

Contents

Preface	vii
1 Introduction	1
2 Identification and Classification of Entodiniomorphid Protozoa	4
2.1 Taxonomy of Entodiniomorphid Protozoa	4
2.2 The Genus <i>Entodinium</i>	6
2.3 The Genus <i>Eodinium</i>	31
2.4 The Genus <i>Diplodinium</i>	33
2.5 The Genus <i>Eremoplastron</i>	43
2.6 The Genus <i>Eudiplodinium</i>	48
2.7 The Genus <i>Ostracodinium</i>	51
2.8 The Genus <i>Polyplastron</i>	57
2.9 The Genus <i>Metadinium</i>	60
2.10 The Genus <i>Epidinium</i>	64
2.11 The Genus <i>Enoploplastron</i>	73
2.12 The Genus <i>Ophryoscolex</i>	74
2.13 The Genus <i>Diploplastron</i>	78
2.14 The Genus <i>Elytroplastron</i>	79
2.15 The Genus <i>Epiplastron</i>	80
2.16 The Genus <i>Opisthotricum</i>	81
2.17 The Genus <i>Caloscolex</i>	81
2.18 The Genus <i>Rhinozeta</i>	82

2.19	The Genus <i>Parentodinium</i>	82
2.20	Evolution of Entodiniomorphid Protozoa	83
3	The Holotrich Ciliates	86
3.1	Classification of the Rumen Holotrich Ciliates	86
3.2	Distribution of Holotrich Ciliates	87
3.3	Population Determinants	92
3.4	Species Description	99
3.5	Evolution of the Holotrich Ciliates	130
4	Methods Used for the Separation and Cultivation of Protozoa	133
4.1	Techniques for the Isolation of Ciliates from Rumen Contents	133
4.2	In situ Culture of Selected Protozoa	139
4.3	Cultivation of Entodiniomorphid Protozoa In vitro	145
4.4	Cultivation of Holotrich Ciliates In vitro	156
4.5	Continuous Culture Techniques	159
5	Association of Bacteria and Fungi with Rumen Ciliates	165
5.1	Intracellular Bacteria	165
5.2	Bacteria Attached to the Pellicle	169
5.3	Intracellular "Parasites" of Rumen Ciliates	172
6	Metabolism of Entodiniomorphid Protozoa	173
6.1	Metabolism of Starch	173
6.2	Metabolism of Cellulose and Cellobiose	184
6.3	Metabolism of Pectin, Hemicelluloses, and Related Compounds	190
6.4	Engulfment and Utilization of Bacteria	192
6.5	Engulfment and Utilization of Ovals and Fungi	210
6.6	Metabolism of Free Amino Acids	212
6.7	Metabolism of Protein	218
6.8	Sources of Amino Acids for Protozoal Growth	221
6.9	Metabolism of Free Constituents of Nucleic Acids	223
6.10	Metabolism of Lipids	224
6.11	Metabolism of Phospholipids	226
6.12	Metabolism of Lactic Acid	229
6.13	Uptake and Metabolism of Other Entodiniomorphid Protozoa	230
	Appendix: Techniques Used in Experiments on the Metabolism of Entodiniomorphid Protozoa	234

7	Structure of Entodiniomorphid Protozoa and Its Relationship to Function	236
7.1	General Description of Structure	236
7.2	Structure of Vestibular and Cytopharyngeal Regions	239
7.3	The Cilia and Infraciliature	243
7.4	The Paralabial Organelle	244
7.5	The Contractile Vacuoles	245
7.6	The Cytoproct (Rectum)	246
7.7	The Pellicle (Cortex)	247
7.8	The Boundary Between Ectoplasm and Endoplasm	249
7.9	Division of Entodiniomorphid Protozoa	249
7.10	Conjugation	251
7.11	Protozoal Chemotaxis and Feeding	251
7.12	Protozoal Metabolic Compartments	253
7.13	Rate of Clearance of Soluble and Particulate Materials	254
8	Metabolism of Holotrich Protozoa	256
8.1	Carbohydrate Metabolism	256
8.2	Oxygen Utilization	285
8.3	Nitrogen Metabolism	288
8.4	Lipid Metabolism	295
8.5	Metabolism of Nucleic Acids	299
9	Factors Affecting Protozoal Populations In vivo	300
9.1	Infection of Young Ruminants	301
9.2	Interrelationships Between Protozoal Species	301
9.3	Host Specificity	302
9.4	Geographical Distribution	306
9.5	Effect of Feed Composition	308
9.6	Diurnal Variation in Densities of Entodiniomorphid Protozoa	315
9.7	Seasonal Variation	316
10	Role of Protozoa in the Rumen	317
10.1	Metabolism of Cellulose and Hemicellulose	317
10.2	Metabolism of Starch	324
10.3	Metabolism of Bacteria	325
10.4	Metabolism of Protein	332
10.5	Effect of Protozoa on Rumen Metabolites	334
11	Effect of Ciliate Protozoa on the Productivity of the Host Ruminant	348
11.1	Post-Ruminal Digestion of Protozoa	349
11.2	Effect of Protozoa on Blood Metabolite Concentrations	353
11.3	Effect of Protozoa on Animal Growth	355

12	Protozoa and the Health of the Host Animal	361
12.1	Appearance of Animal	361
12.2	Detoxification	362
12.3	Lactic Acid Acidosis	362
12.4	Copper Toxicity	364
12.5	Bloat	366
13	The Flagellate Protozoa in the Rumen	368
13.1	Description and Classification	368
13.2	Infection of the Host and Population Density In vivo	370
13.3	Cultivation	371
	References	372
	Index	425