12/2/86

ECOLOGICAL PHYSIOLOGY OF MALLEEFOWL (Leipoa ocellata)

DAVID TERRINGTON BOOTH

BSc. (Hons) (Monash University)

Department of Zoology

The University of Adelaide

A thesis submitted to the University of Adelaide in fulfilment of the requirements for the degree of Doctor of Philosophy.

AUGUST 1985

Awarded 24/12/85

CONTENTS

Page

Frontispiece I

Abstract II

Declaration IV

Acknowledgements V

Abbreviations used in text VII

1 GENERAL INTRODUCTION 1

1.1 A summary of Malleefowl biology 1

1.2 Investigations of the present study 7

2 GENERAL METHODS 11

2.1 Study site 11

2.2 Collection and incubation of eggs 11

2.3 Raising and maintenance of captive Malleefowl 12

2.4 Oxygen consumption measurements 12

3 PHYSIOLOGY AND ENERGETICS OF INCUBATION 13

3.1 INTRODUCTION 13

3.2 MATERIAL AND METHODS 17
- 3.2.1 Measurement of natural incubation mound temperatures 17
- 3.2.2 Laboratory incubation procedure 17
- 3.2.3 Measurement of oxygen consumption and carbon dioxide production 18
- 3.2.4 Measurement of eggshell thickness 19
- 3.2.5 Measurement of eggshell water vapour conductance 19

3.3 RESULTS 21
- 3.3.1 Natural incubation temperatures 21
- 3.3.2 Effect of incubation temperature on egg hatching success 21
- 3.3.3 Effect of incubation temperature on oxygen consumption 21
- 3.3.4 Mass loss during incubation 24
- 3.3.5 Egg temperature during incubation 26
- 3.3.6 Eggshell thinning 28
- 3.3.7 Eggshell water vapour conductance 28

CONTENTS

page

3.4 DISCUSSION
3.4.1 Natural incubation temperature and effect of temperature on hatchability 31
3.4.2 Egg temperature throughout incubation 34
3.4.3 Effect of incubation temperature on oxygen consumption 36
3.4.4 Mass loss of eggs during incubation 40
3.4.5 Respiratory gas exchange ratio in Malleefowl eggs 44

4 METABOLIC RESPONSES OF MALLEEFOWL EGGS TO COOLING, HEATING, AND HIGH OXYGEN TENSION 49

4.1 INTRODUCTION 49

4.2 MATERIAL AND METHODS 52

4.3 RESULTS 54
4.3.1 Cooling eggs 54
4.3.2 Heating eggs 57
4.3.3 Effect of increased oxygen tension on oxygen consumption 57

4.4 DISCUSSION 59
4.4.1 Cooling eggs 59
4.4.2 Heating eggs and effect of increasing the partial pressure of oxygen around full-term eggs 63
4.4.3 Effect of chronic and acute exposure to various incubation temperatures on oxygen consumption 67
4.4.4 Egg cooling and heating rates 69

5 RESPIRATORY GAS EXCHANGE DURING HATCHING 71

5.1 INTRODUCTION 71

5.2 MATERIAL AND METHODS 74

5.3 RESULTS 75
5.3.1 General 75
5.3.2 Patterns of metabolism immediately prior to hatching 75
5.3.3 Metabolic patterns immediately after hatch 77

5.4 DISCUSSION 79
5.4.1 Gas exchange patterns immediately prior to hatching 79
5.4.2 Gas exchange patterns after hatch 82
5.4.3 Energetic cost of the paranatal period 83

CONTENTS

page

6 THERMOREGULATION IN NEONATE MALLEEFOWL AND BRUSH-TURKEYS 87

6.1 INTRODUCTION 87

6.2 MATERIAL AND METHODS 92
  6.2.1 Chicks 92
  6.2.2 Measurement of oxygen consumption and evaporative water loss 92
  6.2.3 Cooling curve determination of conductance 93
  6.2.4 Thermal regime of hatching environment 95

6.3 RESULTS 96
  6.3.1 Malleefowl chicks 96
  6.3.2 Brush-turkey chicks 97
  6.3.3 Thermal conductance 98

6.4 DISCUSSION 102
  6.4.1 Standard metabolic rate and body temperature 102
  6.4.2 Comparison of methods used to calculate thermal conductance 107
  6.4.3 Cold-hardiness in Malleefowl and Brush-turkey hatchlings 109
  6.4.4 Heat stress in Malleefowl and Brush-turkey hatchlings 113
  6.4.5 Thermal conductance of Malleefowl and Brush-turkey hatchlings 114
  6.4.6 Metabolic water production in hatchling Malleefowl 116
  6.4.7 Differences in thermoregulatory parameters of Malleefowl and Brush-turkey hatchlings 116

7 THERMOREGULATION IN TWO-YEAR-OLD MALLEEFOWL 121

7.1 INTRODUCTION 121

7.2 MATERIAL AND METHODS 122

7.3 RESULTS 124
  7.3.1 Body mass 124
  7.3.2 Oxygen consumption and thermal conductance 124
  7.3.3 Evaporative water loss 125
  7.3.4 Body temperature 125
  7.3.5 Respiratory frequency 125

7.4 DISCUSSION 127
  7.4.1 Oxygen consumption and thermal conductance 127
  7.4.2 Evaporative water loss 129
  7.4.3 Body temperature 130

CONTENTS

page

8 WATER TURNOVER 132

8.1 INTRODUCTION 132

8.2 MATERIAL AND METHODS 134
- 8.2.1 Water flux and body water of captive chicks 134
- 8.2.2 Water flux in free-ranging chicks 134
- 8.2.3 Water flux and body water of captive adults 135
- 8.2.4 Water flux and body water of free-ranging adults 135
- 8.2.5 Analysis of tritiated water in blood samples 136
- 8.2.6 Calculation of total body water 136
- 8.2.7 Water flux calculations 137

8.3 RESULTS 139
- 8.3.1 HTO equlibration time trial 139
- 8.3.2 Water flux and body water of chicks 139
- 8.3.3 Water flux and body water of captive adult Malleefowl 141
- 8.3.4 Water flux and body water of free-ranging adult Malleefowl 142
- 8.3.5 Relationship between body water content and body mass 145

8.4 DISCUSSION 146
- 8.4.1 Justification of HTO technique 146
- 8.4.2 Water flux and body water of chicks 147
- 8.4.3 Water flux and body water of adult birds 149
- 8.4.4 Conclusion 156

9 HOME RANGE OF MALLEEFOWL 158

9.1 INTRODUCTION 158

9.2 MATERIAL AND METHODS 160
- 9.2.1 Radio tracking adult birds 160
- 9.2.2 Radio tracking chicks 161

9.3 RESULTS 163
- 9.3.1 Adult Malleefowl location 163
- 9.3.2 Chick location and movement 165

9.4 DISCUSSION 167
- 9.4.1 Home range of adult Malleefowl 167
- 9.4.2 Malleefowl chick movement 170
- 9.4.3 Fox predation of adult Malleefowl 171
- 9.4.4 Conclusion 171

10 EFFECT OF ADDING WATER TO MALLEEFOWL MOUNDS DURING A DROUGHT 172

CONTENTS

page

10.1 INTRODUCTION 172

10.2 MATERIAL AND METHODS 173

10.3 RESULTS 174
- 10.3.1 Mound renovation in 1981 174
- 10.3.2 Mound renovation in 1982 174

10.4 DISCUSSION 176

11 MOUND DENSITY AND HATCHING SUCCESS OF MALLEEFOWL OVER THE STUDY PERIOD 178

11.1 INTRODUCTION 178

11.2 MATERIAL AND METHODS 179
- 11.2.1 Mound survey 179
- 11.2.2 Fecundity and hatching success 179
- 11.2.3 Rainfall patterns 180

11.3 RESULTS 181
- 11.3.1 Mound survey 181
- 11.3.2 Fecundity and hatching success 181
- 11.3.3 Rainfall patterns 183

11.4 DISCUSSION 184
- 11.4.1 Mound density 184
- 11.4.2 Egg mass, clutch size and hatching success 185

LITERATURE CITED 189

ABSTRACT

Aspects of the incubation biology and environmental physiology of Malleefowl Leipoa ocellata have been studied in the field near Renmark, South Australia, and in the laboratory.

Malleefowl eggs were incubated artifically at temperatures of 30, 32, 34, 36, and 38 C. The energetics of incubation at these temperatures was determined by monitoring oxygen consumption over the incubation period. Egg water loss and egg surface temperature were also monitored. No eggs developed at 30 C (N=6), 22% (N=9) hatched at 32 C, 80% (N=10) hatched at 34 C, 44% (N=9) hatched at 36 C, and 38% (N=8) hatched at 38 C. The amount of oxygen consumed during incubation varied with incubation temperature. Eggs incubated at 32 C consumed 42% more oxygen than eggs incubated at 34 C, while eggs incubated at 36 and 38 C consumed 19 % less.

Water loss from developing eggs increased with incubation time at all temperatures. The cause of increased water loss in eggs incubated at 34 C was investigated and can be attributed to an increase in eggshell gas conductance.

During incubation a temperature gradient developed between the eggshell and the surrounding sand at all incubation temperatures. This gradient reached 1.5 - 2.0 C in full term eggs. Egg surface and surrounding sand temperatures were monitored continuously throughout incubation in a natural incubation mound, and sand temperature was found to vary from 27 C to 32 C, while egg surface temperature varied from 27 C to 35 C. This experiment demonstrated that Malleefowl eggs can hatch successfully after exposure to temperatures as low as 28 C for at least a week, and that a temperature gradient of up to 3.0 C develops between the eggshell surface and the surrounding sand.

The ontogeny of thermoregulation was investigated in full term eggs and hatchling chicks. The development of an 'endothermic response' appears during the last week of incubation in most eggs. Hatchlings were found to be competent homeotherms only five hours after hatching, to have low evaporative water loss, and to be tolerant of heat stress.

Water turnover using the tritium labeled water technique was monitored over a twelve month period in both captive birds kept in Adelaide and free-ranging birds at Renmark. Water turnover in captive birds remained relatively constant and was only 33% of the expected rate based on allometric criteria. Water turnover in free-ranging birds was more variable and greater than in captive birds, but was still only about 50% of the predicted rate. These results suggest that Malleefowl have evolved low water requirements in response to their arid environment.