

Contents

Introduction

1 Subterranean Rodents: News from Underground	3
<i>Sabine Begall, Hynek Burda, Cristian E. Schleich</i>	
References	9

Part I Ecophysiology

2 Adaptive Physiological Mechanisms in the Underground Dwellers	13
<i>František Sedláček</i>	
2.1 Energy and Material Fluxes	14
2.2 Neural and Hormonal Regulation.....	16
References	17
3 Microclimate in Burrows of Subterranean Rodents – Revisited	21
<i>Hynek Burda, Radim Šumbera, Sabine Begall</i>	
3.1 Introduction	21
3.2 Microenvironmental Parameters	22
3.2.1 Temperature	22
3.2.2 Humidity	27
3.2.3 Ventilation in Subterranean Burrows.....	27
3.2.4 Burrow Atmosphere	28
3.3 Further Perspectives.....	30
References	31
4 New Data on Metabolic Parameters in Subterranean Rodents	35
<i>František Sedláček</i>	
4.1 Introduction	35
4.2 Variation of Basal Metabolic Rate on Interspecific Level.....	36
4.2.1 Resting Metabolic Rates	36
4.2.2 Energetic Expenditure During Digging.....	38

4.2.3	Endothermy and Poikilothermy in the Naked Mole-rat	39
4.3	Variation of Resting Metabolic Rate on Intraspecific Level	41
4.3.1	Energetics of Reproduction.....	41
4.3.2	Metabolic Rate and Sociality	42
	References	44
5	Skimping as an Adaptive Strategy in Social Fossorial Rodents: The Mole Vole (<i>Ellobius talpinus</i>) as an Example	49
	<i>Mikhail Moshkin, Eugene Novikov, Dmitri Petrovski</i>	
5.1	Introduction	49
5.2	Subjects, Area and Methodological Comments	50
5.3	Standard Metabolic Rate, Cost of Locomotion and Thermoregulation	51
5.4	Growth and Reproduction.....	52
5.5	Immune Defense	55
5.6	Adrenocortical Response to Stress.....	56
5.7	Conclusion	57
	References	58
6	The Reproductive Physiology and Endocrinology of the African Mole-rats: with Special Reference to Southern African Mole-rat Species	61
	<i>Nigel C. Bennett, Gundula H. Gutjahr, Chris G. Faulkes</i>	
6.1	Introduction	61
6.2	Reproductive Strategies in Solitary and Social African Mole-rats	62
6.2.1	Reproductive Strategies in Solitary Mole-rats	62
6.2.2	Reproductive Strategies in Social Mole-rats.....	63
6.2.3	How are Non-breeding Females Physiologically Suppressed?	68
6.3	Seasonal Breeding in Social Mole-rats	69
6.4	Induced vs Spontaneous Ovulation and the Role of Penile Ornamentation.....	70
6.5	Habitat Shapes the Reproductive Physiology of African Mole-rats	71
6.6	Monopolization of Reproduction: Plural Breeding in Males and Females	72
6.7	Perspective	73
	References	74

Part II Sensory Ecology

7 Sensory Ecology of Subterranean Rodents	81
<i>Sabine Begall, Cristian E. Schleich</i>	
References	83
8 Using Odors Underground	85
<i>Giora Heth, Josephine Todrank</i>	
8.1 Introduction	85
8.2 Foraging Underground	86
8.3 Recognizing and Discriminating Between Conspecifics Underground	87
8.3.1 Individual Odors	88
8.3.2 Odor-genes Covariance in Subterranean Rodents.....	88
8.3.3 Individual Recognition	90
8.3.4 Genetic Relatedness Distinctions	92
8.3.5 Two Separate Mechanisms – Two Separate Functions	93
8.4 Conclusion	94
References	94
9 Acoustics, Audition and Auditory System	97
<i>Sabine Begall, Simone Lange, Cristian E. Schleich, Hynek Burda</i>	
9.1 Introduction	97
9.2 Acoustics in Burrows	98
9.3 Hearing in Subterranean Rodents.....	99
9.4 Morphological Adaptations of the Ear.....	103
9.4.1 Outer and Middle Ear	103
9.4.2 Inner Ear	104
9.5 Synthesis	108
References	109
10 Acoustic Communication in Subterranean Rodents	113
<i>Cristian E. Schleich, Silke Veitl, Ema Knotková, Sabine Begall</i>	
10.1 Introduction	113
10.2 Adult Vocalizations	114
10.2.1 Acoustic Environment and Vocalization Structure	114
10.2.2 Social System and Vocal Repertoire.....	118
10.2.3 Territorial Signaling: To Knock or to Shout	120
10.3 Juvenile Vocalizations: Are Care-elicitation Calls Honest Advertisements of Offspring Need?.....	123
10.4 Conclusion	125
References	125

11 Visual Systems and the Role of Vision in Subterranean Rodents: Diversity of Retinal Properties and Visual System Designs	129
<i>Pavel Němec, Pavla Cveková, Hynek Burda, Oldřich Benada, Leo Peichl</i>	
11.1 Introduction	129
11.2 Eye Morphology	129
11.3 Retina	130
11.3.1 Photoreceptors	132
11.3.2 Retinal Interneurons and Circuitry	136
11.3.3 Retinal Ganglion Cells (RGCs).....	136
11.4 Optic Nerve (ON)	139
11.5 Subcortical Visual System	141
11.5.1 Suprachiasmatic Nucleus, Hypothalamus and Basal Telencephalon	142
11.5.2 Thalamic Visual Nuclei	144
11.5.3 Midbrain Nuclei: Pretectum, Superior Colliculus and Accessory Optic System.....	147
11.6 Visual Cortex	150
11.7 Oculomotor Nuclei	152
11.8 Role of Vision.....	152
11.9 Chronobiology	154
References	155
12 Magnetic Compass: A Useful Tool Underground	161
<i>Regina E. Moritz, Hynek Burda, Sabine Begall, Pavel Němec</i>	
12.1 Introduction	161
12.2 Available Information: From Earth to Animal	162
12.3 Compass Mode: From Behavioural Experiment to Proof.....	163
12.3.1 Experimental Design	163
12.3.2 Character of the Magnetic Compass	166
12.4 Transduction Mechanisms: From Signal to Receptor	166
12.4.1 Physical Models and Behavioural Evidence	166
12.4.2 Histological and Neurobiological Evidence	168
12.5 Neuronal Processing: From Receptor to Brain	169
References	170
13 Adaptive Neural Organization of Naked Mole-Rat Somatosensation (and Those Similarly Challenged)	175
<i>Thomas J. Park, Kenneth C. Catania, Dalia Samaan, Christopher M. Comer</i>	
13.1 Introduction	175

13.2	Naked Mole-rat Body Hairs	175
13.3	Somatosensation and Behavior	177
13.4	Somatosensory Specializations in the Central Nervous System of Naked Mole-rats	183
13.5	Comparisons to Star-Nosed Moles	186
13.6	New Directions: Unique Somatic Organization for Processing Painful Stimuli	188
13.7	Conclusion	190
	References	191

Part III Life Histories, Behavioural Ecology, Demography

14	From Natural Histories to Life Histories	197
	<i>Hynek Burda</i>	
	References	202
15	Giant Mole-rats, <i>Fukomys mechowii</i> , 13 Years on the Stage	205
	<i>Mathias Kawalika[†], Hynek Burda</i>	
15.1	Introduction	205
15.2	Taxonomy, Nomenclature and Phylogeny	206
15.3	Morphology of the Giant Mole-rats	207
15.3.1	Body size	207
15.3.2	Pelage Colour	208
15.3.3	Skull	209
15.4	Distribution	209
15.4.1	Geographic Distribution	209
15.4.2	Habitat Characteristics	209
15.4.3	Distributional Borders and Sympatry with Other <i>Fukomys</i> Species	210
15.5	Burrow Systems	210
15.6	Food	211
15.7	Colony Size and Structure	212
15.8	Sex Ratio	213
15.9	Surface Activity	214
15.10	Economic Importance	215
	References	217
16	Biology of the Silvery Mole-rat (<i>Heliophobius argenteocinereus</i>). Why Study a Neglected Subterranean Rodent Species?	221
	<i>Radim Šumbera, Wilbert N. Chitaukali, Hynek Burda</i>	
16.1	Introduction	221

16.2	Taxonomy and Body Size	222
16.3	Population Density and Structure	224
16.4	Food and Habitat Preferences	225
16.5	Burrow Systems and Burrowing	226
16.6	Reproduction	226
16.6.1	Mating Behaviour.....	226
16.6.2	Seasonality of Breeding	227
16.6.3	Pregnancy, Litter Size and Postnatal Development.....	229
16.6.4	Dispersal.....	229
16.7	Economic and Epidemiological Importance.....	230
16.8	Parasites and Sociality in African Mole-rats	230
16.9	Evolution of Sociality in the African Mole-rats	231
16.9.1	Hypotheses on the Evolution of Sociality in Bathyergids.....	232
16.9.2	Silvery Mole-rat and Evolution of Sociality.....	232
16.10	Further Perspectives.....	233
	References	234
17	The Biology and Ecology of Plateau Zokors (<i>Eospalax fontanierii</i>)	237
	<i>Yanming Zhang</i>	
17.1	Introduction	237
17.2	Morphological Characteristics	238
17.3	Physiological Characteristics	238
17.4	Habitat Selection and Distribution	240
17.5	Burrow System and Environment	240
17.6	Foraging and Diet	241
17.7	Activity Rhythms.....	241
17.8	Reproduction	242
17.9	Dispersal	242
17.10	Territoriality and Home Range	243
17.11	Population Dynamics	243
17.12	Burrow Cohabitants	244
17.13	Plateau Zokors as Prey.....	244
17.14	Relationship of Plateau Zokors and Livestock.....	245
17.15	Conclusion	246
	References	247
18	Senescence Patterns in African Mole-rats	
	(Bathyergidae, Rodentia)	251
	<i>Philip Dammann, Hynek Burda</i>	
18.1	Introduction	251

18.2 Longevity of Bathyergid Mole-rats Compared to Other Rodent Families	252
18.3 Intrafamilial Longevity Patterns.....	254
18.4 Intraspecific Aging Rates in Eusocial Bathyergids	257
18.5 "Caste"-Specific Aging: Possible Explanations.....	258
18.6 Conclusions and Perspectives	261
References	262

Part IV Environmental and Economic Aspects

19 The Influence of Subterranean Rodents on the Environment	267
<i>O. J. Reichman</i>	
References	269
20 The Influence of Pocket Gophers on the Biotic and Abiotic Environment	271
<i>O. J. Reichman</i>	
20.1 Introduction	271
20.2 Burrowing Activity	271
20.3 Geometry of Disturbances.....	272
20.3.1 Burrow Spacing.....	272
20.3.2 Mound Spacing.....	272
20.3.3 Comparisons Between Species, Age, Sex, and Size	273
20.4 Activity Patterns	273
20.5 Diets	274
20.6 Impact on Plants.....	275
20.6.1 Individual Plants	275
20.6.2 Plant Defenses	276
20.6.3 Impact on Plant Communities.....	276
20.7 Complex Biotic Interactions	278
20.8 Soil Dynamics	279
20.9 Economic Impacts	281
20.10 Conclusion	282
References	283
21 Subterranean Rodents as Pests: The Case of the Pocket Gopher	287
<i>Gary W. Witmer, Richard M. Engeman</i>	
21.1 Introduction	287
21.2 Pocket Gophers (Family Geomyidae)	288
21.3 Damage by Pocket Gophers	288
21.3.1 Forest Damage.....	288

21.3.2	Rangeland Damage.....	289
21.3.3	Fruit Tree Damage.....	290
21.3.4	Alfalfa and Field Crop Damage.....	290
21.3.5	Wire and Cable Damage.....	291
21.3.6	Hydraulic Structure Damage, Disturbance of Hazardous Waste and Archaeological Sites	292
21.3.7	Invasive Plant Establishment and Dispersal	293
21.4	Pocket Gopher Damage Management	293
21.4.1	Pocket Gopher Population Control.....	293
21.4.2	Habitat Management and Resource Protection	295
21.4.3	Population Densities and Monitoring	295
21.5	Conclusions and Future Needs.....	296
	References	297
22	Influence of Plateau Zokors (<i>Eospalax fontanierii</i>) on Alpine Meadows	301
	<i>Yanming Zhang</i>	
22.1	Introduction	301
22.2	Effects on Soil and Nutrients	302
22.3	Effects on Vegetation and Diversity	303
22.4	Effects on Monocotyledons	303
22.5	Effects on Dicotyledons	305
22.6	Conclusion	306
	References	307
23	Mountain Beaver: A Primitive Fossorial Rodent	309
	<i>Wendy M. Arjo</i>	
23.1	Introduction	309
23.2	Distribution of the Aplodontidae Family.....	310
23.3	Mountain Beaver Ecology	310
23.3.1	Habitat	311
23.3.2	Burrow and Nest Structure	312
23.3.3	Reproductive Behavior.....	313
23.3.4	Population Dynamics.....	314
23.3.5	Movements and Home Ranges	314
23.3.6	Forage Preference.....	315
23.4	Management and Economic Impacts	316
23.5	Conclusion and Future Research Needs.....	317
	References	319

Part V Molecular Ecology and Evolution

24 Molecular Ecology and Evolution	325
<i>Eileen A. Lacey</i>	
References	328
25 The Multiple Meanings of Inbreeding: The Key to Understanding the Social and Genetic Structure of Subterranean Rodent Populations	331
<i>Stanton Braude</i>	
25.1 Introduction	331
25.2 Determinants of Genetic Structure: Mutation, Selection, or Drift	331
25.3 The Influence of Social Structure on Genetic Structure and Genetic Structure on Social Structure	333
25.4 Genetic Structure and Social Structure in Naked Mole-rats: A Classic Example of the Importance of Understanding the Multiple Meanings of Inbreeding	333
25.5 Dispersal	336
25.6 Conclusions	337
References	337
26 Behavior, Demography, and Immunogenetic Variation: New Insights from Subterranean Rodents	341
<i>Eileen A. Lacey, Ana Paula Cutrera</i>	
26.1 Introduction	341
26.2 Genetic Structure in Subterranean Rodents	342
26.2.1 Neutrality vs Selection in Genetic Differentiation	344
26.2.2 Genetic Structure at Major Histocompatibility Complex (MHC) Loci	345
26.3 MHC Variation in Subterranean Rodents	345
26.4 Overview and Future Directions	350
References	351
27 African Mole-rats (Bathyergidae): A Complex Radiation in Tropical Soils	357
<i>Paul A. A. G. Van Daele, Chris G. Faulkes, Erik Verheyen, Dominique Adriaens</i>	
27.1 Introduction	357
27.2 Intergeneric Relationships	358
27.3 Biogeography of the Bathyergidae	359
27.4 Overview of the Six Genera	362

27.4.1	The Eusocial <i>Heterocephalus</i> Rüppell, 1842	362
27.4.2	The Three Solitary Genera	362
27.5	Diversification in Social Mole-rats of the Genera <i>Cryptomys</i> Gray, 1864 and <i>Fukomys</i> (Kock, Ingram, Frabotta, Honeycutt and Burda 2006).....	363
27.6	Prospects (for Phylogenetic Studies and Beyond)	367
	References	370
28	Mosaic Evolution of Subterranean Mammals: Tinkering, Regression, Progression, and Global Convergence <i>Eviatar Nevo</i>	375
28.1	Overview	375
28.2	Visual Adaptations in Subterranean Mammals	377
28.2.1	The Mosaic Evolution of the <i>Spalax</i> Eye: Morphology, Physiology, and Molecular Biology.....	378
28.2.2	α -Crystallin: Structure, Expression, and Evolution....	381
28.2.3	Adaptive Evolution of Small Heat Shock Protein/ α B-Crystallin Promoter Activity in <i>Spalax</i>	381
28.2.4	Retinal Photopigments in <i>Spalax</i>	383
28.3	Evolutionary Adaptive Regulation of Wide Genome Gene Expression.....	384
	References	386