Animal Environmental Science

Sangrak Lee; Youngjun Na

Last update: 2019-02-22

Contents

Welcome

This is the website for **"Animal environmental science"**. To understanding individual animals, we have to understand the relationship they have with their environment. This book will focus at the interaction between animals and the environment.

This website is (and will always be) **free to use**, and is licensed under the Creative Commons Attribution-NonCommercial-NoDerivs 3.0 License. The book is written in RMarkdown with bookdown. Some photographs used in this book was from Unsplash.com. If you click the download button up above, you can download the PDF version of the book.

(Snow Monkey Niseko, Kutchan-chō, Japan)

Chapter 1

Introduction

All living creatures constantly interact with the environment. To understanding individual animals, we have to understand the relationship they have with their environment. Also, animals affect the environment. From birth to death, animals generate carbon dioxide, methane, feces, and urine. The excretes from animals are builded with molecules such as carbon, nitrogen, sulfur, and phosphorus, and are recycled within and between ecosystems.

Basically, animals can find food, shelter, protection, and mates from the environment called *habitat*. The animal habitat includes both phisical (non-living) and biotic (livinig) components (see Table 1.1).

Animal habitat is constantly changed over time. Not only natural disasters (eruption of volcano, earthquake, tsunami, and wildfire), also human activity can affect the animal habitat. Unlike the wildlife, the environment of domesticated animals (such as cow, pig, poultry, and dog) that raised in the facility are controlled by the human. Because it's a very huge field, this book can't cover every topic of both wildlife and domesticated animal. Thus, from now on, we will deal with the topic for the domesticated animal.

Table 1.1: Components of habitat (physical and biotic)

Physical	Biotic
Temperature	Plant matter
Humidity	Predators
Oxygen	Parasites
Wind	Competitors
Soil	Individuals of the same species
Light intensity	
Elevation	

Figure 1.1: Alaskan Malamute has the heat-conserving features.

Chapter 2

Animal and environment

2.1 External environment

Animal never separates from the stimuli from outside. In the domestic animals, the external environment includes both physical (e.g. housing, feeder, paddock, fence, and noise) and biotic (e.g. human, mate, and feed ingredients) components like those of animal habitat 1.

2.2 Internal environment

> "The living body, though it has need of the surrounding environment, is nevertheless relatively independent of it." — Claude Bernard

Higher animals have complex organ systems that respond to stimuli to perform their essential body functions. When the animal receives the signals from the sensory organs, they produce a local reflex action and/or react in the central nervous system. Weak signals produce no responses, but strong stimuli change the physiological or behavioral status of the animal.

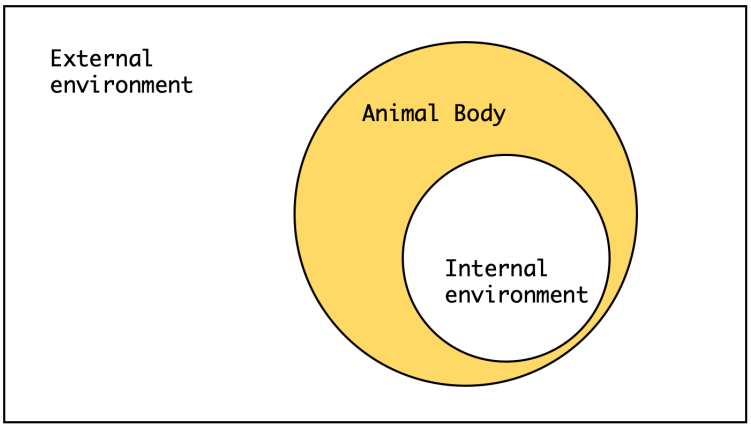

Figure 2.1: External and internal environment

Table 2.1: List of homeostatic control variables

Control variables
Core temperature; Blood glucose; Iron levels; Copper regulation; Levels of blood gases; Blood oxygen content; Arterial blood pressure; Calcium levels; Sodium concentration; Potassium concentration; Fluid balance; Blood pH; Cerebrospinal fluid; Neurotransmission; Neuroendocrine system; Gene regulation; and Energy balance

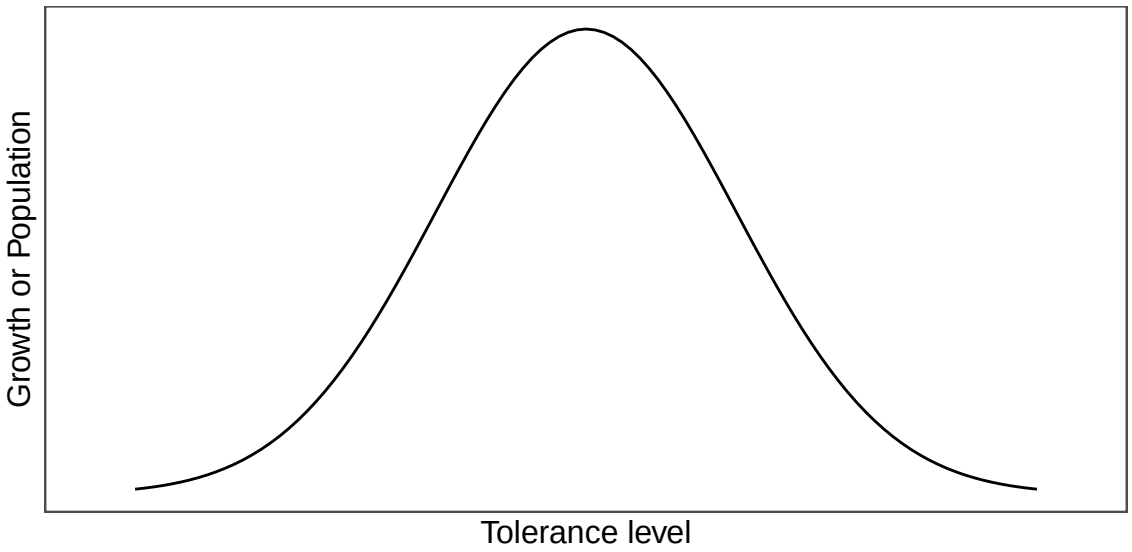

Figure 2.2: Shelford's law of tolerance

2.2.1 Shelford's law of tolerance

> "Each and every species is able to exist and reproduce successfully only within a definite range of environmental conditions." — Ronald Good

Although external environments are continuously changed, if animals in the normal status, they keep the composition of the extracellular fluid (internal environment) constant to maintain their life. We call it *homeostasis*.

However, the capacity to maintain the homeostasis is broken when the animals let the harsh environments and differ by their species. **Animals may be limited in their growth and their occurrence by the minimum, maximum, and optimum condition** (Shelford, 1931) (Fig. 2.2).

The optimum range of environmental condition may differ within the same organism, and it is not necessarily fixed. They can change as:

- Change of seasons
- Change of environmental conditions
- Life stage of the organism

2.2.2 Adaptation

> "Changes in morphological, anatomical, physiological, biochemical and behavioral characteristics of the animal which promote welfare and favor survival in a specific environment." — Hafez

Hafez et al. (1968) defined an adaptation as above. The adaptation helps an animal survive in their external environment. The representative adaptive traits are:

1. Structural adaptation
2. Behavioral adaptation
3. Physiological adaptation

Structural adaptation is the changes in physical features (e.g. body shape, skin, and internal organs) of the animal. Behavioral adaptation is the changes in behaviors (e.g. searching for food, mating, vocalizations, and mitigation) of the animal. Physiological adaptation is the changes in the animal body functions such as growth, temperature regulation, and ionic balance. Sometimes, adapted animal create a new species (*speciation*).

2.2.3 Acclimatization

Acclimatization is the physiological changes induced by a complex of factors such as altitude, temperature, humidity, photoperiod, or pH. Acclimatization is the short-term process (hours to weeks) by comparison with adaptation (take place over many generations).

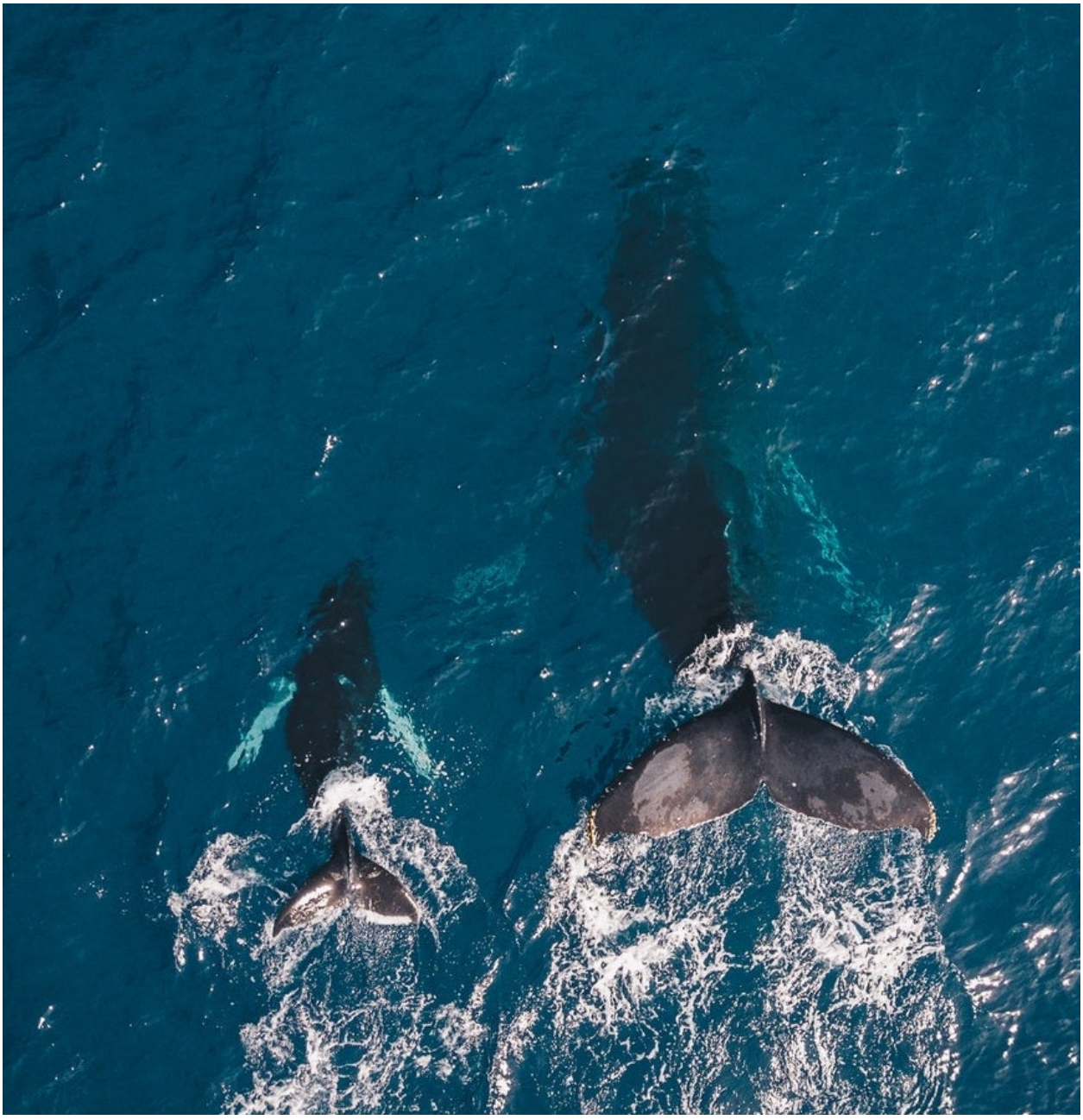

Figure 2.3: Migration is an example of a behavioral adaptation. Grey whales swim from the Arctic to Mexico every year.

Chapter 3

Temperature

Temperature is a quantity expressing of the amount of heat. Because a rate of every chemical reaction occurs in the animal's body is affected by the temperature, it is a very important factor to all animals. Like most chemical reactions, an enzyme-catalyzed reaction rate in the animal's body increases as the temperature is raised. However, extremely high or low temperature results in loss of activity or lose the structure for most enzymes (*denaturation*; Figure 3.1).

3.1 Poikilotherm and homeotherm

Key factors for animal surviving are to adapt to external environmental changes and maintain a consistent internal environment. The animal can be divided into two types for response to external temperatures: *poikilotherm* (cold-blooded animals) and *homeotherm* (warm-blooded animals). Examples of poikilotherms are most fish, amphibians, and reptiles. Their internal body temperature varies considerably according to their external environments. On the other hand, homeotherm maintains their thermal homeostasis regardless of the external temperature. The examples of homeotherm are birds and mammals.

3.1.1 Poikilotherm

The term derives from the acient Greek language *poikilos* (; changeable) and *thermos* (; heat). The body temperature of poikilotherms varies considerably than those of homeotherms (Figure 3.2). They generally use solar radiation for maintaining their body temperature and have four to ten enzyme systems that can operate at different ambient temperature because the temperature affects the chemical reactions.

3.1.2 Homeoterm

Homeotherms can maintain body temperature independently from ambient temperatures by regulating the metabolic process. They preserve their body temperature by muscle contraction and brown adipose tissue is catabolized for heat production (Grigg et al., 2004). In hot environments, they use evaporative cooling (sweating or panting) for maintaining their body temperature. Most of the domestic animals are homeotherm.

In some homeoterms (bears, hedgehog, marmot, and so on) and poikilotherms (frogs, turtles, snake, and so on), they can enter the *hibernation* in the cold season: the body temperature is dropped, and the metabolic rate is depressed. Hibernating bears can recycle their body proteins and urine to avoid muscle loss.

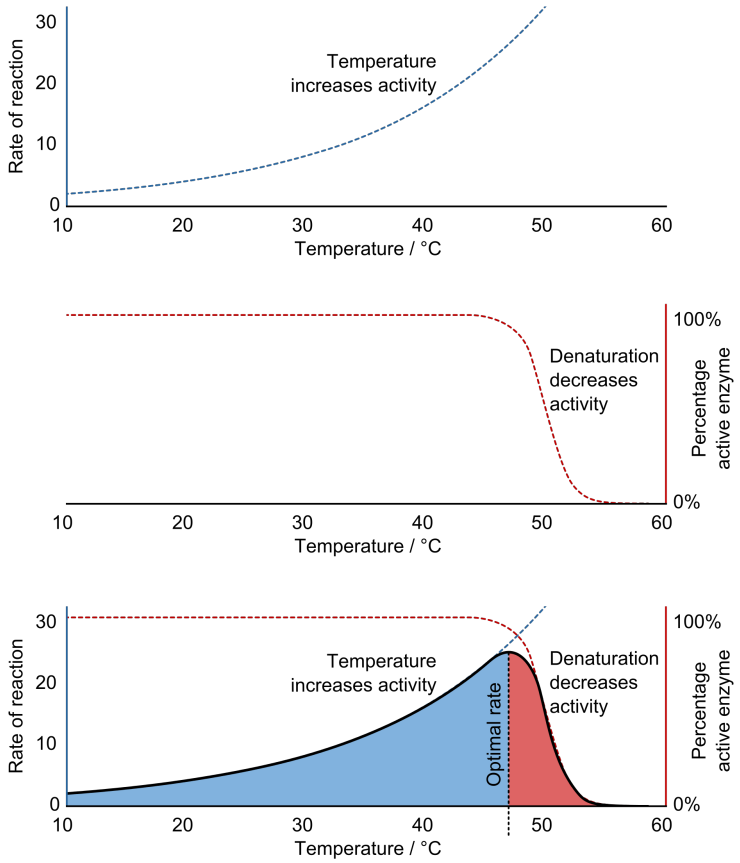

Figure 3.1: The effects of temperature on enzyme activity [@q10]. Top - increasing temperature increases the rate of reaction (Q10 coefficient). Middle - the fraction of folded and functional enzyme decreases above its denaturation temperature. Bottom - consequently, an enzyme's optimal rate of reaction is at an intermediate temperature.

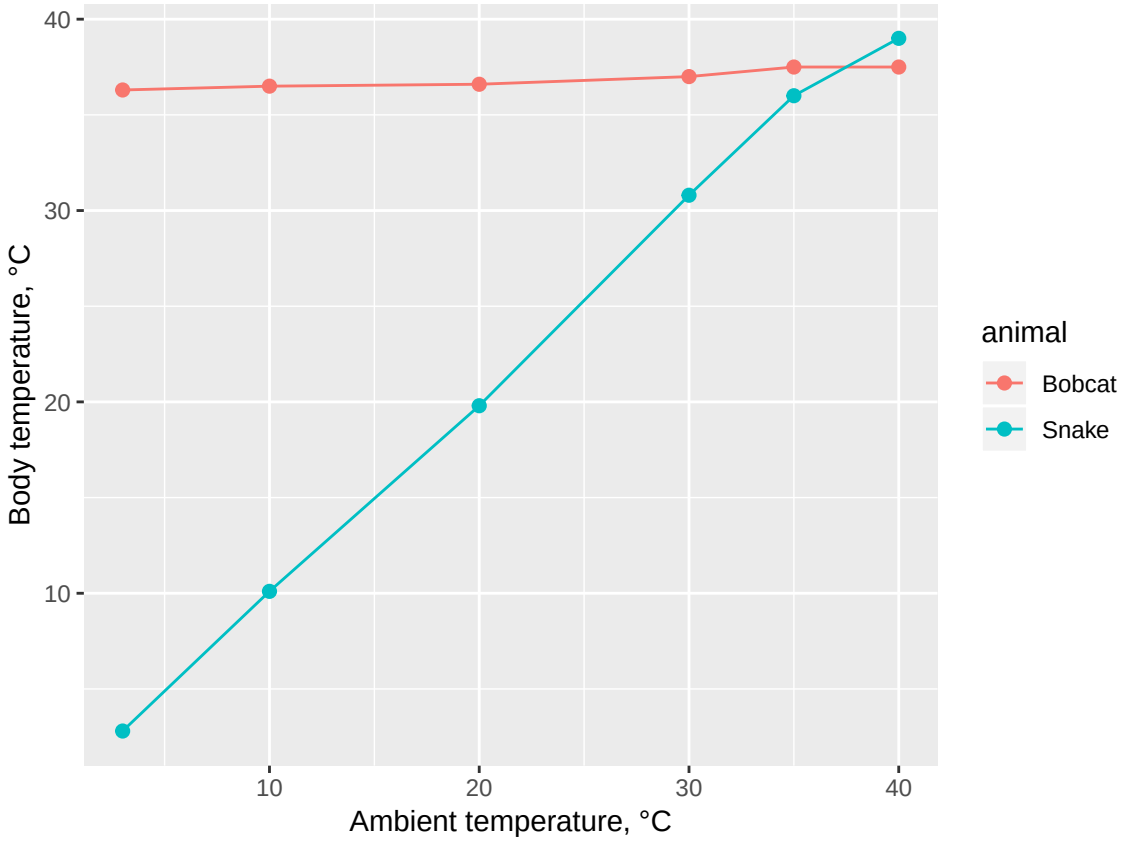

Figure 3.2: Comparison of body temperature response by snake (poikiloterm) and bobcat (homeoterm) to changing ambient temperature.

Figure 3.3: Green frog on blue surface.

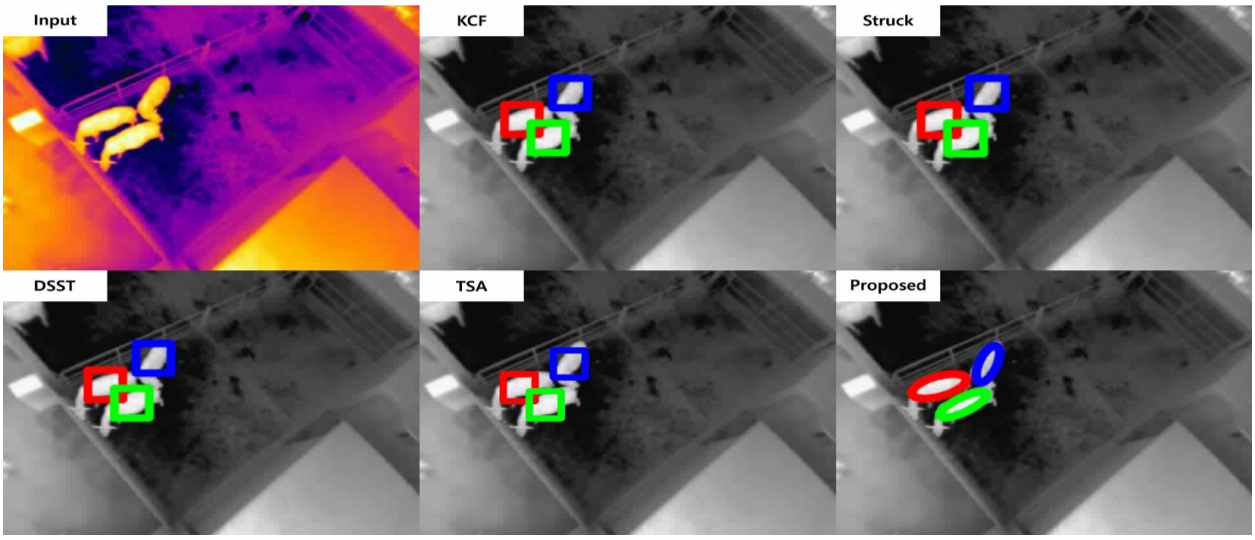

Figure 3.4: Infrared cameras image that cows generating the heats. @kim2018image developed the algorithms for tracking the cows using IR camera video.

Table 3.1: Normal body temperature of the domestic animals; Body temperatures may be 1°C above or below these temperatures.

Animal	Normal temperature (°C)	Animal	Normal temerature (°C)
Cattle	38.5	Donkey	38.2
Calf	39.5	Chicken	42.0
Buffalo	38.2	Camel	34.5-41.0
Sheep	39.0	Horse	38.0
Llama, alpaca	38.0	Pig	39.0
Goat	39.5	Piglet	39.8

Table 3.2: Cooling and heating methods for poikilotherms

Methods	Cooling	Heating
Convection	Increasing blood flow to body surfaces	Climbing to higher ground
Conduction	Lying on cool ground; Staying wet in a river, lake or sea; Covering in cool mud	Lying on a hot surface
Radiation	Releasing heat by radiating it away from the body	Lying in the sun; Folding s

3.1.3 Heterotherm

Heterotherms exhibit the characteristics of both poikilotherm and homeotherm. They can switch between poikilothermic and homeothermic strategies. In some bat species, for example, body temperature and metabolic rate are elevated only when they are active. When they at rest, metabolic rate is drastically dropped thereby the body temperature is decreased to the ambient temperature.

3.2 Thermoregulation

In homeotherms, thermoregulatory physiology is mainly controlled by nervous and endocrine systems. If the ambient temperature is going to cold, they generate heat via metabolic processes to keep their body temperature. In contrast, poikilotherms use external sources of temperature to keep their body temperatures (Table 3.2).

3.3 Temperature humadity index (THI)

The productivity of domestic animals is primarily affected by air temperature, and altered by wind, humidity, and radiation.

3.4 Effects on production

3.4.1 Dairy cattle

3.4.2 Beef cattle

3.4.3 Swine

3.4.4 Poultry

Chapter 4

Light

4.1 Photoperiodic response

4.2 Effects on productivity

4.2.1 Wool

4.2.2 Feathers

4.2.3 Antlers

4.2.4 Puberty

4.2.5 Reproduction

4.2.6 Behavior

4.2.7 Light control in poultry production

Chapter 5

Sound

Chapter 6

Air quality

Chapter 7

Water quality

Chapter 8

Cycles of materials

8.1 Ecosystem

8.2 Trophic level

8.3 Carbon cycle

8.4 Nitrogen cycle

8.5 Calcium and Phosphorus cycle

Chapter 9

Manure

9.1 Charateristics of animal manure

9.2 Manure treatment

9.2.1 Composting

9.2.2 Liquid fertilizer

9.2.3 Purification

9.2.4 Energy generation

9.2.5 Animal feed

Chapter 10

Greenhouse gases

Here is a review of existing methods.

Chapter 11

Animal welfare

Here is a review of existing methods.

Chapter 12

Sustainable livestock industry

"In essence, the conflict between livestock and the environment is a conflict between different human needs and expectations." — Henning Steinfeld (FAO)

Bibliography

Grigg, G. C., Beard, L. A., and Augee, M. L. (2004). The evolution of endothermy and its diversity in mammals and birds. *Physiological and Biochemical Zoology*, 77(6):982–997.

Hafez, E. S. E. et al. (1968). Adaptation of domestic animals. *Adaptation of domestic animals.*

Shelford, V. E. (1931). Some concepts of bioecology. ISBN 1939-9170.