



STUDYING CAPTIVE ANIMALS

A Workbook of Methods in Behaviour, Welfare and Ecology

Paul A. Rees



WILEY Blackwell

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For Katy, Clara, Mum and Dad

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WILEY Blackwell

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Contents

Preface	xi
Acknowledgements	xiii
About the Companion Website	xv
Part 1 Introduction	1
1. Studies of Behaviour, Welfare and Ecology in Captive Animals	3
1.1 What Are Captive Animals?	4
1.1.1 Introduction	4
1.1.2 A Short and Incomplete History of Captive Animal Studies	4
1.2 Types of Studies	8
1.2.1 Behaviour Studies	8
1.2.2 Animal Welfare Studies	10
1.2.3 Ecological Studies	10
1.3 Possible Study Locations	11
1.4 Advantages and Disadvantages of Studying Captive Animals	11
1.5 What Types of Research Have Been Conducted on Animals Living in Zoos?	13
1.6 What Sort of Study Should I Undertake?	16
2. Designing Your Study	19
2.1 Introduction	20
2.2 Selecting Subjects for Study	20
2.2.1 Selecting a Species	20
2.2.2 Simple vs Complex Zoo Environments: Choosing the Right Enclosure	20
2.2.3 Specialised Zoo Facilities for Studying Animals	25
2.3 How Does Science Work?	25
2.4 Experimental Design	29
2.4.1 Introduction	29
2.4.2 Controlling Subject Variables	30
2.4.3 Controlling Situational Variables	32

2.4.4	Confounding Variables	32
2.4.5	The Link Between Experimental Design and Statistics	32
2.4.6	Cross-Sectional and Longitudinal Studies	32
2.5	Data Collection	33
2.5.1	Who Should Collect the Data?	33
2.5.2	Sampling	34
2.5.3	Replication: How Many Subjects Should be Studied?	35
2.5.4	Pseudoreplication	35
2.5.5	Accuracy and Reliability of Data	35
2.5.6	Inter-Observer Reliability	36
2.5.7	Observer Drift	37
2.5.8	Can Untrained Observers be Used to Collect Behavioural Data?	38
2.5.9	Collecting Data Using Questionnaires	39
2.6	Keeper/Trainer Assessments of Animals	42
2.7	Pilot Studies	42
2.8	Making Observations	43
2.8.1	What to Wear and How to Behave	43
2.8.2	Vantage Points, Camouflage and Screening	43
2.9	Submitting a Research Proposal	45
2.9.1	Introduction	45
2.9.2	Zoo Research Departments	47
2.9.3	Ownership of Research Data	47
2.10	Some Problems Associated with Working in Zoos	47
2.10.1	Working in the Zoo Environment	47
2.10.2	Interspecies Interactions and Mixed Species Exhibits	54
2.11	Legislation	55
2.11.1	Ethical and Legal Considerations	55
2.11.2	Does Your Study Need a Licence?	57
2.12	Risk Assessment and Health and Safety Considerations	58
2.12.1	Insurance	59
2.12.2	Hazardous Animal Categorisation	59
3.	Equipment	63
3.1	Introduction	64
3.2	Binoculars	64
3.2.1	Choosing Binoculars	64
3.2.2	The Dioptre Adjustment	66
3.3	Voice Recorders	67
3.4	Personal Digital Assistants (PDAs)	68
3.5	Still Cameras	68
3.5.1	Camera Traps	68
3.6	Digital Video Cameras	70
3.7	Event Recorders	70
3.8	Trail Monitors	71
3.9	Accelerometers	71
3.10	GPS and GIS	71
3.11	Radio Collars	73
3.12	Data-Loggers	73
3.13	Proximity Data-Loggers	73

3.14	Radio Frequency Identification (RFID) Technology	74
3.15	Too Much Equipment?	74

Part 2	Measuring Animal Behaviour and Welfare	75
4.	Identifying Individuals and Recording Behaviours	77
4.1	Identifying and Naming Individual Animals	78
4.1.1	Identification	78
4.1.2	Naming Individuals	82
4.2	Describing and Interpreting Behaviour	83
4.2.1	Using Drawings to Illustrate Behaviour	83
4.2.2	What is an Ethogram?	83
4.2.3	Constructing an Ethogram	85
4.2.4	How Many Behaviours? Behaviour Discovery Curves	86
4.3	Interpreting Behaviours	87
4.3.1	Establishing the Meaning and Purpose of a Behaviour	87
4.3.2	Gestures and Vocalisations	90
4.4	How Can Behaviour be Measured?	90
4.5	How to Sample and Record Behaviour	92
4.5.1	Introduction	92
4.5.2	Recording Rules	95
4.5.3	Sampling Rules	97
4.6	When Should Samples be Taken?	101
4.7	Recording Behaviour in the Field	102
4.7.1	Behaviour Record Sheets	102
4.7.2	Recoding on an iPhone	102
5.	Activity Budgets and Welfare	103
5.1	Introduction	104
5.1.1	Indirect Measures of Welfare	105
5.2	Activity Budgets	105
5.2.1	Introduction	105
5.2.2	Problems with 'Invisible' Animals	107
5.2.3	How Many Samples?	107
5.2.4	Temporal Patterns	108
5.2.5	Stereotypic Behaviour	109
5.2.6	Enrichment Studies	111
5.3	Numerical Rating Scales and Analogue Visual Scales	113
5.4	Body Condition and Welfare	114
5.4.1	Body Condition Scoring	114
5.4.2	Measuring Obesity	115
5.4.3	Computer Monitoring of Welfare	115
5.5	Animal Personality	116
5.5.1	Measuring Personality	116
5.5.2	The Use of Cluster Analysis to Compare the Behaviour of Individuals in a Group	117
5.5.3	Measuring Tameness	119
5.6	Preference Tests	119
5.7	Visitor Studies	120

5.8	The Parasitology of Captive Animals	121
5.9	Exercises	122
6.	Measuring Social Behaviour	125
6.1	Introduction	126
6.2	Associations Between Individuals	127
6.2.1	Defining Associates	127
6.2.2	Association Indices	128
6.2.3	Chance Encounters Between Animals	130
6.2.4	Sociograms	135
6.3	Maintenance of Proximity Index (MPI)	139
6.4	Nearest Neighbour Measurements	142
6.5	Relationship Indices	143
6.6	Social Facilitation	143
6.7	Agonistic Behaviours: Aggression and Appeasement	145
6.7.1	Index of Fighting Success	150
6.8	Dominance Hierarchies	151
6.8.1	Constructing a Matrix of Dominance Relationships	152
6.8.2	A Simple Dominance Index	154
6.9	Courtship, Mating and Mate Selection	154
6.9.1	Social Learning of Sexual Behaviour	157
6.10	Exercises	159
Part 3	Measuring Ecology	161
7.	Enclosure Use, Habitat Selection and Feeding Ecology	163
7.1	Introduction	164
7.2	Enclosure Size and Use	164
7.2.1	Introduction	164
7.2.2	Spread of Participation Index (SPI)	167
7.2.3	Electivity Index	170
7.2.4	Utilisation of Vertical Space	170
7.2.5	Visibility	173
7.3	Feeding Ecology and Behaviour	175
7.3.1	Gross Assimilation Efficiency and Food Passage Time	177
7.4	Exercises	178
8.	Population Studies	181
8.1	Introduction	182
8.2	How Many Animals Are There and How Are They Dispersed? Counting Animals in the Field	183
8.2.1	Use of Transects to Estimate Population Size or Density	183
8.2.2	The Dispersion of Animals	185
8.3	Studies of Population Growth	186
8.3.1	Life Tables and Survivorship Curves	186
8.3.2	Predicting Population Growth	188
8.3.3	Sex Ratio	193
8.3.4	Breeding Potential: Calculating Effective Population Size	194
8.4	Family Histories	195
8.5	Long-Term Studies of Zoo Populations	196

8.6	National and Global Studies of Zoo Populations	200
8.6.1	Where to Find Secondary Data on Zoo Populations	202
8.7	Exercises	204
Part 4	Statistics and Report Writing	209
9.	How to Analyse Your Data – Statistics	211
9.1	Introduction	212
9.1.1	What are Statistics?	212
9.1.2	What is a Variable?	212
9.1.3	Populations and Samples	213
9.2	Descriptive Statistics	214
9.2.1	Graphs	214
9.2.2	Measures of Central Tendency	220
9.2.3	Measures of Dispersion	221
9.3	Types of Distributions	224
9.3.1	Cumulative Frequency Distributions	224
9.3.2	The Normal Distribution	224
9.3.3	The Poisson Distribution	228
9.3.4	The Binomial Distribution	229
9.4	Inferential Statistics	231
9.4.1	Hypotheses and Hypothesis Testing	231
9.4.2	Statistical Significance and Probability	232
9.4.3	One-Tailed or Two-Tailed?	233
9.4.4	Degrees of Freedom	234
9.4.5	Type I and Type II Errors	234
9.4.6	Fishing Trips and Statistical Significance – the Bonferroni Correction	235
9.5	Statistical Tests	236
9.5.1	Choosing a Statistical Test	236
9.5.2	Testing Samples for Differences	236
9.5.3	Correlation and Regression	239
9.5.4	Goodness of Fit, Testing for Homogeneity and Contingency Tables	242
9.6	Meta-Analysis	244
9.7	Statistical Packages – a Warning	244
10.	How to Write a Report	245
10.1	Academic Journals	246
10.1.1	What is an Academic Journal?	246
10.1.2	How to Choose a Journal	246
10.1.3	Impact Factors	247
10.1.4	Submitting a Paper for Publication	247
10.1.5	The Peer Review Process	247
10.2	Writing Style	248
10.2.1	Tenses and Voices	248
10.2.2	British vs American English	249
10.2.3	Scientific Names of Animals	249
10.2.4	How to Refer to Individual Animals in Scientific Writing	250

x	10.3	Writing a Report	251
Contents	10.3.1	Structure	251
	10.3.2	Choosing a Title	251
	10.3.3	Authors and Affiliations	254
	10.3.4	Abstract	254
	10.3.5	Introduction/Literature Review	255
	10.3.6	Methods	256
	10.3.7	Results	258
	10.3.8	Discussion	259
	10.3.9	Acknowledgements	259
	10.3.10	Summary	259
	10.3.11	References	259
	10.4	Referencing the Work of Others	260
	10.4.1	Referencing Systems	260
	10.4.2	The Vancouver System	260
	10.4.3	The Harvard System	260
	10.4.4	Referencing Software	265
		Appendix	267
	References	269	
	Further Reading	287	
	Index	289	

Preface

What is This Book For?

Many students undertake research projects concerned with animal behaviour, animal welfare or ecology, usually in their final year as undergraduates, or for their master's degree or doctorate. They may be students of biology, zoology, animal welfare, wildlife conservation, zoo biology or even psychology, and often their studies are conducted on captive animals. Many excellent general textbooks on animal behaviour, welfare and ecology exist, and there are others that specifically cover methodology. However, the latter do not generally show students how they should record and collect data and they do not explain how to perform the calculations necessary to quantify animal behaviour, welfare and ecology, often presenting formulae with little or no explanation. Furthermore, existing texts do not discuss the particular challenges of studying captive animals.

This book is intended to fill this gap by providing a step-by-step guide to some of the most useful methods available to study captive animals. Although some of the high-tech methods used by behavioural scientists and ecologists are discussed, emphasis has been placed on methods that require very little equipment because most students have no budget for electronic gadgets and in any event I believe the principles of studying animals 'in the field' are best learnt by watching animals and making simple recordings rather than using data-loggers and GPS equipment.

For convenience, I have divided the book into 10 chapters grouped into four parts, although the contents of each necessarily overlap. It is not possible to separate out completely ecology from behaviour or behaviour from welfare. For example, feeding is a behaviour but it is affected by an animal's ecology. Nutrition affects an animal's welfare, and poor nutrition may result in obesity. I have discussed the measurement of activity (including feeding), enclosure use (which may be determined by the location of food sources) and body condition in different chapters although these subjects are clearly related. I have tried to be logical in the way I have grouped topics. If the reader disagrees I hope the index will make up for any deficiencies.

Most studies conducted on captive animals concern terrestrial mammals, and a very high proportion of these are behaviour studies. Where possible I have included examples from other taxa, but inevitably these are few and far between in the scientific literature. However, most of the methods I have described may be used on a wide variety of taxa so I hope my choice of examples will not act as an impediment to their wider application to little studied species.

Paul A. Rees BSc (Hons) LLM PhD CertEd

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My daughter once advised one of her teachers that she could not draw and he retorted that she should not say she could not do things. Her response was to confirm that she could not fly! I definitely cannot draw so my friend and ex-colleague Dr Alan Woodward drew the individual diagrams that make up Fig. 4.8 from a series of photographs I took of elephant courtship at Chester Zoo. For the same reason, I have used images kindly made available by Openclipart (www.openclipart.org) in several figures (Figs 6.5, 6.10, 6.15, 6.22, 7.5, 8.4, 8.5 and 9.3) and am grateful to various contributors to this enterprise for allowing unrestricted use of their work.

Almost all of the photographs reproduced here are my own. However, I am grateful to Chetham's Library, Manchester, for permission to reproduce Fig. 1.2, and to Prof. Geoff Hide (University of Salford) for permission to reproduce the photograph of giant pandas used in Fig. 1.5. Prof. Hide also provided me with advice on sources of information on methods used in parasitology.

At Wiley Blackwell I would like to thank Ward Cooper (Commissioning Editor) for believing that this project was worthwhile, and Kelvin Matthews (Senior Project Editor), Rosie Hayden and Andrew Hallam for overseeing the production process.

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Finally, I should like to thank my wife, Katy, for implicitly accepting a division of labour in our household whereby – at least for the moment – I write the textbooks and she does most everything else.

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/rees/captiveanimals

The website includes:

- PowerPoint slides of all the figures from the book, for downloading
- PDF files of all the tables from the book, for downloading

Introduction



The first three chapters of this book are concerned with setting the historical background to the study of captive animals, examining the design of such studies and assessing the usefulness of some of the equipment available. Photo: Herdwick ram (*Ovis aries*).

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Studies of Behaviour, Welfare and Ecology in Captive Animals

To begin at the beginning

Dylan Thomas (1954)



Fig. 1.1 North American porcupine (*Erethizon dorsatum*).

1.1.1 Introduction

For the purposes of this book I have defined captive animals as those that are, or have recently been, under the control of humans. This includes zoo and farm animals, companion animals and free-ranging feral animals, but not animals kept in laboratory conditions. In most cases they are confined in relatively small areas (or volumes) by fences, walls and other barriers, and are unable to escape. In some cases they are free-ranging but still remain closely associated with humans.

1.1.2 A Short and Incomplete History of Captive Animal Studies

Studies of animals kept in captivity have a long history. Over 2300 years ago the Greek philosopher Aristotle wrote his *History of Animals* (Aristotle, 350 BC; trans. 1910). Alexander the Great captured many exotic animals on his military expeditions and sent them back to Greece where they were kept in menageries. Most of the city states of Greece had such menageries and these would have given Aristotle the opportunity to study animals that he would not have been able to see in the wild. The *History of Animals* contains descriptions of various aspects of animal behaviour that can only relate to captive animals. For example, he discusses mating in the camel:

The male camel declines intercourse with its mother; if his keeper tries compulsion, he evinces disinclination. On one occasion, when intercourse was being declined by the young male, the keeper covered over the mother and put the young male to her; but, when after the intercourse the wrapping had been removed, though the operation was completed and could not be revoked, still by and by he bit his keeper to death.

Aristotle even refers to the training of elephants:

Of all wild animals the most easily tamed and the gentlest is the elephant. It can be taught a number of tricks, the drift and meaning of which it understands; as, for instance, it can be taught to kneel in presence of the king. It is very sensitive and possessed of an intelligence superior to that of other animals.

The Roman emperors kept many animals in private collections for study and for use in the Roman Games, where they perished in very large numbers. These animals were supplied by the Roman military and acquired from the rulers of the countries where the animals were endemic (Epplett, 2001). Thousands of wild animals were slaughtered when the Colosseum was inaugurated in AD 80.

The first zoo created for scientific purposes was the Regent's Park Zoo in London, now known as ZSL London Zoo. It was founded in 1828. Two years earlier in 1826 Stamford Raffles had founded the Zoological Society of London (ZSL). The first scientific meetings of the Society were held in 1830 and in the same year the first *Proceedings of the Zoological Society of London* were published. Initially the zoo was open only to Fellows of the Zoological Society and others with a written 'order' from a Fellow. It was fully opened to the public some 20 years later in 1847.

The scientific interest in zoo animals in Victorian times was largely concerned with anatomy and taxonomy and did not extend to concern for their welfare or any detailed consideration of their behaviour. Early enclosures were barren and many species were held behind iron bars (Fig. 1.2).



Fig. 1.2 The polar bear (*Ursus maritimus*) enclosure at the former Belle Vue Zoo, Manchester (UK), constructed c.1850. Source: Reproduced with permission, Chetham's Library, Manchester.

Animal welfare legislation is not yet 200 years old. In England in 1882 Richard Martin MP (who earned the nickname 'Humanity Dick') was responsible for the passing of *An Act to prevent the improper Treatment of Cattle*. The Act made it an offence to:

...wantonly and cruelly beat, abuse or ill treat any Horse, Mare, Gelding, Mule, Ass, Ox, Cow, Heifer, Steer, Sheep or other Cattle...

This Act was the first national legislation in the world that punished cruelty to animals.

The Royal Society for the Prevention of Cruelty to Animals (RSPCA) was founded more than half a century earlier, in 1824 in London, as the Society for the Prevention of Cruelty to Animals (SPCA). The 'R' was added in 1840 with the permission of Queen Victoria. The Society has been funding animal welfare research for many years and, indeed, funded my own PhD in 1977. It now has a Science Group whose staff study and provide expert advice on welfare issues relating to companion animals, farm animals, research animals and wildlife.

The twentieth century saw the founding of many new organisations concerned with the keeping and welfare of animals, and many of these now undertake and publish research.

The Association of Zoos and Aquariums (AZA) was founded in 1924 – originally as the American Association of Zoological Parks and Aquariums (AAZPA) – and in 1926 Major Charles Hume founded the University of London Animal Welfare Society (ULAWS), which became the Universities Federation for Animal Welfare (UFAW) in 1938. Both organisations publish their own journals.

In a short article entitled ‘Zoo Experiments’ published in 1931, *The Spectator* (Anon., 1931) reported the release of a number of guinea fowl from Whipsnade, proclaiming that:

The new Zoo in Whipsnade has just proved the means of fulfilling the very first and original idea of the Zoological Society. It was to be a garden of acclimatization, designed at least in part to introduce animals to wild life in England. The very first animal selected for experiment was the guinea-fowl.

Serious studies of animals living in zoos and circuses date from the 1950s and were pioneered by the Swiss zoologist Professor Heini Hediger. He is considered to be the ‘father of zoo biology’ and was once the Director of Zurich Zoo. Hediger published a number of early books on captive animals including *Studies of the Psychology and Behaviour of Captive Animals in Zoos and Circuses* (Hediger, 1955), *Wild Animals in Captivity: An Outline of the Biology of Zoological Gardens* (Hediger, 1964) and *Psychology and Behaviour of Animals in Zoos and Circuses* (Hediger, 1969).

Academic journals concerned with animal behaviour appeared in the middle of the last century. The journal *Behaviour* was founded by Niko Tinbergen and W.H. Thorpe in 1948. The first issue carried a paper by Tinbergen and van Iersel (1947) entitled “‘Displacement reactions” in the three-spined stickleback’ along with the classic study of wolf social behaviour and communication conducted by Schenkel (1948) in Basle Zoological Gardens (see Fig. 4.12). Over 25 years later, Altmann (1974) published an important and often quoted paper in *Behaviour* in which she described the seven major types of sampling for observational studies of social behaviour that were at that time being used in the literature. The journal *Animal Behaviour* was originally published in 1953 as the *British Journal of Animal Behaviour*, and its first issue included articles on behaviour problems in laboratory rats (Lane-Petter, 1953) and grazing behaviour in dairy cattle (Castle and Halley, 1953).

The Zoological Society of London established a research institute – the Institute of Zoology – in 1960–61 as a result of the efforts of Lord Solly Zuckerman, who was a pioneer in the study of primate behaviour and served as both Secretary and President of the Society. A few years later, the American zoologist Lee S. Crandall published the classic text *The Management of Wild Mammals in Captivity* while working at the Bronx Zoo (Crandall, 1964).

Around the same time, in the UK, there was great concern for the welfare of farm animals. The report of an investigation into farm animal welfare entitled *Report of the Technical Committee to Enquire into the Welfare of Animals kept under Intensive Livestock Husbandry Conditions* (the Brambell Report) was published in 1965 and led to the establishment of the ‘five freedoms’ that are now widely used as the basis for good animal welfare in farms, zoos and other captive environments (HMSO, 1965). In the same year in the USA the Smithsonian’s National Zoo created its zoological research division to study the reproduction, behaviour and ecology of zoo species.

The British and Irish Association of Zoos and Aquariums (BIAZA) was founded in 1966 as the Federation of Zoological Gardens of Great Britain and Ireland. It is the professional organisation that represents the zoo and aquarium community in Britain and Ireland; among other things, it promotes research within its member institutions.

In 1971 UFAW published the first edition of *Management and Welfare of Farm Animals: The UFAW Farm Handbook*. The academic journal *Applied Animal Ethology* (now *Applied Animal Behaviour Science*) was first published in 1974. The first issue contained papers on subjects ranging from the social behaviour of roe deer (Espmark, 1974) to agonistic and mating behaviour in chickens (Craig and Bhagwat, 1974).

Eight years later, in 1982, the journal *Zoo Biology* was first published. It was the first journal to concern itself exclusively with scientific studies of zoos and zoo animals. Its first editor was Dr Terry Maple, and the very first paper was co-authored by Dr Frans de Waal. It concerned the effects of spatial crowding on social behaviour in a chimpanzee colony at Arnhem Zoo in The Netherlands (Nieuwenhuijsen and de Waal, 1982). The second paper was an account of an enrichment study of otters co-authored by Dr Hal Markowitz, who pioneered the engineering of active environments for animals living in zoos (Foster-Turley and Markowitz, 1982).

In 1986 Donald Broom became the first Professor of Animal Welfare in the world, in the Department of Veterinary Medicine at the University of Cambridge. He has published a number of books including the *Biology of Behaviour* (Broom, 1981), *Farm Animal Behaviour and Welfare* (Fraser and Broom, 1990) and *Domestic Animal Behaviour and Welfare* (Broom and Fraser, 2007). The academic journal *Animal Welfare* was published by UFAW for the first time in 1992. The first volume contained papers describing the use of a puzzle feeder as an enrichment device for gorillas at London Zoo (Gilloux *et al.*, 1992) and the behavioural responses of laying hens to carriage on conveyors (Scott and Moran, 1992). The *Journal of Applied Animal Welfare Science* was first published in 1998 and its first issue included papers on abnormal behaviour in caged birds (van Hoek and Ten Cate, 1998) and the use of toys as enrichment for chimpanzees (Brent and Stone, 1998).

Building on Crandall's earlier work, *Wild Mammals in Captivity: Principles and Techniques* was first published in 1996 (Kleiman *et al.*, 1996) and then revised as *Wild Mammals in Captivity: Principles and Techniques for Zoo Management* (2nd edition), published in 2010 (Kleiman *et al.*, 2010).

Since April 2002 zoos located within the Member States of the European Union have been required by Council Directive 1999/22/EC of 29 March 1999 on the keeping of wild animals in zoos – the Zoos Directive – to have a conservation function. One of the ways in which they may discharge this obligation is to participate in research whose results benefit the preservation of species. Although research is not a mandatory requirement, this legislation has acted as an important incentive for zoos in Europe to undertake their own research and to co-operate with universities and other research organisations.

Scientific interest in the welfare of animals living in zoos has gained increased attention in recent years. The first conference on the welfare of zoo animals (From Good Care to Great Welfare – Advancing Zoo Animal Welfare Science and Policy) was held by the Detroit Zoological Society at Detroit Zoo in August 2011 under the auspices of the zoo's Center for Zoo Animal Welfare. Papers from the symposium were published in 2013 in a special issue of the *Journal of Applied Animal Welfare Science* (vol. 16, issue 4). In 2013 Terry Maple published a major text entitled *Zoo Animal Welfare* (Maple and Perdue, 2013). In June 2013 the Chicago Zoological Society's Center for the Science of Animal Welfare (CSAW) organised a second international symposium: Zoo Animal Welfare: Innovations and Future Directions.

Welfare concerns about the keeping of some species in zoos have recently stimulated considerable research effort. The welfare challenges associated with the keeping of elephants in zoos have been of international concern for a number of years, resulting in two major studies in the UK. The first was conducted by Clubb and Mason (2002) and funded by the Royal Society for the Prevention of Cruelty to Animals; the second was conducted by Bristol University (Harris *et al.*, 2008) and was commissioned by the Department for Environment, Food and Rural Affairs (Defra) and also received funding from BIAZA, RSPCA and the International Fund for

Animal Welfare (IFAW). A review of the latter by the Zoos Forum (now the Zoos Expert Committee) resulted in the formation of an Elephant Welfare Group by BIAZA at the request of the UK government (Zoos Forum, 2010). It was charged with proposing a series of improvements in the welfare and care of elephants in UK zoological collections.

There has been concern for some time about the keeping of a number of other species in captivity – especially chimpanzees, bears and marine mammals – and about the use of animals in circuses. There is also unease about the conditions in which pigs and hens are kept on intensive farms – much of which has been addressed by legislation (e.g. in the European Union, the Pigs Directive and the Welfare of Laying Hens Directive) – and about obesity in some animals kept in zoos and in some companion animals, especially cats and dogs. There is even concern about the amount of space provided by members of the public for their pet rabbits; the Welsh Assembly has issued a *Code of Practice for the Welfare of Rabbits* (Anon., 2009) under section 14 of the Animal Welfare Act 2006. This increased interest in animal welfare provides many opportunities for scientists to conduct new research that may contribute to the debate about how we should treat animals under human care.

1.2 Types of Studies

Captive animals may be used for a very wide range of scientific studies. However, this book focuses on research that may be undertaken by observation alone and falls into one of three types: behaviour, welfare and ecology.

1.2.1 Behaviour Studies

Studies undertaken with captive animals are often concerned with some aspect of their behaviour. These animals represent an important resource for students and researchers who are unable to study animals in the wild and also because there are certain aspects of behaviour that only occur in captive situations – especially on farms and in zoos – and many of these have welfare implications.

Behaviour may be defined in a number of different ways, for example:

- 1 The repertoire of responses that an animal may make to changes in its environment.
- 2 A specific response made by an organism to a specific stimulus.
- 3 ‘...all those processes by which an animal senses the external world and the internal state of its body, and responds to changes which it perceives’ (Manning, 1972).

One of the main functions of the nervous system is to control the activity of the body – along with hormones – and produce behaviour. We may attempt to explain this behaviour in terms of neurophysiological mechanisms or we may simply study the observed behaviour itself. It is possible to both study and manipulate the behaviour of animals without fully understanding the underlying physiological mechanisms. Indeed, many behaviour studies make little reference to the underlying physiology. This approach treats the animal as a ‘black box’ (i.e. we do not know what is going on inside) and is useful if we are primarily concerned with understanding the causes of behaviour rather than the underlying neural mechanisms (Fig. 1.3).

Keeping animals in captivity inevitably restricts the range of behaviours that they are able to exhibit. However, apart from being of interest for its own sake, knowledge

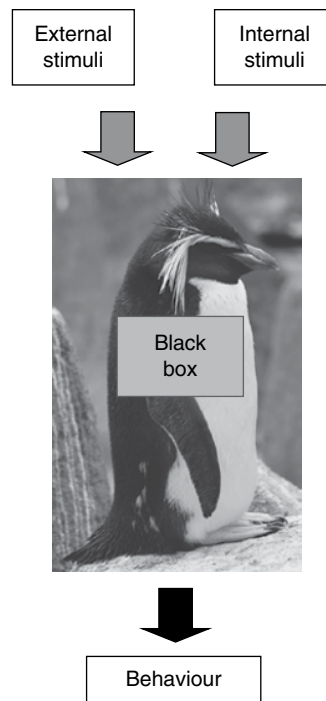


Fig. 1.3 The animal as a black box. It is not necessary to understand all of the processes that occur in the nervous system to study behaviour. The nervous system can be treated like a black box, which receives an input of stimuli and causes the generation of a behavioural response. Rockhopper penguin (*Eudyptes moseleyi*).

of behaviour is important if we are to understand many of the factors that affect animal welfare. For example, poor husbandry may have an adverse effect on the reproduction of animals used in a captive breeding programme in a zoo, or the productivity of animals kept on a farm.

Over 50 years ago, Tinbergen (1963) published an important paper in which he outlined the four major questions in the study of animal behaviour: the ‘four whys’:

- 1 Causation – What causes an animal to exhibit a particular behaviour? What mechanisms underlie the behaviour? What is its motivation?
- 2 Development – How did a particular behaviour develop during the lifetime of the animal, i.e. what is the ontogeny of the behaviour?
- 3 Function (survival value) – Why does an animal exhibit a particular behaviour? How does it help it to survive? What are the consequences for the animal’s fitness?
- 4 Evolution – How did evolution produce a particular behaviour?

When we undertake a study of a particular behaviour it is important to consider which of the four questions above is being addressed. In a zoo context we would probably be more interested in the causation, development and function of behaviour and less interested in its evolution (Fig. 1.4). For example, understanding the cause of an abnormal behaviour might help a zoo to prevent it, and understanding how a normal behaviour develops might help a zoo to provide appropriate conditions for normal development. Understanding the function of behaviours is important in appreciating the relationship between animals and their environment, and the possible consequences of releasing poorly adjusted animals from captive breeding programmes back into the wild.



Fig. 1.4 Keeper knowledge may be essential in understanding the origin of some unusual behaviours. This Bornean orangutan (*Pongo pygmaeus*) shows her teeth to visitors who approach the window to her enclosure. She was trained to do this by zoo staff when she had a dental problem and needed regular checkups.

1.2.2 Animal Welfare Studies

Animal welfare is now established as a legitimate discipline of academic study and there has been increasing concern in recent years about the welfare of farm animals, companion animals and animals living in zoos. Most of this concern has been focused on mammals, and, to a lesser extent, birds. However, recently crayfish have been demonstrated to exhibit anxiety-like behaviour following exposure to stress (Fossat *et al.*, 2014); the first time such behaviour has been recorded in an invertebrate.

Animal welfare science is a branch of applied animal behaviour. Welfare studies may be undertaken with captive animals provided that they do not compromise their well-being. They may involve measuring behaviour under various conditions, assessing an animal's preference when given a choice between different conditions, or assessing its physical condition. Such studies might, for example, involve comparing the behaviours observed when different floor types are available (Meller *et al.*, 2007), assessing the effectiveness of an enrichment device (Jenny and Schmid, 2002) or scoring body condition (Gregory and Robins, 1998).

The relationship between behaviour and welfare is complex. Mason and Mendl (1993) have noted that some responses used to assess animal welfare can be elicited by neutral or even pleasant events as well as by aversive ones; they lack specificity. This often makes behavioural studies very difficult to interpret.

1.2.3 Ecological Studies

Ecology is the study of the relationship between organisms and each other and organisms and their environment. Although animals living in zoos, and other captive animals, clearly do not have the same ecological relationships that they would have

in their natural habitat, they nevertheless have *an* ecology and this is worthy of investigation. Many ecological studies involve more than mere observation of the animals. For example, studies of parasites may require the collection of samples of faeces and blood; studies of feeding ecology may require animals to be confined and food intake and faeces production to be carefully measured (e.g. Rees, 1982a, 1983). Such confinement may be problematic in a zoo environment but perfectly normal in a farm environment. However, ecological studies that involve purely observational methods are possible in captive environments. Field studies might, for example, examine habitat selection within an enclosure, and studies of population biology are possible using data from zoo records and studbooks.

Some studies are concerned with the interface between ecology and behaviour. Behavioural ecology is the study of the ecological and evolutionary basis of animal behaviour, and its role in adapting an organism to its environment. Hypotheses in behavioural ecology assume that behaviour is optimised. Captive environments are useful for studying behavioural ecology because the environment can be artificially controlled.

1.3 Possible Study Locations

Many students undertake studies of captive animals as part of their studies in zoology, animal behaviour, psychology, animal welfare or some related discipline. Indeed, many research scientists routinely use animals under human control for their work.

Where might we find animals suitable for study (Figs. 1.5 and 1.6)? Traditional zoos such as ZSL London Zoo or San Diego Zoo are obvious places where a wide range of species is potentially available to the researcher. In addition to these large facilities, there are many other smaller zoos that contain interesting species, specialist collections of birds (such as those kept by the Wildfowl and Wetlands Trust in the UK) and aquariums, seal sanctuaries and marine parks, which keep aquatic species. Some zoos and colleges keep animals for teaching and research purposes. Some colleges have a sufficient number and range of exotic species that they are required to have a zoo licence. Others have flocks of sheep, herds of dairy or beef cattle, horses, pigs, goats and other livestock including poultry. Working farms also offer research opportunities.

Companion animals such as dogs and cats make interesting subjects of study, especially where they have established feral populations, as do feral horses, goats and other feral species, along with the deer populations on deer farms and those established in the grounds of many stately homes in the UK.

First-rate opportunities are available for the study of some species that are kept in specialist research facilities such as the Yerkes National Primate Research Center, which is operated by Emory University in Georgia, USA (see Section 2.2.3).

1.4 Advantages and Disadvantages of Studying Captive Animals

There are advantages and disadvantages associated with using captive animals in behavioural and ecological studies. Finding animals in the wild is time-consuming, and clearly this is not a problem when captive animals are studied. Often wild subjects have an unknown history whereas the history of farm, zoo or companion animals is likely to be well known and their caretakers (farmers, keepers or owners) are likely to be able to assist with the identification of individual animals. Natural environments



Fig. 1.5 Sources of animals for study. Centre: safari parks – a giraffe (*Giraffa camelopardalis*) at West Midlands Safari Park, UK. Clockwise from top left: feral animals – a herd of British primitive goats (*Capra aegagrus bircus*), Galloway Forest, Scotland; domestic pets – rabbits (*Oryctolagus cuniculus*); free-ranging farm animals – hill sheep (*Ovis aries*); aquariums – Sealife Centre, Blackpool, UK; specialist research centres – giant pandas (*Ailuropoda melanoleuca*) at the Chengdu Panda Breeding Research Centre, China (photograph courtesy of Prof. Geoff Hide, University of Salford. Reproduced with permission); deer parks – fallow deer (*Dama dama*) at Dunham Massey Park, UK; traditional zoos – chimpanzees (*Pan troglodytes*) at Chester Zoo, UK; college farms – a herd of dairy cattle (*Bos taurus*) at Reaseheath College, UK.

are fairly unpredictable and outside of the researcher's control. In contrast, captive animals often live in controlled conditions, which may be relatively easy to manipulate by, for example, adding an enrichment device, or altering the types of bedding available in a stall on a farm.

However, there are disadvantages inherent in using captive animals as research subjects. If the purpose of the study is to investigate natural behaviour this may be impossible if the animals are not kept in naturalistic environments and normal social groups, or if individuals have developed stereotypic behaviours. The presence of humans may affect behaviour. In zoos, animals are disturbed by keepers (e.g. during feeding and enclosure cleaning) and visitors, and on farms the animals are disturbed by farm workers. Although these interactions may be of interest for some studies, for many others they interfere with data collection.

Access to animals may be restricted due to safety considerations, so that it is not possible to make recordings at certain times of the day or during the night. Researchers working in a zoo may only be allowed on the premises when the zoo is open to the public. A zoo may only be open for 8 hours a day in the summer (e.g. 10:00 to 18:00), and this may be reduced to just 6 hours in winter (e.g. 10:00 to 16:00). The cost of studying captive animals may also be a barrier to data collection. For example, some zoos require students and researchers to purchase a research pass for access to the zoo. In addition, if the researcher does not live near the zoo the cost of travelling (and possibly accommodation) may be prohibitive.

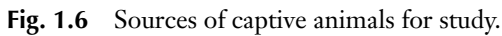
1.5 What Types of Research Have Been Conducted on Animals Living in Zoos?

Captive animals offer opportunities to study a wide range of aspects of their biology, such as behavioural enrichment, social behaviour and dominance hierarchies, parental behaviour, aggression, activity budgets, food selection and feeding strategies, cognition, enclosure use, population biology and interactions between animals and people (Figs. 1.7 and 1.8).

There appears to be no published analysis of the nature of the research conducted on farm or companion animals. However, a number of accounts have been published on the nature of zoo research.

A recent study by Maple and Bashaw (2010) noted that the type of research conducted in zoos is relatively stable, is primarily non-experimental, and consists of studies on the behaviour, nutrition, genetics and reproduction of mammals. Within the Mammalia, primates and carnivores are the most popular taxa. Anderson *et al.* (2008) found that 35.5% of the 991 articles published in *Zoo Biology* between 1982 and 2006 were conducted on members of the order Primates, 23.4% on Carnivora, 13.9% on Artiodactyla, 8.8% on Proboscidea and 6.0% on Perissodactyla. Most articles focused on the behaviour and reproduction of animals, and longitudinal trends in the content of the journal included an increase in experimental studies, and studies of diet and nutrition, while studies of behaviour and population biology declined in number.

A similar study was undertaken by Hardy (1996). This study analysed 353 papers published in *Zoo Biology* between 1982 and 1992 and found that of the 287 papers on mammals, 29.6% were studies of behaviour or behavioural ecology, a further 5.9% involved behavioural/environmental enrichment and 20.2% were studies of reproductive biology. Only 3.8% of papers were concerned with genetics or population



I examined 349 papers published in *Zoo Biology* between 1996 and mid-2004 and identified a significant change in emphasis in the research carried out by zoos during this period (Rees, 2005). Reproductive studies replaced behaviour as the largest category (34%), followed by studies of nutrition, growth and development (19%) and behaviour and enrichment (17%). Studies concerned with ecology, field biology, conservation and reintroduction only accounted for some 2% of the total, but there was an increase in papers on taxonomy, genetics and population biology (10%).