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Climatic Changes on the Island of Rhodes

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IMPLICATIONS OF EXPECTED CLIMATIC CHANGES ON THE ISLAND OF RHODES

CLIMATE OF THE ISLAND OF RHODES

by

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F I R S T D R A F T

N O T T O B E C I T E D

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2.2. CLIMATE OF THE ISLAND OF RHODES

1. General remarks

The island of Rhodes is situated in the Eastern Mediterranean Sea in the SE margin of the Aegean Archipelago.

It exhibits a semi-mountainous and mountainous morphology as well as a number of small valleys where various agricultural activities take place. North of the island of Rhodes and in a small distance from it the land of Asia minor is extended while sea waters with greatly varying depths surroud the island.

The climate of Rhodos belongs to the Mediterranean type which is characterized by two climatically contrasting periods that is, one cold and rainy lasting from November to March and another warm and dry lasting from April to October (MARIOLOPOULOS,E. and KARAPIPERIS,L., 1963). Althought the mediterranean climate in its main features shows everywhere a characteristic uniformity, it presents many variations in its particular characteristics due to macro and especially to meso and microclimatic factors (DIKAIAKOS,J.,1982).

These variations tend to become more pronounced in mountainous regions, valleys and highlands inland the coasts and more weak in long and open to the sea coastal regions as well as in small islands with low mean ground elevation.

The geographical position of Rhodes, the land masses of Asia Minor, the extensive sea waters, the shape and size of the semi-mountainous and mountainous morphology with the existing valleys of the island of Rhodes are the main physical and geographical factors which affect the climatic conditions of the island very much during all seasons of the year.

The dynamical factors of the climate of Rhodes in the other hand are mainly the depressions coming from North Atlantic, Gulf of Lion, North Adriatic Sea as well as the ones which develop in the coasts of Tynisia, Tripolis and some times over the Aegean Sea and the greater area of Cyprus. The Siberian anticyclone, the one of the Atlantic, as well as the anticyclones which are developed over the west and central Europe are also considered as main dynamical factors affecting the climate of Rhodes.

These anticyclonic and mainly cyclonic types of weather show their greatest frequency of occurence during the cold period of the year while they disappear or show a low or a very low frequency during the warm period of the year (CARALIS,J.,1969). During the latter period and especially the summer the weather conditions are mainly depended on the high pressure fields which are developed very frequently over the western and central Europe and mainly the Balcan Peninsula. These high pressure centers acting alone or mainly in association with the so called Indian low or fields of low pressure over the Eastern Mediterranean Sea produce over the Aegean Sea a typical seasonal air stream comming from the north sector which is well known even from the ancient Greeks as " Etessians " or "Etessian winds". This stream blows with very high frequency of occurence from N or NE direction in the north Aegean Sea. In central Aegean Sea it blows from the north while in the south and mainly the southeastern margins of the Aegean Sea it blows from NW or even W direction.

During the Etessian days that is the days during which the Etessian winds blow mainly from west, the weather conditions over Rhodes are typical and remain nearly steady for long or very long period. The sunshine takes high values reaching the theoretical ones, the temperature does not go up very much while rain never appears in Rhodes. Rain is a rather rare phenomenon during the warm period of the year and especially the summer. When it appears it lasts very little has a local character and it is mainly due to strong or very strong thermal convection developed under special conditions of static stability of the air.

On the countrary almost all the mean annual amount of rainfall appears during the cold period of the year, during which the phenomenon of rain has not the local character mentioned before except perhaps, in few cases in the beginning and the end of the period. In all other cases the rain can be characterized as pure frontal rain. Of course there are few cases in which rain is a combined effect of an upper level instability and low level forced convection. These are the cases of orographic rain which can be considered as the only case of rain with local character during the cold period of the year. During the same period continental arctic (cA), maritime arctic (mA), continental polar (cP), maritime polar (mP) and more rarely continental tropical (cT) air masses do invade East Mediterranean area due to the action of the depressions and anticyclones mentioned before.

Phenomena of rain, some times very heavy ones, floods, hail,stong or very strong winds, storms, thunderstorms and gales, low or very low temperatures and frost appear during the invasion of these air masses with frequency, of course, depended on the phenomenon and the type of the air mass with which this phenomenon is associated . On the contrary there are long or very long spells of mild and very good weather which is characterized by a number of succesive sunny days with relatively high temperatures and very weak winds. This type of weather prevails over Rhodes during the cold period of the year and for this reason the climatic conditions during the same period are considered as very mild with a maritime character very much pronounced. During the beginning and the end of the warm period that is during April and May and also in September and October the climatic conditions are also mild or very mild with a maritime character

Although the temperature of the air remains in, more or less, high levels at the same time the climatic conditions during the summer cannot be characterized as hot or very hot from a human bioclimatic point of view. This is because the wind field over Rhodes during summer is exceptionally strong (CATSOULIS,B.,1970) and therefore the cooling power does not declime very much (DIKAIAKOS,J. and NASTOS, P., 1987).

2. Temperature

The temperature of the air in Rhodes shows a simple annual course and a mean annual value equal to 18.8 .C (Table 1, fig 1). After Haurwitz and Austin (HAURWITZ,B. and AUSTIN,M.,J., 1944) this course belongs to the temperate type with a rather well expressed maritime character mainly because of the maximum mean monthly value which appears in August. The mean annual value of 18.8 .C in the other hand can considered as a very high one for a mean annual temperature regime in Greece while, the one of 19.6 .C given by Mariolopoulos, E. (1961) and Karapiperis, Ph. (1962) suggests that Rhodes is on the average the warmest Greek island. On the contrary, during the warm period of the year and especially the summer Rhodes is not the warmest Greek island. In July e.g. the temperature of the air in Rhodes shows maximum mean monthly value equal to 28.3 .C while at the same time in islands Corfu, Mytilini, Zakynthos, Kythira and Crete (Heraklion) it shows values equal to 30.7, 31.8, 30.3, 29.7, and 29.6 .C respectively (MARIOLOPOULOS, E., 1961, p. 16, Table 6).

An annual course similar to the one mentioned before is followed by both the maximum and minimum mean monthly values of the temperature of the air in Rhodes. The maximum and minimum of both these values appear in August and January respectively while the maximum and minimum thermal regime in February differs very little from that in January.

This maritime character of the climate of Rhodes can also be seen if the values which show the mean annual range of the temperature of the air and any other relevant indices are taken into account. So not only the value of the annual range which is equal to 14.0 .C but also the value of the index of continentality introduced by Kerner, which are equal to 23.7 % and 33.6 % respectively show clearly that Rhodes is of a rather pure maritime climatic character (KARAPIPERIS,PH.,1962, p.9, Table 2)

Although the climatic character of Rhodes is clearly maritime, the temperature of the air does not always remain close to average levels but it varyies significantly around it and some times very much indeed. So days with maximum temperature higher than 30 .C or even 35 .C very often appear in summer while days with minimum temperature near to 0 .C are not rarely appear in winter. In the other hand, the absolute maximum and minimum values which shows the temperature of the air in Rhodes during the period e.g. 1955 - 1988 are equal to 42 .C and -4.2.C respectively.

From fig. 2 it can easily be seen that the mean annual and seasonal values of the air temperature in Rhodes show a steady tendency to increase during the period 1955 - 1988 except the ones during summer which at the same time show a similar tendency to decrease.

More precisely the mean annual, winter, spring a nd autumn values during the formentioned period show of positive total changes equal to 0.49,0.92,0.76 and 0.58 .C respectively while the mean summer values show a negative total change equal to -0.246 .C . Although the length of the time series is rather small the magnitude, the steadines of these changes are with no doupt very significant and interesting not only to theoretical but also to applied climatology.

3. Relative humidity

The relative humidity of the air in Rhodes shows a simple annual course (Table 2, Fig 3), maximum and minimum mounthly values in December (73%) and July (56%) respectively and a mean annual value equal to 60%.

Taking into account mean monthly and annual values which shows the relative humidity of the air in other Greek islands near or far from Rhodes (see e.g THEOHARATOS,G., 1978), it can be said that Rhodes is one of the driest islands of the Aegean Sea.

4. Rainfall

The mean annual ammount of rain in Rhodes for the period 1955-1988 is equal to 714.6 mm (Table 3). The maximum and minimum mean mounthly rainfall appear in December (165.0 mm) and August (just 0.1 mm) respectively (Fig 4) while 85% of the annual rainfall appears during the cold period of the year (November-March). During the warm period of the year and especially the summer, rainfall is very low indeed as it is in most coastal regions and islands of Mediterranean Sea and especially the ones at the eastern Mediterranean.

Taking into account that the mean maximum (931.8mm) and minimum (364.1mm) rainfall appear in the islands of Icaria and Thira respectively then Rhodes with mean annual rainfall equal to 714.6 mm can considered as one of the wettest islands of the Aegean Sea.

All the mean monthly and annual values which show the number of the rainy days and the intensity of rain (Table 3) can be considered as high or even very high ones in comparison with the corresponding values in all other islands of the Aegean Archipelago.

Although rainfall in Rhodes can be considered relatively high, the water deficit (with adopted field capacity for the soil 100mm) is very high (607mm) while the water surplus is also very low (407mm) (BALAFOUTIS, CH., 1988). This in connection with the fact that Rhodes is an island which accepts too many tourists every year during the warm period of it, indicates that adequate water supply is a serious problemm for this island.

5. Winds

The wind system of Rhodes shows features which are mainly affected by the geographical position of the island.

The wind speed in Rhodes shows a double annual course (Fig 5) as it does in many other islands of the Aegean Sea. The first maximum appears in July (6.76 m/sec) while the secondary one in April (4.87 m/sec). This annual course has all the typical features of a place with monsoon climate and it is due to Etessians which are very strong and steady during the summer and especially the July over the major area of Rhodes (MARIOLOPOULOS,E. and KARAPIPERIS,L.,1963,p.18)..

How important is the geographical position of the island and the etessian winds to the wind system can easily be seen if the wind roses of July and January over Rhodes in one hand and the island of Thira in the other (Fig 6) are taken into account . These two islands have the same more or less latitude but the first one is situated in the southeastern margin of the Aegean Sea while the other is situated in the central Aegean.

6. Human bioclimate

The mean monthly values of both the cooling power of the air (CP) and the effective temperature (ET) were calculated according to CENA, M. et al. (1966) empirical formula (Table 4, Fig 7 and 8). According to Cena's classification the outdoor human bioclimate is cold from December to April, cool in all other months of the year except in August in which it is warm. Although the enviroment is climatically warm or even hot during the warm period of the year, especially the summer, the wind system and especially the Etessian winds which at the same time blow with high frequency and intensity increase the cooling power significantly and make the outdoor enviroment less warm and hot from a human bioclimatic point of view. How important are the Etessian winds can easily be seen if the outdoor and indoor conditions during the summer are compared. Indeed according to the effective temperature the indoor enviroment is out of the comfort zone and rather hot from the end of June to the end of the September.From the end of April to the end of June and from the end of September to the middle of October the indoor conditions are into the comfort zone. During all other months it is rather cool and cold mainly during the winter.

7. Extreme events and other meteorological phenomena

Detailed data concerning to extreme events are not available at the present time. The available ones as they have been given us by the Nat. Met. Service of Greece for these study are given in Table 5. From these data it is suggested that in Rhodes most of the main meteorological phenomena occur with frequency of occurence and seasonal distribution not much different to those appeared in other coastal regions and islands of Greece (compare e.g. Theoharatos, G.,1978, pp. 146,147 and 149 as well as Mariolopoulos,E.,1961,p. 37). On the contrary the values which show both the absolute maximum rainfall in 24 Hrs and especially the number of days with thunderstorms during the whole year are exceptionally high.

8. Climatic implications of the greenhouse effect

An attempt for the assesment of the implications of a future global temperature increase in the climate of Rhodes is made here based on data taken from the report of the climatic research unit (CRU) of the East Anglia Univercity (GUO, X.,et al., 1991).

These implications concern to changes in temperature and precipitation (Table 6) which are supposed to appear in Rhodes by the middle of the next century (by 2050), when the mean global temperature is expected to increase by 1 C. From data of table 6 it is easy to be seen that:

a. The annual and seasonal temperature changes are all positive and relatively small or even very small ones since

i. the minimum and maximum seasonal changes are 20 %, 30 % or even 40 % smaller than the global change, except the maximum changes of the summer and autumn on one hand and the minimum of the summer in the other which are onlyy 20 % and 10 % respectivel greater than the global change,

ii. the maximum annual and seasonal temperature changes in Rhodes are smaller than the corresponding maximum changes in the whole N - E Mediterranean region while the ones of the winter and spring are the smallest in the region.

iii. the mean annual temperature change in Rhodes is smaller not only from the global one but also from the average in the same region.

b. The annual and seasonal precipitation changes which are expected to appear in Rhodes by 2050 are positive and relatively quite significant, except the one at the summer which is negative and practically very small. More precisely the precipitation is going to increase by an amount varying between 0 - 22.1mm in winter, 3.6 - 7.15mm in spring and 18.0 - 39.1mm in autumn while the precipitation in summer is expected to decrease between 0.6 and 0.8 mm only.
Finally, the annual precipitation is expected to increase by an amount varying between 20.8 mm and 67.8 mm.

From all the forementioned details we can conclude that the climate of Rhodes is going to become warmer and wetter as the mean global temperature is expected to increase due to the greenhouse effect. The rate of the temperature change is slower than the global and much more slower than the maximum rate in the NE Mediterranean Sea. The rate of the precipitation change is one of the faster in the same region. Thus, it could be said that the climate of Rhodes, compared with the one of the NE regions of the Mediterranean Sea is expected to become cooler and wetter.

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TABLES

TABLE 1. Mean monthly and annual values of the air temperature (C) in Rhodes (1955-1968).

J	F	M	A	M	J	J	A	S	O	N	D	Y
(Mean temperature)												
11.8	11.9	13.3	16.2	20.0	24.1	26.4	26.7	24.3	20.5	16.6	13.4	18.8
(Mean max temperature)												
15.1	15.4	16.9	20.1	24.5	28.7	30.8	31.0	28.4	24.7	20.3	16.7	22.7
(Mean min temperature)												
8.4	8.5	9.7	12.3	15.5	19.6	22.0	22.4	20.1	16.4	12.9	10.1	14.6

TABLE 2. Mean monthly and annual values of relative humidity (%) in Rhodes (1955-1968).

J	F	M	A	M	J	J	A	S	O	N	D	Y
(Relative humidity (%))												
71	70	69	67	64	57	56	58	61	67	72	73	60

TABLE 3. Mean monthly and annual values of rainfall, number of days and intensity of rain in Rhodes (1955-1968).

J	F	M	A	M	J	J	A	S	O	N	D	Y
(Rainfall (mm))												
161.5	115.4	77.6	25.5	16.0	2.7	0.4	0.1	7.2	56.6	86.6	165.0	714.6
(Number of days)												
17.1	13.4	10.7	7.6	4.8	1.4	0.2	0.1	1.6	6.9	9.5	15.9	89.2
(Intensity of rain in (mm/Number of Rain days))												
9.4	8.6	7.2	3.4	3.3	1.9	2.0	1.0	4.5	8.2	9.1	10.4	8.0

TABLE 4. Mean monthly values of the cooling power and the effective temperature of the air in Rhodes (1955-1968).

J	F	M	A	M	J	J	A	S	O	N	D
(Cooling power in mcal/cm2/min)											
18.6	18.3	18.4	17.0	13.3	11.9	10.1	9.4	10.4	10.3	12.4	18.3
(Effective temperature in C)											
11.6	11.7	12.9	15.4	18.6	21.7	23.5	23.9	22.1	19.1	15.9	13.0

TABLE 5. Extreme events and other meteorological phenomena (1955-1968).

J	F	M	A	M	J	J	A	S	O	N	D	Y
(Absolute maximum temperature in C)												
22.0	22.0	27.4	30.6	34.8	37.4	40.0	42.0	36.6	33.2	28.4	22.8	42.8
(Absolute minimum temperature in C)												
4.0	2.2	0.2	5.2	5.0	12.6	14.6	17.0	10.6	7.2	2.4	1.2	4.0
(Absolute maximum rainfall in 24hrs in mm)												
126.2	92.4	76.9	51.7	60.4	28.6	6.9	1.6	34.4	124.4	178.8	146.4	
(Number of days with snow)												
0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
(Number of days with hail)												
0.8	0.5	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	
(Number of days with thunderstorm)												
5.8	5.3	3.8	2.0	2.3	0.6	0.2	0.1	1.0	4.8	4.7	6.1	
(Number of days with dew)												
4.6	4.0	6.2	6.9	5.9	3.5	3.0	3.7	4.9	6.8	7.6	5.5	
(Number of days with frost)												
0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

TABLE 6. Minimum (m) and maximum (M) seasonal and annual (the annual values are calculated from the seasonal ones), air temperature and precipitation changes in the North - Eastern Mediterranean (N-E-M) and the island of Rhodes for a mean global temperature increase of 1 C. The seasonal values of Rhodes are assesed from figures 2, 3, 4 and 5 of Guo, X., et al., (1991)

	WINTER	SPRING	SUMMER	AUTUMN	ANNUAL
	m - M	m - M	m - M	m - M	m - M
	Air temperature change C				
N-E-M	0.6 - 1.6	0.7 - 1.3	0.8 - 1.4	0.7 - 1.5	0.7 - 1.4
RHODES	0.6 - 0.8	0.7 - 0.8	1.1 - 1.2	0.8 - 1.2	0.8 - 1.0
	Precipitation %				
N-E-M	(-14) - 9	(-10) - 19	(-25) - 26	(-17) - 26	(-8) - 7
RHODES	0 - 5	3 - 6	(-25)-(-18)	12 - 26	3 -10

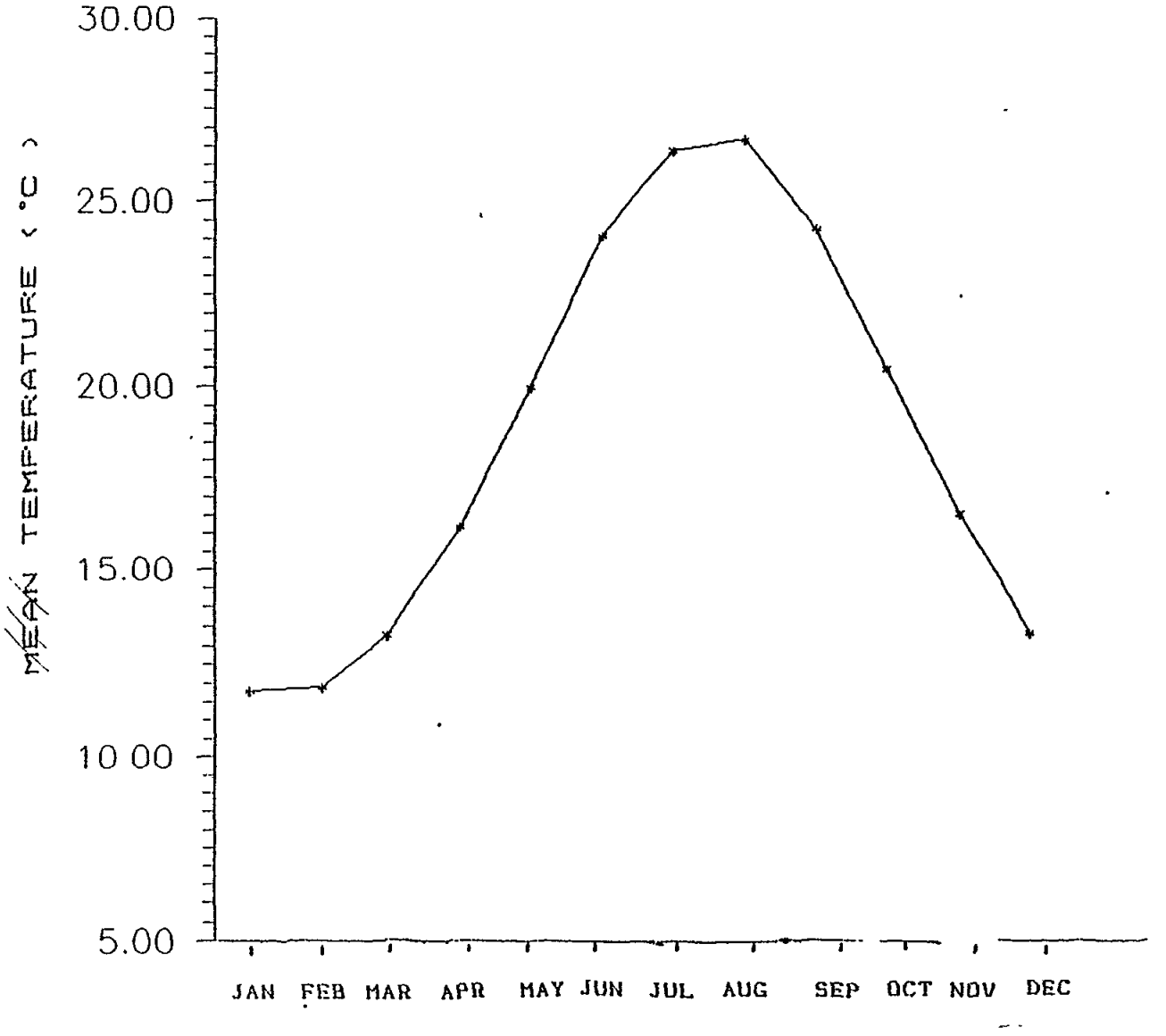

MEAN TEMPERATURE (°C)
30.00
25.00
20.00
15.00
10 00
5.00
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 1

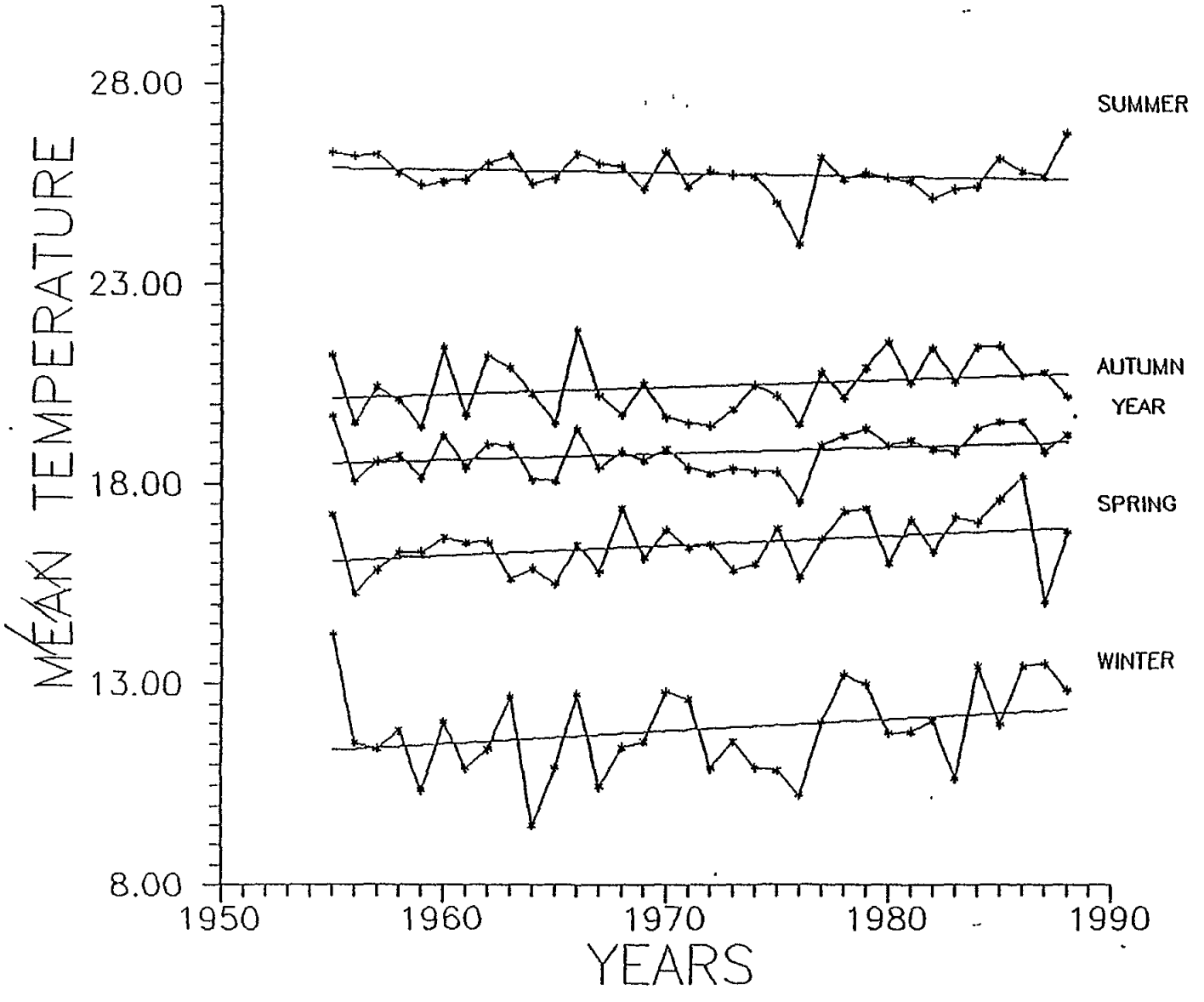

MEAN TEMPERATURE
28.00
23.00
18.00
13.00
8.00
1950
1960
1970
1980
1990
YEARS
SUMMER
AUTUMN
YEAR
SPRING
WINTER

Fig. 2

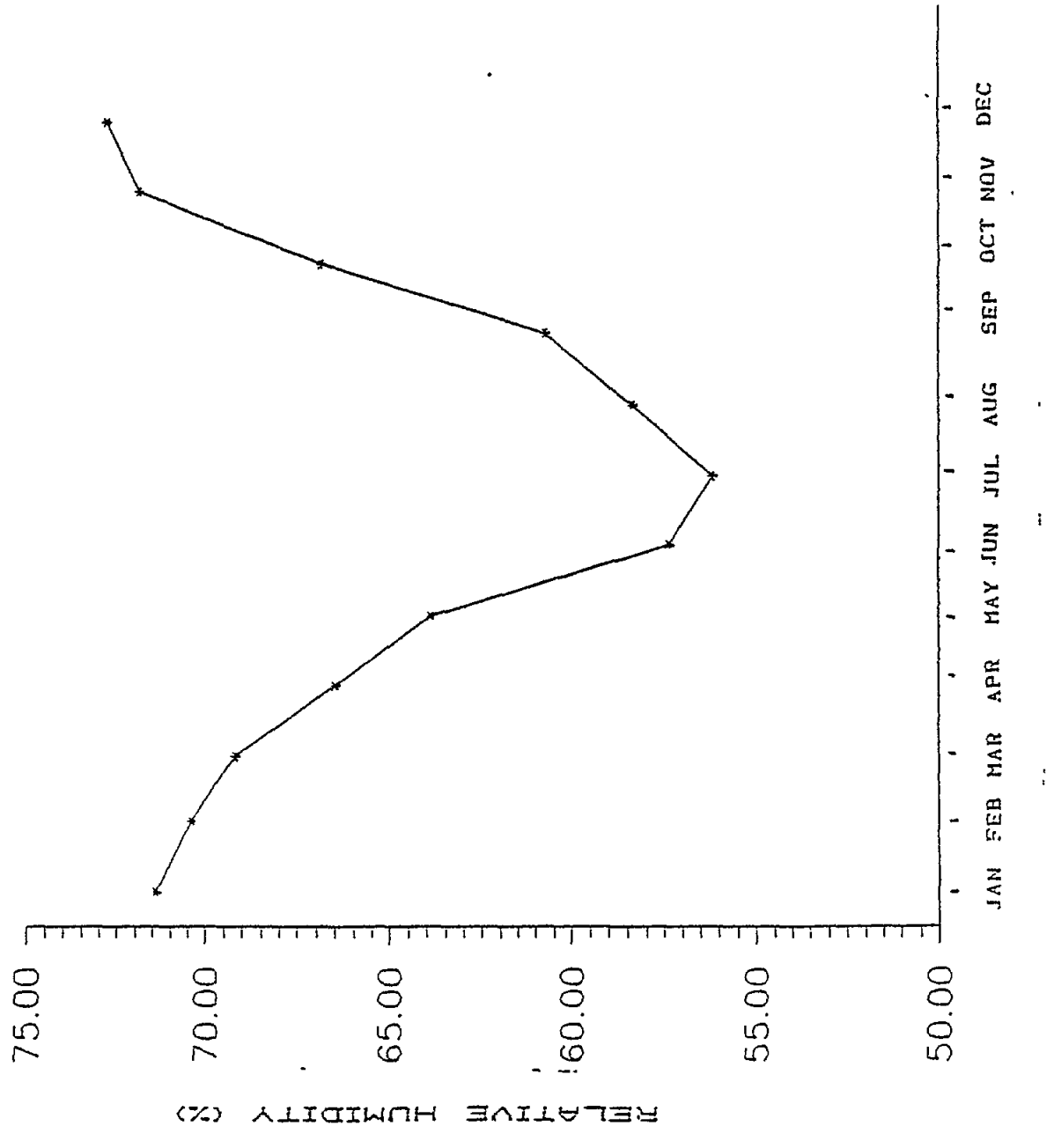

RELATIVE HUMIDITY (%)
75.00
70.00
65.00
60.00
55.00
50.00
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 3

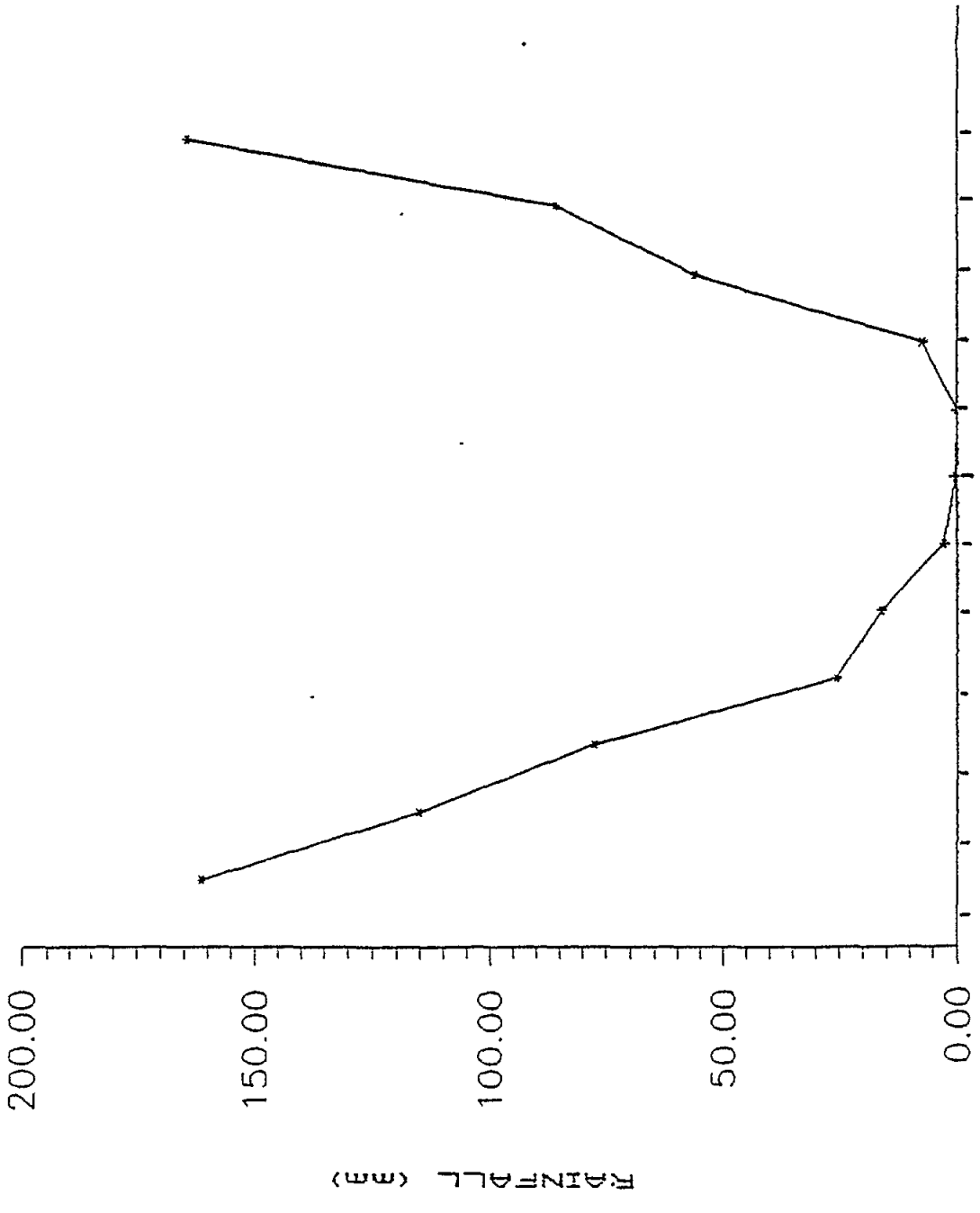

RAINFALL (mm)
200.00
150.00
100.00
50.00
0.00
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 4

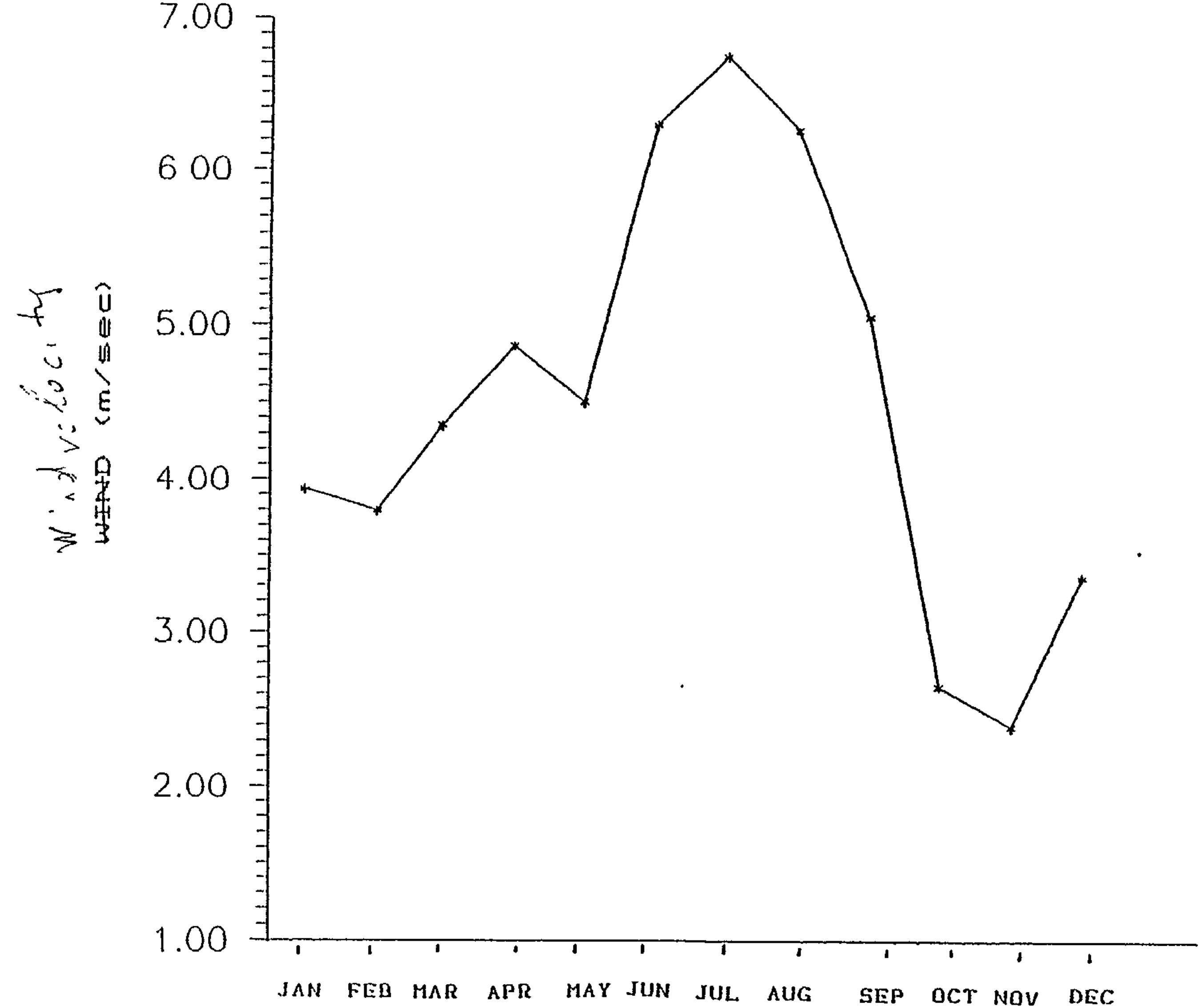
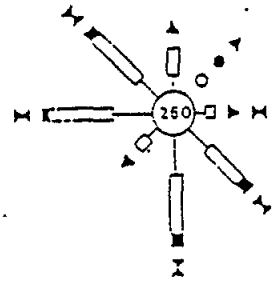
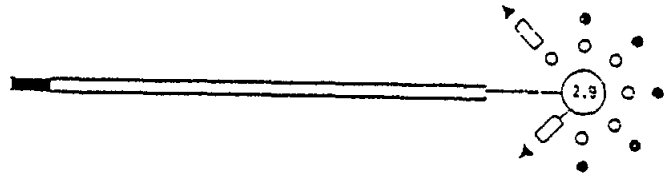

WIND (m/sec)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 5

Fig. 6



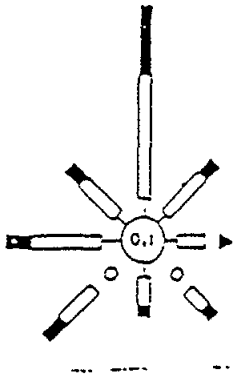
JANUARY (RHODES)



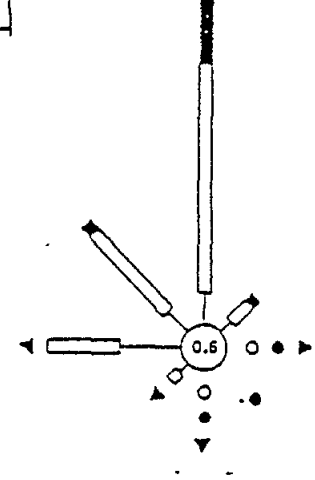
JULY (RHODES)

FORCE	FREQUENCY	
	>1%	<1%
1 - 2 Beauf	——	o
3 - 5 "	▭	•
6 - 7 "	▬	▲
> 7	▨	⧗

1 mm = 2%



JANUARY (THIRA)



JULY (THIRA)

WIND ROSES FOR JANUARY AND JULY IN RHODES AND THIRA

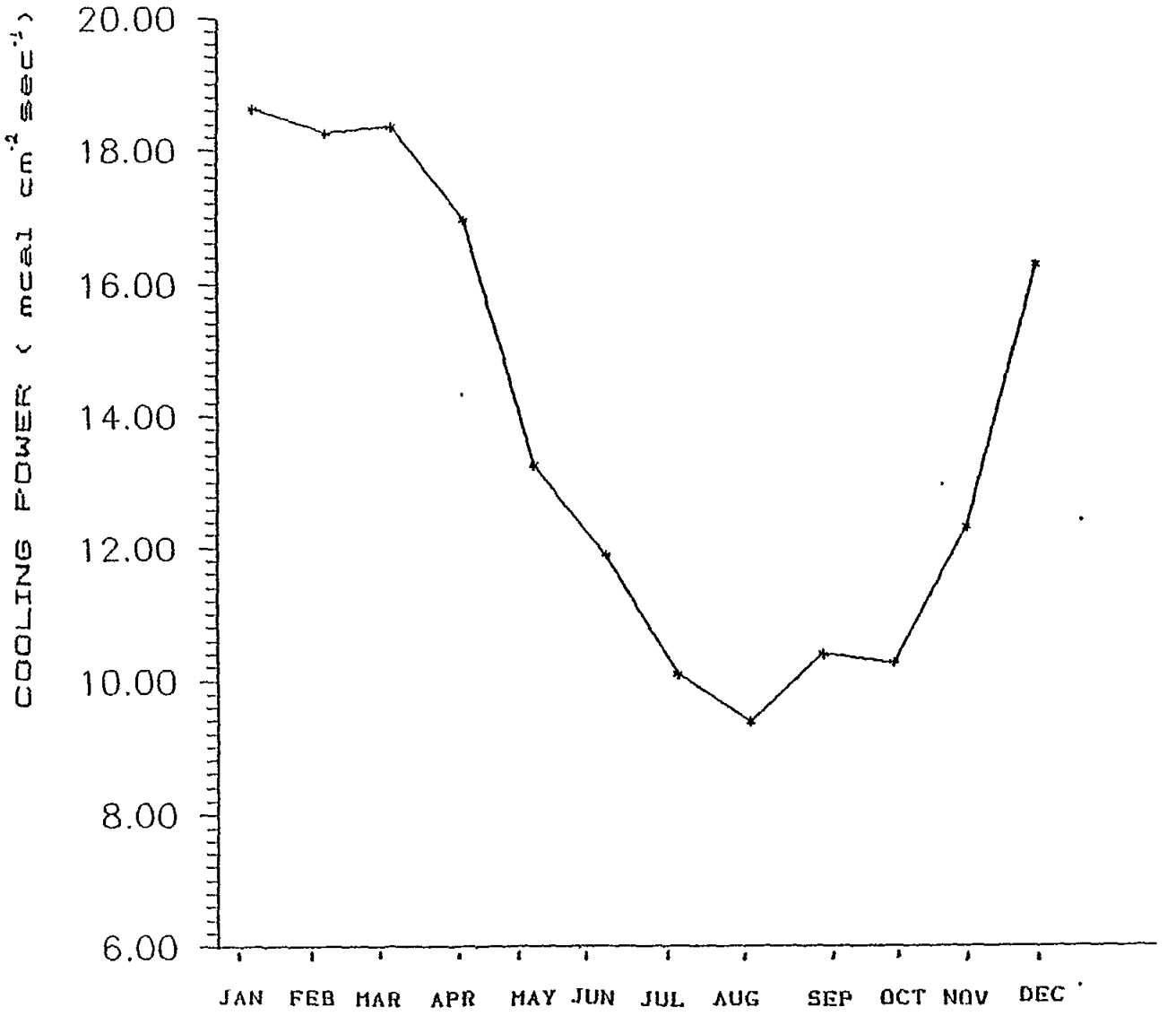

COOLING POWER (mcal cm-2 sec-1)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Fig. 7

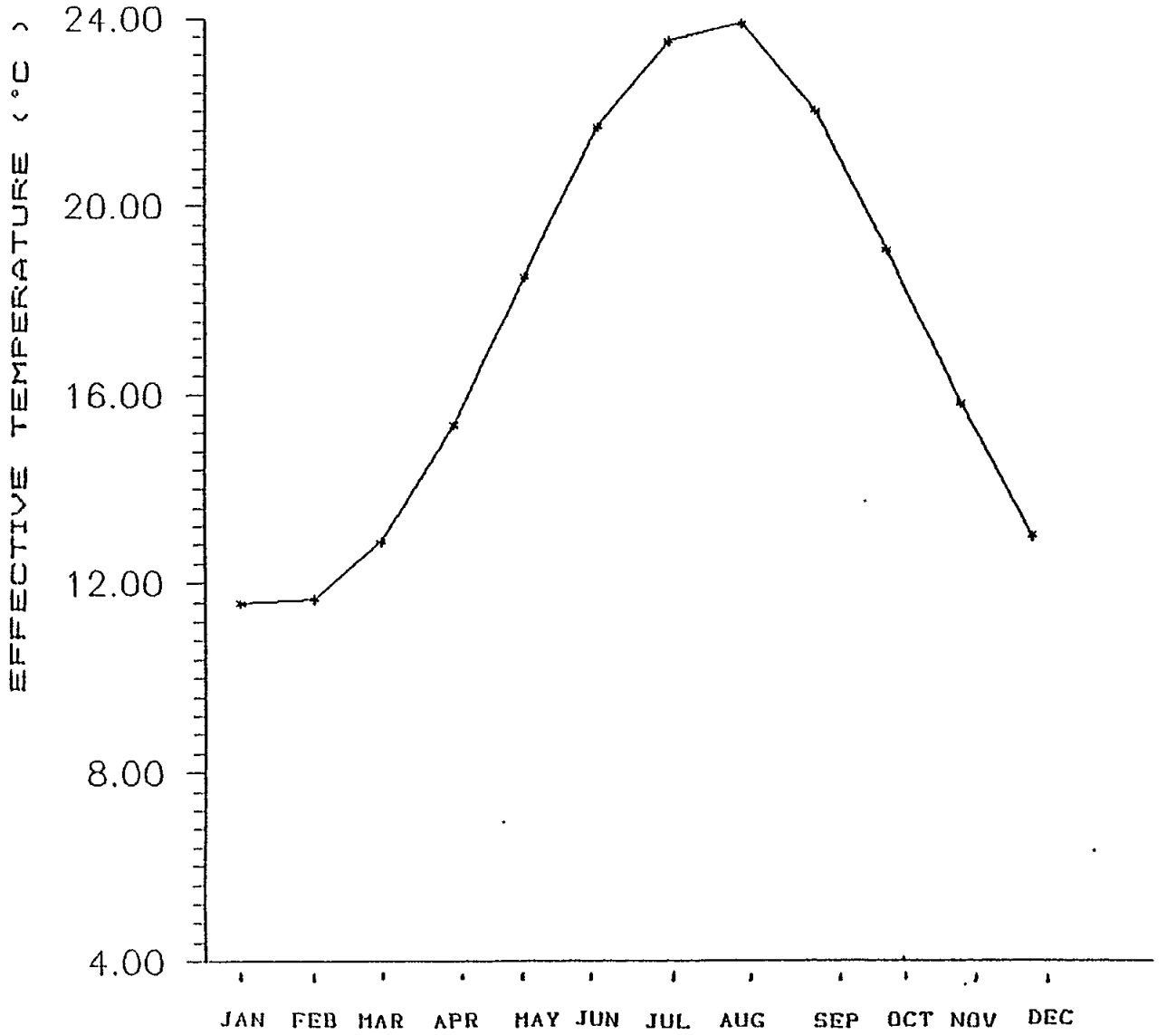

EFFECTIVE TEMPERATURE (°C)
24.00
20.00
16.00
12.00
8.00
4.00
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Fig. 8