Lecture #2

Water and its function, regulation and comparative use of farm animal

Properties and function of water

Water is the most important nutrient for different animals. It is required for all life's processes. A loss of 20 percent of the body water is fatal. Life could not be sustained without water. It make up about one half to two third of body mass of adult animals and up to 90% of that in newborn animals, and accounts for more than 99% of the molecules in the body .

Water functions and properties summarized in following point.

-Solvent and ionizing powers-ideal for dispersal of organic and inorganic molecules, facilitation of cell reactions.

- High specific heat- readily absorbs metabolic heat, helps body temperature regulation.

- Surface tension – reduces evaporation from liquid –air interfaces, opposes pulmonary inflation.

-Facilitation digestion, transport, and excretion of other nutrients and metabolites.

-Involved in many biochemical reactions as a reactant (e.g. Hydrolysis) or product (e.g. Oxidation).

Metabolic water or water of oxidation results from the oxidation of organic components in the cells of the body. Oxidation of 1 mol of glucose required 6 mol of O_2 and produced 6 mol of Co_2 and 6mol of H_2O.Therefore, the amount of O_2 required for oxidation of fat, carbohydrate, and protein are vary therefore the amount of water produced from oxidation are also different.

Nutrient group	Metabolic water yields g/g food
Starch	0.56
Fat	1.07
Protein	0.40

Table (2-1) metabolic water production from nutrient

Water Absorption:-

Water is absorbed readily from most section of the GI tract. In ruminant, usually there is a net absorption from the rumen and omasum. In the abomasum, of ruminants or the glandular stomach in other species, usually there is a marked net outflow of fluids (which accompany gastric secretion). The same is true for the duodenum where fluids from the pancreas, bile, and intestinal glands cause a net inflow of water. In all species, there is a net absorption from the ileum, jejunum, cecum and large gut, but the amount absorbed varies considerably from species to species and from diet to other within species.

Factors affecting on water absorption:-

- Osmotic relationships within the particular organ have a marked effect on absorption. (Following a meal, more solute in the digests would increase the osmotic pressure, which may result in an inflow of water into the organ.

- Polysaccharides tend to form a gel in the GI tract, and such gels hold water and reduce absorption from the GI tract and as a result, are usually laxative.
- In some species the ingestion of indigestible fiber also tends to reduce absorption of water.
- Any factor promoting diarrhea, whether from the diet ingested, microbial toxins, altered osmotic relationships or other physiological reaction (stress) will results in reduced water absorption from the GI tract.

Distribution and turnover of water:-

Water easily passes through most cell membrane and from one fluid compartment to another. This passage is controlled primarily by differences in osmotic or hydrostatic pressure gradients, and it is a passive diffusion in that energy is not required.

Water absorbed from GI tract enters the extracellular fluid in the blood and lymph. The volume and osmotic pressure of the extracellular fluid are also regulated by thirst and by antidiuretic hormone produced by the pituitary and other endocrine factors under control of the adrenal gland and kidney.

Total body water content is closely and inversely related to age and body fat content. This means that body water content is a good predictor of body fatness e. g. Cornell data for cattle varying widely in age and body condition.

Water content of lean (= fat free body) body tissues is relatively constant at 70-75% e.g. compare the variation in water content in the total body versus the lean of three classes of cattle differing in age and body condition.

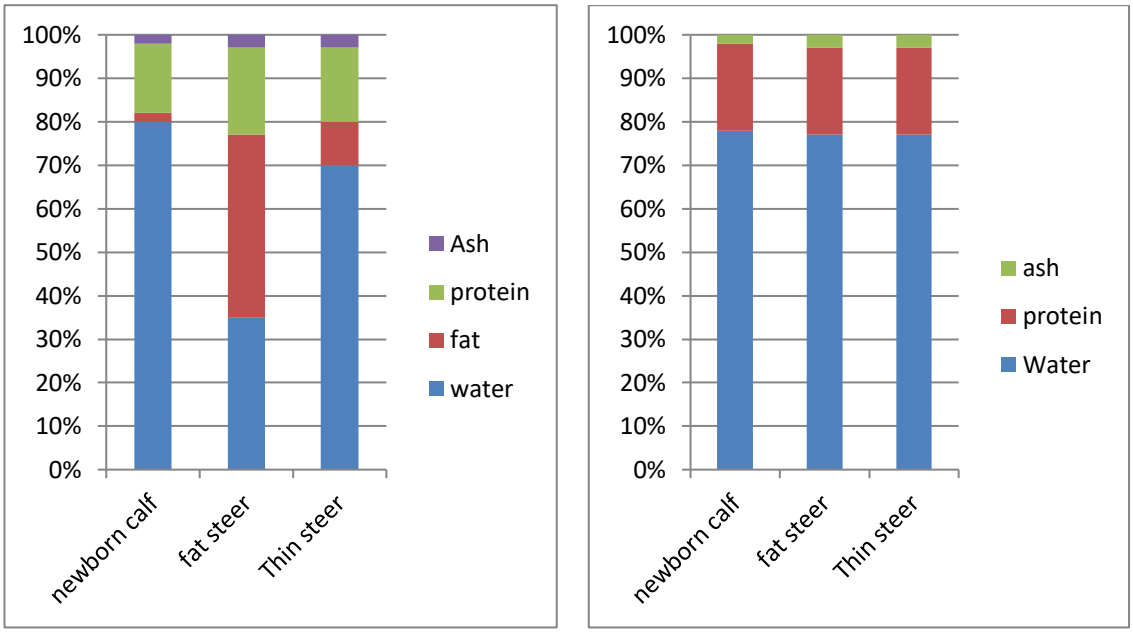


Figure (2-1) Total body composition (%) with fat and free fat

More body water is contained in intracellular fluid, mostly in the muscles (60-70%) or (40% of total body weight) than in extracellular fluid, found in interstitial fluid and, blood plasma, and other fluid, which account about (30-40%) of the total body water.

Water turnover is a term used to express the rate at which body water is excreted and replaced in the tissues. In cattle a typical half - life value is about 3.5 days while in non-ruminant species probably have less water in the GI tract.

In general, Body water turnover is directly related to body water content. Factors affecting water content and turnover are:

1- Genotype
2- Age
3- Environmental temperature
4- Feed quantity and quality
5- Physiological state

Water Balance:

Water balance= water supply – water loss

Sources of water supply

(a) Drinking free water (most important in majority of animal requirement)

(b) In or on feed e.g. fresh pasture can contain up to 80% water.

(c) Metabolic water from nutrient oxidation

(d) Polymerization reactions

(e) Preformed water in catabolized tissues.

Sources of water loss

(a) Feces: Affected by the following
- Genotype e.g. sheep vs cattle,
- Water intake
- Dry matter intake
- Fiber content of feed

(b) Urine: Affected by the following
- Ambient temperature
- Digestible dry matter intake
- N intake, metabolism, and excretion.

(c) Evaporation: Affected by
- Environmental temperature (most important)
- Hair or wool coat

Some water is lost from skin and upper respiratory tract at all times (insensible water loss).

As environmental temperature increases, the active thermoregulatory mechanism is stimulated to increase water loss and evaporative cooling e.g. sweating (human, horses, cattle) panting (dogs, sheep), spreading saliva (Kangaro), wallowing (pig).

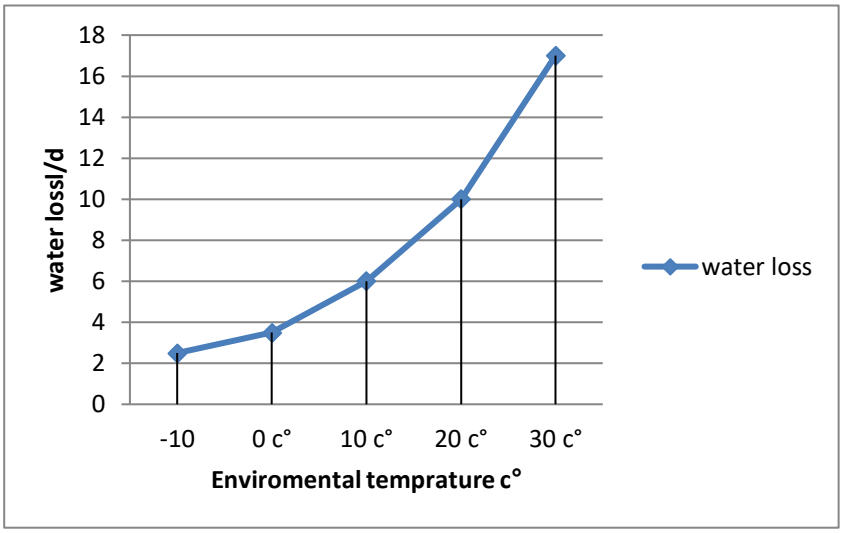


Figure (2-2) Effect of ambient temperature on evaporative water loss in Angus steers

The regulation of drinking is a highly complex physiological process. It is induced by many ways as the following:

- Drinking induced as a results of dehydration of body tissue.

- May also occur when there is no apparent need to rehydrate tissue.

- When an animal is thirsty, salivary flow usually is reduced and dryness of the mouth and throat may stimulate drinking.

- Trace decrease in plasma volume also stimulate for water drinking.

Water requirement:

Water requirement for any class or species of healthy animals are difficult to delineate except in very specific situations. This is so because

numerous dietary and environmental factors affect water absorption and excretion and because water is so important in regulation of body temperature. Other factors, such as ability to conserve water or differences in activity and in physiological state i.e. growth, gestation, and lactation, compound the problem when different classes or species of animals are compared. As a result of this factor, relatively little effort has been made to quantify water needs, except in a few specific situations. It is well recognized that the water requirement of animals depends on several factors can summarize as follows:

1- Dietary factors (dry matter intake)

Dry matter is highly correlated with water intake at moderate temperature. The water content of the feed consumed also affected total water intake.

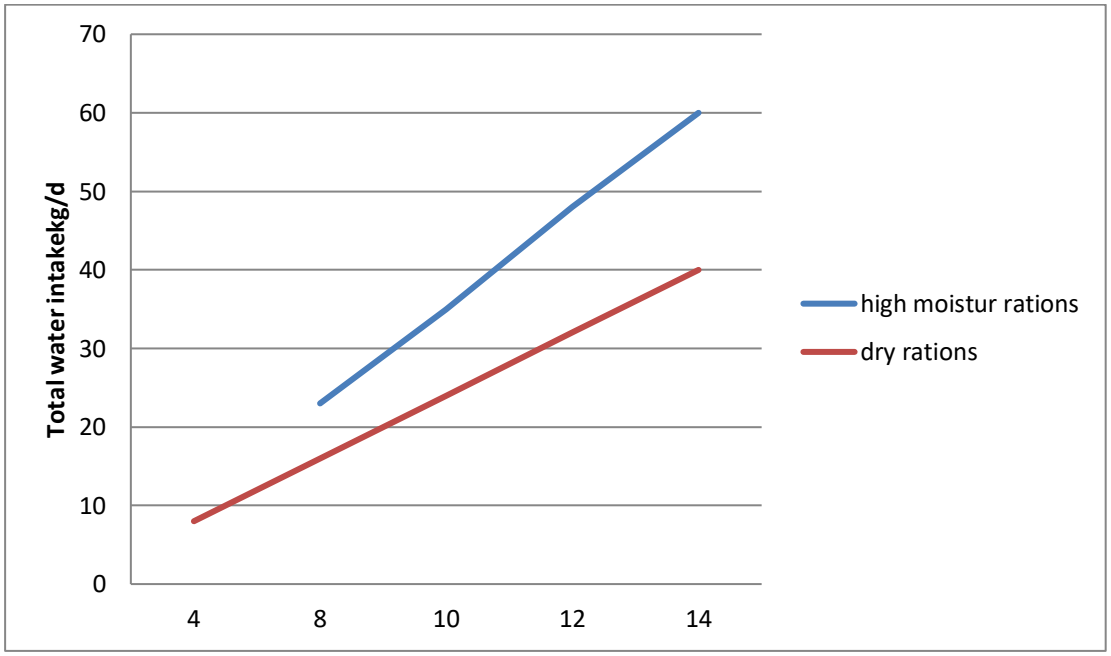


Figure (2-3) Relation between total water intake and dry matter intake in dry dairy cows. Cows fed high moisture rations consumed 5.5kg water per kg DM; cows fed dry rations consumed 4.6kg water per kg DM.

2- Environmental factors

Associated with heat stress is high humidity, which also increases the need for water because heat losses resulting from evaporation of water from the body surface and lungs are reduced with highly humidity.

3- Physiological state

E.g. lactating dairy cattle require 0.9 kg water per kg milk produced

4- Genotype

In very general terms animals will consume 2-5 kg of water for every kg of dry feed consumed when they are not heat stressed. Those species that have the ability to conserve water require less and those adapted to a wet environment consume more.

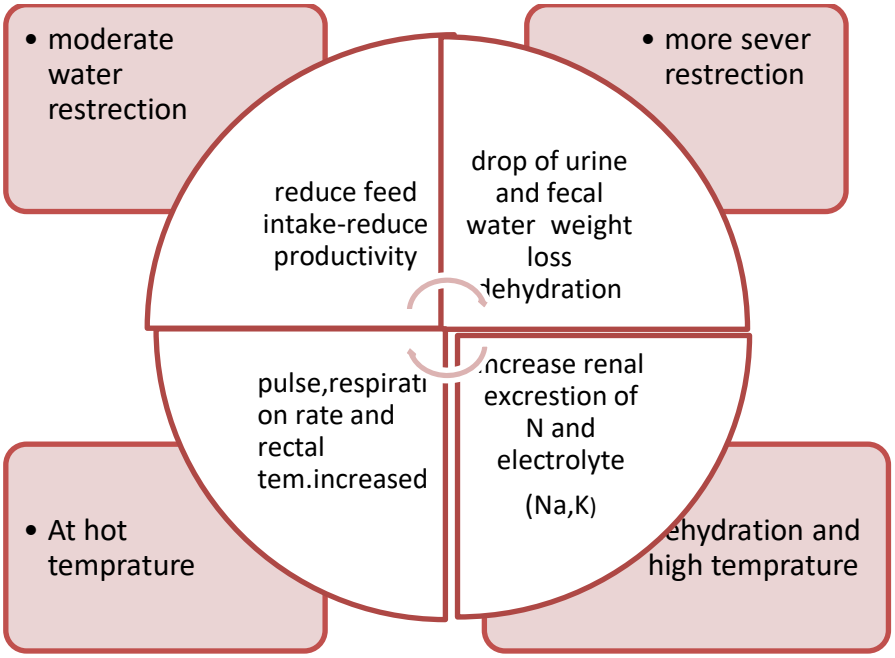
Table 2- 3 The Expected water consumption in various classes and species of adult animal livestock in a temperate climate (NRC 1974)

ANIMAL	*LITERS/ DAY*
Beef cattle	*22-66*
Dairy cattle	*38-110*
Sheep and goat	*4-15*
Horses	*30-45*
Swine	*11-19*
Chicken	*0.2- 0.4*
Turkeys	*0.4-0.5*

Water restriction

In many areas in the world water supplies are more restrictive than feed supplies, either because of a lack of surface water or well water or because the available water is brackish and not suitable for consumption in adequate amount to sustain the animals . Consequently, a relative high

percentage of animals, both domestic and wild are faced with water shortage at some time during the year.



Figure(2-4) symptoms of different levels water restriction in different

Water Quality:

Generally it has been assumed that water safe for human consumption may be used safely by stock, but it appears that animals can tolerate higher salinity than human; thus, it is probable that tolerances for other substances may be different, also water quality may affect feed consumption directly because low quality water normally will results in reduced water consumption and, hence, lower feed consumption and production. Substances that may reduce palatability of water include various salts. At high rates of consumption, these salts may be toxic. Substances that may be toxic without much effect on palatability include titrates, fluoride, and salts of some heavy metals. Other materials that may affect palatability or be toxic include pathogenic microorganism (bacteria, protozoa, and fungi), algae, hydrocarbons, and other oily

substances, pesticide, and many industrial chemicals that sometimes pollute water supplies.

Most domestic animals can tolerate a total dissolved solid concentration of 15.000 – 17.000mg/L, but production is apt to be reduced at this concentration.

-Water classify as good should have less than 2500 mg/L of dissolved solids.

- Water containing less than 1000 mg/L of total soluble salts is safe for any class of livestock or poultry.

- Water containing 1000 – 5000 mg/L is safe but may cause temporary mild diarrhea in animals not accustomed to it.

-Concentration between 3000 – 5000 mg/L may cause watery feces and increase mortality in poultry.

- Water with 5000 – 7000 mg/L is considered acceptable to all domestics' animals except poultry.

- Concentration greater than 7000 mg/L are unfit for poultry and swine and should not be used for pregnant or lactating cattle, horses, or sheep or for young growing animals of any species.

- Water containing more than 10.000 mg/L (1%) of soluble salts is unfit for use as drinking water under any condition

It should be pointed out that all of the dietary essential mineral elements are usually found in most water supplies. A substantial portion of the Na, Ca, and S requirement may be supplies should not be overlooked as a source of some of the needed mineral elements.