CHAPTER IV :

RESULTS & DISCUSSION

1. CHLOROPHYLLS :

Chlorophyll content is one of the most important physiological parameter because it determines the rate of photosynthesis. Chlorophyll content is influenced by the environment in which plant grows.

It is evident from Table 1 and Fig. 1 that in Nephrolepis exaltata Schott. total chlorophyll content is more during vegetative stage than the reproductive stage. In rachis, it is clear that the values of total chlorophyll in vegetative stage are 49.132 mg 100^{-1} gm of fresh material. This value is decreased during reproductive stage and it is 25.784 mg per 100 gm of fresh plant material. This Table also shows that during vegetative stage total chlorophyll content in leaflet is 195.696 mg per 100 gm of fresh tissue and this value decreases upto 85.372 mg per 100 gm plant material during reproductive stage.

In Gymnopteris contaminans Bedd. also the same pattern of chlorophyll content is observed. The total chlorophylls are more in vegetative stage than the reproductive stage. In sterile rachis and sterile leaflet chlorophyll contents are more in vegetative stage than the reproductive stage. The total chlorophyll in sterile rachis are 231.938 mg 100^{-1}gm and in leaflet are 285.168 mg 100 $^{-1}$ gm of fresh tissue. This value decreases in both sterile rachis and sterile leaflet during reproductive stage and it is

about 48.39 gm 100^{-1} mgm and 185.24 mg per 100 gm of fresh material in sterile rachis and sterile leaflet in reproductive stage.

The total chlorophyll content decreases in the reproductive stage. The fertile rachis and fertile leaflet of G. contaminans shows very less total chlorophylls 36.24 mg 100^{-1} gm of fresh plant material of fertile rachis and in fertile leaflet the chlorophylls slightly increase 37.042 mg 100^{-1} gm of fresh tissue.

From this it is clear that during reproductive stage in rachis and leaflet total chlorophylls decrease while they increase in vegetative stage of both the plants N. exaltata and G. contaminans.

~~N.S.~~ Vyas and ~~B.D.~~ Sharma (1988) studied the phytochemistry of Rajasthan pteridophytes. Table - 3 shows relationship among chlorophyll a, chlorophyll b, and total chlorophylls in different ferns and fern allies collected from various places throughout Rajasthan. Chlorophyll a, chlorophyll b and total chlorophylls are calculated by using Arnon (1949) formulae. Adiantum lunulatum, Marsilea minuta and Tectaria macrodonta have more chlorophylls in comparison to narrow, reduced and coriaceous laminated forms such as Equisetum ramosissimum, Actiniopteris radiata, Pteris vittata. The proportion of chlorophyll 'a' is more than chlorophyll 'b' in reduced, coriaceous

TABLE 1.

CHLOROPHYLL CONTENTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE.

	Vegetative stage			Reproductive stage		
Plant Parts	Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll a+b	Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll a+b
Rachis	29.254	19.612	49.132	13.088	12.544	25.784
Leaflet	122.634	72.036	195.696	51.964	32.952	85.372

The values are expressed in mg/100 gm of fresh tissue.

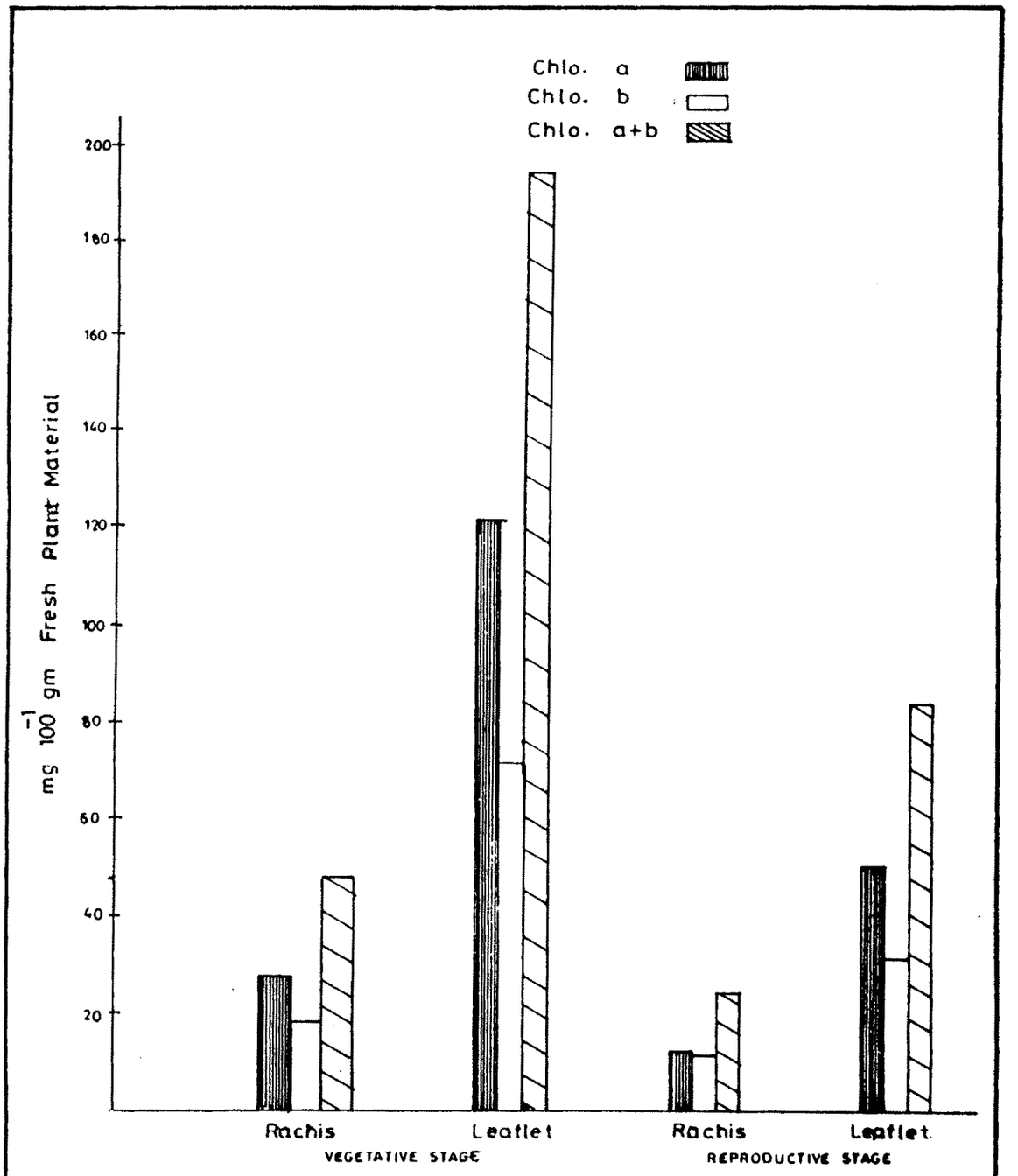

FIG. NO. 1 CHLOROPHYLL CONTENT OF Nephrolepis exaltata IN VEGETATIVE AND REPRODUCTIVE STAGE.

TABLE 2.

CHLOROPHYLL CONTENTS OF *Gymnopteris contaminans* IN THE VEGETATIVE AND REPRODUCTIVE STAGE.

Plant Parts	Vegetative stage			Reproductive stage		
	Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll a+b	Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll a+b
Sterile rachis	145.344	85.776	231.938	14.208	33.884	48.39
Sterile leaflet	160.284	123.288	285.168	113.012	71.242	185.242
Fertile rachis	-	-	-	22.71	13.34	36.24
Fertile leaflet	-	-	-	23.98	12.872	37.042

The values are expressed in mg/100 gm of fresh tissue.

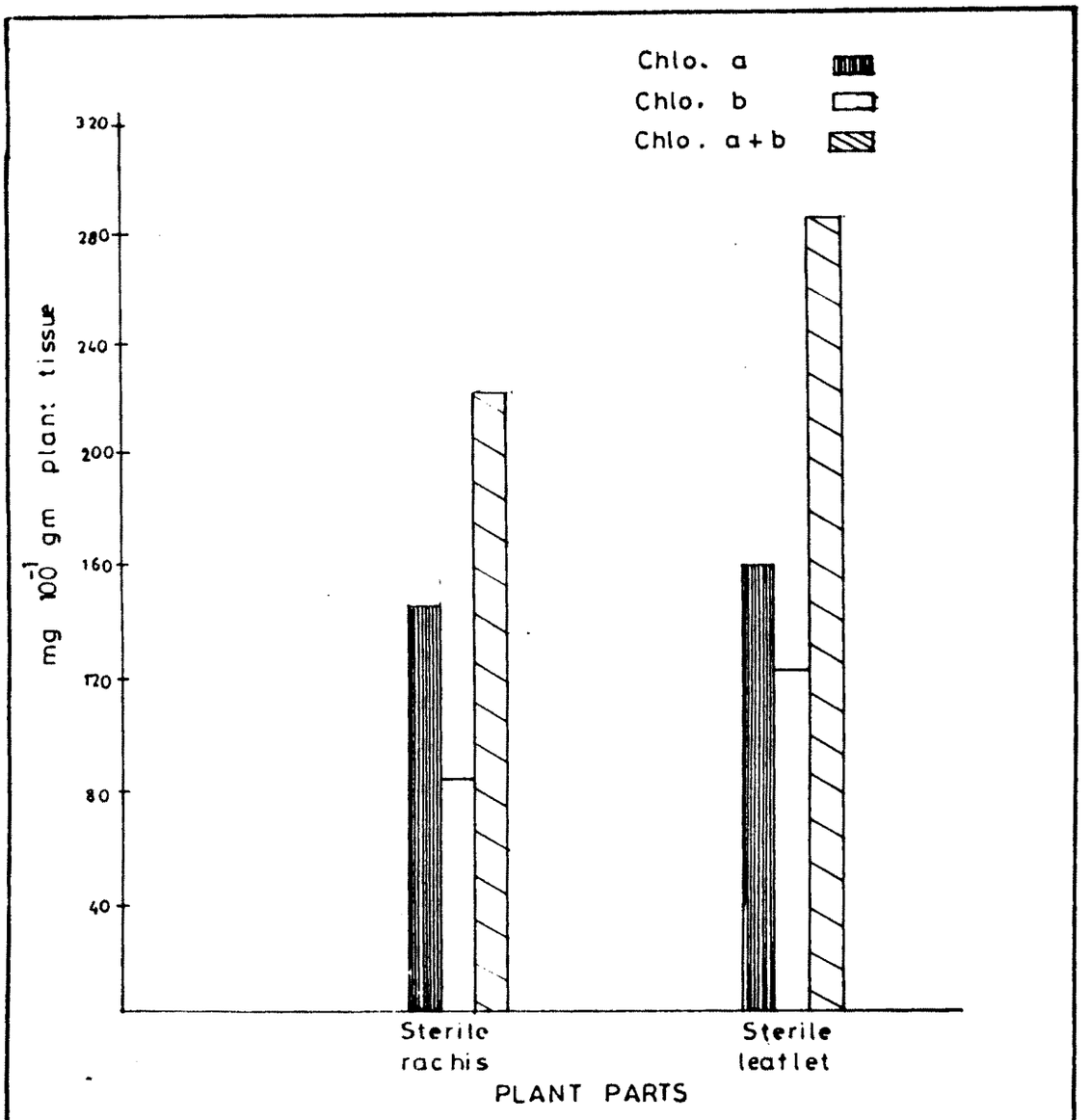

FIG. NO 2 CHLOROPHYLL CONTENT IN THE VEGETATIVE STAGE OF Gymnopteris contaminans Bedd.

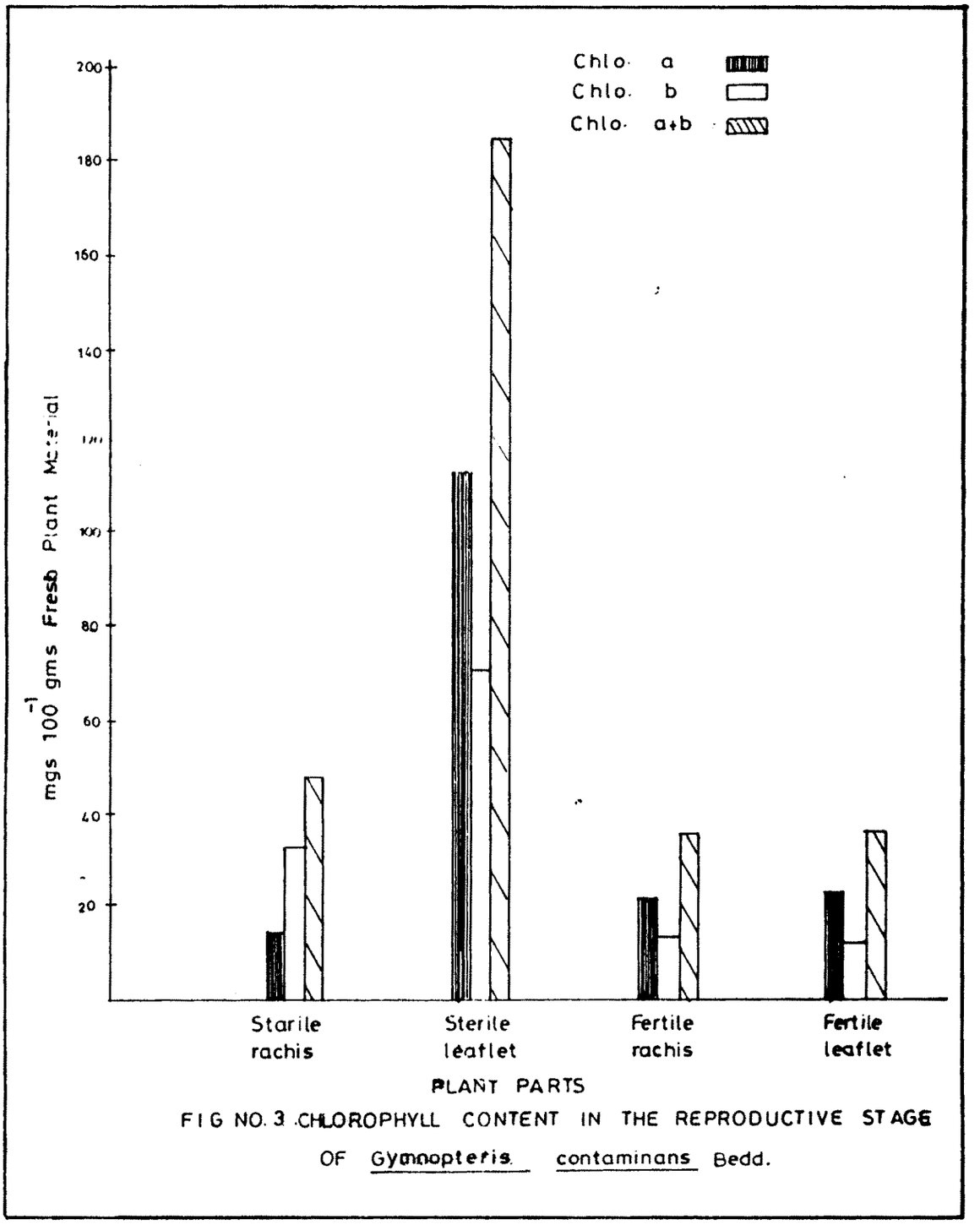

FIG NO. 3 CHLOROPHYLL CONTENT IN THE REPRODUCTIVE STAGE OF *Gymnopteris contaminans* Bedd.

TABLE 3

STUDY OF CHLOROPHYLLS IN DIFFERENT SPECIES OF FERNS AND FERN ALLIES COLLECTED FROM VARIOUS PLACES THROUGHT RAJASTHAN (Vyas and Sharma, 1988).

Name of plant	Chlo.a gm/lit	Chlo.b gm/lit	Total chlo. gm/lit
Equisetum ramosissium	0.85	0.82	1.67
Marsilea minuta	2.41	2.17	4.59
M. aegyptiaca	1.92	1.21	3.14
Actiniopteris radiata	1.80	1.14	2.92
Pteris vittata	2.81	3.00	5.76
Cheilanthes farinosa	1.72	1.64	3.36
Adiantum lunulatum	2.60	2.98	5.57
A. incisum	1.50	1.02	2.52
A. capillus-veneris	1.43	1.00	2.44
Nephrolepis cordifolia	1.00	0.73	1.71
Hypodematium crenatum	1.45	2.31	3.76
Techtania coadunata (*I. macrodonta*)	0.73	0.56	1.38
Cyclosorus dentatus	1.74	1.06	2.81
Asplenium pumilum	1.61	2.50	4.16
Araiostegia pseudo-cystopteris	1.46	1.90	3.28

laminated forms in comparison to soft and broad laminated types. on the other hand chlorophyll 'b' occurs in more amount than chlorophyll 'a' in broad laminated forms as Adiantum lunulatum, Hypodematium crenatum, Tectaria macrodonta etc.

Shetty (1971) studied chlorophyll contents in Acrostichum aureum in saline and non saline conditions. The non saline leaves contain more chlorophyll than the saline ones.

2. TITRATABLE ACID NUMBER (TAN) :

The TAN values in roots, stolon, rhizome, rachis and leaflet of N. exaltata during vegetative and reproductive stage are recorded in Table 4. The TAN values in vegetative stage of N. exaltata are more than the reproductive stage. During vegetative stage stolon and rhizome show more TAN while roots and leaflet show least the TAN value. At reproductive stage more TAN is observed in rachis while less in roots. Thus there are definite variations in TAN values in all the parts.

The TAN values in roots, rhizome, rachis, leaflet, fertile rachis and fertile leaflet of G. contaminans during vegetative and reproductive stage are recorded in Table 5.

The TAN values in vegetative stage of G. contaminans are more in rhizome (34.2) and less in the leaflet. The TAN values during reproductive stage of

TABLE 4

TAN CONTENTS OF Nephrolepis exaltata IN VEGETATIVE AND REPRODUCTIVE STAGE.

Plant parts	Vegetative stage	Reproductive stage
Roots	22.988	17.420
Stolon	34.482	26.735
Rhizome	34.482	25.742
Rachis	28.735	27.988
Leaflet	22.98	21.420

Note : Values are expressed in gm/100 gmof fresh tissue.

TAN (Titratable Acid Number) represents the number of ml of decinormal NaOH required to neutralize the acid contents from 100 gms of fresh material.

TABLE 5

TAN ~~CONTENTS~~ OF *Gymnopteris contaminans* IN VEGETATIVE AND REPRODUCTIVE STAGE.

Plant parts	Vegetative stage	Reproductive stage
Roots	15.4	11.494
Rhizome	34.2	28.335
Sterile rachis	17.1	25.861
Sterile leaflet	14.25	28.735
Fertile rachis	-	31.608
Fertile leaflet	-	31.608

Note : Values are expressed in gm/100 gm of fresh tissue.

TAN (Titratable Acid Number) represents the number of ml of decinormal NaOH required to neutralize the acid contents from 100 gms of fresh material.

G. contaminans are highest in the sterile leaflet and fertile leaflet and less in the roots. There is definite variation in TAN in all parts. N. exaltata in general shows more TAN than G. contaminans.

Shetty (1971) has studied the effect of NaCl on TAN in Acrostichum aureum. He has observed that TAN increases with increasing concentration of NaCl upto 0.02 m, where the TAN is the highest. Afterwards the TAN decreases with increasing concentration of NaCl.

TAN gives an idea about the acidity status of the plant tissue. Among various organic compounds, organic acids are of considerable importance because major organic acids like malate are the intermediates of TCA cycle. Further they provide carbon skeleton for synthesis of number of important metabolites. Organic acids can be regarded as a link between the carbohydrate metabolism, respiratory process and nitrogen metabolism of plants. Osmond (1967) has indicated that oxalic acid may play an osmoregulatory role in Atriplex.

3. CARBOHYDRATES :

The values for reducing sugars, total sugars, starch and carbohydrates in Nephrolepis exaltata in vegetative stage and reproductive stage are recorded in Table 6 and Fig. 4 and Fig. 5.

It is clear from the Table 6 that the

reproductive parts of plant contain more starch, total sugars and carbohydrates than the vegetative ones. However, the reducing sugar is also more in reproductive parts. Only leaflet shows less proportion of total sugars and carbohydrates in reproductive stage. The carbohydrate content in rachis is more than that in the leaflet, rhizome, stolon and roots.

The values for reducing sugars, total sugars, starch and carbohydrates in different parts of Gymnopteris contaminans in vegetative and reproductive stage are recorded in Table 7, and Fig. 6 and Fig. 7. From these tables it is clear that in the vegetative stage, Total carbohydrates are more in the rhizome and less in the sterile rachis. The sterile leaflet in the vegetative stage shows more carbohydrates than the sterile leaflet of reproductive stage. In the reproductive stage sterile rachis and sterile leaflet contain more carbohydrates than fertile rachis and leaflet. But in both the stages reducing sugars are less than the total sugars, starch and carbohydrates.

Gymnopteris contaminans in general contains more carbohydrates than that of N. exaltata.

Shetty (1971) have observed in Acrostichum aureum that the saline plants (ferns) contain more starch, total sugars, and carbohydrates than the non saline ones. However, the reducing sugar is more in non saline leaves. The carbohydrate contents in roots are more than the leaves and rachis. The distribution

of sugars and carbohydrates follow the similar trends in saline and non saline plants.

Vyas and Sharma (1988) studied reducing sugars and total carbohydrates in fourteen species of ferns collected from various places throughout Rajasthan. Similar to proteins, the amount of reducing sugars and total carbohydrates is much more in the vegetative fronds in comparison to the fertile ones. In other words, reducing sugars and total carbohydrates minimise during the production of sporangia. Amongst the types studied Adiantum incisum shoved the maximum amount of reducing sugars (16.0 mg/gm) and Asplenium pumilum, the minimum (00.2 mg/gm). There is neither any relationship between leaf morphology and reducing sugars nor with the ecological adaptations. Tectaria macrodonta which has well developed lamina possesses very little amount of reducing sugars in comparison to the dissected narrow laminated plants of Adiantum incisum. Similarly Marsilea aegyptica , a terrestrial plant has very little amount of reducing sugars while the other terrestrial plant like Actiniopteris radiata has quite high concentration of reducing sugars.

There is no relation between reducing sugars and the total carbohydrates present in different species of pteridophytes. Adiantum incisum possesses maximum amount of reducing sugars both in vegetative and fertile fronds while it has minimum total

TABLE 6

DISTRIBUTION OF CARBOHYDRATE CONTENTS IN DIFFERENT PARTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE

	Vegetative stage				Reproductive stage			
Plant parts	Reducing Sugar	Total Sugar	Starch	Total Carbohydrate	Reducing Sugar	Total Sugar	Starch	Total Carbohydrate
Root	0.01	0.11	0.58	0.69	0.01	0.16	2.30	2.46
Stolon	0.01	0.20	1.45	1.65	0.06	0.29	2.41	2.70
Rhizome	0.01	0.10	1.84	1.94	0.01	0.12	1.97	2.09
Rachis	0.10	0.23	2.02	2.25	0.23	0.94	2.17	3.11
Leaflet	0.14	0.54	0.86	1.40	0.15	0.45	0.90	1.35

The values are expressed in gm/100 gm of dry tissue.

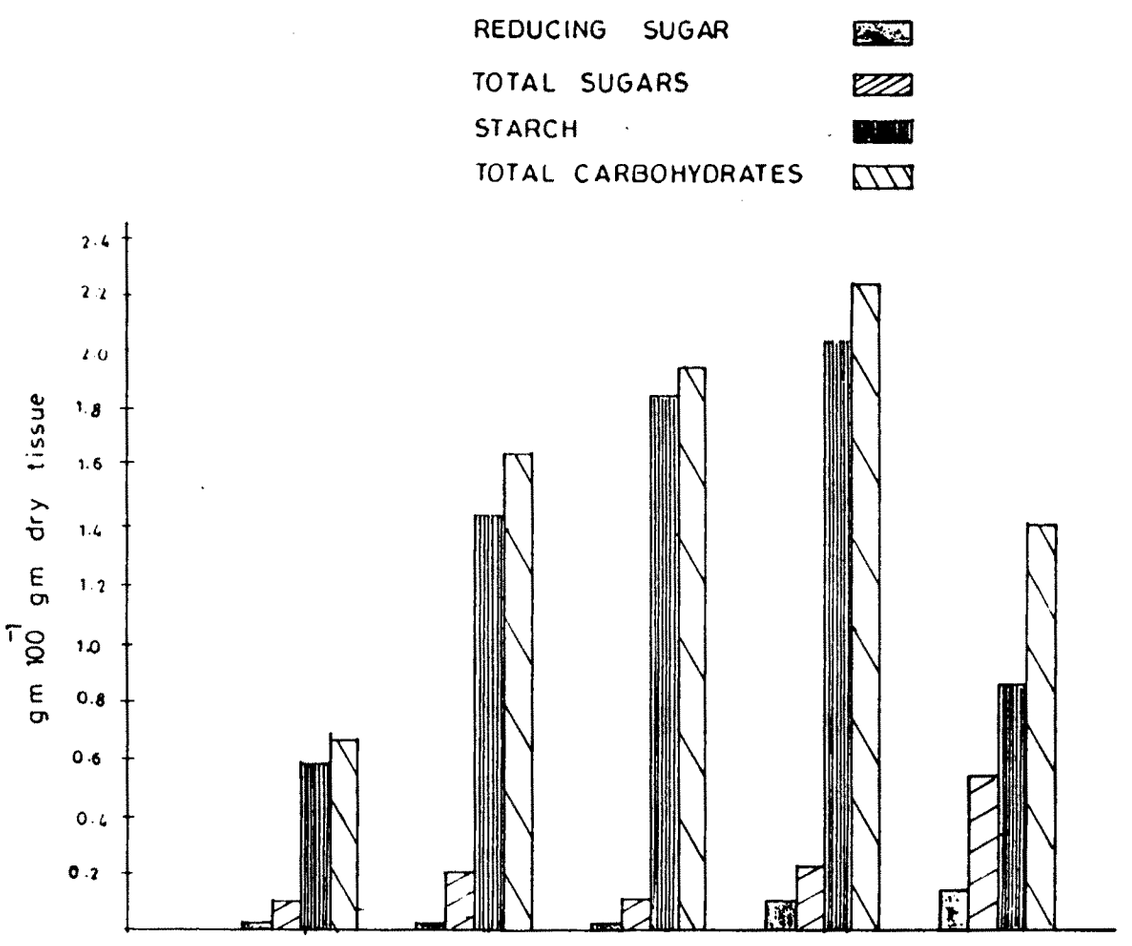

FIG. NO. 4 DISTRIBUTION OF CARBOHYDRATE CONTENTS IN DIFFERENT PARTS OF N. exaltata IN VEGETATIVE STAGE

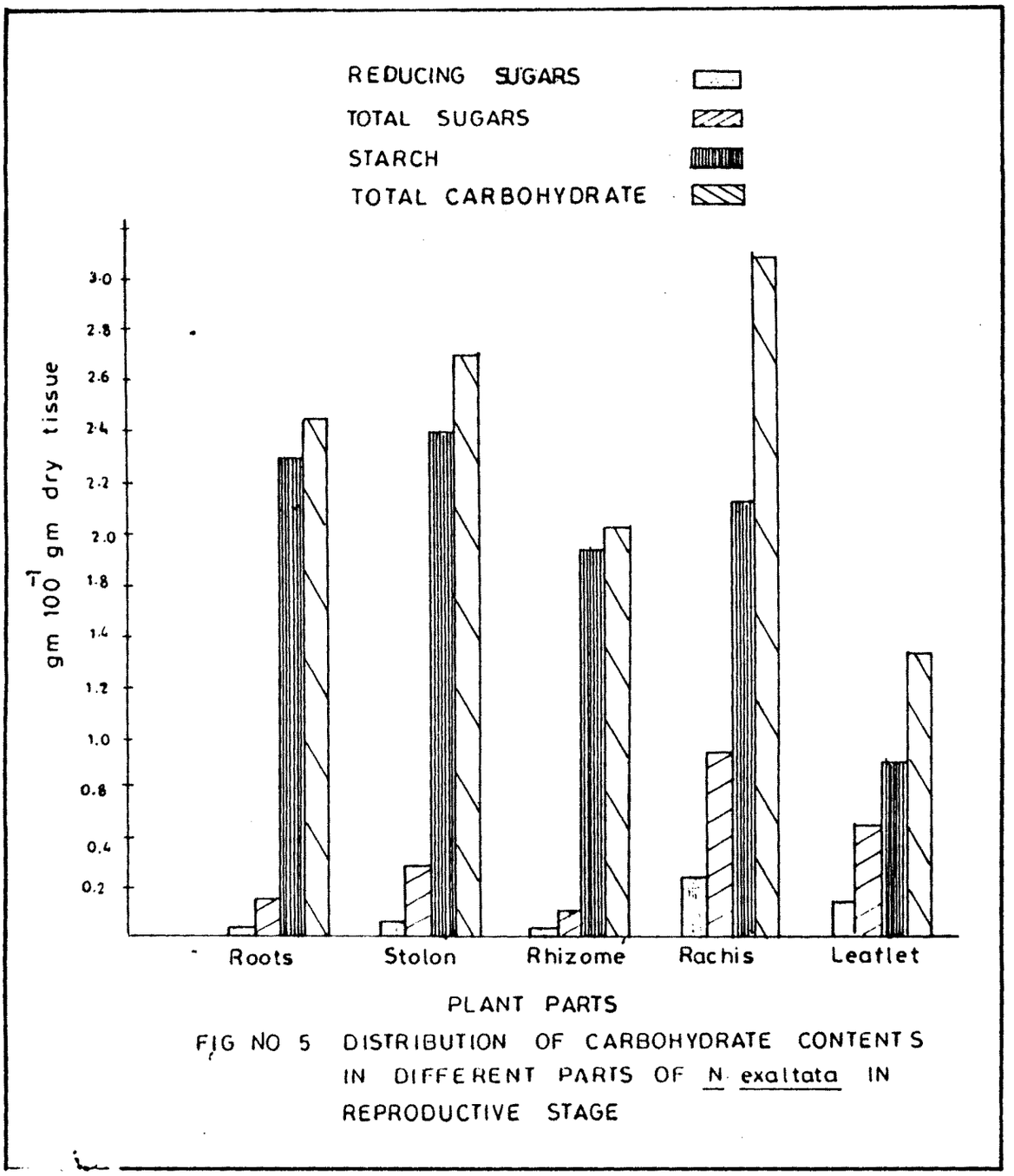

FIG NO 5 DISTRIBUTION OF CARBOHYDRATE CONTENTS IN DIFFERENT PARTS OF N. exaltata IN REPRODUCTIVE STAGE

TABLE 7

DISTRIBUTION OF CARBOHYDRATE CONTENTS IN DIFFERENT PARTS OF *Gymnopteris contaminans* Bedd. IN VEGETATIVE AND REPRODUCTIVE STAGE

	Vegetative stage				Reproductive stage			
Plant parts	Reducing Sugar	Total Sugar	Starch	Total Carbohydrate	Reducing Sugar	Total Sugar	Starch	Total Carbohydrate
Root	0.02	0.05	2.66	2.71	0.08	0.05	0.75	0.80
Rhizome	0.25	0.66	2.85	3.51	1.40	2.53	1.45	3.98
Sterile rachis	0.19	0.55	0.02	0.57	0.69	1.76	1.39	3.15
Sterile leaflet	0.20	0.42	2.47	2.89	0.45	1.12	0.45	1.57
Fertile rachis	-	-	-	-	1.25	1.68	1.18	2.86
Fertile leaflet	-	-	-	-	0.09	0.47	0.65	1.12

The values are expressed in gm/100 gm of dry tissue.

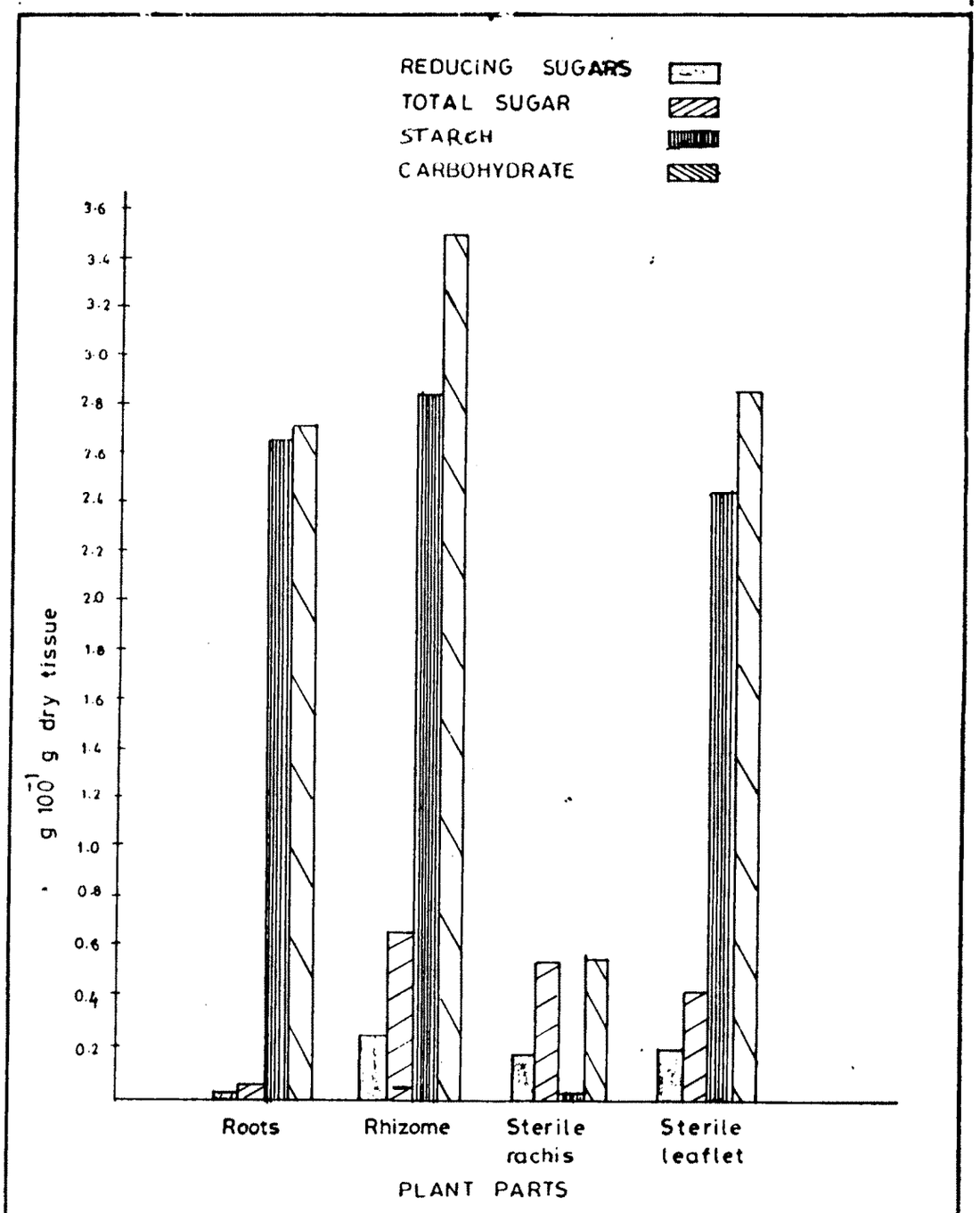

FIG. NO. 6 CARBOHYDRATE CONTENTS IN DIFFERENT PARTS OF Gymnopteris contaminans IN VEGETATIVE STAGE.

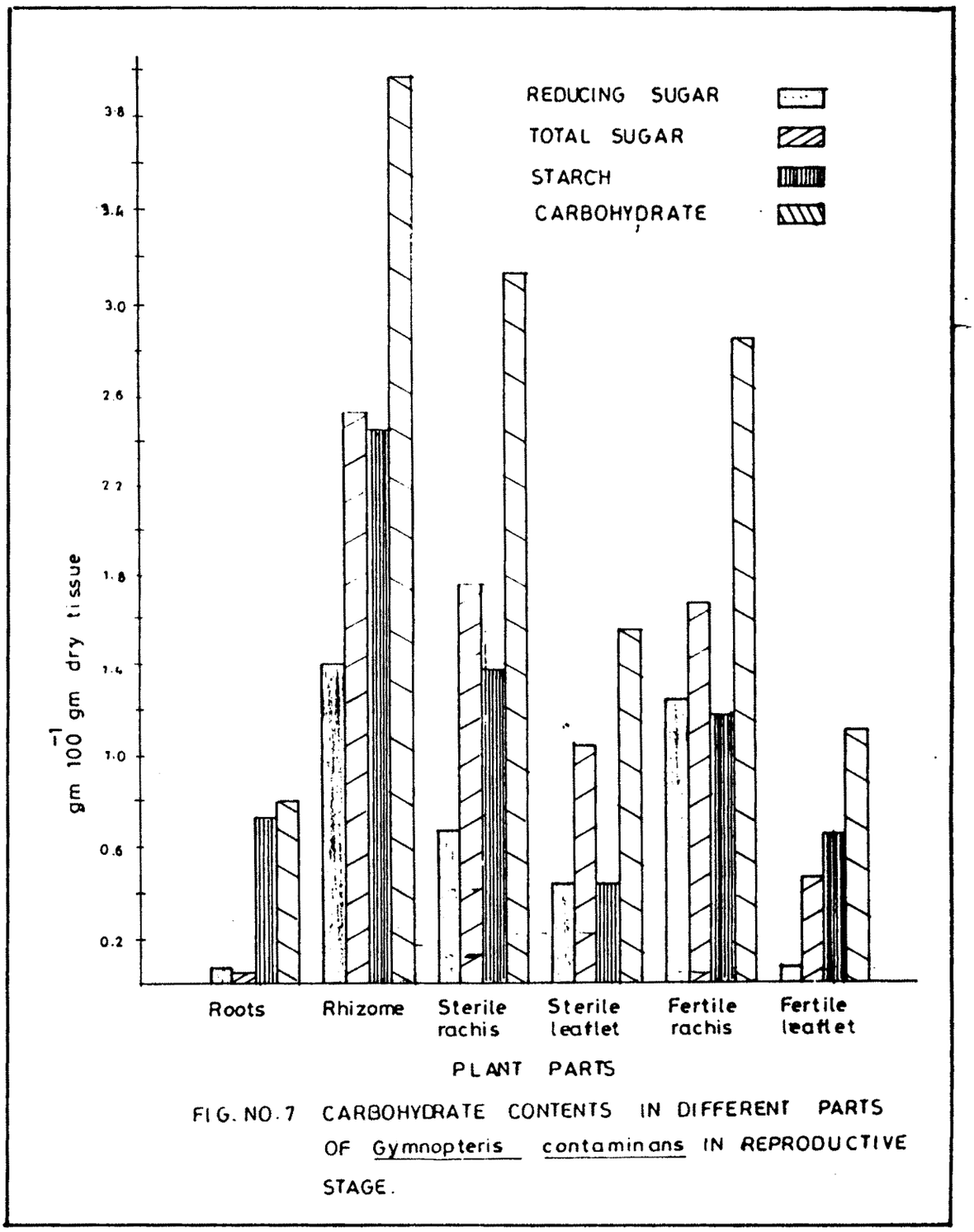

FIG. NO. 7 CARBOHYDRATE CONTENTS IN DIFFERENT PARTS OF Gymnopteris contaminans IN REPRODUCTIVE STAGE.

carbohydrates, in its sporophylls, Araiostegia pseudocystopteris possesses the maximum total carbohydrates and Asplenium pumilum the minimum.

However, soluble proteins and carbohydrates are maximum in the rhizomorph except in Isoetes reticulata and the chemicals reduce considerably in the sporophyll. In green vegetative portion of leaves carbohydrates occur in sufficient amount, on the other hand reducing sugars are maximum in green leaves and less in rhizomorph as well as in sporophyll.

Our observations are on the similar lines. During the vegetative and reproductive stage the reducing sugars are less while other sugars are more.

4. PROLINE :

Drought resistant ferns possess more concentration of proline than the aquatic or moisture loving plants. Proline influences stress probably through its effect on the degradation of chlorophylls and accumulation of carotenoids in ferns. (D. Rathore and B.D. Sharma, 1988)

Table 8 and Fig. 8 show the proline content in different parts of Nephrolepis exaltata in vegetative and reproductive stage. From the table it is clear that proline content in general is more in the vegetative stage. In vegetative stage rachis and rhizome show more concentration of proline than leaves

and roots, the stolon shows the least. In reproductive stage leaflet shows more proline than all other parts. The highest value of proline is in the leaflet 0.39 gm 100^{-1} gm of dry tissue. In Nephrolepis exaltata proline content is more in vegetative stage than reproductive stage except leaflet. In reproductive stage at the time of spore formation proline content increases in the leaflet. Kaur et al. (1986) have also observed that proline content increases during sporangia formation.

Table 9 and Fig. 9 shows the proline content in different parts of Gymnopteris contaminans Bedd. in vegetative and reproductive stage. It is evident from the table that proline content is less in the vegetative stage and it is increased in the reproductive stage. In reproductive stage proline content is increased in all parts such as roots, rhizome, sterile rachis, sterile leaflet, fertile rachis and fertile leaflet, while in vegetative stage proline content is less in all the parts.

If the proline content of Nephrolepis exaltata is compared with that of Gymnopteris contaminans controversy results are observed. Nephrolepis exaltata shows more proline in the vegetative stage while in Gymnopteris contaminans more proline is observed in the reproductive stage. This may be due to the ecological factors.

These observations are quite similar to the observations of Kaur et al. (1989) and Rathore and Sharma (1988).

Aquatic ferns and those which survive in moist shady places (non stressed) e.g. Marsilea and Asplenium, possess comparatively lesser amount of proline than those plants which grow on the exposed and dry rocks. (Stressed) e.g. Actiniopteris radiata and Adiantum incisum. Rathore and Sharma (1988) observed the drought resistant (stressed) forms have greater percentage differences between the stressed and non stressed plants than those which survive in moist and shady places. The physiological significance of proline is controversial i.e. it is a pathological consequence (Henson et al. 1977), source of solute for intercellular osmotic adjustment (Stewart and Lee 1974) or a storage compound for both nitrogen and carbon to be utilized in growth after stress (Barnett and Naylor 1966) or in other words it serves as energy donor during environment stress (Dashek and Erickson 1981). Their investigation favours 'energy donor' hypothesis and may be that proline inhibits degradation of chlorophylls and promotes the accumulation of carotenoids in ferns.

Rathore and Sharma (1988) have recorded that the proline contents are maximum at the time of maximum vegetative growth in the month of August and so also the differences between stressed and non stressed

TABLE 8

PROLINE CONTENTS IN DIFFERENT PARTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE

Plant parts	Vegetative stage	Reproductive stage
Roots	0.14	0.13
Stolon	0.15	0.14
Rhizome	0.36	0.32
Rachis	0.37	0.33
Leaflet	0.27	0.39

Values are expressed in gm/100 gm dry tissue.

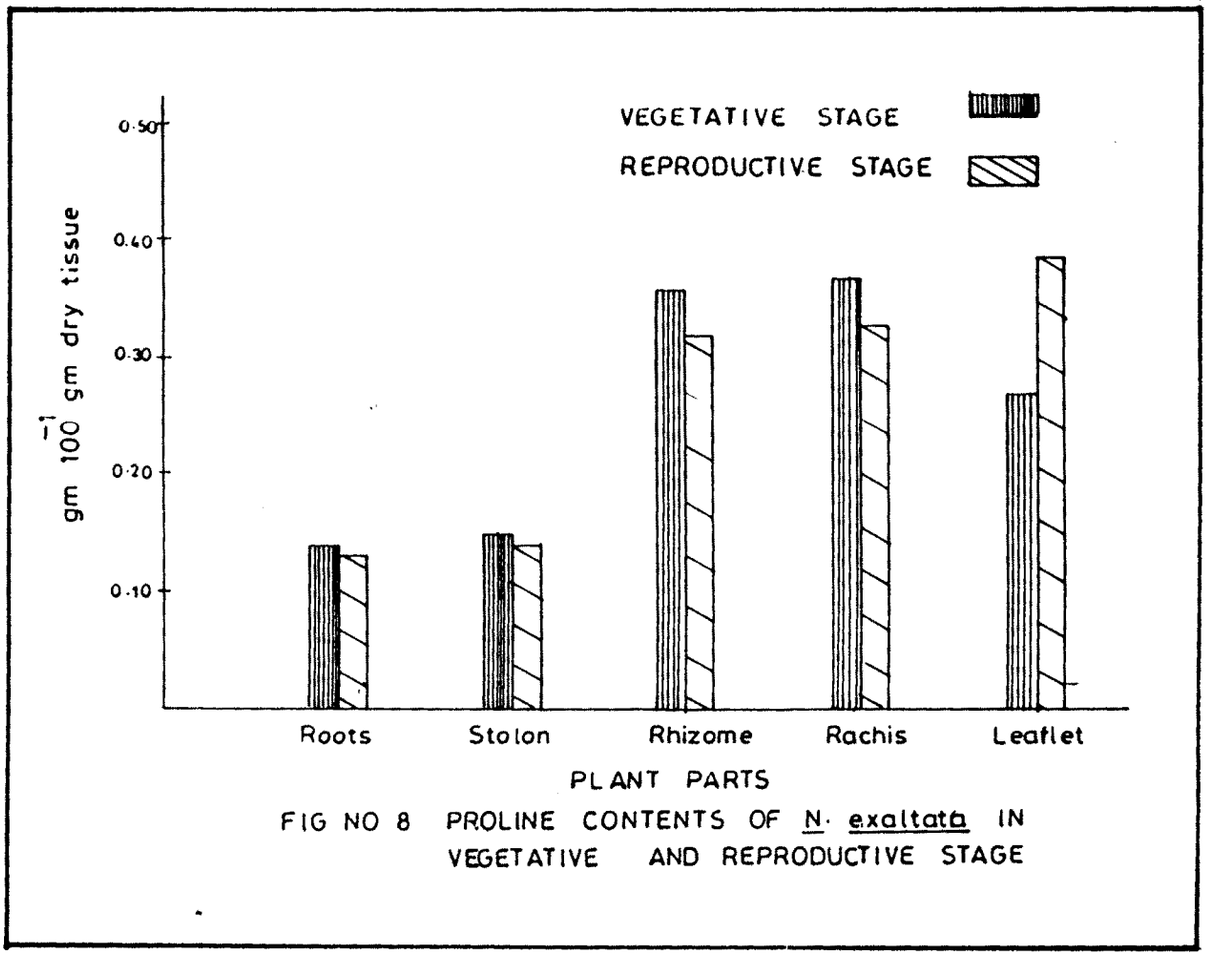

FIG NO 8 PROLINE CONTENTS OF N. exaltata IN VEGETATIVE AND REPRODUCTIVE STAGE

TABLE 9

PROLINE CONTENTS IN DIFFERENT PARTS OF *Gymnopteris contaminans* IN VEGETATIVE AND REPRODUCTIVE STAGE.

Plant parts	Vegetative stage	Reproductive stage
Roots	0.10	0.11
Rhizome	0.15	0.17
Sterile rachis	0.19	0.21
Sterile leaflet	0.27	0.32
Fertile rachis	-	0.39
Fertile leaflet	-	0.45

Values are expressed in gm/100 gm dry tissue.

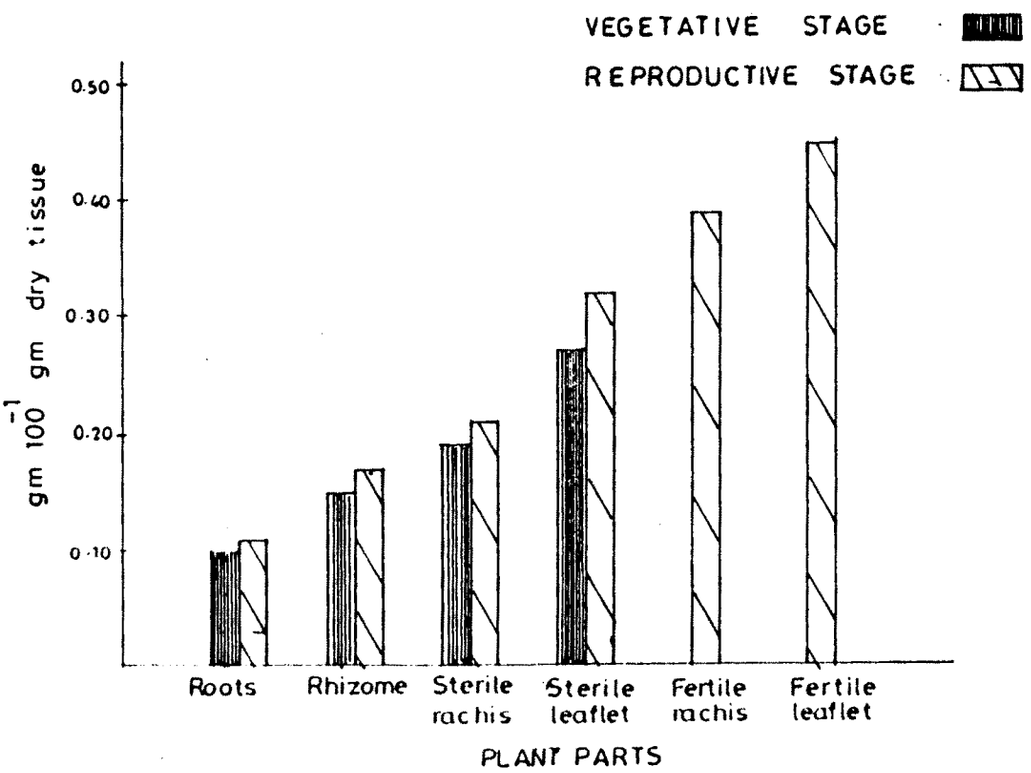

FIG. NO. 9 PROLINE CONTENTS IN Gymnopteris contaminans IN VEGETATIVE AND REPRODUCTIVE STAGE

plants. The proline contents decline in the month of September i.e. when majority of fronds in the plants become fertile. This is in contrast to the observations of Kaur et al. (1986) that proline content increases during sporangia formation but more work is required in this connection.

The amount of free proline is variable. It is maximum in moist and shade loving plants (Ophioglossum reticulatum 2.40 ug/g) and minimum in aquatic one (Marsilea minuta 1.0 ug/g). On the other hand, free proline occurs in sufficient amount in a terrestrial plant Adiantum incisum (2.14 ug/g) and minimum in a moist and shade loving plant Adiantum capillus veneris 1.1 ug /g). But free proline increases during stress and this is directly proportional to the drought resistant capacity of the plant (Bohra et al. 1979).

5. POLYPHENOLS

Polyphenols have a wide distribution in plants. They have a property of astrigency and found to have similar action as in tanning of hide into leather. Leather production was one of the oldest known crafts and it is therefore natural that the early studies of polyphenols were more from the point of their capacity to tan. The term tannin dates back to 1976 when it was first used by Seguim to denote

substances present in plant extracts which possessed the property of converting animal skin into leather. This definition implies a limitation and many examples in the literature of substances which give those reactions characteristic of polyphenols but which have no tanning action, may be excluded.

The conversion of hide into leather is carried out by affecting combination of tanning principle of the plant product with the collegen of hide. In order to have sufficient large number of attachments the tannin molecules should have a number of phenolic groups. To combine the best qualities of proper cross linking and capacity to diffuse into collegen a molecular weight of 600 to 2000 has been found to be ideal (White, 1956).

Ferns contain appreciable amount of polyphenols. In this direction, many investigators (Bohm, 1969, Bate Smith 1953, Glass and Bohm, 1968) recorded the presence of polyphenols in various ferns.

The total polyphenols in two different ferns viz. Nephrolepis exaltata and Gymnopteris contaminans in two different stages viz., vegetative stage and reproductive stage are recorded in Table 10 and Table 11 and Fig. 10 and Fig. 11.

It is clear from the Table that the distribution of polyphenols shows similar trends in these two ferns.

The polyphenol content in roots, stolon, rhizome, rachis and leaflet of Nephrolepis exaltata in both stages is recorded in Table 10 and Fig. 10. In the stolon polyphenol contents are more than root, rhizome, rachis and leaflet. Stolon shows maximum polyphenol in vegetative stage, while the leaflet and rachis contain less polyphenols. In the leaflet, root, rachis and rhizome polyphenol content is less. The polyphenol content in the reproductive stage of Nephrolepis exaltata slightly decreases in the stolon and rhizome. In the roots there is no change. The polyphenols increase in the rachis of reproductive stage. Leaflet shows more polyphenols in the reproductive stage.

In both the stages of Nephrolepis exaltata polyphenol contents are changed in all the parts except the roots. In the roots there is no change. In vegetative stage roots and rachis show similar polyphenol contents, while in reproductive stage polyphenol contents are similar in rhizome and leaflet.

Polyphenol content in Gymnopteris contaminans is recorded in Table 11 and Fig. 11.

From Table 11 it is clear that the distribution of polyphenol shows similar trends under both the stages viz., vegetative and reproductive. In the vegetative stage of Gymnopteris contaminans the rhizome contains more polyphenols while the rachis and leaflet contain least amount. However, the roots

contain appreciable amount of polyphenols. The polyphenolic content of Gymnopteris contaminans in vegetative stage ranges from 0.51 gm to 2.4 gms 100^{-1} gm of dry tissue. The roots contain 1.7 gm of polyphenols. The rhizome contains more polyphenols than the roots. It contains about 2.4 gms 100^{-1} gm of dry tissue, while the rachis shows very less polyphenol contents i.e. 0.51gms 100^{-1} gm of dry tissue. In the leaflet there is slightly higher polyphenol content than the rachis.

The polyphenolic content of Gymnopteris contaminans in reproductive stage is more than the vegetative one. The root shows maximum polyphenolic content than all other parts such as rhizome, leaflet and rachis of the sterile and fertile frond. The root contains about 3.4 gms of polyphenols in 100^{-1} gms of dry tissue while it decreases in the rhizome (1.8 gm 100^{-1} gm dry tissue). The polyphenol content in the sterile rachis is about 1.7 gm 100^{-1} gm of dry tissue and it is less in the fertile rachis. Sterile rachis contains more polyphenols than the fertile rachis. Fertile rachis contains about 1.3 gm 100^{-1} gm dry tissue, while in the reproductive stage of Gymnopteris contaminans, the polyphenolic content in the sterile leaflet and fertile leaflet is same i.e. about 1.6 gm 100^{-1} gms of dry tissue of the plants.

From the Table 11 it is clear that the polyphenols are maximum in reproductive stage than the

vegetative stage of Gymnopteris contaminans. The polyphenolic content ranges from 1.3 gm to 3.4 gms 100^{-1} gm dry tissue. However, these values range from 0.51 gm to 2.4 gms 100^{-1} of dry tissue in vegetative stage of Gymnopteris contaminans.

However, the polyphenolic contents in Gymnopteris contaminans are less than the Nephrolepis exaltata. This may be possibly due to the fact that the Gymnopteris grows in shaded area where there is less light. Nephrolepis receives much more amount of light, a factor for stimulation. From this it can be considered that the total polyphenols are more in the Nephrolepis. The accumulation of polyphenols can be attributed to various factors, of these light is the most important one. It is evident that in Isoetes coromandelina total polyphenols are maximum in green leaves and become less in rhizomorph, as well as in sporophyll. (Rathore and Sharma, 1990).

M.S. Vyas, D. Rathore and B.D. Sharma (1989) have studied the phenols in relation to stress. They found that Athyrium pectinatum, Hypodematium crenatum and Tectaria macrodonta possess sufficient amount of total phenols in their soft, green, well laminated leaves, while Equisetum ramosissimum, a leafless pteridophyte has comparatively much less amount of total phenols. It is minimum in soft, green laminated pteridophytes and in the types with reduced and coriaceous fronds. Cheilanthes farinosa is one of the

TABLE 10

POLYPHENOL CONTENTS IN DIFFERENT PARTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE

Plant parts	Vegetative stage	Reproductive stage
Roots	1.7	1.7
Stolon	3.7	2.5
Rhizome	2.9	2.6
Rachis	1.7	2.3
Leaflet	0.57	2.6

Values are expressed in gm/100 gm dry tissue.

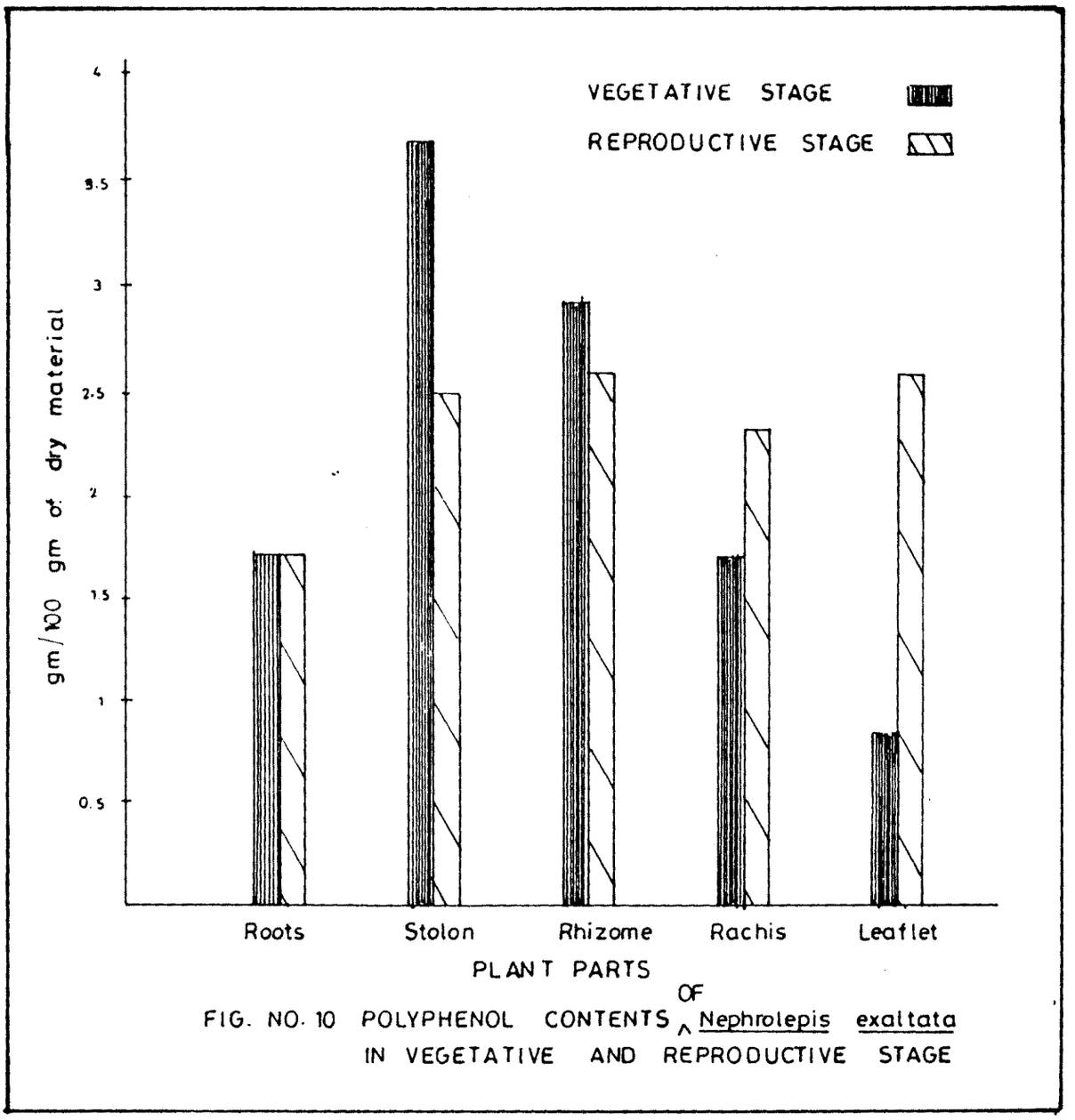

FIG. NO. 10 POLYPHENOL CONTENTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE

TABLE 11

POLYPHENOL CONTENTS IN DIFFERENT PARTS OF *Gymnopteris contaminans* IN VEGETATIVE AND REPRODUCTIVE STAGE.

Plant parts	Vegetative stage	Reproductive stage
Roots	1.70	3.40
Rhizome	2.40	1.80
Sterile rachis	0.51	1.70
Sterile leaflet	0.57	1.60
Fertile rachis	-	1.30
Fertile leaflet	-	1.60

Values are expressed in gm/100 gm dry tissue.

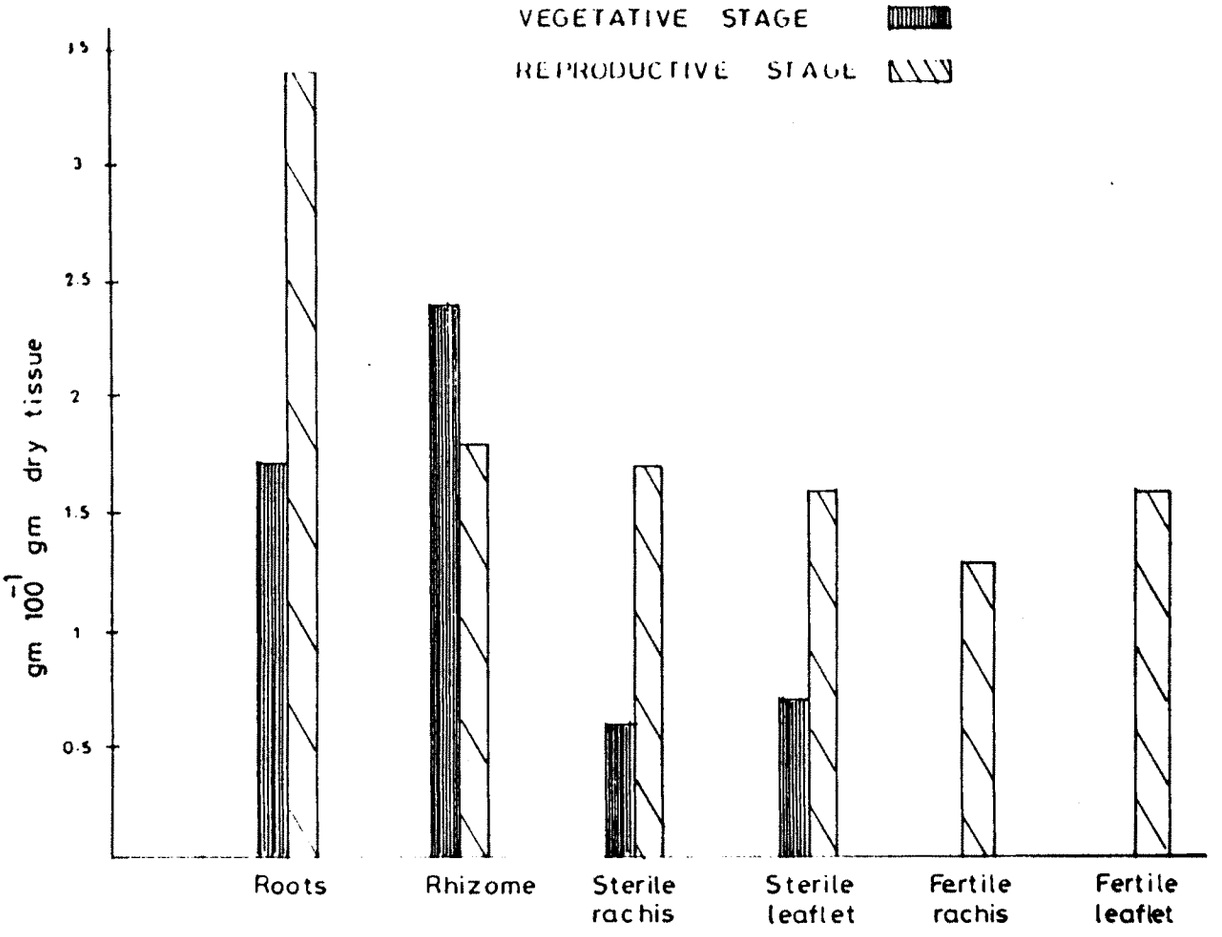

FIG. NO. 11 POLYPHENOL CONTENTS OF Gymnopteris contaminans IN VEGETATIVE AND REPRODUCTIVE STAGE

drought resistant ferns (Bohra et al. 1979, Sharma and Purohit 1985) and shows resurrection habit to some extent (Gaff 1977). Similarly, Equisetum ramosissimum is also a well known xerophytic pteridophyte (Hauke 1963). It has been concluded that increase in phenols during stress is comparatively more in drought resistant ferns than the moisture and shade loving ferns.

In ferns there are more polyphenols in roots than in the leaves and this pattern does not change even with the change in environment. Bohm (1969) who has done extensive work on polyphenols in ferns has collected data from numerous species. However, his values are mostly restricted to leaves.

Shetty (1971) studied the polyphenolic content in Acrostichum aureum. The roots contain maximum polyphenols, while the rachis contains least amount. However, the leaves contain appreciable amount of polyphenols. The non saline plant contains more polyphenols than the saline one.

6. NITROGEN METABOLISM :

A. TOTAL NITROGEN AND CRUDE PROTEIN :

The values for total nitrogen and crude protein content in different parts of Nephrolepis exaltata in vegetative and reproductive stage are recorded in Table 12 and Fig. 12 and Fig. 13.

From the Table 12 it is clear that in the roots of Nephrolepis exaltata total nitrogen content is more in vegetative stage while in reproductive stage it decreases. Similar observations are found in stolon, rhizome and rachis but it is slightly increased in the leaflet during reproductive stage. Crude protein content is also more in the roots in vegetative stage of Nephrolepis exaltata and it decreases in the reproductive stage. In vegetative stage Nitrogen contents are very less in rhizome while in reproductive stage stolon & rhizome show similar nitrogen content. In vegetative stage leaflet contains less nitrogen than the leaflet of reproductive stage. The protein contents are less in vegetative leaflet than the reproductive stage, while in roots, stolon, rhizome and rachis protein contents are more in the vegetative stage but in reproductive stage root, stolon, rhizome and rachis contain less proteins. The nitrogen and protein content is more in the vegetative parts than the reproductive parts except the leaflet.

The values for total nitrogen and crude protein content in different parts of Gymnopteris contaminans during vegetative and reproductive stage are recorded in Table 13 and Fig. 14,15. From the Table 13 it is clear that in vegetative stage sterile rachis shows more nitrogen content than roots, rhizome and sterile leaflet. The nitrogen content is less in the rhizome. In vegetative stage protein contents are

also more in the sterile rachis and rhizome shows less protein content than other parts.

In reproductive stage of Gymnopteris contaminans nitrogen and protein contents are more in fertile leaflet, and less in roots, rhizome, fertile rachis and sterile rachis. The nitrogen and protein contents are less in the sterile leaflet than the other parts. In vegetative stage of Gymnopteris contaminans nitrogen and protein contents are more in the sterile rachis, while in reproductive stage fertile leaflet shows more nitrogen and protein content.

In both the ferns studied Nephrolepis exaltata and Gymnopteris contaminans nitrogen and protein contents are more in the vegetative stage than the reproductive stage.

The vegetative fronds possess much higher concentration of protein in comparison to their fertile parts of Actiniopteris radiata, Asplenium pumilum (Vyas and Sharma, 1988)

Rathore and Sharma (1992) have recorded soluble proteins which decrease during stress, all other parameters like amino acids, proline and phenols increase. Aquatic and shade loving plants generally have more soluble proteins than terrestrial and drought resistant types. However, Actiniopteris radiata is an exception which has sufficient amount (68.5 mg/gm) and also shows maximum degradation during stress (22.3%).

TABLE 12

TOTAL NITROGEN AND CRUDE PROTEIN CONTENTS IN DIFFERENT PARTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE

Plant parts	Vegetative stage		Reproductive stage	
	Nitrogen	Protein	Nitrogen	Protein
Roots	4.25	24.22	0.12	0.71
Stolon	0.75	4.27	0.05	0.28
Rhizome	0.55	3.13	0.05	0.28
Rachis	0.60	3.42	0.15	0.85
Leaflet	1.00	5.70	1.30	7.41

Values are expressed in gm/100 gm plant material.

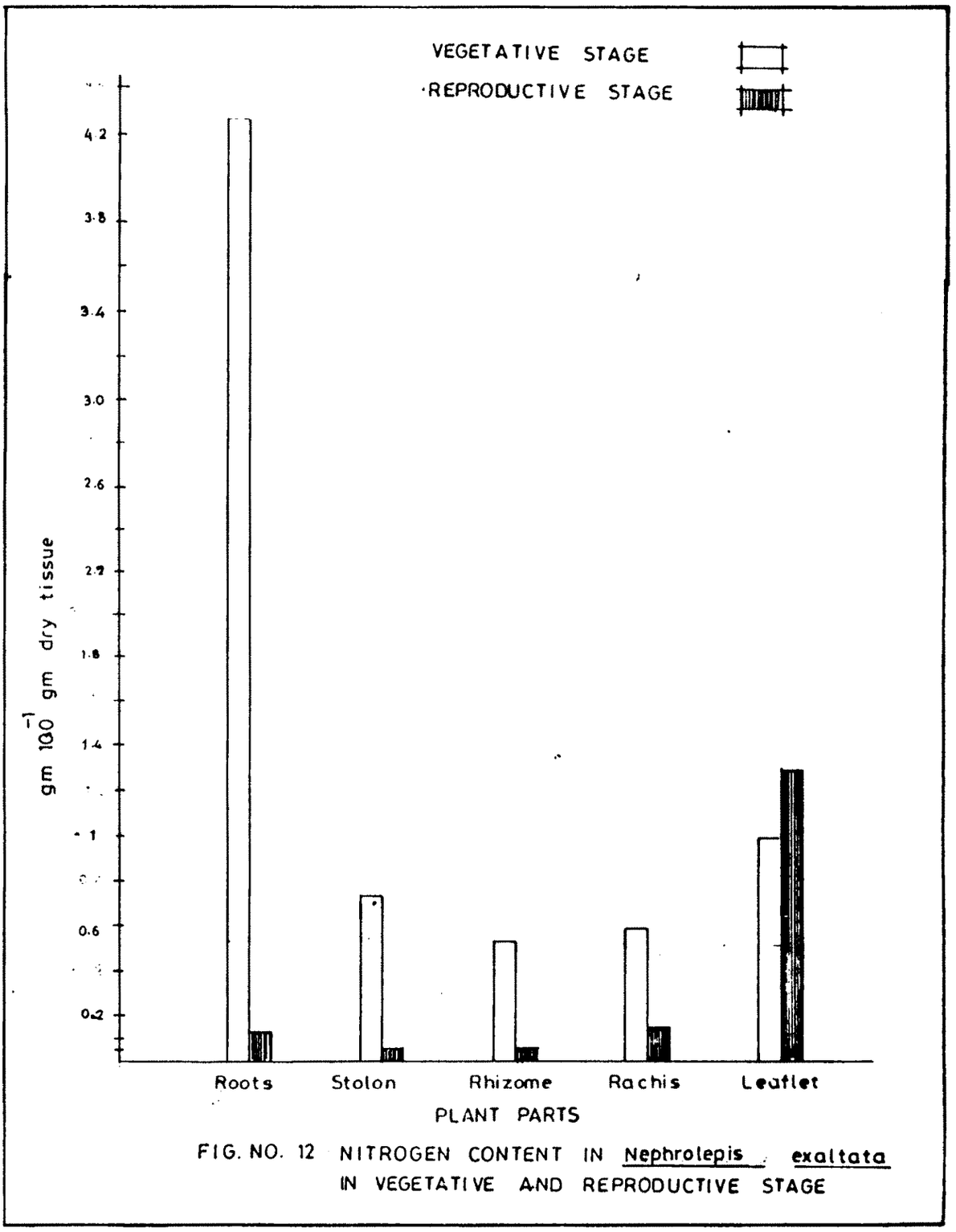

FIG. NO. 12 NITROGEN CONTENT IN Nephrolepis exaltata IN VEGETATIVE AND REPRODUCTIVE STAGE

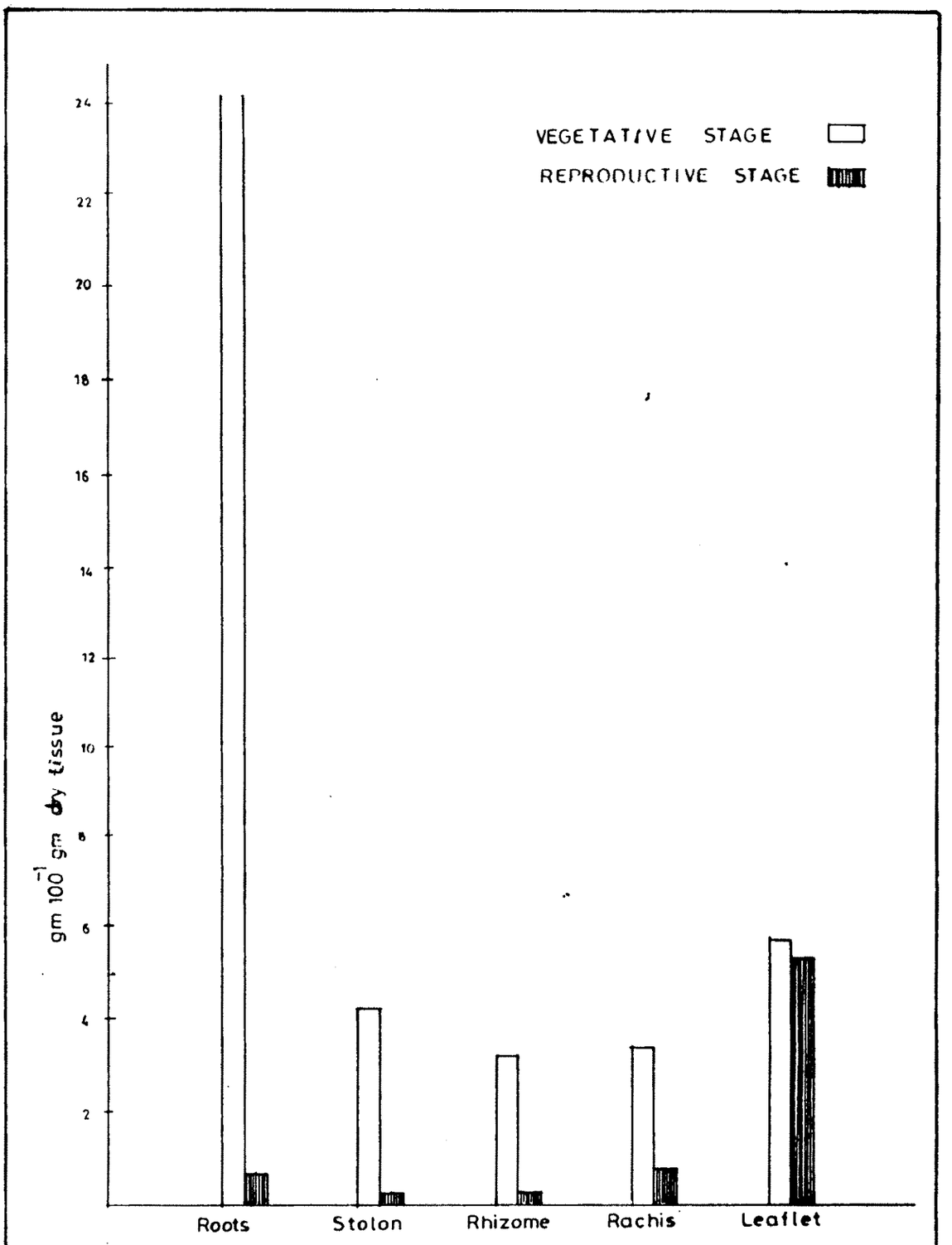

FIG. NO. 13 PROTEIN CONTENT IN Nephrolepis exaltata IN VEGETATIVE AND REPROPRCTIVE STAGE.

TABLE 13

TOTAL NITROGEN AND CRUDE PROTEIN CONTENTS IN DIFFERENT PARTS OF *Gymnopteris contaminans* IN VEGETATIVE AND REPRODUCTIVE STAGE.

Plant parts	Vegetative stage		Reproductive stage	
	Nitrogen	Protein	Nitrogen	Protein
Roots	2.10	11.97	1.60	9.12
Rhizome	1.40	7.98	1.70	9.69
Sterile rachis	3.80	21.66	2.10	11.97
Sterile leaflet	1.75	9.97	1.15	6.55
Fertile rachis	-	-	1.60	9.12
Fertile leaflet	-	-	2.20	12.54

Values are expressed in gm/100 gm plant material

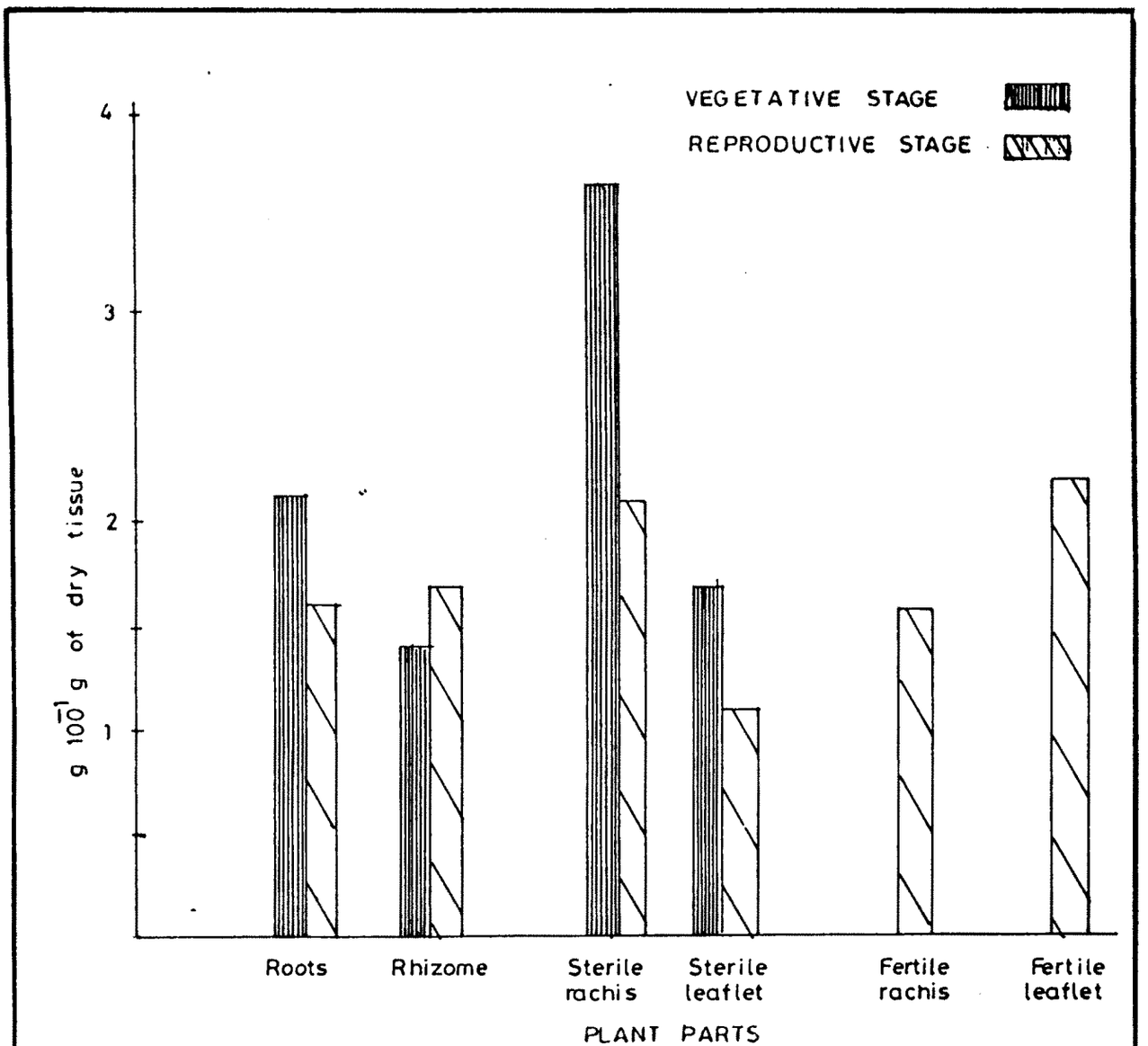

FIG. NO. 14 NITROGEN CONTENT OF Gymnopteris contaminans IN VEGETATIVE AND REPRODUCTIVE STAGE

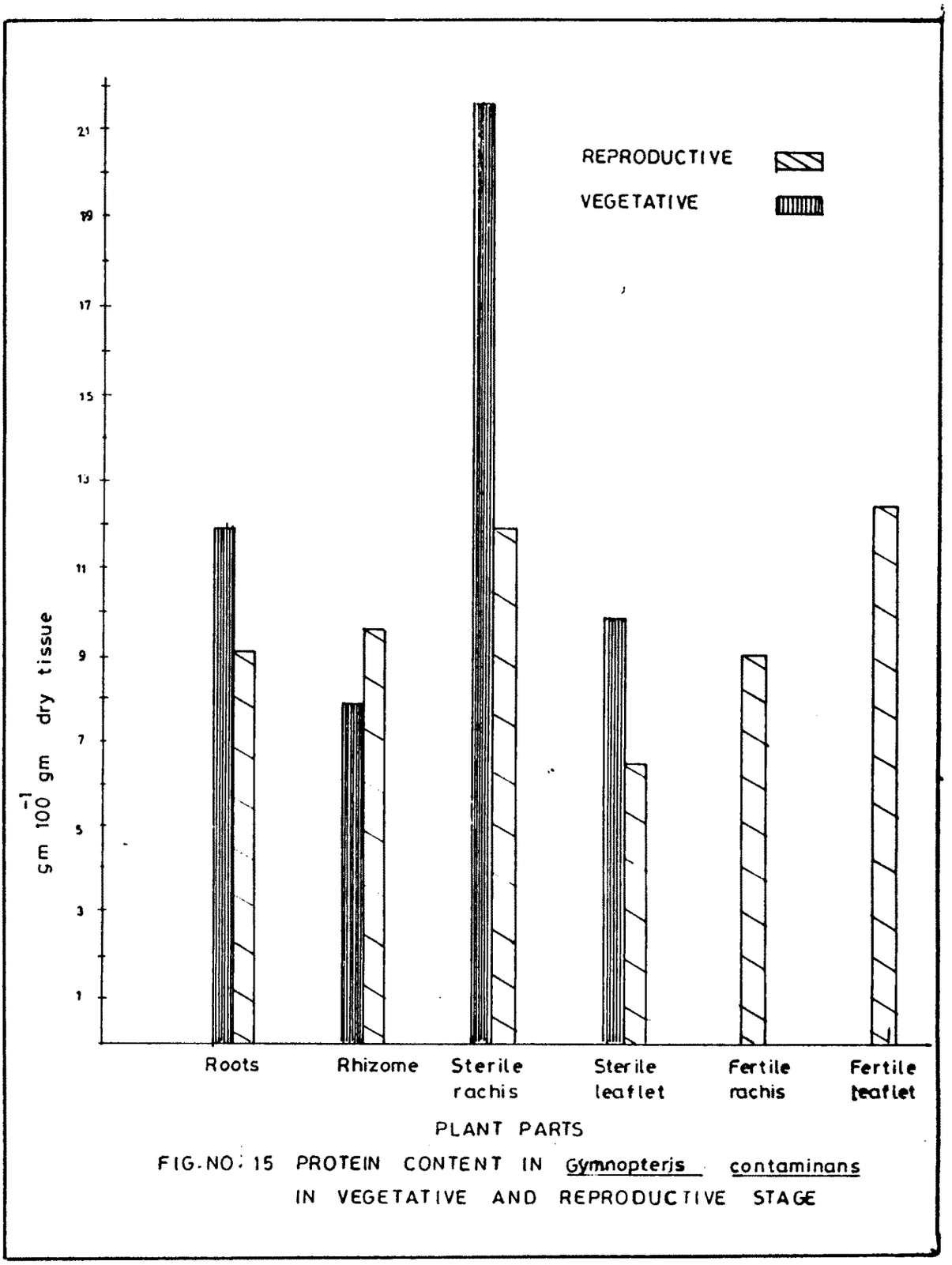

FIG.NO. 15 PROTEIN CONTENT IN Gymnopteris contaminans IN VEGETATIVE AND REPRODUCTIVE STAGE

Shetty (1971) has recorded the nitrogen content ranging from 1.12 to 8.73 gm per 100 gm dry matter in saline plants. As compared to other saline plants Acrostichum aureum contains appreciable amount of nitrogen.

B. NITRATE REDUCTASE (NR) :

Nitrate reductase was first detected by Evans and Nason (1953) in Soyabean leaves. Nitrate reductase is the key enzyme of nitrogen metabolism. It is a source of inorganic nitrogen from the soil. Nitrate uptake by the roots of the plant must be reduced to ammonia prior to its availability in the overall nitrogen economy of the plant. This important process, called nitrate reduction consists of basically two steps, the reduction of No_3^- to No_2^- and the further reduction of No_2^- to NH_3^-. The two enzymes involved in the process are nitrate reductase (NR) and nitrite reductase (NiR) (Hewitt 1975, and Beevers 1976).

Nitrate reductase is present in all parts of the plant e.g. Cotyledon, roots, shoots, leaves (Beevers and Hageman, 1969). There has been however much controversy with regard to the location of the enzyme within the cell. Losada et al., (1965) Coupe et al., (1967) are of the opinion that the NR activity is associated with the chloroplast but the general view is that the enzyme is synthesized and localised in the cytoplasm Ritenour et al. (1967) Schrader et al.(1968).

The results of nitrate reductase activity in vegetative and reproductive stage of Nephrolepis exaltata has been shown in Table 14.1 and Fig. 16.1.

It is clear from the results that the root in the vegetative stage shows higher nitrate reductase (NR) activity as compared to stolon, rhizome, rachis and leaflet.

The NR activity in the root is more during the vegetative stage than the reproductive stage, while NR activity is less in the vegetative stolon than the reproductive one. The rhizome in the vegetative stage shows more NR activity and in the rhizome of reproductive stage NR activity is not detected. The leaflet of vegetative stage shows more NR activity than the leaflet of reproductive stage. Thus NR activity is more in the vegetative stage than the reproductive one.

The results of nitrate reductase activity in vegetative and reproductive stage of Gymnopteris contaminans have been shown in Table 14.2 and Fig. 16.2

It is clear from the results that the sterile leaflet in the vegetative stage shows more NR activity than the roots, rhizome, and sterile rachis, while in the reproductive stage of Gymnopteris contaminans rhizome shows more NR activity than the sterile rachis, sterile leaflet, fertile rachis and fertile leaflet. In the roots of reproductive stage NR activity is not detected.

TABLE 14.1

NITRATE REDUCTASE ACTIVITY IN DIFFERENT PARTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE

Plant parts	Vegetative stage	Reproductive stage
Roots	128.07	102.45
Stolon	0.85	1.10
Rhizome	12.80	N.D.
Rachis	3.41	3.41
Leaflet	11.09	6.83

N.D. = Not Detected.

Values are expressed as μg NO_2/hr/gm plant material.

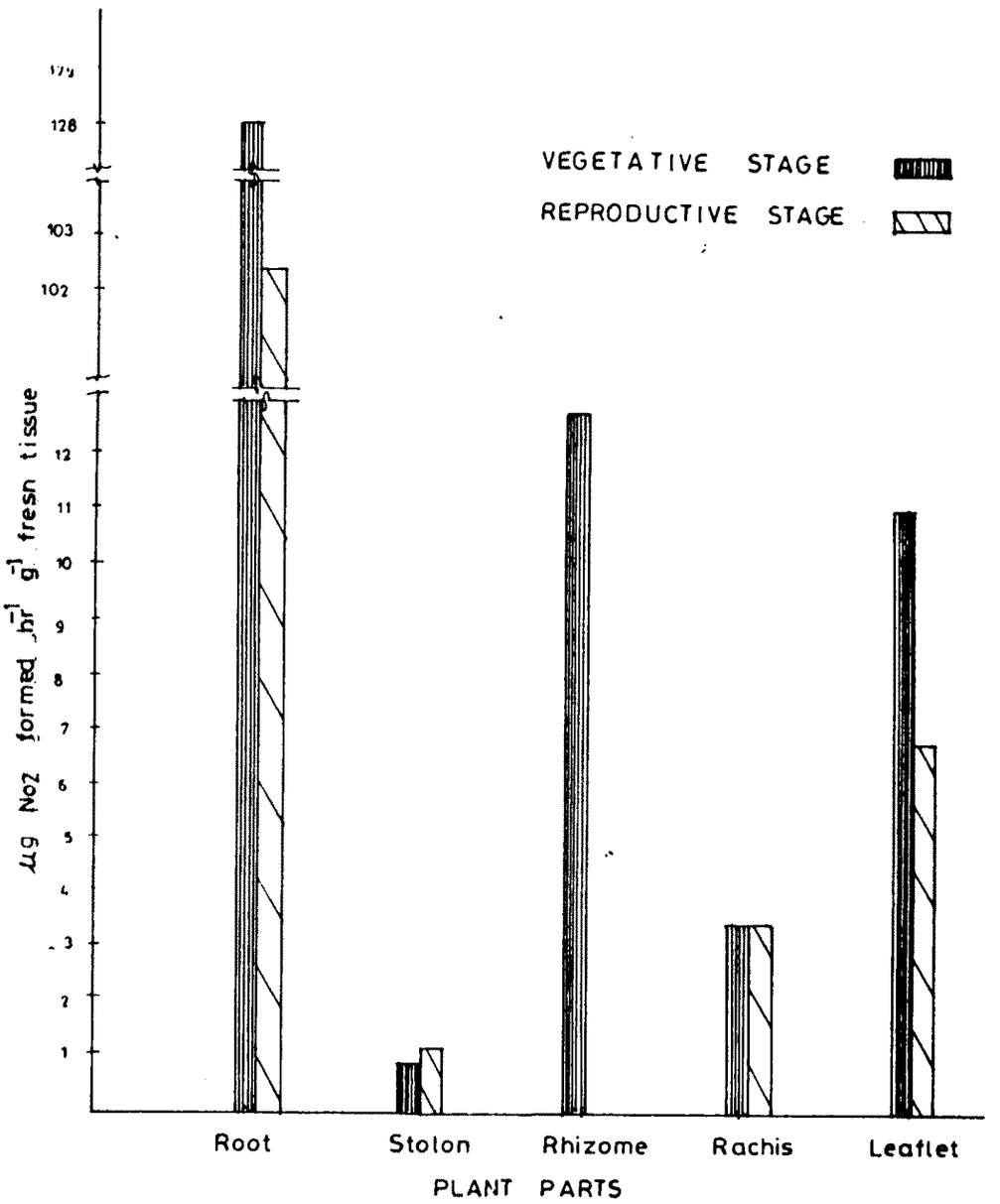

FIG. NO. 16.1 NITRATE REDUCTASE ACTIVITY IN Nephrolepis exaltata IN THE VEGETATIVE AND REPRODUCTIVE STAGE.

TABLE 14.2

NITRATE REDUCTASE ACTIVITY IN DIFFERENT PARTS OF *Gymnopteris contaminans* IN VEGETATIVE AND REPRODUCTIVE STAGE.

Plant parts	Vegetative stage	Reproductive stage
Roots	64.03	N.D.
Rhizome	27.32	35.00
Sterile rachis	1.45	0.85
Sterile leaflet	98.18	8.53
Fertile rachis	-	23.05
Fertile leaflet	-	21.34

N.D. = Not Detected.

Values are expressed as µg NO_2/hr/gm plant material.

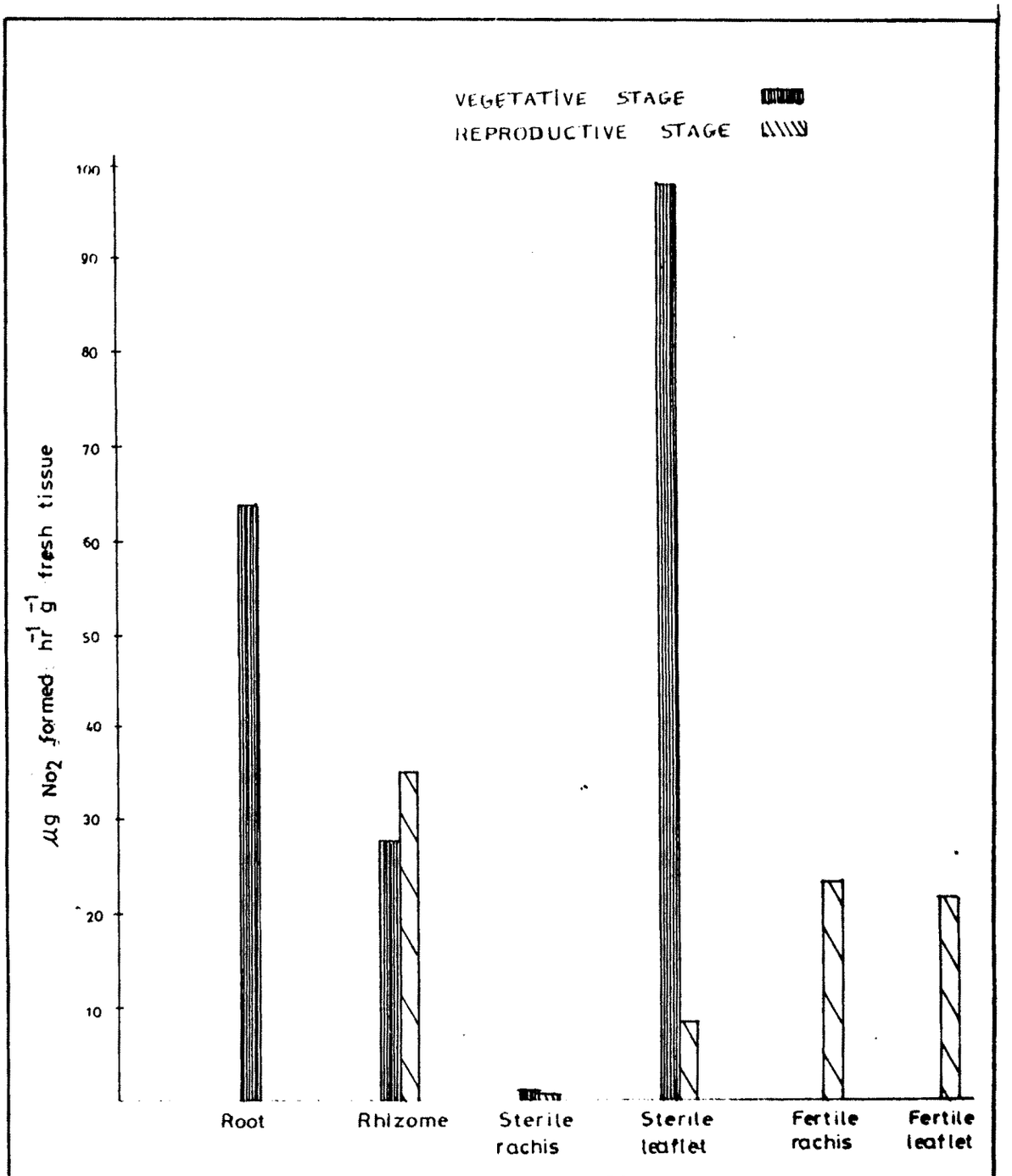

FIG. NO. 16.2 NITRATE REDUCTOSE ACTIVITY IN Gymnopteris contaminans IN THE VEGETATIVE AND REPRODUCTIVE STAGE

C. NITRITE REDUCTASE (NiR) :

The results of nitrite reductase activity in vegetative and reproductive stage of Nephrolepis exaltata has been shown in Table 15.1 and Fig. 17.1

It is clear from the results that the rhizome in the vegetative stage shows more nitrite reductase (NiR) activity as compared to roots, stolon, rachis and leaflet. In the vegetative stage leaflet shows less NiR activity than the rest of the parts. In the reproductive stage rhizome shows more nitrite reductase activity than that in the roots, stolon, rachis and leaflet. The rhizome in both the stages shows more nitrite reductase activity than other parts, while the roots, stolon and leaflet in the vegetative stage show less nitrite reductase than the roots, stolon and leaflet of reproductive stage.

The results of nitrite reductase activity in vegetative and reproductive stage of Gymnopteris contaminans have been shown in Table 15.2 and Fig. 17.2.

It is clear form the results that the rhizome in the vegetative stage shows more nitrite reductase activity than the roots, sterile rachis and sterile leaflet. In vegetative stage sterile rachis shows less activity as compared to rhizome, roots, and sterile leaflet.

TABLE 15.1

NITRITE REDUCTASE ACTIVITY IN DIFFERENT PARTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE

Plant parts	Vegetative stage	Reproductive stage
Roots	22.86	35.48
Stolon	28.38	31.54
Rhizome	47.31	39.43
Rachis	15.77	15.77
Leaflet	7.88	20.50

Values are expressed as µg Nitrite ~~reductase activity~~/gm/hr.

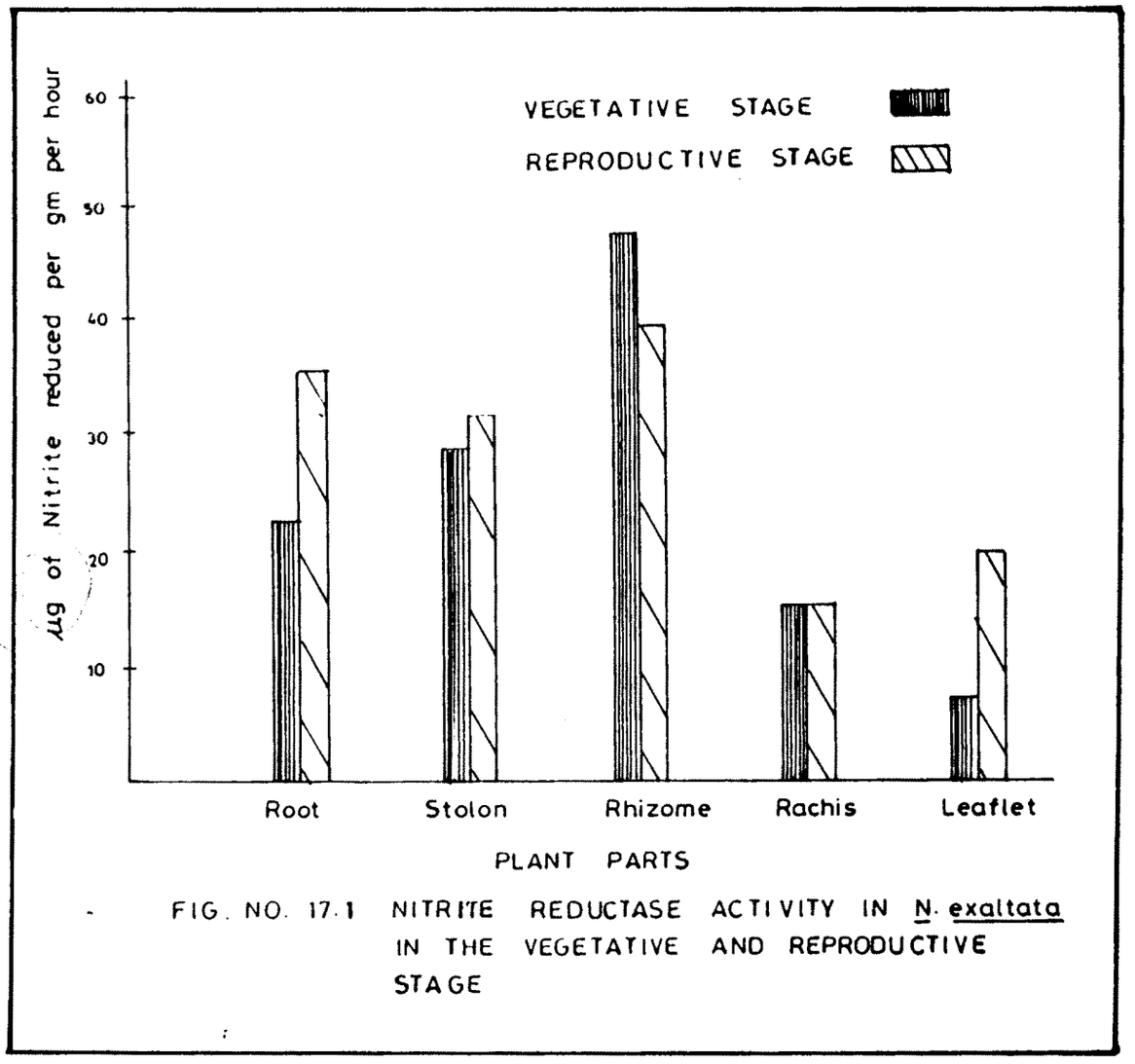

FIG. NO. 17.1 NITRITE REDUCTASE ACTIVITY IN N. exaltata IN THE VEGETATIVE AND REPRODUCTIVE STAGE

TABLE 15.2

NITRITE REDUCTASE ACTIVITY IN DIFFERENT PARTS OF *Gymnopteris contaminans* IN VEGETATIVE AND REPRODUCTIVE STAGE.

Plant parts	Vegetative stage	Reproductive stage
Roots	40.21	37.06
Rhizome	59.93	31.54
Sterile rachis	26.81	36.52
Sterile leaflet	51.25	45.73
Fertile rachis	-	53.62
Fertile leaflet	-	26.81

Values are expressed as µg Nitrite ~~reductase activity~~/gm/hr.

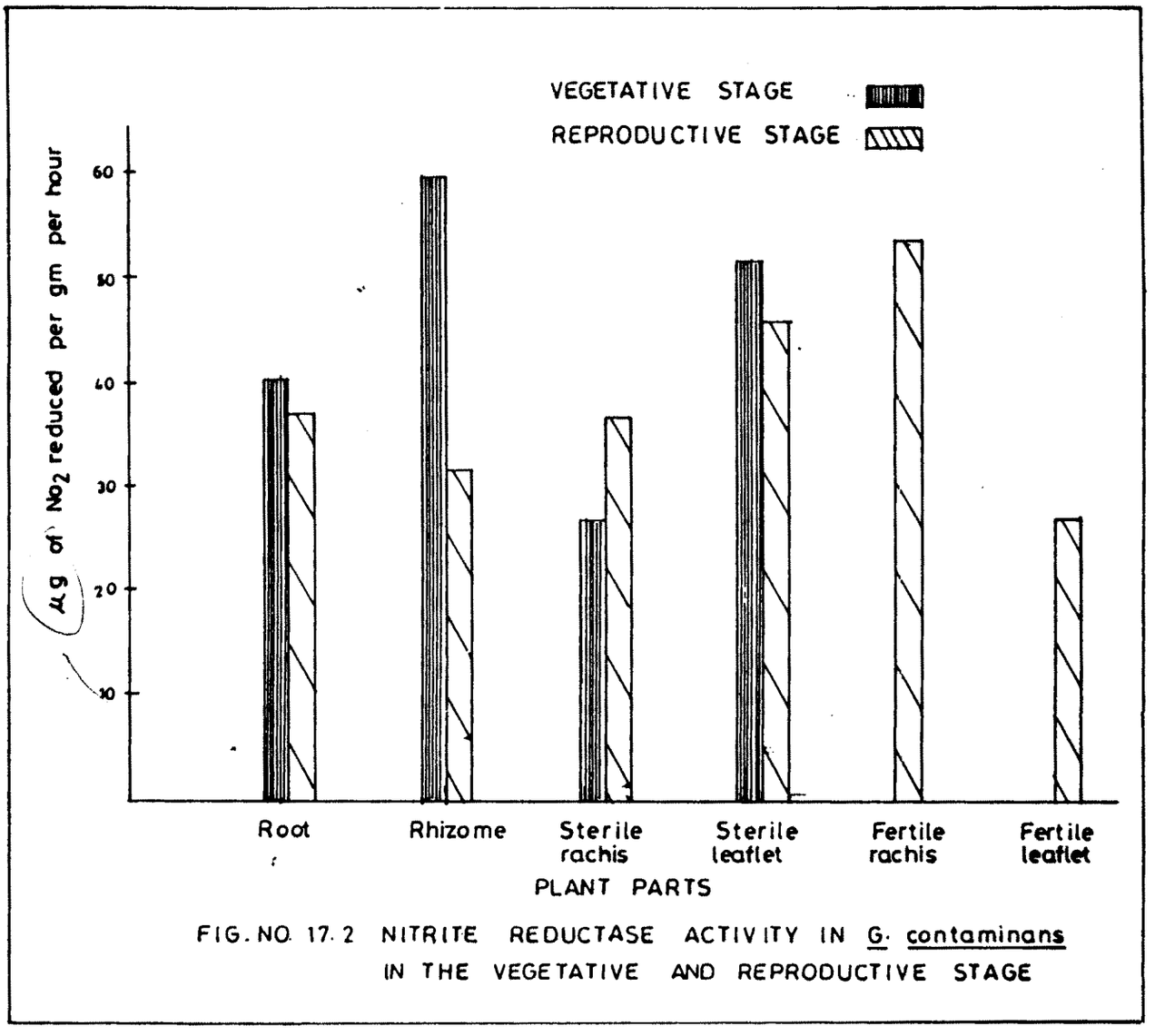

FIG. NO. 17.2 NITRITE REDUCTASE ACTIVITY IN G. contaminans IN THE VEGETATIVE AND REPRODUCTIVE STAGE

In reproductive stage fertile rachis shows more nitrite reductase activity than the roots, rhizome, sterile rachis, sterile leaflet and fertile leaflet. Fertile leaflet in reproductive stage shows very less NiR activity than the other parts.

In general, in the vegetative stage nitrite reductase activity is more than the reproductive stage.

In Nephrolepis exaltata , the leaflet during the reproductive stage shows more NiR activity than the leaflet during the vegetative stage but in Gymnopteris contaminans sterile leaflet shows more NiR activity than the fertile leaflet. This may possibly be due to the difference in their morphology and ecology.

7. INORGANIC CONSTITUENTS :

Mineral composition of Nephrolepis exaltata in different parts has been recorded in Table 16 and Fig. 18, 20, 22, 24, 26, 28, 30 and 32. Similarly, the values of different inorganic constituents of some ferns including Nephrolepis exaltata in both vegetative and reproductive stage have been recorded in Table 16 for comparison. The object of the present discussion is to record organwise distribution of each element and its presence in both stages.

a. Na^+ (SODIUM) :

Na^+ is present in large amounts on this earth. It is useful for the plants in very small quantities.

Table 16 and Fig. 18 shows the sodium values in various parts of Nephrolepis exaltata in both the vegetative and reproductive stage. It is evident from the Table that Na content of vegetative stage is less than that of reproductive stage. In vegetative stage the values range from 0.14 to 0.30 gm per 100 gm dry matter while these values in reproductive stage range from 0.22 to 0.64 gm per 100 gm dry tissue. In the vegetative stage of Nephrolepis exaltata leaflet accumulates more sodium than the root, while in reproductive stage also roots accumulate less Na^+ than the leaflet.

Na^+ accumulation increases in the reproductive stage in all parts (stolon, rachis, rhizome, leaflet) except root. In leaflet during vegetative stage Na^+ accumulation is very low (0.30 gm 100^{-1} gm of dry tissue) and it is increased during the reproductive stage (0.48 gm 100^{-1} gm of dry tissue). Na^+ accumulation is more in the rachis during reproductive stage and it is very less during vegetative stage as compared to the reproductive stage.

From the above observations it is clear that in Nephrolepis exaltata Na^+ accumulation increases in

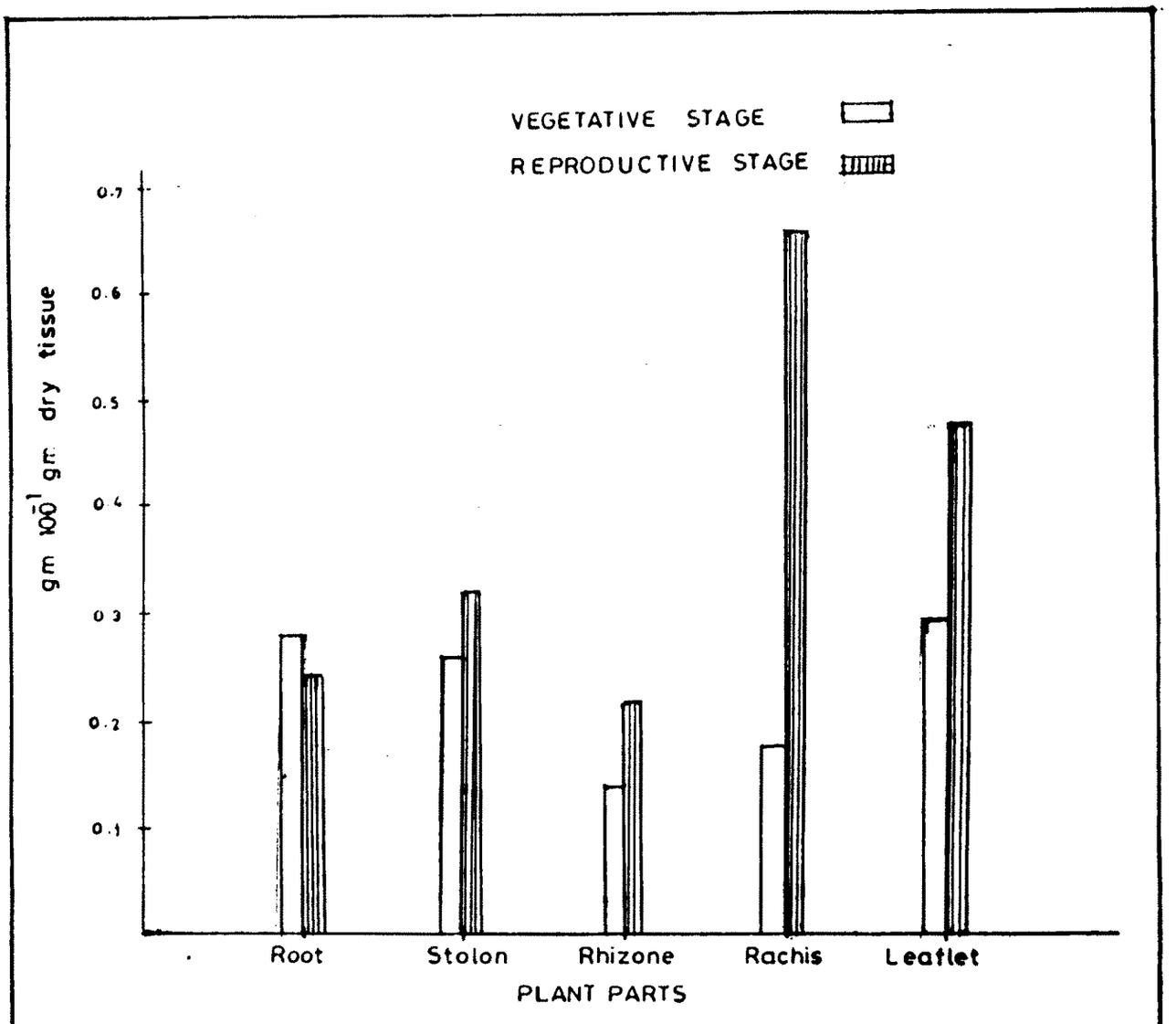

FIG. NO. 18 Na^+ CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN *N. exaltata* Schott.

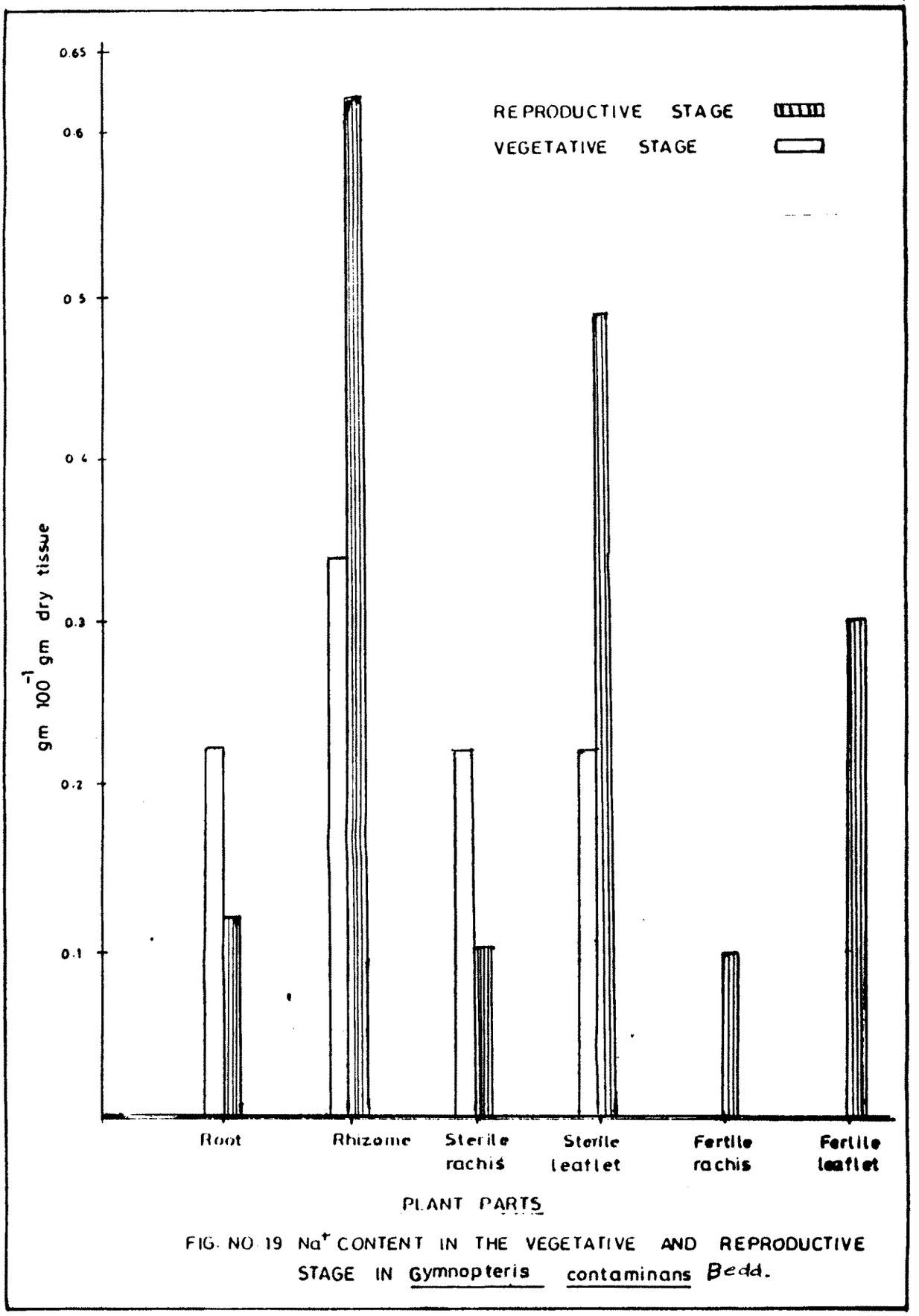

FIG. NO 19 Na^+ CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN Gymnopteris contaminans Bedd.

all other parts except the roots during the reproductive stage than the vegetative stage.

Table 17 and Fig. 19 shows Na^+ values in various parts (roots, rhizome, rachis, and leaflet) of Gymnopteris contaminans in vegetative stage and in various parts (roots, rhizome, sterile rachis, sterile leaflet, fertile rachis and fertile leaflet) in reproductive stage. It is evident from the Table that Na^+ content in vegetative stage was more or less similar in the roots, rachis and leaflet. The rhizome showed more Na^+ content in vegetative stage than that in all other parts.

During the reproductive stage of Gymnopteris contaminans rhizome and sterile leaflet showed more Na^+ accumulation than the fertile rachis and fertile leaflet. Rhizome shows maximum Na^+ content. Sterile rachis and fertile rachis shows more or less similar Na^+ accumulation.

In Gymnopteris contaminans Na^+ accumulation is more in the rhizome of vegetative and reproductive stage.

Shetty (1971) showed that Na^+ content in the rachis of A. aureum was less than the laminae and roots.

Na^+ uptake is dependent on climate and the place where the fern is growing (Shetty 1971).

b. K^+ (POTASSIUM) :

The values for K^+ in vegetative and reproductive stage of Nephrolepis exaltata are recorded in Table 16 and Fig. 20.

During the vegetative stage of Nephrolepis exaltata leaflet shows more K^+ accumulation and it is very less in the rhizome than all other parts. The highest value (2.4 %) is recorded in leaflet, while the rhizome shows the least (0.06 %). In the reproductive stage rachis shows more K^+ content and it is very less in rhizome.

In Nephrolepis exaltata K^+ content is highest in the leaflet of the vegetative stage.

Leaflet, roots and stolon of the vegetative stage accumulate more K^+ than that of the reproductive stage. More accumulation of K^+ during the reproductive stage is observed in the rachis.

Table 17 and Fig. 21 records K^+ values in different parts of Gymnopteris contaminans in vegetative and reproductive stage. In vegetative stage rachis shows more K^+ content and the roots contain the least. In the reproductive stage sterile leaflet shows more K^+ accumulation than other parts. K^+ accumulation is very less in roots during reproductive stage.

In the reproductive stage K^+ content is less in the fertile leaflet than that in the sterile leaflet.

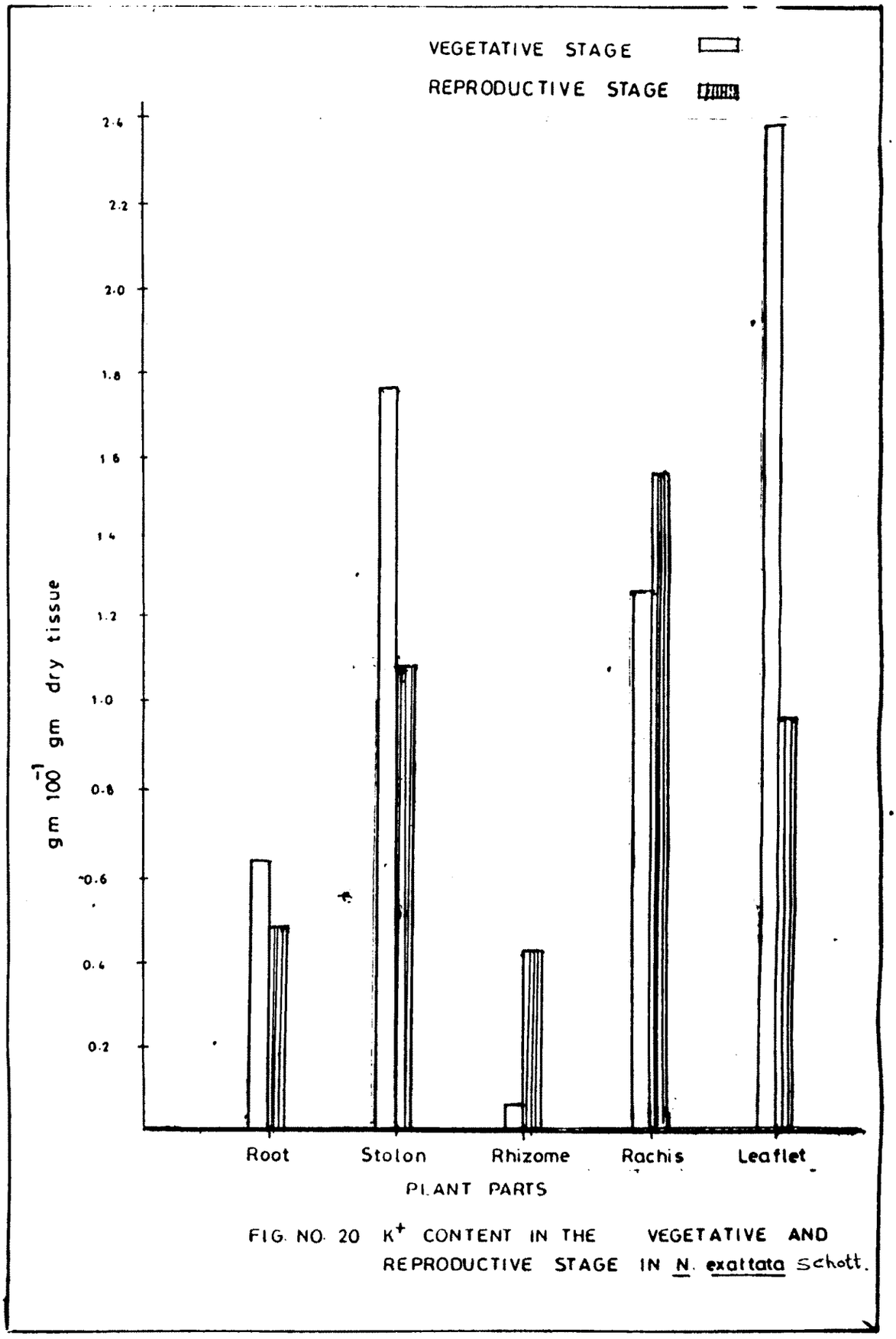

FIG. NO. 20 K^+ CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN N. exaltata Schott.

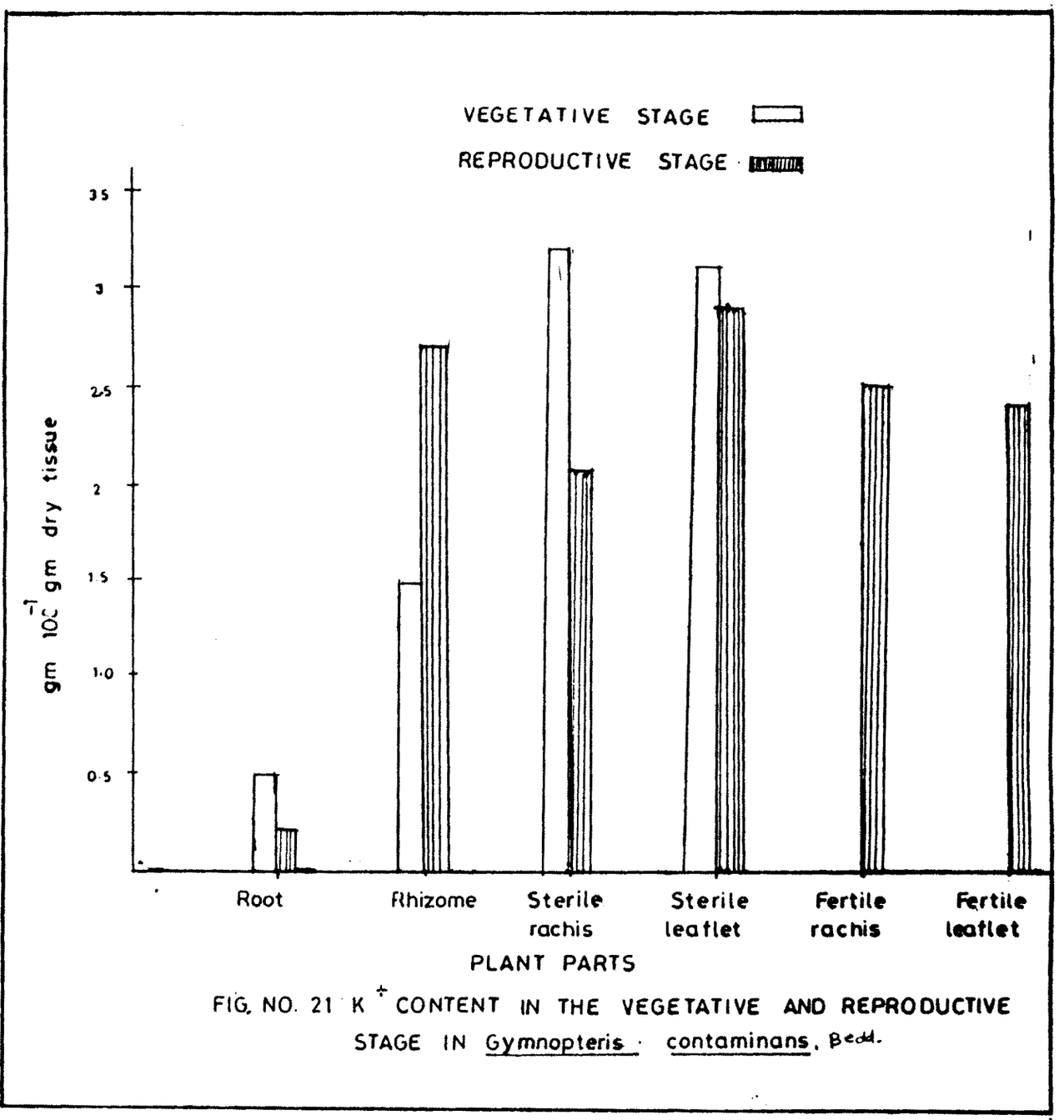

FIG. NO. 21 K^{+} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN Gymnopteris contaminans, Bedd.

Amongst the two ferns studied, the various parts except roots of both the stages of Gymnopteris contaminans show more K^+ accumulation.

K^+ uptake mechanism is of efficient type in the fern (Epstein, 1965).

Shetty (1971) from his observations on Acrostichum aureum has shown that the non saline plants contain appreciably high amounts of K^+ than that of saline ones.

c. Ca^{+2} (CALCIUM) :

The values for calcium in vegetative and reproductive stage of Nephrolepis exaltata are recorded in Table 16 and Fig. 22.

In the vegetative stage of Nephrolepis exaltata Schott. Ca^{+2} accumulation is more in the roots and very less in the rachis. The uptake of this divalent cation is more in the roots than in the leaflet. The highest value recorded was 5.58 gm 100^{-1} gm dry matter. During reproductive stage Ca^{+2} accumulation is more in the rachis. The highest value recorded was 6.44 gm 100^{-1} gm of dry tissue. Ca^{+2} accumulation is less in the root during the reproductive stage. Ca^{+2} accumulation increases in the stolon during reproductive stage than the stolon of vegetative stage. During vegetative stage Ca^{+2} accumulation was more in the roots and in reproductive

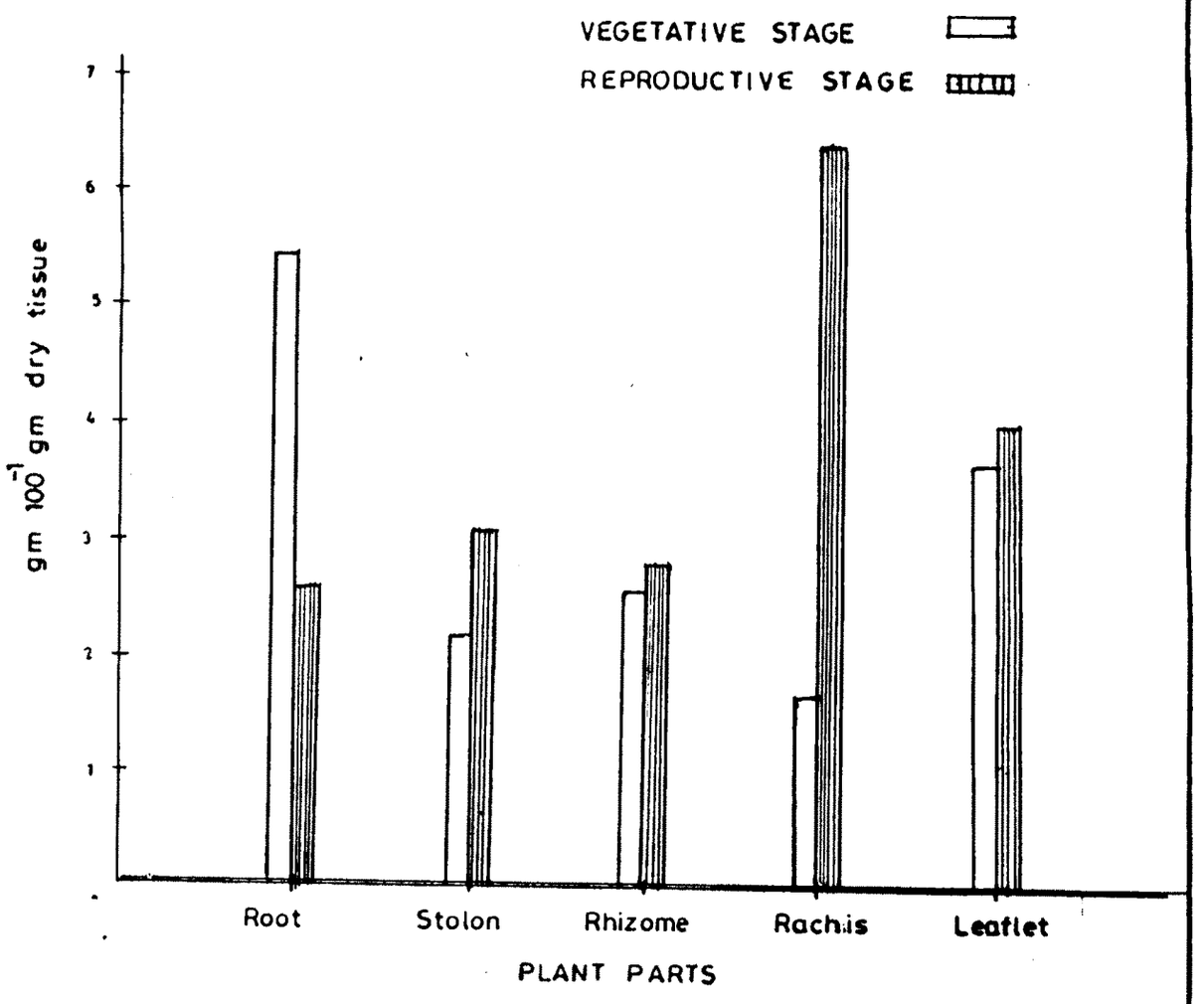

FIG. NO. 22 Ca^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN *N. exeltata* Schott.

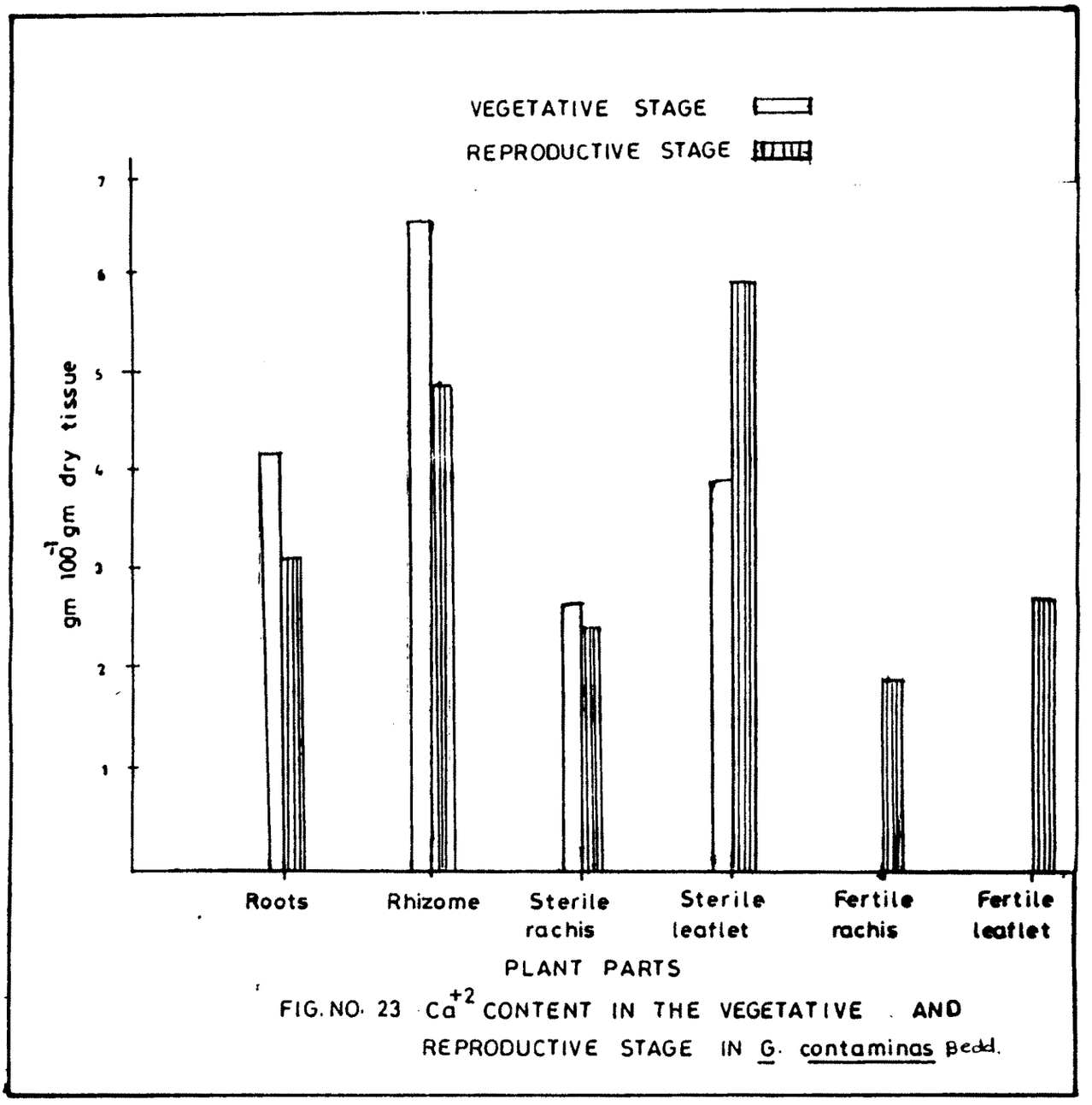

FIG. NO. 23 Ca^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN G. contaminas Bedd.

stage it was more in the rachis and less in the roots and the rhizome.

The values for Ca^{+2} accumulation in vegetative and reproductive stage of Gymnopteris contaminans Bedd. are recorded in Table 17 and Fig. 23. In the vegetative stage of Gymnopteris contaminans Bedd. calcium contents are more in rhizome. The highest value recorded is 6.68 gm 100^{-1} gm of dry matter and it is very less in rachis i.e. 2.66 gm 100^{-1} gm of dry tissue. In reproductive stage Ca^{+2} content decreases in the rhizome, rachis and roots and increases in the sterile leaflet. Ca^{+2} accumulation in the roots of vegetative stage is more and it is less in the reproductive stage. During reproductive stage sterile leaflet shows more Ca^{+2} content than all other parts. From the Table 17 and Fig. 23 it is clear that Ca^{+2} contents are more in the vegetative stage than the reproductive stage except sterile leaflet.

From this it is observed that in the reproductive stage of both the ferns studied Ca^{+2} content decreases in leaflets when they bear sporangia.

The distribution of Ca^{+2} in plants indicates that more Ca^{+2} is present in the root, next to this is in leaves (Shetty, 1971).

d. Mg^{+2} (MAGNESIUM) :

Magnesium is an important element because it is a constituent of chlorophyll. It is a major

constituent of all green plants. It is a part of chlorophyll 'a' and 'b' molecule and hence present in all autotropic plants. It is required in large number of physiological reactions where ATP is involved. Mazelis and Stumpf (1955) have found that Mg^{+2} is involved along with adenine nucleotide and a Krebs cycle intermediate, in the esterification of P^{+5} into ATP.

The values for magnesium in vegetative and reproductive stage of Nephrolepis exaltata Schott. are recorded in Table 16 and Fig. 24

It is clear from the Table 16 that the magnesium contents are in general more in the reproductive stage than the vegetative stage. The leaflet of the vegetative stage as well as of the reproductive stage shows more magnesium content. However, the leaflet of the reproductive stage contains more magnesium than that of the vegetative stage.

In the roots Mg^{+2} contents are more in vegetative stage than the reproductive stage and it increases in all other parts such as stolon, rhizome, rachis and leaflet.

There is in general an increase in Mg^{+2} accumulation in reproductive stage than the vegetative stage.

However leaflet and rachis during reproductive stage contain appreciable high amount of Mg^{+2} as compared to roots, rhizome and stolon. This

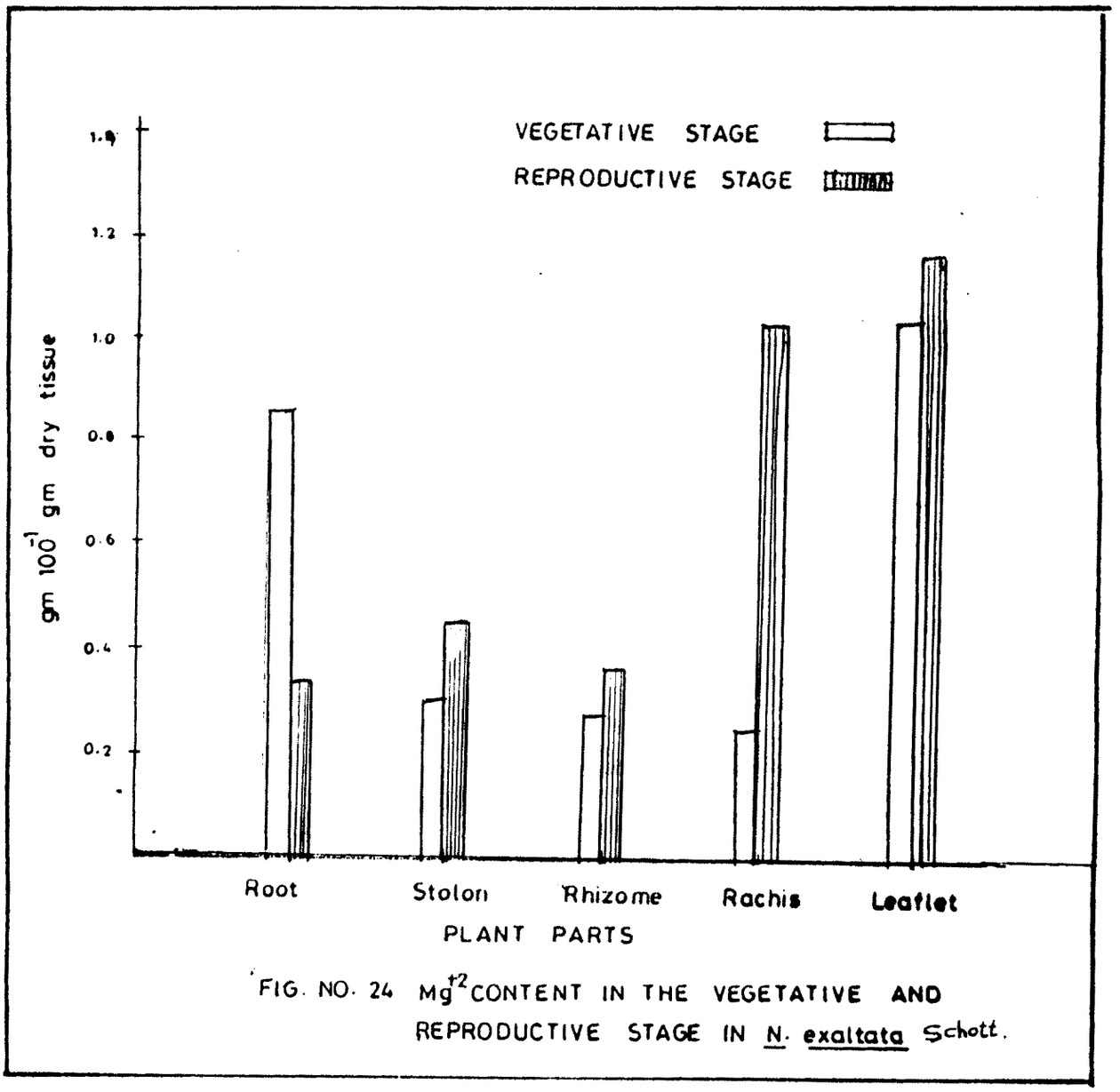

FIG. NO. 24 Mg^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN N. exaltata Schott.

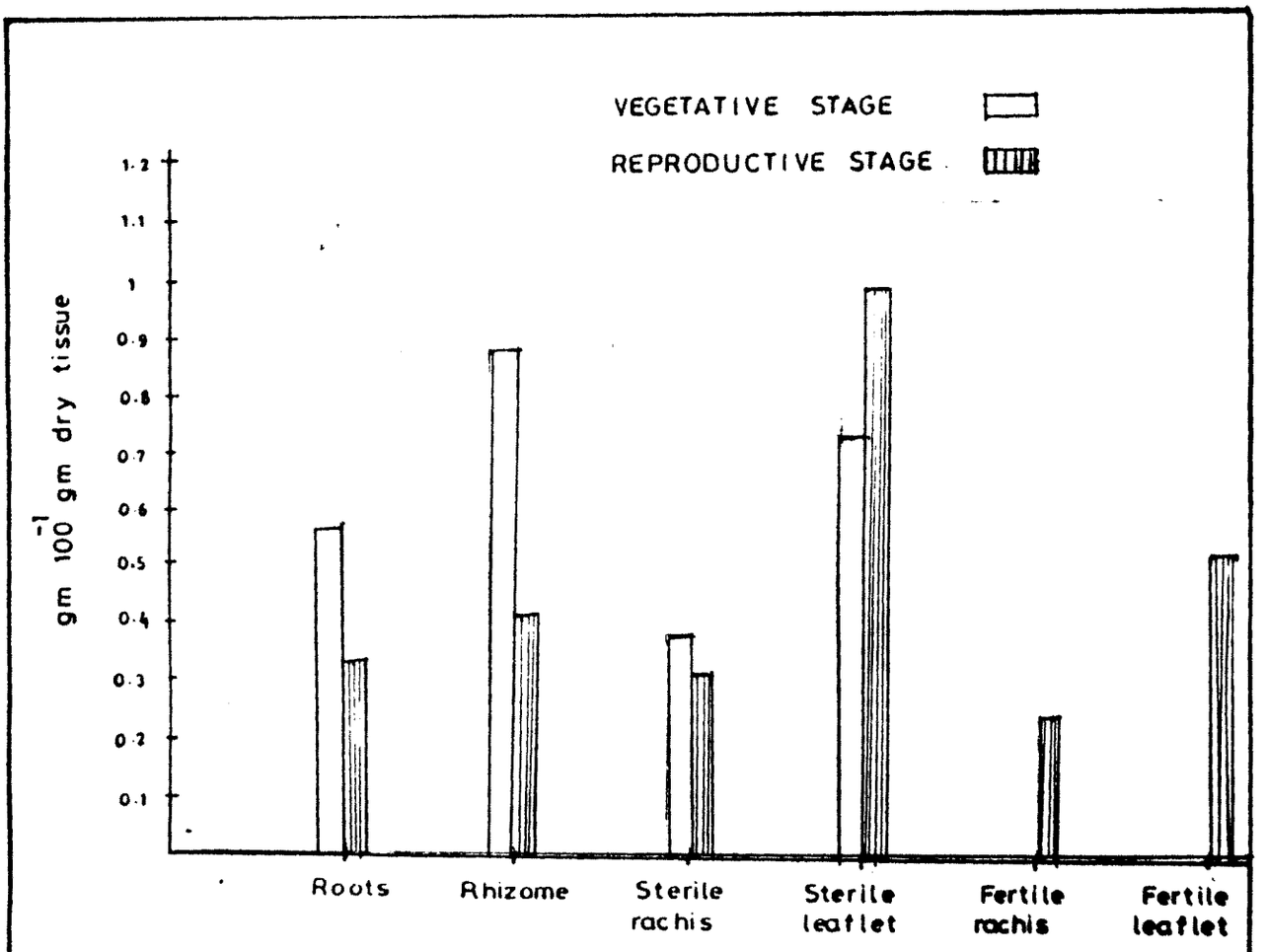

FIG. NO. 25 Mg^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN G. contaminans Gedd.

indicates that Mg^{+2} is redistributed in plants. It appears that the absorbed Mg^{+2} is rapidly transported to leaflets where it is more essential. The reproductive stage contains large amount of Mg^{+2}.

The values for Mg^{+2} in vegetative and reproductive stage of Gymnopteris contaminans Bedd. are recorded in Table 17 and Fig. 25.

It is observed from the Table that the Mg^{+2} contents are more in sterile leaflet during the reproductive stage than the leaflet of vegetative stage. Mg^{+2} content is more in the parts such as roots, rhizome and leaflets in vegetative stage and it is maximum in the sterile leaflet during the reproductive stage.

The roots of the vegetative stage accumulate more magnesium than the roots of reproductive stage. Mg^{+2} content is less in leaflet of vegetative stage and it increases in sterile leaflet during the reproductive stage but decreases in fertile leaflet of the same stage.

From the studies of both these ferns, it is observed that the Mg^{+2} content is more in the reproductive stage of Nephrolepis exaltata Schott. than that of Gymnopteris contaminans Bedd.

Shetty (1971) has studied the Mg^{+2} contents of Acrostichum aureum in saline and non saline conditions. Non saline plants contain more Mg^{+2} than saline plants. The leaves contain more Mg^{+2} than

rachis and roots. This indicates that Mg^{+2} is redistributed in plants. It appears in the brackish fern that absorbed Mg^{+2} is rapidly transported to the leaves where it is more essential. The nonsaline leaves contain large amount of Mg^{+2}.

e. Fe^{+3} (IRON) :

Iron is an important element which is required in microquantity for the growth of plants. Fe^{+3} is active in ferrous state in plants. Usually Fe^{+3} is absorbed in ferric form but it is rapidly converted into the ferrous form. Fe^{+3} occurs in living cells in the form of porphyrins.

The values for Fe^{+3} contents in the Nephrolepis exaltata Schott. are recorded in Table 16 and Fig. 26.

It is observed from the Table that in vegetative stage of Nephrolepis exaltata Schott. the root shows more iron content than stolon, rhizome, rachis and leaflet. In reproductive stage the stolon shows more Fe^{+3} content than the other parts, but it is very less than the roots of vegetative stage. IN vegetative stage Nephrolepis exaltata Schott. root shows maximum Fe^{+3} content. It is 0.42 gm 100^{-1} gm of dry tissue. Vegetative leaflet contains more iron than reproductive leaflet.

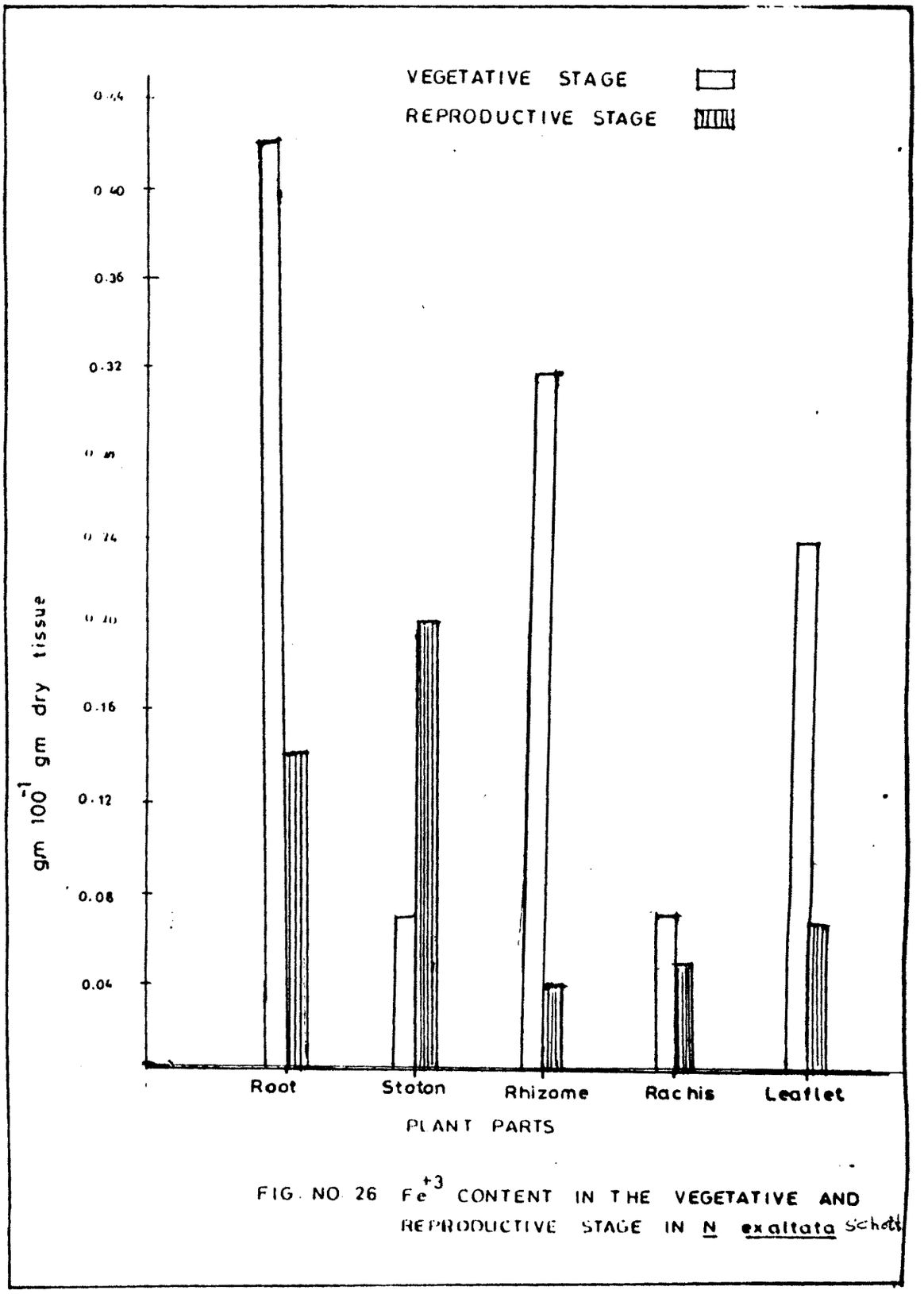

FIG. NO. 26 Fe^{+3} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN N exaltata Schott

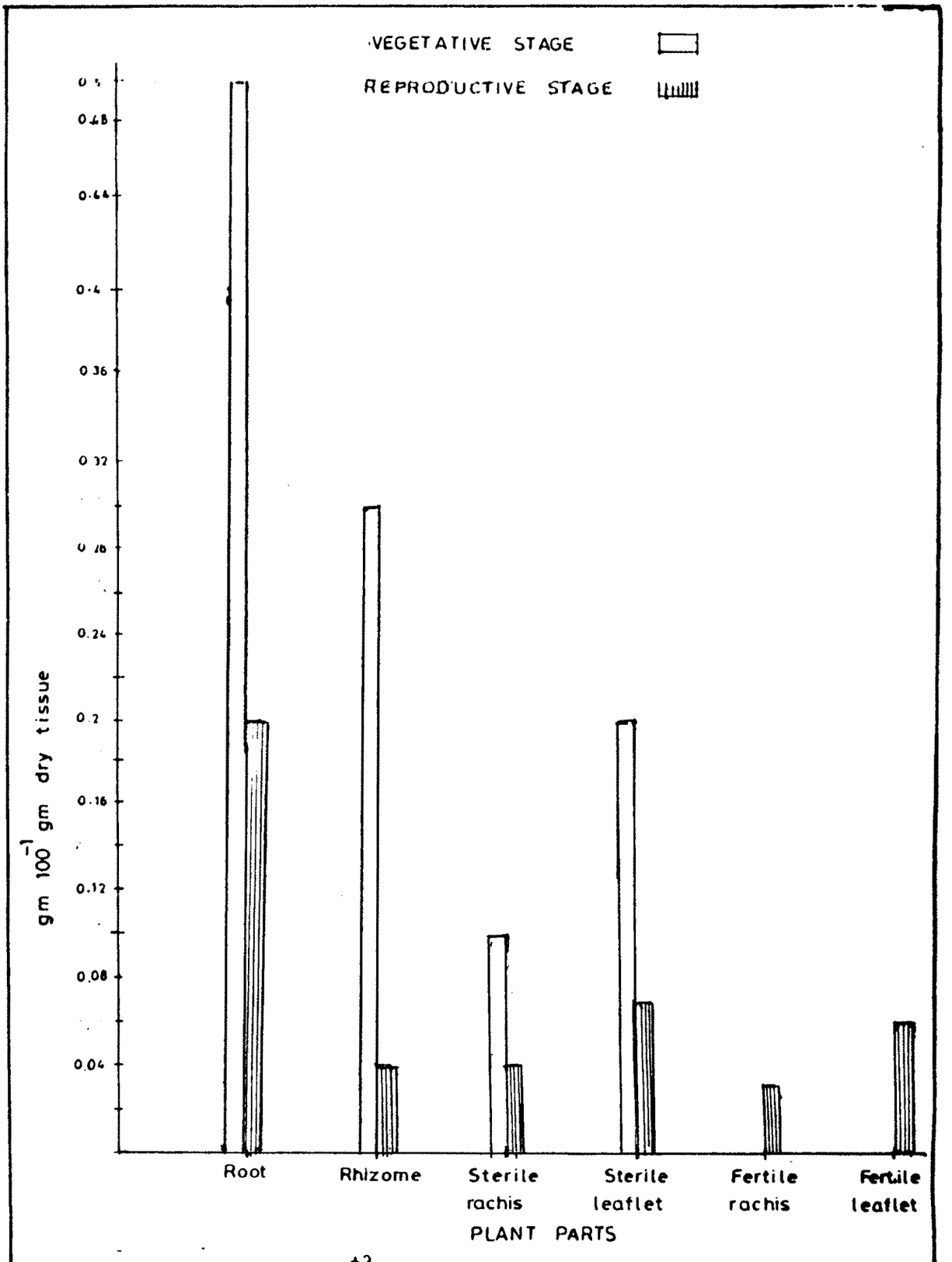

FIG. NO. 27 Fe^{+3} CONTENT IN VEGETATIVE AND REPRODUCTIVE STAGE IN G. contaminans Bedd.

From the above observation, it is clear that in Nephrolepis exaltata Schott. iron content is more in the roots.

The Table 17 and Fig. 27 shows the Fe^{+3} content during the vegetative and reproductive stage of Gymnopteris contaminans Bedd.. The roots show more Fe^{+3} content in both the stages. The roots of the vegetative stage contain more iron than the roots of the reproductive stage. Accumulation of Fe^{+3} is maximum in roots than rhizome, rachis and leaflet in both the stages.

In Gymnopteris contaminans Bedd. , iron content is maximum during the vegetative stage than the reproductive stage.

Fe^{+3} contents are more in the fern than other plants (Shetty, 1971). According to him the roots of Acrostichum aureum contain more Fe^{+3} while the leaf contains less. Singh (1967) and Karmarkar (1965) indicate that Fe^{+3} is one of the most immobile of all the elements in plants. Leaf gets very less amount of Fe^{+3} because of its immobility.

f. Mn^{+2} (MANGANESE) :

Mn^{+2} is an important micronutrient which plays an important role in many enzymatic reactions as a co-factor.

Uptake and distribution of Mn^{+2} in different parts of Nephrolepis exaltata Schott. in vegetative and

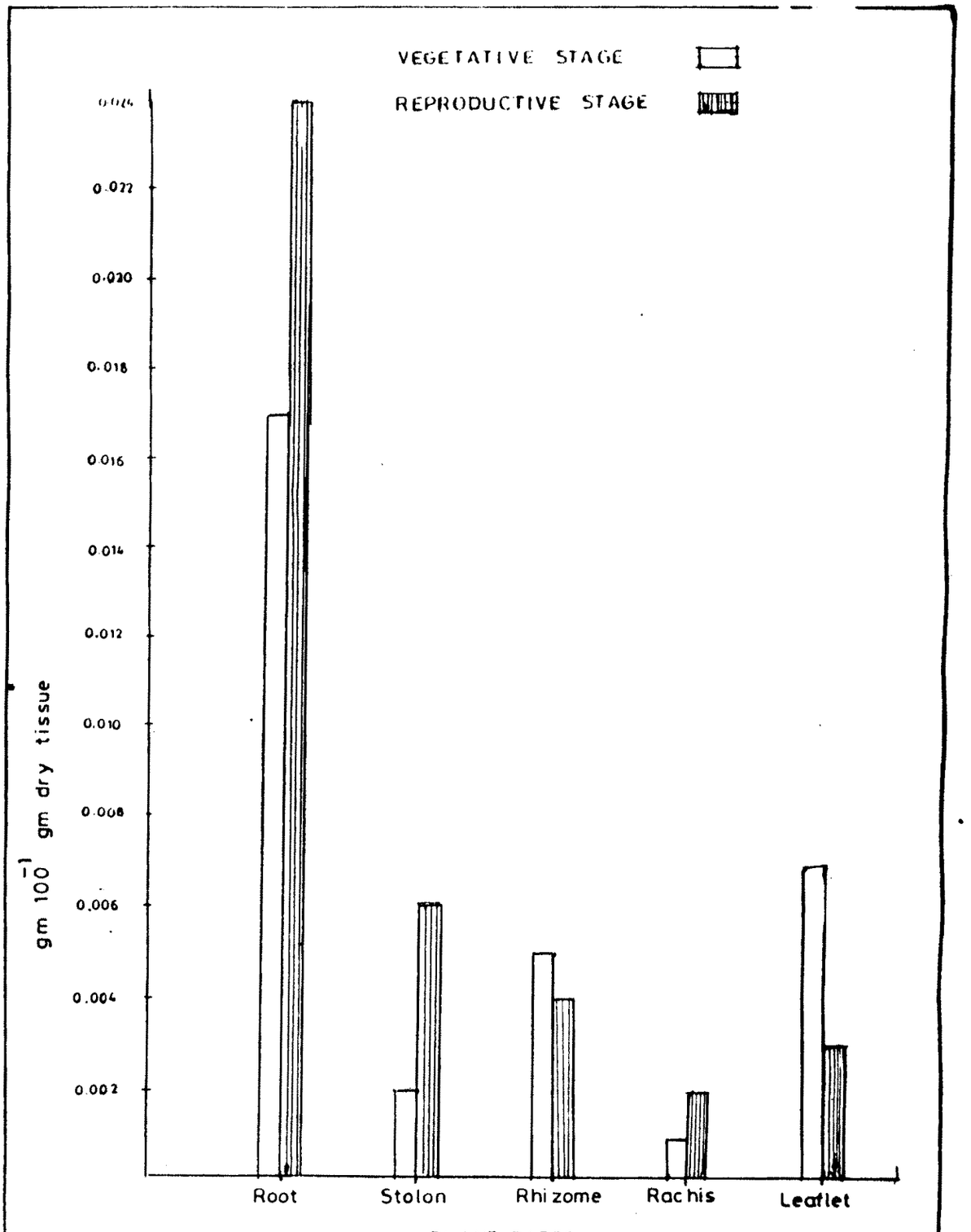

FIG. NO. 28 Mn^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN *N. exaltata* Schott.

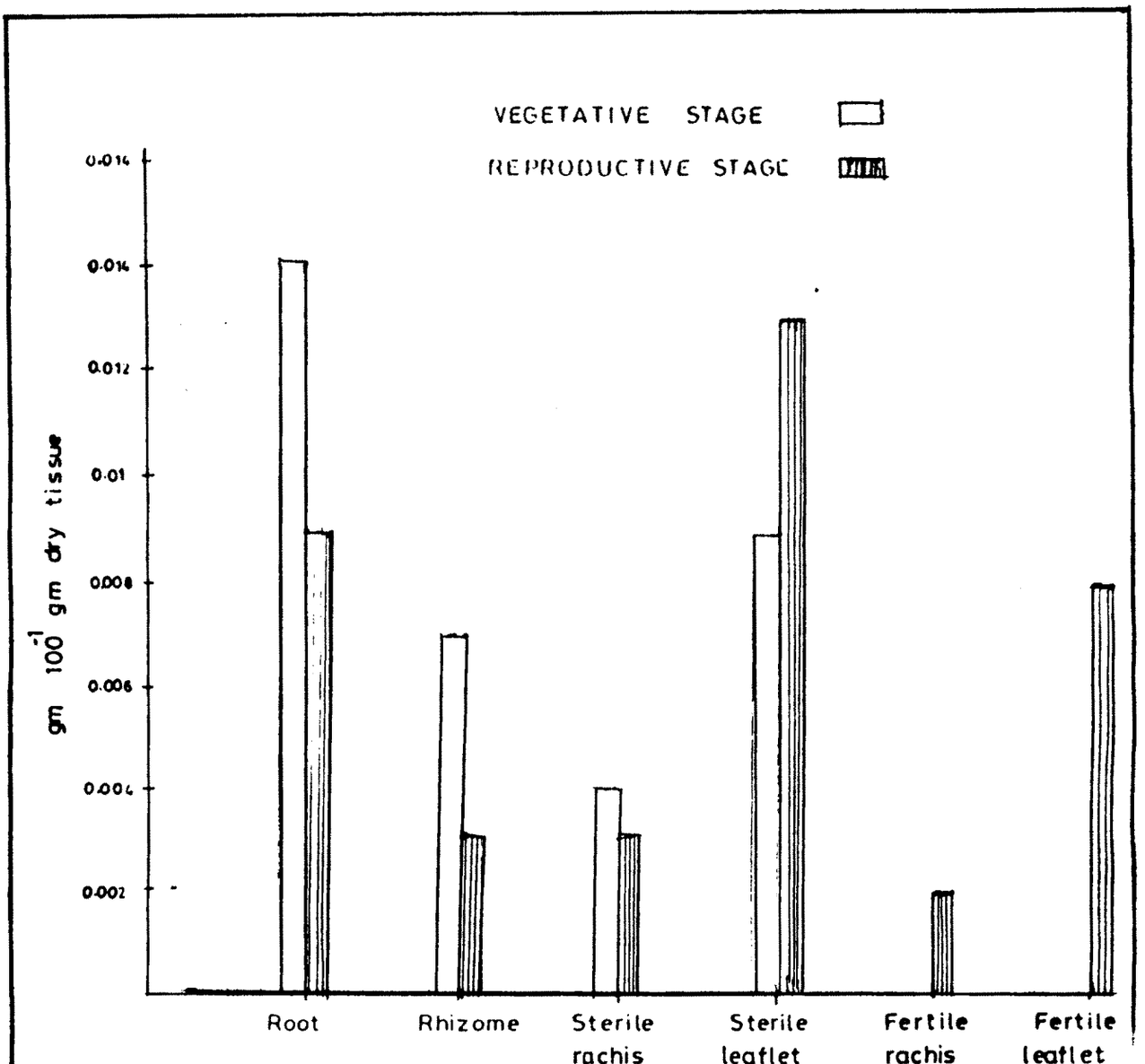

FIG NO. 29 Mn^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN G. contaminans Bedd.

reproductive stage has been depicted in Table 16 and Fig. 28.

It is evident that Mn^{+2} content is less in roots and stolon of vegetative stage than that of the reproductive stage and it is more in rhizome and leaflet. In vegetative stage Mn^{+2} content is more in the rhizome and leaflet and it is decreased in reproductive stage. In reproductive stage of Nephrolepis exaltata Schott. Mn^{+2} accumulation increases in the roots and stolon and decreases in the rhizome and leaflet.

Uptake and distribution of Mn^{+2} in different parts of Gymnopteris contaminans Bedd. in vegetative and reproductive stage has been recorded in Table 17 and Fig. 29. It is evident that in the vegetative stage of Gymnopteris contaminans Bedd. Mn^{+2} contents are more in the roots than rhizome, rachis and leaflet. Leaflet shows very little accumulation of Mn^{+2} than roots. In the reproductive stage of Gymnopteris contaminans Bedd. Mn^{+2} content decreases in the root, rhizome and rachis and it increases in the sterile leaflet. The fertile leaflet shows less Mn^{+2} content than the sterile leaflet.

Mn^{+2} contents are more in the roots of both the ferns studied.

g. Cu^{+2} (COPPER) :

Uptake and distribution of these cations in different parts of Nephrolepis exaltata Schott. in the vegetative and reproductive stage has been recorded in Table 16 and Fig. 30.

In the vegetative stage of Nephrolepis exaltata Schott. root shows more accumulation of Cu^{+2} than the other parts and it is very less in the stolon. In the reproductive stage also there is more accumulation of Cu^{+2} in the roots than all other parts. In reproductive stage there is more uptake of Cu^{+2} than the vegetative stage. In the vegetative stage leaflet shows more Cu^{+2} uptake but it is decreased in the leaflet during reproductive stage.

Uptake and distribution of these cations in different parts of Gymnopteris contaminans Bedd. in vegetative stage and reproductive stage has been recorded in Table 17 and Fig. 31.

It is evident that the uptake of Cu^{+2} is more in the roots than the rhizome, rachis and leaflet in vegetative stage.

In reproductive stage there is more copper uptake in fertile leaflet and less in sterile leaflet. In the rhizome there is no change in both the stages.

From the two ferns studied it is observed that in Nephrolepis exaltata Schott. there is more copper uptake than that in Gymnopteris contaminans Bedd.

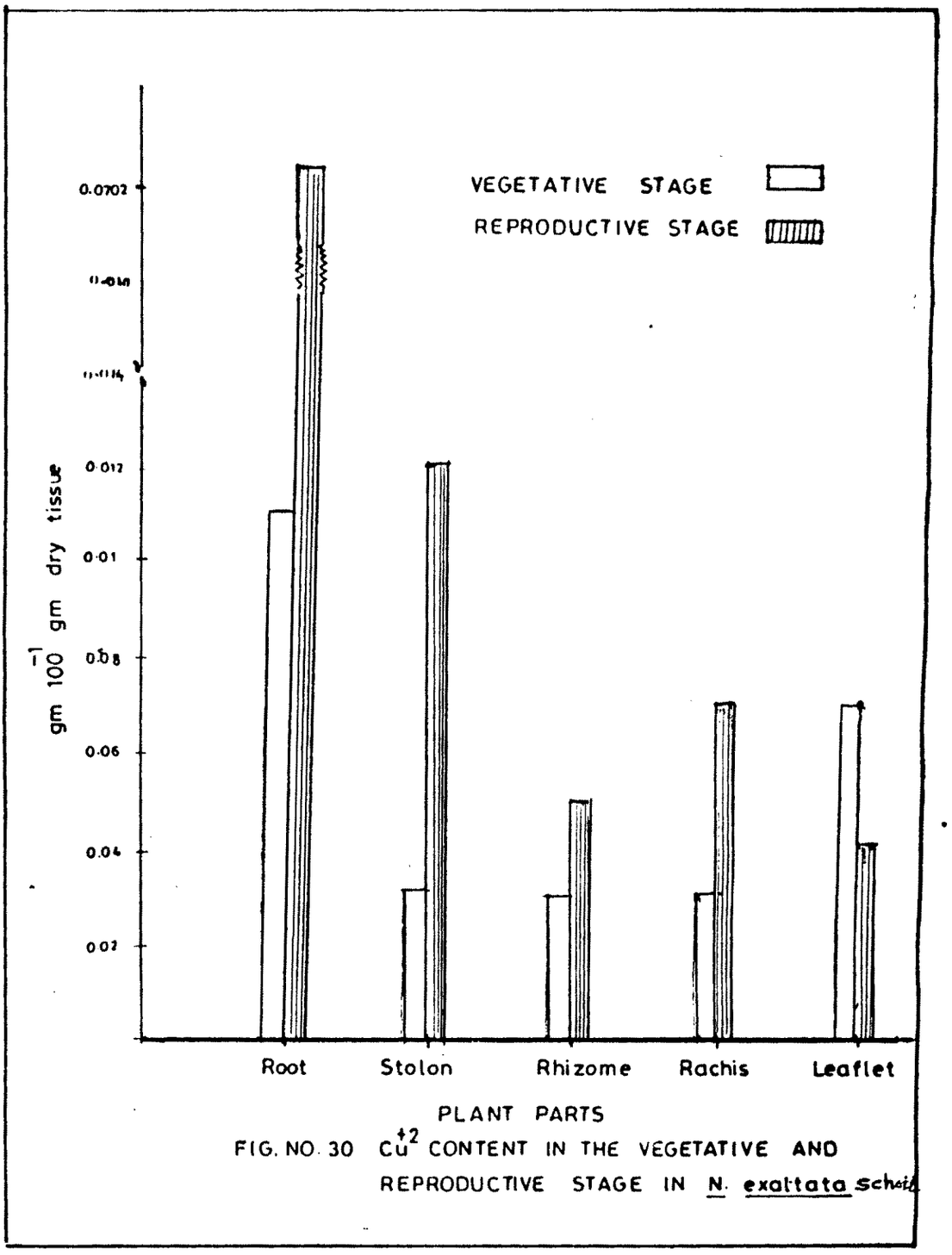

FIG. NO. 30 Cu^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN *N. exaltata* Schei

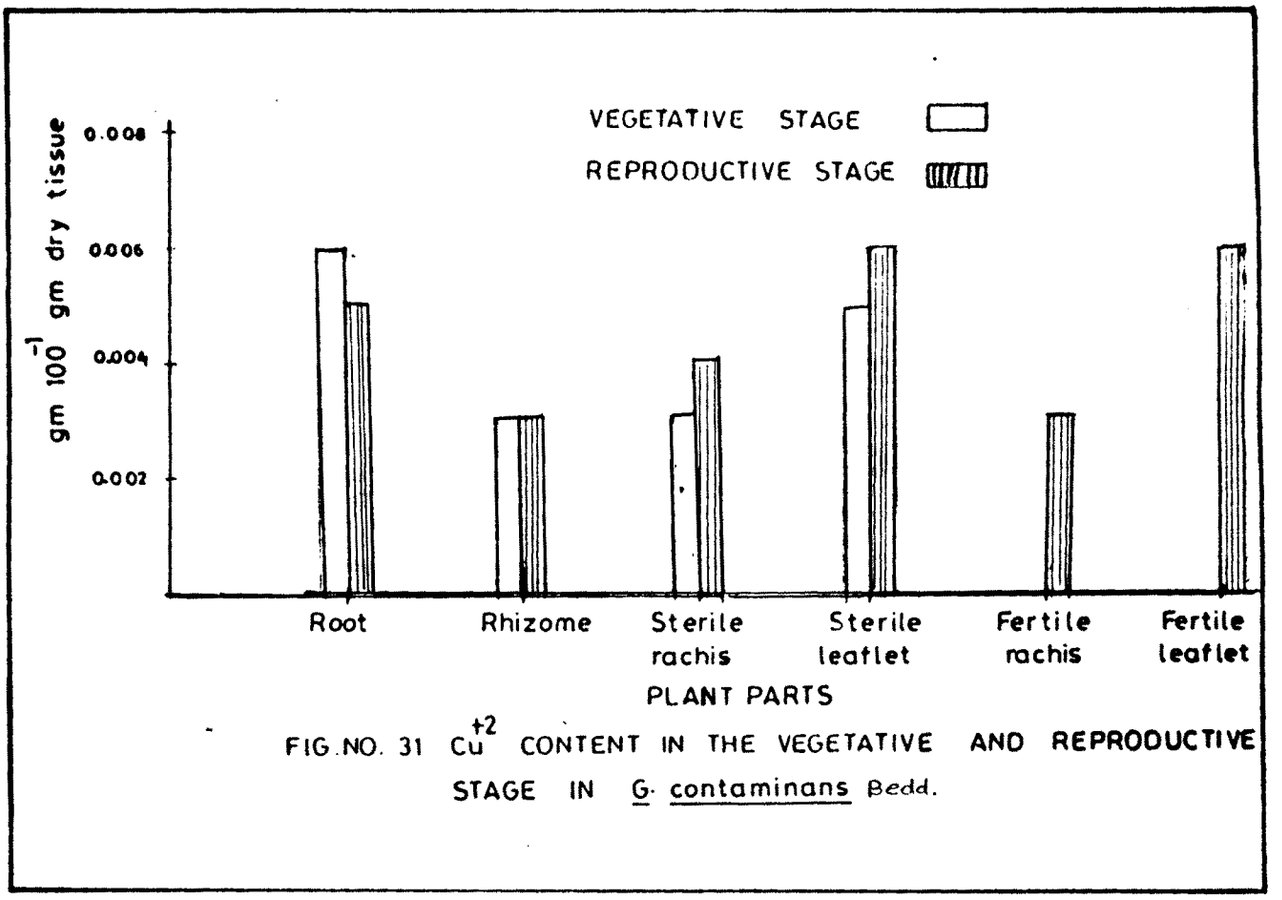

FIG.NO. 31 Cu^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN G. contaminans Bedd.

h. Zn^{+2} (ZINC) :

Zinc is an essential micronutrient required for growth. It is abundant in the plants.

The zinc content in different parts of Nephrolepis exaltata Schott. in vegetative and reproductive stage is recorded in Table 16 and Fig. 32.

From the Table 16 it is clear that in vegetative stage of Nephrolepis exaltata Schott. root contains more Zn^{+2} than the stolon, rhizome, rachis and leaflet. Zinc is very less in the rachis of vegetative stage but it increases in the rachis of reproductive stage. From the study of zinc content of various parts studied, it is observed that the zinc content in the rachis of reproductive stage is more than the rest of the parts. In Nephrolepis exaltata Schott. Zn^{+2} contents are more in the roots in vegetative stage, while in reproductive stage Zn^{+2} contents are more in the rachis and less in the stolon.

The Zn^{+2} content in different parts of Gymnopteris contaminans Bedd. in vegetative and reproductive stage is recorded in Table 17 and Fig. 33.

In the vegetative stage roots show higher concentrations of zinc than the rest of the parts. Rachis contains very less concentration of zinc, while in the reproductive stage Zn^{+2} contents are more in the fertile leaflet and very less in the rhizome. In the vegetative stage of Gymnopteris contaminans Bedd.

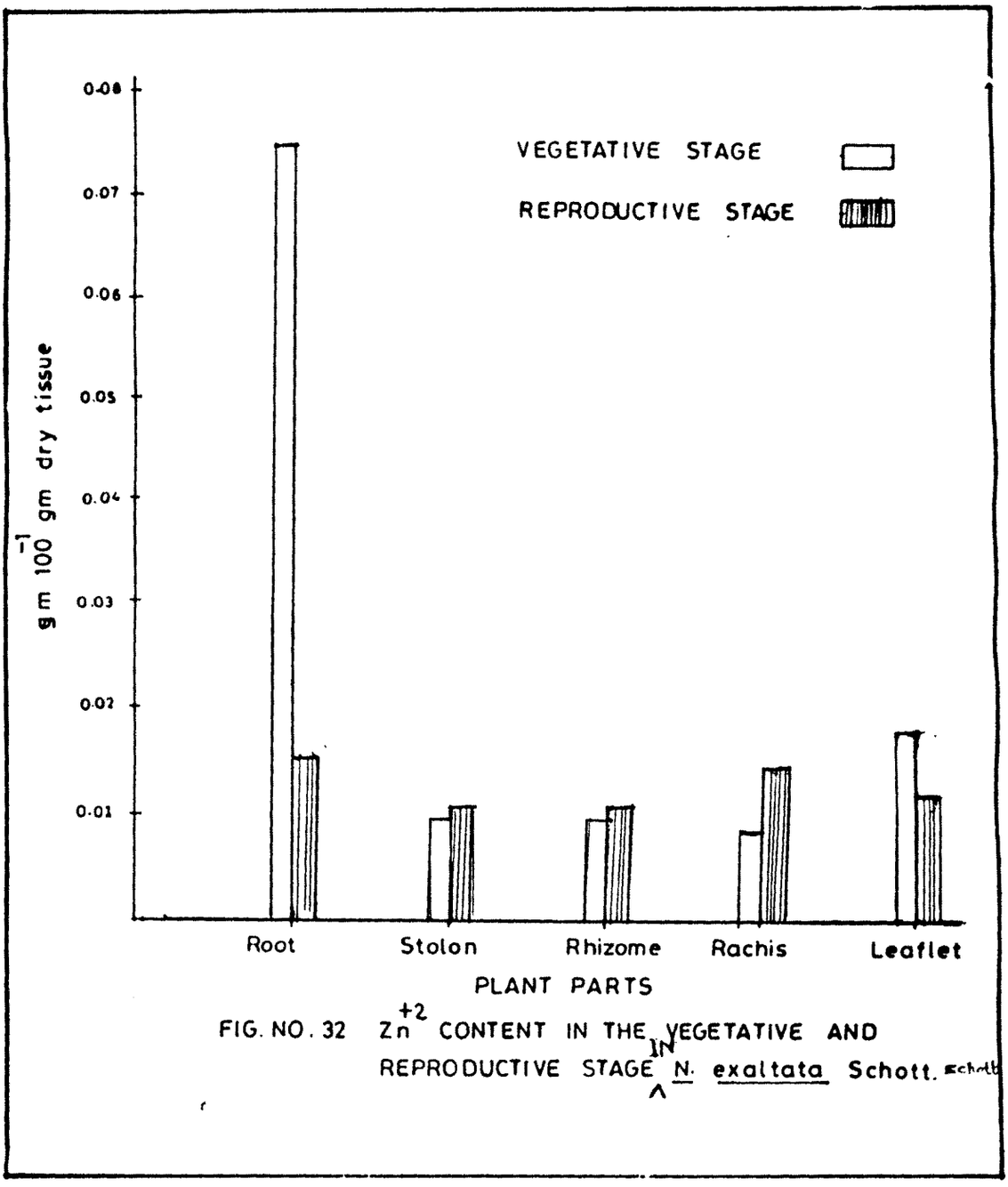

FIG. NO. 32 Zn^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN *N. exaltata* Schott.

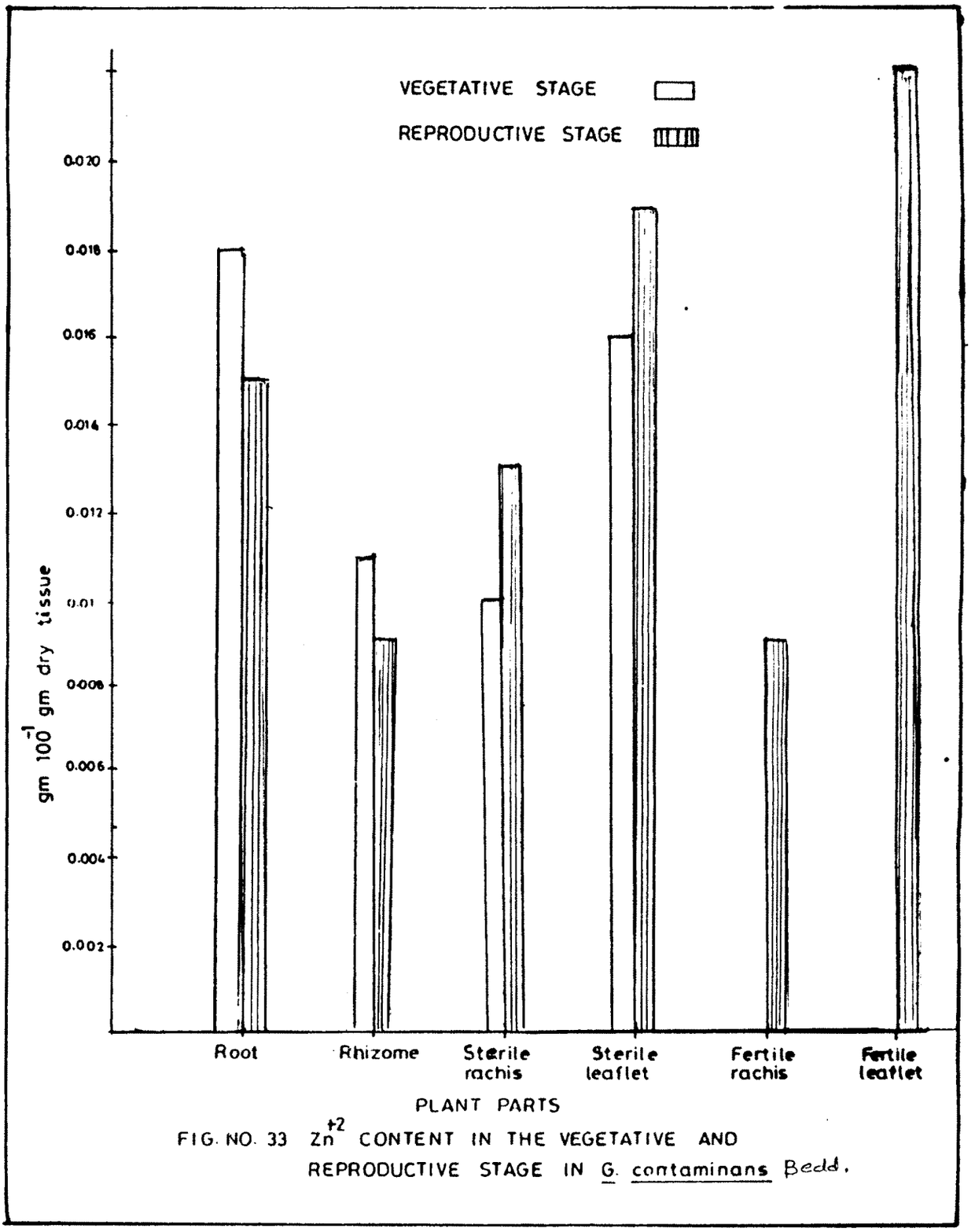

FIG. NO. 33 Zn^{+2} CONTENT IN THE VEGETATIVE AND REPRODUCTIVE STAGE IN G. contaminans Bedd.

TABLE 16

INORGANIC CONSTITUENTS IN Nephrolepis exaltata IN THE VEGETATIVE AND REPRODUCTIVE STAGE.

	Vegetative stage					Reproductive stage				
Elements	Root	Stolon	Rhizome	Rachis	Leaflet	Root	Stolon	Rhizome	Rachis	Leaflet
Sodium	0.28	0.26	0.14	0.18	0.30	0.24	0.32	0.22	0.64	0.48
Potassium	0.62	1.76	0.06	1.28	2.4	0.48	1.08	0.42	1.58	0.98
Calcium	5.58	2.22	2.82	1.78	4.0	2.64	3.18	2.64	6.44	3.70
Magessium	0.862	0.310	0.282	0.260	1.04	0.338	0.456	0.366	1.042	1.174
Iron	0.42	0.077	0.32	0.0714	0.24	0.14	0.20	0.0448	0.0558	0.0778
Manganese	0.0174	0.002	0.0054	0.0018	0.0074	0.0246	0.0062	0.0048	0.002	0.0032
Copper	0.011	0.003	0.0038	0.0032	0.0072	0.0702	0.012	0.0058	0.0072	0.0044
Zinc	0.0756	0.0106	0.0104	0.0092	0.0182	0.0156	0.0112	0.0116	0.0174	0.0126

The values are expressed in gm/100 gm of dry tissue.

TABLE 17

INORGANIC CONSTITUENTS IN *Gymnopteris contaminans* IN THE VEGETATIVE AND REPRODUCTIVE STAGE.

	Vegetative stage				Reproductive stage					
Elements	Root	Rhizome	Rachis	Leaflet	Root	Rhizome	Sterile rachis	Sterile leaflet	Fertile rachis	Fertile leaflet
Sodium	0.22	0.34	0.22	0.22	0.12	0.62	0.10	0.48	0.10	0.30
Potassium	0.58	1.54	3.24	3.18	0.22	2.72	2.10	2.96	2.52	2.48
Calcium	4.26	6.68	2.66	3.96	3.12	4.90	2.48	5.96	1.92	2.76
Magessium	0.572	0.89	0.388	0.736	0.33	0.42	0.322	1.066	0.258	0.53
Iron	0.52	0.38	0.10	0.24	0.20	0.0434	0.0488	0.078	0.0316	0.0604
Manganese	0.0142	0.0078	0.0042	0.009	0.0094	0.0034	0.0036	0.0136	0.0028	0.0086
Copper	0.0064	0.0038	0.0038	0.0052	0.0052	0.0038	0.0046	0.006	0.0036	0.0062
Zinc	0.0184	0.0114	0.0108	0.0164	0.015	0.0096	0.013	0.019	0.0098	0.0228

The values are expressed in gm/100 gm of dry tissue.

roots show more Zn^{+2} content while in reproductive stage fertile leaflet shows more Zn^{+2} content. In vegetative stage of Nephrolepis exaltata Schott. as well as in Gymnopteris contaminans Bedd. roots show more Zn^{+2} content, while in reproductive stage of Nephrolepis exaltata Schott. rachis shows more Zn^{+2} content but in the reproductive stage of Gymnopteris contaminans Bedd. more Zn^{+2} content is observed in the fertile leaflet.

i. Cl^- (CHLORIDES) :

It has been observed that chlorides when present in low concentrations, stimulate plant growth. However, Cl^- in larger quantities are harmful. Though many plants contain appreciable amounts of Cl^- in their tissues, the exact function of Cl^- is not yet well understood. The recent investigation indicates the absolute necessity of Cl^- ions for photosynthesis.

The role of chlorides in the plant metabolism is being understood well in recent years. Their presence in traces helps the plants to grow vigorously.

Table 18 and Fig. 34 shows the chloride contents in different parts of Nephrolepis exaltata Schott. during vegetative stage and reproductive stage. It is clear from the Table that Nephrolepis exaltata Schott. contains more chlorides during the reproductive stage than the vegetative stage except rhizome. The chloride contents are more in the leaflets and less in

the roots. In both the stages - vegetative as well as reproductive, chloride contents are more in leaflets and less in all other parts. The pattern of distribution of Cl^- in different organs of the fern indicates that Cl^- is the most mobile element. The rachis, rhizome, stolon and roots contain less amount of Cl^-. Thus the pattern of distribution of Cl^- is more or less same in vegetative as well as reproductive stage of this fern. The accumulation of Cl^- in this fern is of the following order

root < rhizome stolon < rachis < leaflet.

The distribution of chlorides in different parts of Gymnopteris contaminans Bedd. in vegetative as well as reproductive stage has been recorded in Table 19 and Fig. 35.

It is clear from the Table 19 that the Cl contents during vegetative stage of Gymnopteris contaminans Bedd. are more in the sterile leaflet than the rachis and very less in the rhizome and roots. In reproductive stage of Gymnopteris contaminans Bedd. chloride contents are more in sterile leaflet than the fertile leaflet and same thing is observed in the rachis. The chloride contents are more in the sterile rachis than the fertile rachis. The rhizome as well as the roots contain very less chlorides. The sterile

leaflet during vegetative stage shows more chlorides than the sterile and fertile leaflet of reproductive stage. The chloride contents of Gymnopteris contaminans Bedd. during vegetative stage are more in all the parts than the reproductive parts.

It is observed that Gymnopteris contaminans Bedd. shows more accumulation of chlorides than that of Nephrolepis exaltata Schott.

Shetty (1971) worked on Acrostichum aureum, a bracken fern. In saline plants the Cl^- values range from 1.75 to 2.52 gm per 100 gm dry tissue. However, the leaves contain more Cl^-. The rachis contains less chlorides and the roots the least. The pattern of distribution of Cl^- in different organs of the bracken fern indicates that Cl^- is the most mobile element. Saline plants accumulate more Cl^- and act as store houses. On the other hand the Cl^- values in non saline plants range from 1.15 to 2.17 gm per 100 gm dry matter. The rachis and root contain less amount of Cl^-. Thus the pattern of distribution of Cl^- is more or less same in saline as well as non saline plants.

Acrostichum aureum has more chlorides than glycophytes and other ferns that are usually restricted to evergreen forests. However, Acrostichum aureum grows in bracken soils where the fresh water constantly enters in the sea water.

TABLE 18

CHLORIDE CONTENTS IN DIFFERENT PARTS OF *Nephrolepis exaltata* IN VEGETATIVE AND REPRODUCTIVE STAGE

Plant parts	Vegetative stage	Reproductive stage
Roots	0.44	0.47
Stolon	0.47	0.53
Rhizome	0.83	0.53
Rachis	1.00	1.13
Leaflet	1.13	1.83

Values are expressed in gm/100 gm dry tissue.

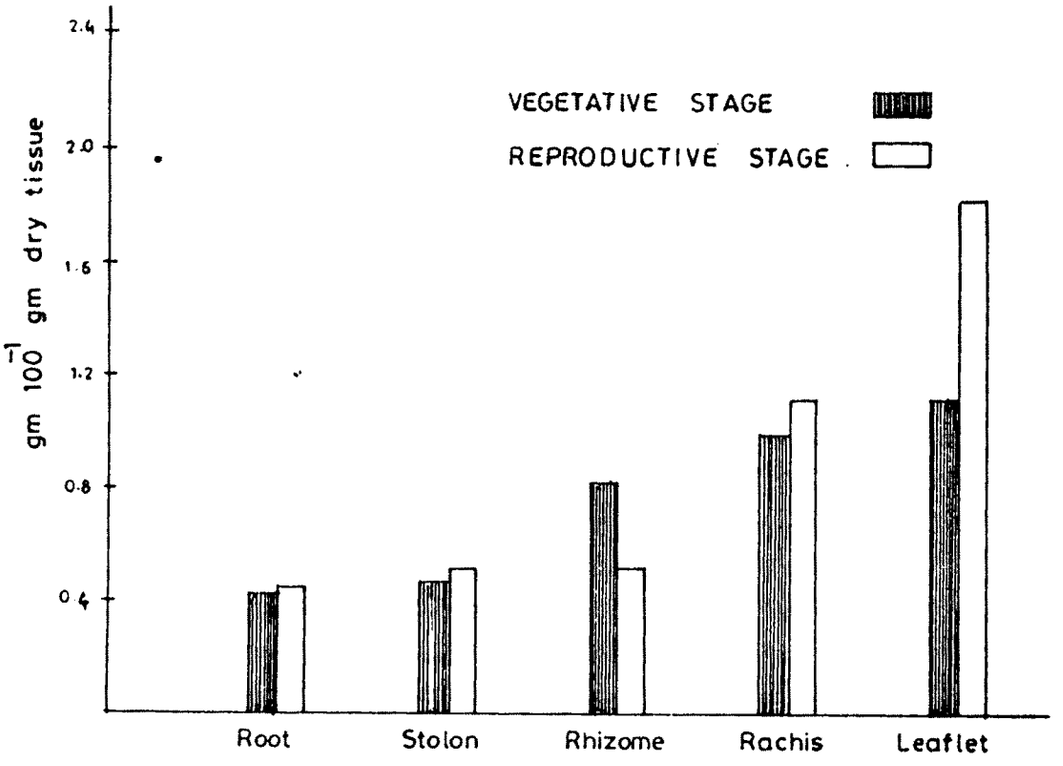

FIG.NO. 34 CHLORIDE CONTENT IN N. exaltata IN VEGETATIVE AND REPRODUCTIVE STAGE

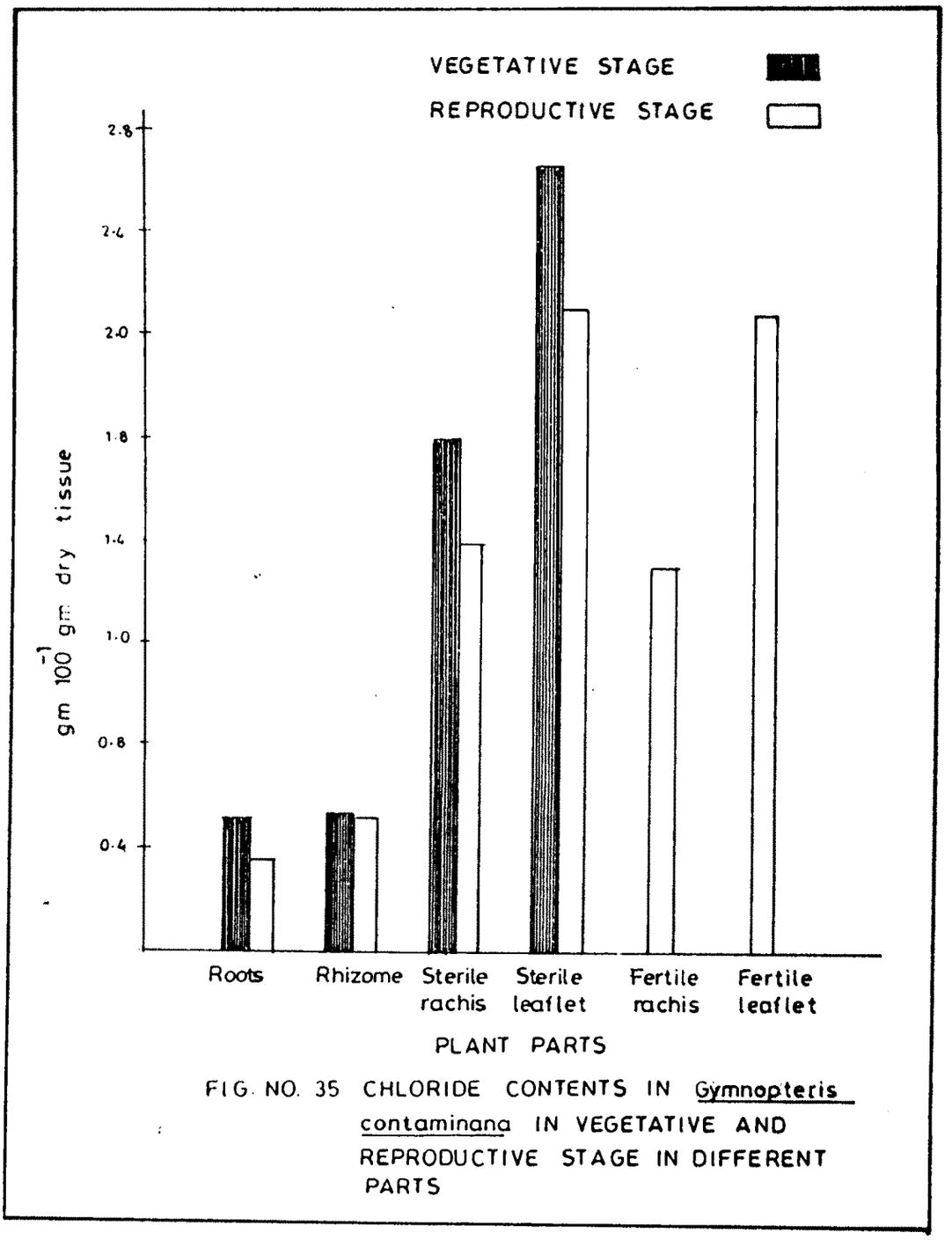

FIG. NO. 35 CHLORIDE CONTENTS IN Gymnopteris contaminana IN VEGETATIVE AND REPRODUCTIVE STAGE IN DIFFERENT PARTS

TABLE 19

CHLORIDE CONTENTS IN DIFFERENT PARTS OF *Gymnopteris contaminans* IN VEGETATIVE AND REPRODUCTIVE STAGE.

Plant parts	Vegetative stage	Reproductive stage
Roots	0.53	0.35
Rhizome	0.54	0.53
Sterile rachis	1.82	1.43
Sterile leaflet	2.66	2.13
Fertile rachis	-	1.33
Fertile leaflet	-	2.12

Values are expressed in gm/100 gm dry tissue.