nullisomics of *C. gigantea* ($2n = 18$) occurred in exceptionally high frequency in the population[9] contributing $n = 9$ gametes, in greater number than even the normal gametes ($n = 10$). However, the *C. aquatica* parent constantly contributed gametes with $n = 5$ chromosomes. The two genomes could be easily identified in the hybrid constitution because of the notable difference in the size of the chromosomes; *aquatica* has larger chromosomes than *gigantea*. The two genomes are partially homologous and although the hybrids have shown regular pairing between the parental chromosomes giving heteromorphic bivalents and some multivalents[6]; segregational irregularities have led to unequal chromosomes at anaphase-I mainly due to the variable number of univalent laggards. Whatever the chromosomal pairing in the hybrids, the distribution of univalent chromosomes at anaphase-I, both in regard to the number and kind, has led to the formation of some functional female gametes that usually carried five or more chromosomes from *gigantea* and *aquatica* parents. This is evident from the fact that when these hybrids were grown in close association with *C. gigantea* (especially nullisomics, $2n = 18$) and *C. aquatica* ($2n = 10$) and allowed to open-pollinate, it resulted in a progeny of plants showing a wide range of chromosomal numbers from $2n = 10$ to $2n = 21$ (table 1). Among these, plants with $2n = 10$ and $2n = 18$ resembled the *aquatica* and the nullisomic *gigantea* parents, morphologically and cytologically (unpublished data). Such a parental recovery from hybrids through a single spontaneous back-cross is unusual, although types close to original parents have been isolated from the F-2 generation by Anderson[10] and from the F-2 and F-3 generations of hybrids involving New World X Asiatic species of cotton[11]. The male meiosis of the present interspecific hybrids shows some tendency towards genomic segregation at anaphase-I, and a similar segregation is likely in some of the megaspore mother cells producing parental gametes. This is explained on the basis of non-random assortment of chromosomes mediated by genotypic affinity among the centromeres contributed to the hybrid by each parent[12].

One of the authors (DSD) is grateful to UGC for a fellowship.

15 July 1985; Revised 25 November 1985

1. Clausen, J., *Hereditas*, 1926, **8**, 1.
2. Muntzing, A., *Hereditas*, 1930, **13**, 185.
3. Clausen, J., Keck, D. D. and Hiesey, W. W., *Am. Nat.*, 1947, **81**, 114.
4. Bor, N. L., *Grases of Burma, Ceylon, India and Pakistan*, Pergamon Press, New York, 1960.
5. Sapre, A. B. and Barve, S. S., *Cytologia*, 1984, **49**, 345.
6. Sapre, A. B., Barve, S. S. and Deshpande, D. S., *Cytologia*, 1986, **50**, (in Press).
7. Sapre, A. B. and Barve, S. S., *Genetica*, 1985, **66**, 73.
8. Sapre, A. B. and Barve, S. S., *J. Hered.*, 1985, **76**, 387.
9. Sapre, A. B. and Barve, S. S., *Curr. Sci.*, 1983, **51**, 486.
10. Anderson, E., *Ann. Missouri Bot. Gard.*, 1936, **23**, 159.
11. Phillips, L. L., *Heredity*, 1964, **19**, 21.
12. Wallace, M. E., *Heredity*, 1960, **14**, 263.

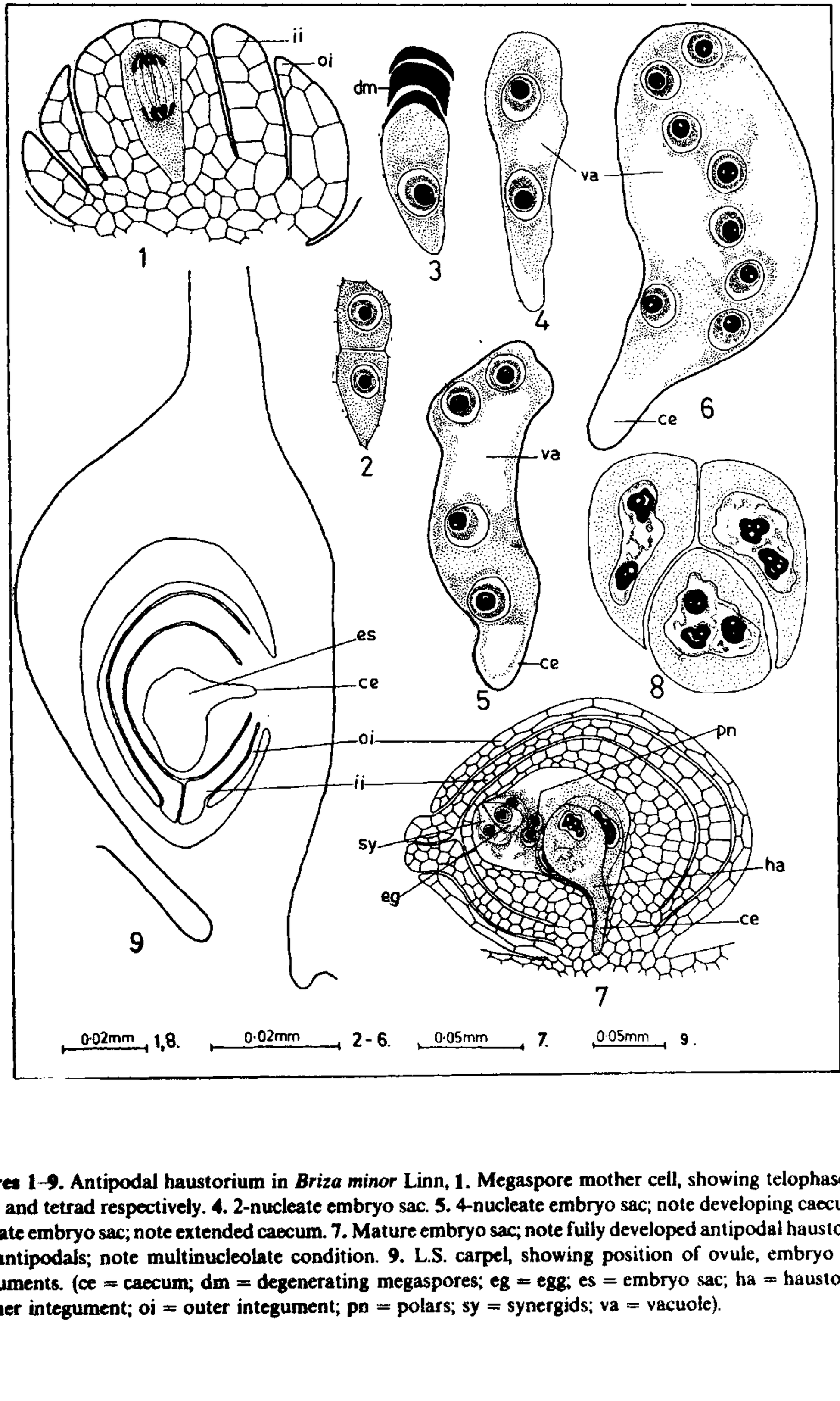
Table 1 *Number of plants isolated in each of the chromosomal types from $2n = 10$ to $2n = 21$ among the hybrids and hydrid-derivatives of Coix.*

Chromosome number in hybrid derivatives ($2n$)	No. of plants
10	56
11	14
12	4
13	3
14	101
15	22
16	21
17	5
18	24
19	4
20	1
21	1
Total no of plants screened	256

ANTIPODAL HAUSTORIUM IN *BRIZA MINOR* LINN

S. M. BHUSKUTE and K. H. MAKDE
Department of Botany, Nagpur University, Nagpur 440010, India.

EMBRYOLOGICALLY the family Poaceae (Gramineae) has been worked out significantly because of its high economic potential. A perusal of the literature indicates that the antipodals in the family are characteristic and exhibit variation in respect of their number,



Figures 1–9. Antipodal haustorium in *Briza minor* Linn, **1.** Megaspore mother cell, showing telophase I. **2, 3.** Dyad and tetrad respectively. **4.** 2-nucleate embryo sac. **5.** 4-nucleate embryo sac; note developing caecum. **6.** 8-nucleate embryo sac; note extended caecum. **7.** Mature embryo sac; note fully developed antipodal haustorium. **8.** T.S. antipodals; note multinucleolate condition. **9.** L.S. carpel, showing position of ovule, embryo sac and integuments. (ce = caecum; dm = degenerating megaspores; eg = egg; es = embryo sac; ha = haustorium; ii = inner integument; oi = outer integument; pn = polars; sy = synergids; va = vacuole).

position, structure and behaviour. Three antipodals have been reported in *Pennisetum typhoidium*[1], *Oriza sativa*[2], *Digitaria*[3], *Sporobolus*[3] and *Ergrostiella bifaria*[4]. Formation of antipodal complex has been reported in several taxa of the family[2, 3]. They offer close analogy to the tapetum[5]. Beaudry[6] assigned secretory role for antipodals. Hoshikawa and Higuchi[7] attributed haustorial function, which has also been accepted by others[8, 9]. Besides haustorial function antipodals also perform storage function[10, 11]. Haustorial structure rarely occurs in the Poaceae and the present investigation is the first report of its kind.

The material of *Briza minor* Linn was collected from the Botanical Garden, Ooty, during the botanical excursion in 1981–82. The spikelets at various stages of development were fixed in FAA (70%). Routine methods of microtomy were followed. The sections of 10–12 μm were stained with Delafield's hematoxylin and counterstained with saffranin or erythrosin-B.

The ovules are bitegmic and tenuinucellate (figures 1, 7). The micropyle is organised by inner integument alone (figures 7, 9). Both the integuments grow faster away from the funiculus which results in the amphitropous condition of the ovule (figure 7). This condition has also been reported in *Eustachys glauca* and *E. petraea*[12].

The single hypodermal archesporium functions as megaspore mother cell and undergoes meiosis (figures 1, 2) to form a linear tetrad of megaspores (figure 3). The chalazal megaspore is functional and forms Polygonum type of female gametophyte (figure 7). At four- and eight-nucleate stage, it extends at the chalazal end forming the caecum (figures 5–7, 9). However, the embryo sac remains much broader at micropylar end and tapers towards the chalazal end (figure 7). The three antipodals are much enlarged and occupy three-fourths of the embryo sac (figure 7). One of the antipodal cells projects into the caecum of the embryo sac and finally penetrates into nucellar tissue, thus forming the haustorium (figure 7, 10). Our efforts to dissect the embryo sac to study the haustorium were futile since the ovaries and ovules are extremely small. The hypertrophied antipodals are densely protoplasmic, their nuclei are multinucleolate and show abundant chromatin material (figure 8). The haustorium appears to play nutritional role.

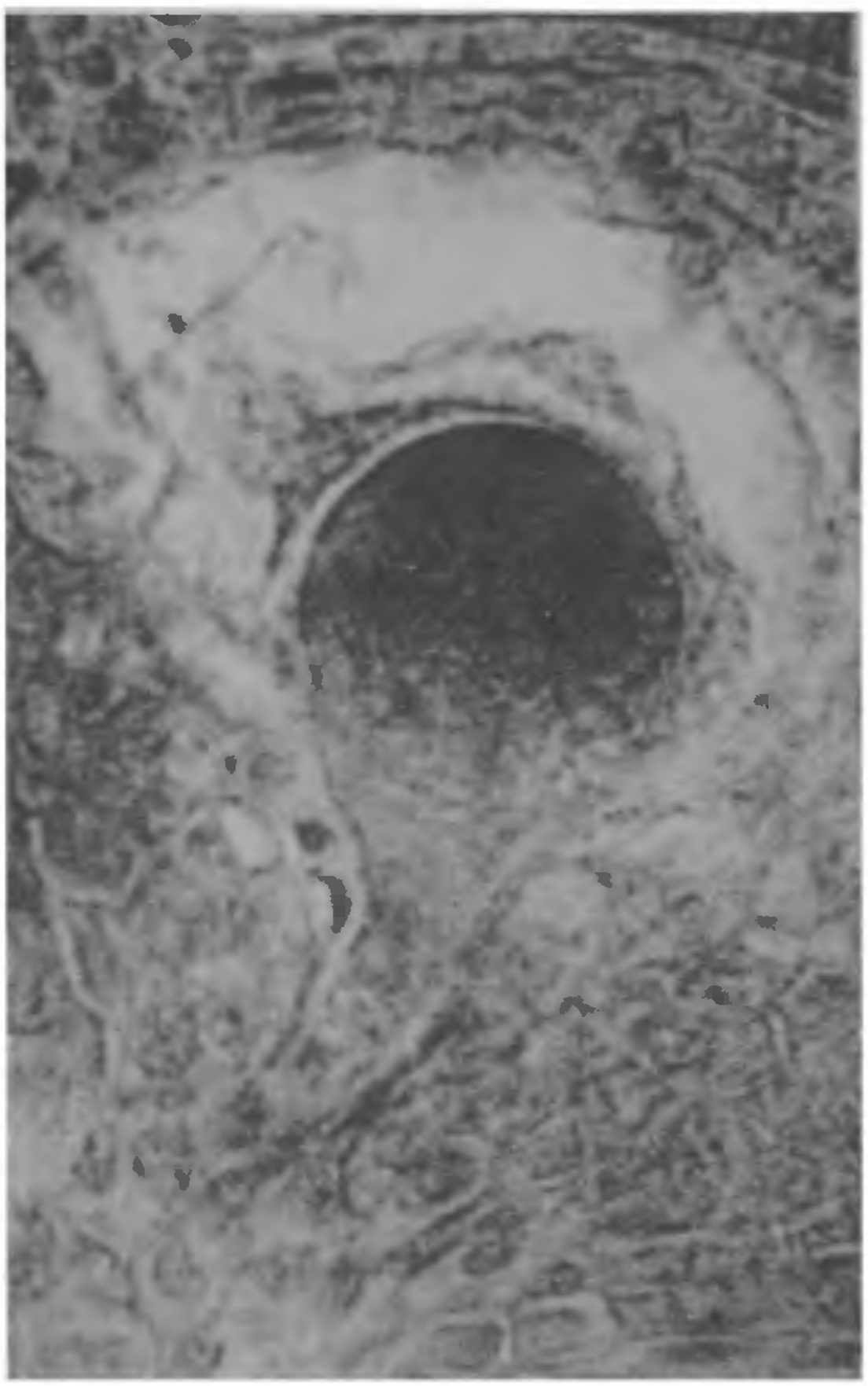


Figure 10. L.S. ovule showing antipodal haustorium × 1000.

The authors express their indebtness to Prof. P. K. Deshpande, for valuable suggestions. Grateful thanks are due to Prof. M. D. Padhye for his keen interest.

15 April 1985; Revised 28 October 1985

1. Narayanaswamy, S., *Phytomorphology*, 1953, **3**, 98.
2. Raju, P. S. G., *Ph.D. Thesis*, Nagpur University, Nagpur, 1980.
3. Diwanji, P., *Ph.D. Thesis*, Nagpur University, Nagpur, 1981.
4. Sonpipare, S. A., *Ph.D. Thesis*, Nagpur University, Nagpur, 1981.
5. Maheshwari, P., *An introduction to the embryology of angiosperms*, McGraw Hill, New York, 1950.
6. Beaudry, J. R., *Genetics*, 1951, **36**, 109.
7. Hoshikawa, K. and Higuchi, A., *Proc. Crop Sci. Soc. Jpn*, 1960–61, **29**, 253.
8. Rangaswami, K. J., *J. Indian Bot. Soc.*, 1935, **14**, 125.
9. Chikkannaiah, P. S. and Mahalingappa, M. S., In: *Embryology of crop plants*, Indo-Soviet Symposium sponsored by INSA and University of Delhi, 1976.

10. Narayanaswamy, S., *Lloydia*, 1955, **18,** 61.
11. Narayanaswamy, S., *Phytomorphology*, 1955, **5,** 161.
12. AuLabach-Smith, C. A. and J. M. Herr (Jr.), *Am. J. Bot.*, 1984, **71,** 427.

AMMONIA ASSIMILATING ENZYMES IN *ANABAENA TORULOSA*

N. ANAND and C. CHANDRASEKARAN
Centre of Advanced Studies in Botany, University of Madras, Madras 600025, India.

ACTIVITIES of three ammonia assimilating enzymes *viz*, glutamine synthetase (GS), glutamic acid dehydrogenase (GDH) and alanine dehydrogenase (ADH) in *Anabaena torulosa* (Carm) Lagerh ex Born et Flah under N_2-fixing and nitrogen-amended (as inorganic nitrogen source) conditions are reported. Cultures of *A. torulosa* isolated from the rice fields of Kerala State, India, and made axenic by triple antibiotic treatment with chloramphenicol, streptomycin and benzyl penicillin[1] were maintained in BG_{11} medium[2] at 27 ± 1 C and 2000 lux flourescent illumination. Inorganic nitrogen source used was 20 mM KNO_3 or NH_4Cl. For each of the conditions cultures were grown in triplicates.

For extraction and assay of the enzymes the cultures were harvested by centrifugation and washed twice with 50 mM Tris/HCl buffer (pH 7.5), the filaments were disrupted under ice by using ultrasonic disintegrator for 5 min. The cell debris was removed by centrifugation at 8000 rpm for 30 min and the supernatant assayed for the activity of the enzymes. In the crude extract GS was assayed by the modified γ-glutamyl transferase assay[3]. The activities of GDH and ADH were measured (UNICAM SP 800 B spectrophotometer[4]) as decrease in extinction at 340 nm due to the oxidation of NADPH to NADP at 25°C. Protein was estimated according to Lowry *et al*[5] using bovine serum albumin as the standard.

Table 1 presents data on the specific activities of the three ammonia assimilating enzymes in *A. torulosa*.

GS, which is one of the main ammonia assimilating enzymes, showed maximal activity in nitrogen-fixing cultures and relatively low activity in nitrate and ammonium-grown cultures. This is in accordance with the report of Meeks *et al*[6], who showed that the specific activity of GS was about one half as much in ammonium grown cultures as in nitrogen-fixing cultures of *A. cylindrica*. Similarly GDH and ADH showed higher levels of activity than those reported by Meeks *et al*[6]. Haystead *et al*[7] reported trace amounts of GDH activity in *A. cylindrica*. GDH activity has been detected in some but not all non-heterocystous bluegreen algae[8,9]. Interestingly both GDH and ADH activities were more in cultures supplied with nitrogen either as nitrate or as ammonium, probably the availability of substrates has triggered the assimilatory pathways in both glutamine and alanine directions to offset the substrate inhibition of the assimilation process.

Table 1 *Specific activity (μ mol. min^{-1}, mg prot^{-1}) of ammonia assimilating enzymes in 15-day-old cultures of A. torulosa. (Values are average of three determinations).*

Enzyme	N_2 fixing	Culture condition KNO_3^- grown (20 mM)	NH_4^+ grown (20 mM)
Glutamine synthetase	0.196	0.149	0.101
Glutamic acid dehydrogenase	1.76	2.62	2.69
Alanine dehydrogenase	0.286	0.147	0.613

We thank UGC New Delhi for financial assistance.

24 October 1985; Revised 7 December 1985

1. Droop, M. R., *Brit. Phycol. Bull.*, 1967, **3,** 295.
2. Rippka, R., Deruelles, J., Waterbury, J. B., Herdman, M. and Stanier, R. Y., *J. Gen. Microbiol.*, 1979, **111,** 1.
3. Sampaio, M. J. A. M., Rowell, P. and Stewart, W. D. P., *J. Gen. Microbiol.*, 1979, **111,** 181.
4. Rowell, P. and Stewart, W. D. P., *Arch. Microbiol.*, 1976, **107,** 115.
5. Lowry, O. H., Rosenbrough, N. J., Farr, A. L. and Randall, R. J., *J. Biol. Chem.*, 1951, **193,** 265.
6. Meeks, J. C., Wolk, C. P., Thomas, J., Lockav, W., Shaffer, P. W., Austin, S. M., Chein, W. and Goilomety, A., *J. Biol. Chem.*, 1977, **202,** 7894.
7. Haystead, A., Dharmawardene, M. W. N. and Stewart, W. D. P., *Plant Sci. Letts-Tokyo*, 1975, **1,** 439.
8. Pearce, T., Leach, C. K. and Carr. N. G., *J. Gen. Microbiol.*, 1969, **55,** 371.
9. Neilson, A. H. and Doudoroff, M., *Arch. Mikrobiol.*, 1973, **89,** 15.