study is the biostratigraphical and paleoecological analysis of the Neogene deposits of Kalamos island (Ionian Sea, Western Greece). The Neogene sediments are represented by small exposures which consist of marly deposits with partly thin alternations of brackish sediments.

The biostratigraphical analysis based on calcareous nannofossils and planktonic foraminifera revealed a middle Tortonian age for the studied sediments. In addition, the quantitative paleoecological analysis of the benthic foraminifera indicates a not very deep environment without great variety of coastal species and relatively poor in planktonic foraminifera.

**KEY WORDS:** Neogene deposits, calcareous nannofossils, planktonic foraminifera, quantitative paleoecological analysis.

### 1. INTRODUCTION

Kalamos island is a small rocky island of the Ionian Sea (Western Greece) which geographically is located opposite of the Mytikas Gulf (Fig. 1).



It forms part of the External Hellenides, which constitute a NNW-SSE trending belt. In terms of the concept developed by AUBOUIN (1959, 1965), Kalamos island belongs to the Ionian zone which together with the Gavrovo-Tripolitza zone to the east, constitute a carbonate platform (JACOBSCHAGEN *et al.*, 1978, Fig. 1).

**Fig. 1:** The study area and the position of the major thrusts which is approximated (after BIZON & BIZON, 1967, MULDER, 1975).

Pre-Neogene rocks are covering most of the part of the island of Kalamos and have been studied in detail by RENZ, 1932 (Fig. 2). Neogene sediments occur only in small outcrops.

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The main purpose of the present study is the paleoenvironmental reconstruction of the Neogene deposits which are exposed along the coastal area of Kalamos island. For this purpose a detailed biostratigraphical and paleoecological study of the Neogene rocks has been carried out.

## 2. LITHOSTRATIGRAPHY OF THE STUDY AREA

The Neogene of Kalamos island is represented by small exposures which are not continuous and are restricted in the north, east and south sides of the island (Fig.2). Therefore, it was difficult to find the basal part and the evolution of the Neogene as the construction of a lithostratigraphical column was impossible.

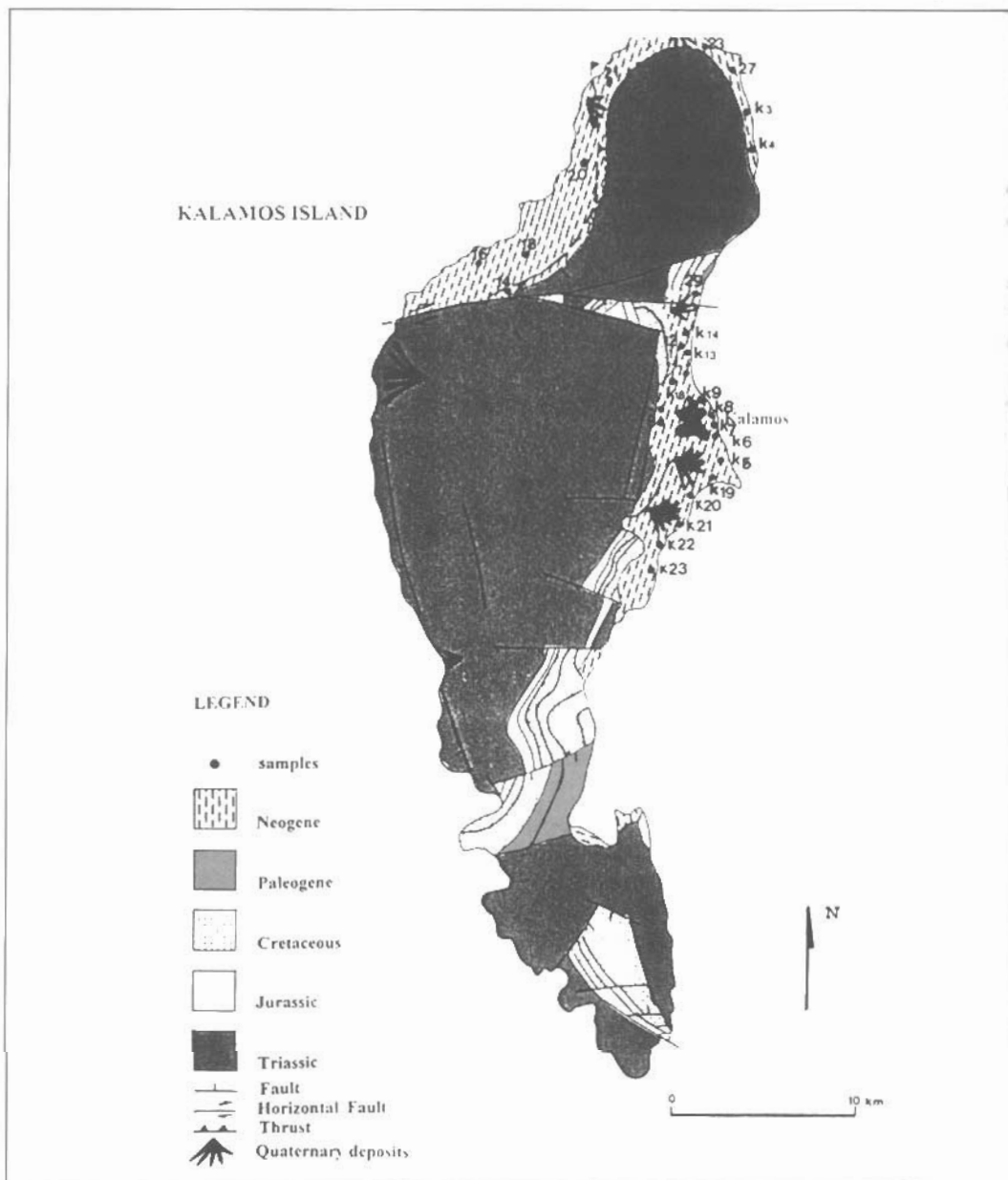


Fig. 2: Geological map of Kalamos island based on B.P. (1971) and own observations. Samples which underwent biostratigraphical and paleoecological analysis are mentioned.

The Neogene sediments of Kalamos island unconformably overlie the pre-Neogene rock units and consist of marine deposits with partly thin alternations of brackish sediments. In addition, breccias, conglomerates and sands are found above a basal unconformity. Coarse lithofacies of the sequence are characterized by clasts of limestone, chert, sandstone and shale. Limestone clasts are characteristic of Pre-Oligocene Ionian zone carbonates and are readily distinguishable from neritic limestones of the pre-Adriatic zone.

The Quaternary deposits of Kalamos island are represented by alluvial fan sediments which are better exposed next to Kalamos village in the south edge of the island.

### 3. BIOSTRATIGRAPHY

In order to achieve the biostratigraphical dating of Kalamos Neogene sediments, 28 samples have been collected and undergone detailed biostratigraphical analysis.

Although the Neogene of the Mediterranean area has proved especially hard to calibrate with the standard of the open oceans (MULLER 1978, THEODORIDIS 1984, DERMITZAKIS & TRIANTAPHYLLOU 1990, ANASTASAKIS *et al.* 1995) the biostratigraphy of the studied area was finally established based on the scarce presence of age diagnostic species with regard to the whole assemblages.

The in situ nannoflora of Kalamos Neogene sediments is dominated by the species *Helicosphaera stalis*, *H. carteri*, *Reticulofenestra pseudoumbilicus*, *Discoaster surculus*, *D. variabilis*, *D. pansus*, *D. brouweri*, *D. intercalaris*, *D. quinquerramus*, *Sphenolithus abies*.

The species *H.stalis* and *D.quinquerramus* are extremely rare in our samples, however their presence has been well certified.

Moreover the appearance of *Cyclicargolithus floridanus* is observed along with dramatically scattered specimens of *D. hamatus* and frequent *Sphenolithus heteromorphus*, *S. belemnus*, *Helicosphaera ampliaperta*, *H. mediterranea*, *H. intermedia*, *H. recta*, *Discoaster exilis*, *D. pseudovariabilis* suggesting a strong reworking from Langhian - Serravallian and Lower Tortonian sediments.

As far as the planktonic foraminifera are concerned, the microfauna is characterised by the presence of *Neogloboquadrina acostaensis*, *N. continuosa*, *Globoturborotalita nepenthes*, *Globorotalia gigantea*, *Gr.suturata*, *Globoquadrina altispira*, *Gq. dehiscens*, *Globoturborotalita woodii*, *G. druryi*, *Globigerinoides sicanus* and *Praeorbulina glomerata* and the absence of the species *Globorotalia conomiozea* and *Gr. crassula*.

In addition, *Globorotalia menardii* form 4 and the species *Catapsydrax parvulus*, which has generally been recorded from Early to Middle Miocene *Gr. menardii* zone, have been recognized.

The coexistence of *N. continuosa* and *N. acostaensis* characterises the base of N16 biozone (BLOW 1969). The determined specimens of *N.continuosa* are typical forms of the species and transitional ones to *N.acostaensis*. Concerning the fact that nannoflora associations are strongly reworked from Langhian - Serravallian to Lower Tortonian sediments, we assume that *N. continuosa* forms are also reworked in our material along with *Globoturborotalita woodii*, *G. druryi*, *Globigerinoides sicanus* and *Praeorbulina glomerata*.

In conclusion (Fig. 3), the contemporaneous presence of *H.stalis*, *D.surculus*, *D.brouweri*, *D.quinquerramus* along with the absence of *D. calcaris*, *D. hamatus*, *Amaurolithus spp.* and *Reticulofenestra rotaria* allows the biostratigraphic correlation of the studied sediments based on calcareous nannofossils with the lower part of NN11 biozone (MARTINI 1971) which corresponds to CN9a (OKADA & BUKRY 1980) and *Minylitha convallis* zone / *Geminolithella rotula* b subzone (THEODORIDIS 1984). This biostratigraphic interval can be correlated concerning planktonic foraminifera -presence of *Globoturborotalita nepenthes*, *Globorotalia gigantea*, *Gr.suturata*, *Globoquadrina altispira*, *Gq. dehiscens* in combination with the existence of *N.acostaensis* with the lower part of N17 biozone (BLOW 1969) and with the lower part of *Globorotalia conomiozea* zone (ZACHARIASSE 1975, DERMITZAKIS 1978), which point chronostratigraphically to the lower part of the Langhian - Serravallian stage.

TIME (Ma)	CHIRONS	POLARITY	EPOCH	AGE	PLANKTONIC FORAMINIFERA		CALCAREOUS NANNOPLANKTON			
					BLOW, 1969	ZACIARLASSE, 1975 DERMITZAKIS, 1978	THEODORIDIS, 1984	MARTINI, 1971	OKADA & BUKRY, 1980	
8	C3Br		MIOCENE	TORTONIAN	N17	<i>Globorotalia conomiozea</i>	<i>C. pelagicus</i>	NN11	CN9	a
9	C4a				N16	<i>N. acostaeensis</i>				<i>M. convallis</i>
9	C4r						a			
10	C4a									
10	C4Ar									
11	C5b						NN9	CN7	b	
11	C5r				N15	<i>N. costanensis</i>	<i>E. calcaris</i>			a

Fig. 3: Biostratigraphic location of the studied Kalamos sediments, based on calcareous plankton biostratigraphy in the Mediterranean. Magnetostratigraphy is based on BERGGREN et al., (1995).

#### 4. PALEOECOLOGY

Paleoecological observations and paleoenvironmental interpretation of the studied sediments have been conducted through quantitative analysis of the major representatives of benthic microfauna. Due to the fact that the Neogene sediments are exposed discontinuously and to the strong reworking which has affected them, the paleoecological analysis has been carried out only in a selected, small number of samples.

The qualitative analysis has revealed the presence of the following species:

<i>Ammonia beccarii</i> (LINNAEUS)	<i>Lagena</i> sp.
<i>Bolivina alata</i> (SEGUENZA)	<i>Lagena striata</i> (D'ORBIGNY)
<i>Bolivina antiqua</i> D'ORBIGNY	<i>Lenticulina</i> sp.
<i>Bolivina dilatata</i> REUSS	<i>Massilina miletti</i> (WIESNER)
<i>Bolivina pseudoplicata</i> HERON-ALLEN & EARLAND	<i>Melonis pompilioides</i> (FICHTEL & MOLL)
<i>Bolivina spathulata</i> (WILLIAMSON)	Miliolidae
<i>Bulimina aculeata</i> (D'ORBIGNY)	<i>Neoconorbina</i> sp.
<i>Bulimina costata</i> D'ORBIGNY	<i>Nonion boueanum</i> (D'ORBIGNY)
<i>Cancris auriculus</i> (FICHTEL & MOLL)	<i>Nonionella</i> sp.
<i>Cassidulina carinata</i> SILVESTRI	<i>Nodosaria scalaris</i> (BATSCH)
<i>Cibicides refulgens</i> MONTFORT	<i>Oridorsalis umbonatus</i> (REUSS)
<i>Cibicides lobatulus</i> (WALKER & JACOB)	<i>Pararotalia</i> sp.
<i>Cibicides ungerianus</i> (D'ORBIGNY)	<i>Pyrgo</i> sp.
<i>Cribronion</i> sp.	<i>Quinqueloculina bicarinata</i> (D'ORBIGNY)
<i>Elphidium fichtellianum</i> (D'ORBIGNY)	<i>Quinqueloculina lucida</i>
<i>Elphidium crispum</i> (LINNE)	<i>Robulus</i> sp.
<i>Elphidium</i> sp.	<i>Rosalina globularis</i> D'ORBIGNY
<i>Discorbis</i> sp.	<i>Siphonina reticulata</i> CZIZEK
<i>Gavellinopsis praegeri</i> (HERON-ALLEN & EARLAND)	<i>Spiroplectammina carinata</i> D'ORBIGNY
Miscellaneous	<i>Spiroplectammina depressa</i>
<i>Globobulimina pyrula</i> D'ORBIGNY	<i>Textularia candeiana</i> D'ORBIGNY
<i>Globocassidulina subglobosa</i> (BRADY)	<i>Uvigerina proboscidea</i> FORMASINI
<i>Gyroidinoides soldanii</i> (D'ORBIGNY)	<i>Uvigerina peregrina</i> CUSHMAN
<i>Gyroidinoides umbonatus</i> SILVESTRI	<i>Uvigerina bononiensis</i> FORMASINI
<i>Hanzawaia boueana</i> (D'ORBIGNY)	<i>Valvulinera bradyana</i> FORMASINI
<i>Hoeglundina</i> sp.	

The quantitative analysis of the main benthic microfauna representatives and of the characteristic marker species led to the production of frequency curves, concerning isolated samples. For the quantitative computer analysis we entered the species scores of some selected species or groups of species. Generally the most frequent categories were chosen for the statistical analyses. The relative frequencies were all based on 200-counts in the 125  $\mu$  size fraction.

The determined benthic foraminifera species have been grouped following the grouping criteria of V.D. ZWAAN (1982) and (1983) which is based on the general structure of shallow and relatively deep-water mud-communities. This arrangement of the species can be recognized in analyses of almost all Miocene shallow and relatively deep-water mud-associations at present available (e.g. DRINIA, 1996; DRINIA *et al.*, 1997). It is characterized by the occurrence of three groups:

**Group A:** This group consists of epiphytes or vegetation-bound species like: *Ammonia beccarii*, *Cibicides refulgens*, *Cibicides lobatulus*, *Cibicides* sp., *Discorbis* sp., *Elphidium* sp., *Elphidium fichtellianum*, *Elphidium crispum*, *Bolivina pseudoplicata*.

**Group B:** The species of this group are not tolerant to environmental stress of any nature, more particularly high salinities and oxygen depletion. These species are: *Cibicides dutemplei*, *Cibicides ungerianus*, *Hanzawaia boueana*, *Uvigerina peregrina*, *Gyroidinoides soldanii.*, *Gyroidinoides* sp., *Melonis pompilioides*, *Nonion boueanum*, *Siphonina reticulata*, *Valvulineria bradyana* and Agglutinants (*Spiroplectammina carinata*, *Textularia candeiana*).

**Group C:** This group consists of species tolerant to environmental stress, which is mostly represented by oxygen-deficiency at the bottom. These species are: *Bulimina costata*, *Bulimina aculeata*, *Bolivina spathulata*, *Bolivina dilatata*, *Valvulineria bradyana*, *Valvulineria complanata*, *Cassidulina carinata*, *Globocassidulina subglobosa*, *Globobulimina* sp..

In addition, the general relationship between Depth and %P ( $\%P = P/P + BX 100$ ) is described according to:  $Depth = e(3.58718 + (0.03534 \times \%P))$  (V.D. ZWAAN *et al.*, 1990).

From the plotted diagrams (Fig.4) it should be noted that representative species of Group B prevail in almost all the samples apart from Kal9 and Kal14 where Group C is in excess. The predominance of Group B suggest stable marine conditions and point to an open marine environment with mainly clayey sedimentation. On the contrary, the predominance of Group C in Kal9 and Kal14 samples suggest an abrupt increase in oxygen content and a transition from normal conditions to strongly low oxygen environments (high content of nutrients), (JORISSEN, 1988).

As far as the P/B ratio is concerned, apart from Kal3 and Kal4 samples which show relatively low P/B ratios indicative of a coastal environment (Fig. 5), the P/B ratios from Kal9, Kal 13 and Kal14 samples are rather constant (~2) indicating a shallow-marine environment of deposition (~250 m). The high P/B ratio of Kal18 sample in combination with the fact that only representatives of Group B prevail, suggest a rather deep environment of deposition (~750 m). Moreover, the P/B ratio which is correlated with depth (GRIMSDALE & VAN MORKHOVEN, 1955; STEHLI, 1966; HALLAM, 1967), is also known to be sensitive to productivity (PHLEGER, 1960; DIESTER-HAASS, 1978; LUTZE, 1980). Therefore, when interpreting P/B ratios, then, three environmental factors-depth, food supply and partial dissolution of carbonate- must be considered. In addition, BERGER & DIESTER-HAASS (1988) used the P/B ratio as a productivity index. Under this respect, the elevated percentage of the planktonic foraminifera (P/B=6) in Kal18 sample may be due to an increase to the flux of primary produced organic matter (ZACHARIASSE *et al.*, 1990, ZUIDERVELD *et al.*, 1991) or a shortage in terrigenous clastic material influx.

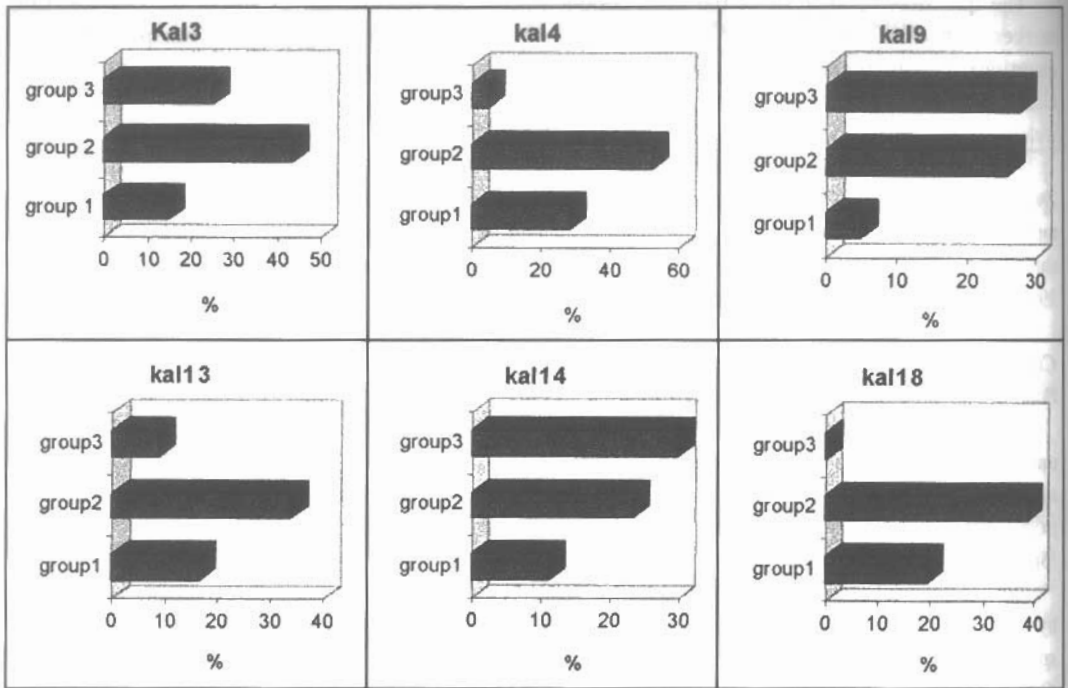


Fig. 4: Relative abundance of the foraminiferal groups in the studied samples.

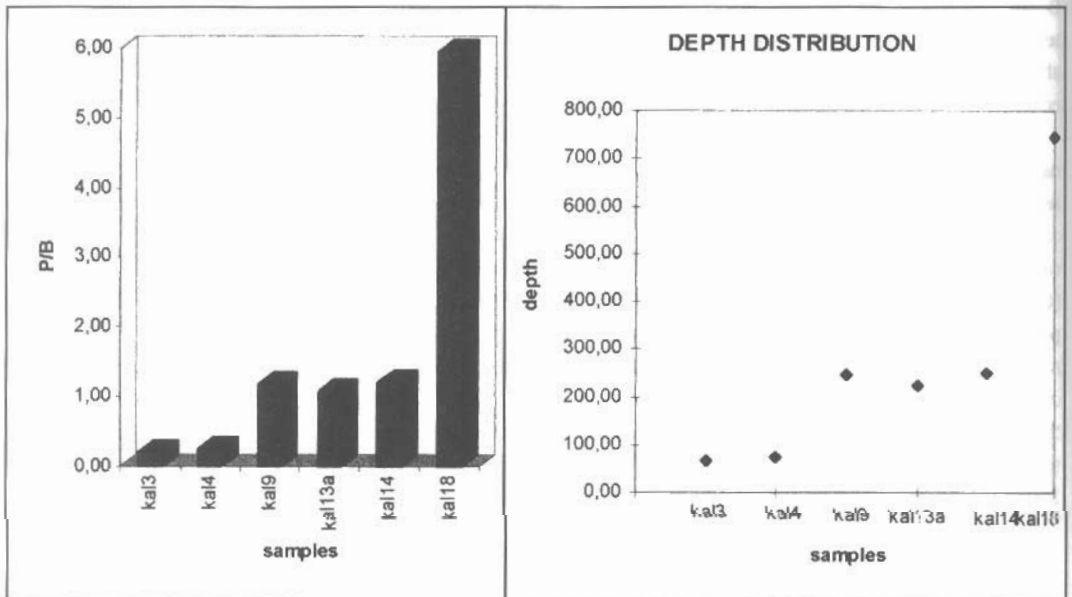


Fig. 5: Relation of the estimated planktonic/benthic ratios in the studied samples and depth distribution.

## 5. DISCUSSION-CONCLUSIONS

The Neogene deposits of Kalamos island are represented by small exposures which consist of marly deposits with partly thin alternations of brackish sediments.

The biostratigraphical analysis led to the correlation of the studied sediments based on calcareous nanofossils with the lower part of NN11 biozone (MARTINI, 1971). This biostratigraphic interval can be correlated concerning planktonic foraminifera with the lower part of N17 biozone (BLOW, 1969) which chronostratigraphically points to a middle Tortonian age.

In Kalamos island, Pliocene sedimentation did not take place. Kalamos seems to have become inactive in the Pliocene while a second basin - the Mytikas basin - began to receive sediments. In Mytikas basin, Middle to Upper Pliocene sediments (DOUSOS *et al.*, 1987) unconformably overlie folded and faulted Mesozoic to Lower Miocene strata, providing evidence of tectonism at some time during the mid-Miocene to Early Pliocene interval. The sedimentation began during the Middle Pliocene and continued very probably up to Pliocene/Pleistocene boundary as indicated by the biozone *Globorotalia aemiliana* (IACCARINO, 1985) with *Globorotalia cf. aemiliana* COLALONGO & SARTONI and *Globorotalia gr. crassaformis* GALLOWAY & WISSLER which is characteristic of Piacentian (DOUSOS *et al.*, 1987).

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