Ann. Anim. Sci., Vol. 10, No. 2 (2010) 107–115

BIOLOGY OF *BUBALUS BUBALIS*

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Abstract

Breeding water buffaloes does not require high expenditure because they are undemanding in terms of food and shelter. These primitive animals are well suited for extensive husbandry due to their immunity and ability to make efficient use of nutrients. Buffaloes may provide a good alternative for owners of wetland, where keeping domestic cattle is impossible. With its typical flavour and health qualities, buffalo milk can be used to expand the range of dairy products.

Key words: *Bubalus bubalis*, water buffalo, dairy use, mozzarella

Water buffaloes (*Bubalus bubalis*) are primitive animals, especially suitable for extensive husbandry. It is possible to keep these bovine animals throughout the year on wet fields where breeding of domestic cattle (*Bos taurus*) is not possible. These animals are characterized by high immunity to diseases (Sivakumar et al., 2006) and ability to feed on large amounts of cheap fodder while utilizing feed components efficiently. They are valued in many countries for the unique attributes of their milk.

The aim of this paper was to outline the origin and species specificity of water buffalo (*Bubalus bubalis*).

Origin of buffalo and historic outline

A review of available literature indicates the existence of several types and varieties of buffaloes, mostly in Asia, Africa and some European countries. Taxonomy classifies buffaloes as follows (Integrated Taxonomic Information System):

Kingdom : *Animalia* (animals)
Phylum : *Chordata* (chordates)
Subphylum : *Vertebrata* (vertebrates)
Class : *Mammalia* (mammals)

Order : *Artiodactyla* (artiodactyls)
Family : *Bovidae* (bovids)
Subfamily : *Bovinae*
Genus : *Bubalus* (buffalo)
Species : *Bubalus bubalis* (Linnaeus, 1758) – Water buffalo
Bubalus depressicornis (H. Smith, 1827)
Bubalus mephistopheles (Hopwood, 1925)
Bubalus mindorensis (Heude, 1888)
Bubalus quarlesi (Ouwens, 1910)
Genus : *Syncerus*
Species : *Syncerus caffer* (Sparrman, 1779) – African buffalo

Water buffaloes are estimated to have inhabited the Earth for approximately 3.5 million years. Initially they lived in the north-west of the Indian subcontinent. From that location they migrated to Eastern China and southern and south-eastern Asia (Kiple, 2007).

The exact time and place of their domestication still remain controversial. Until recently it was thought that they had been domesticated 4000 years ago in the Indus Valley. The latest research, however, indicates that due to changes in natural habitat which occurred at that time, buffaloes were domesticated 1000 years later (Kiple, 2007).

The place of wide-scale taming and domestication of buffaloes was Yangtze Valley in China. Animals were used mainly for cultivation of wet rice fields, and their shoulder blades served as parts of primitive ploughs (Kiple, 2007).

Buffaloes were introduced into Europe in the Middle Ages by pilgrims and crusaders who came back to the Old Continent from the Holy Land (Popenoe et al., 1984).

The current world population of buffaloes is about 168 million head: 161 million (95.83%) are found in Asia, 3.717 million in Africa, almost entirely in Egypt (2.24%), 3.3 million (1.96%) in South America, 500 000 (0.30%) in Europe and 40 000 (0.02%) in Australia (Borghese and Mazzi, 2005).

The domesticated species of water buffalo (*Bubalus bubalis*) is divided into two separate types: river buffalo and swamp buffalo.

River buffaloes can be found mainly in Egypt and in some European countries (e.g. Italy, Germany, Bulgaria and England). The natural behaviour of these animals is wallowing in water, especially on hot days. This variety is suitable for dairy use. The genome of river buffalo includes 50 paired chromosomes (2n = 50). In karyotype image, one can see morphological types of chromosomes, four of which are metacentric, six are submetacentric and forty are acrocentric (Popenoe et al., 1984; Borghese and Moioli, 2002; Songsri and Ramirez, 2004; Thomas, 2004; Kumar et al., 2007).

Swamp buffaloes are most numerous in India, Bangladesh and China. Because of their low milk productivity (1–2 kg/day), they are kept for meat or as work stock. This type of buffalo prefers baths in stagnant waters and mud. These buffaloes have 48 pairs of chromosomes (2n = 48). During mitotic metaphase one can easily notice

six metacentric chromosomes, four submetacentric and 38 acrocentric (Songsri and Ramirez, 2004; Thomas, 2004; Kumar et al., 2007).

These two types of buffaloes can be mated to produce offspring with 49 pairs of chromosomes (2n = 49). The acrocentric chromosome 24 remains unpaired. Resulting animals sometimes face reproductive problems. Males can be infertile, and females can display lengthy calving periods (Songsri and Ramirez, 2004; Borghese and Mazzi, 2005).

Body characteristics

The model of body structure of water buffalo is almost identical to that of domestic cattle. During the direct assessment of body structure zoometric measurements were used, similarly to domestic cattle (Table 1).

Table 1. Average values of zoometric measurements of *Bubalus bubalis* (Soysal et al., 2007)

Sex	Withers height (cm)	Rump height (cm)	Body length (cm)	Chest depth (cm)
Adult male	138.23	135.71	145.09	77.2
Adult female	133.14	132.57	142.43	71.1

Differences between males and females prove dimorphism between sexes. Buffaloes are black, graphite- or slate-coloured. Typical horns are massive, straight and curved up and to the back (Popenoe et al., 1984).

Housing requirements

Water buffaloes are usually kept outdoors in similarity to natural extensive system. Animals can stay all year round on wet pastures where breeding of domestic cattle would be impossible (Borghese and Moioli, 2002).

As demonstrated by research carried out by Joshi et al. (1968), buffaloes have fewer sweat glands than cattle (*Bos taurus*), i.e. 1.07 per cm^2 compared to domestic cattle's 3.08 per cm^2. As a result, for the thermoregulation system to work effectively, it must be supported by water baths. This is crucial especially on hot days, therefore animals must have access to ponds, flowing rivers or artificial pools with clean water. As an alternative, showers with cool water are advised.

In the summer, it is important to provide shaded shelter; it can be a couple of trees or a simple roofed construction, made of straw, fabric or other materials. It must not be forgotten to place feeding, watering and milking spots in places protected from sunshine and rain. In very cold climate, it is advisable to build roofed, three-walled shelters to protect animals from snow and strong wind. In case of long-lasting severe weather conditions, animals must be provided with fodder inside the shelter. Additionally, a separate space is required in case of dairy use. Should animals be kept in extremely cold climate (e.g. Caucasus) a heated barn may be indispensable (Högberg and Lind, 2003). Thanks to their flexibility in adapting to various natural conditions, buffaloes can be met on almost every continent. They are kept in developed countries, as well as in countries with more primitive farming techniques (Borghese and

Mazzi, 2005). Buffaloes kept for milk can be placed in chamber barns in intensive systems all year round (Borghese and Moioli, 2002).

Feeding

Buffaloes, similarly to domestic cattle, are classified as ruminants because of their body structure and specific nature of their digestive tract (Högberg and Lind, 2003).

Thomas (2004) has noted that water buffaloes are well suited for pastures. Compared to domestic cattle, they are less demanding in terms of quality of underbrush. They effectively use the undergrowth that is low in nutrients. They can live in poor nutrition conditions with just slightly lowered milk productivity.

Högberg and Lind (2003) point to the fact that the basic food of buffaloes are bulky feeds, i.e. hay or haylage. Among papilionaceous plants, lucerne and clover are most suitable.

Straw is a feed with high fibre content. Authors advise to use rice, barley, wheat or sorghum-based straw in buffalo feeding. Bulky feeds should be supplemented with concentrates such as leguminous plants (e.g. *Leucaena leucocephala*, *Gliricida* spp., *Sesbania* spp.) and grain (corn, barley, wheat, oat, rye, sorghum). In tropical countries, common supplements are oilseed cakes, the byproducts of the oil industry. According to Borghese and Moioli (2002), buffaloes willingly eat various types of riverside plants.

Reproduction

According to Perera (2008), reproduction of water buffaloes (*Bubalus bubalis*) does not differ substantially from reproduction of domestic cattle (*Bos taurus*). Buffaloes are late-maturing animals (Zoheirr et al., 2007). Females are sexually mature at the age of 15–18 months and ready to reproduce when they are 24–36 months old (Barile, 2005). Ingawale and Double (2004) claim, however, that females are ready to reproduce at the age of 36–42 months. When mating heifers, the breeder must consider not only their age, but also their weight. For the first mating or insemination, they should weigh between 250 and 275 kg (Barile, 2005). The first calving takes place when heifer is approximately 37–40 months old (Högberg and Lind, 2003). When born, calves weigh between 35 and 40 kg (Popenoe et al., 1984). Other characteristics are as follows:

- heifer's cycle lasts 21 days
- heat lasts for 12–24 hours
- ovulation takes place 10–14 h after heat ends
- optimal insemination time is the last 8 hours of heat
- pregnancy lasts for 310 days
- involution of womb takes place 25–35 days after birth (Ingawale and Double, 2004).

Barile's research (2005) showed that female buffaloes are polyestral and their reproduction is seasonal. The highest percentage of females in heat was observed

in November, the lowest in June. External symptoms are hardly noticeable, thus full acceptance of the male is the most reliable symptom. A common phenomenon is heat with no symptoms, known as silent oestrus (Zoheir et al., 2007). Male water buffaloes are sexually mature at the age of 18 months (Javed et al., 1998) and can be used as sires from the age of 3 years (Högberg and Lind, 2003).

Reproduction is carried out either by natural mating or artificial insemination (Ingawale and Double, 2000).

Dairy use

Ingredients and characteristics of colostrum

Ingredients and characteristics of colostrum differ from those of regular milk. Arain et al. (2008) showed changes in chemical structure that occur when colostrum transforms into milk (Table 2).

Table 2. Percentage ingredients of the colostrum of female *Bubalus bubalis* (Arain et al., 2008)

Postpartum milking (h)	Fat (%)	Protein (%)	Casein (%)	Lactose (%)	Ash (%)
4	5.41	18.75	5.06	2.70	1.64
12	5.78	12.01	4.59	3.12	0.97
24	5.95	8.56	4.21	3.42	0.95
36	5.84	8.30	4.29	3.54	0.92
48	5.84	7.41	4.09	3.99	0.98
60	5.88	6.90	4.16	3.97	0.89

Colostrum allows the young organism to naturally build passive immunity. It is a result of antibodies present in colostrum. Antibodies are connected with the gammaglobulin fraction of proteins (Żukowski, 2006). As the above table shows, the largest concentration is in the first hours after calving, and is sharply reduced afterwards. There is a slight decrease in casein and ash. Lactose concentration increases by 1.27% and fat level remains almost unchanged.

Högberg and Lind (2003) claim that buffalo colostrum contains much higher levels of iron and copper than milk. A newborn calf feeds on colostrum for 5–6 days. Within that period, colostrum transforms into regular milk (Arain et al., 2008).

Productivity and milk ingredients

Milk of water buffalo has 7–8% fat. Some varieties, such as the Chinese buffalo, produce 13% fat milk. The milk fat of buffaloes melts at higher temperatures than that of domestic cattle. This results from the higher proportion of saturated to unsaturated fatty acids (77 : 23). Buffalo milk is lower in phospholipids and cholesterol and higher in protein, lactose and ash. There are trace amounts of carotene, which makes milk very white. There is vitamin A instead of the precursor (Högberg and Lind, 2003).

The table (Jorge, 1999) presents ingredients of milk produced by *Bubalus bubalis* and *Bos taurus* (Table 3).

Table 3. Average composition of bovine and buffalo milk (Jorge, 1999)

Composition of milk	*Bubalus bubalis*	*Bos taurus*
Protein (%)	4.00	3.50
Fat (%)	8.00	3.50
Lactose (%)	4.90	4.70
Ash (%)	0.80	0.70
Cholesterol (m)	214	319
Water (%)	82.00	87.90

Buffalo milk is higher in calcium and magnesium and lower in sodium, chlorine and potassium (Jorge, 1999).

Female *Bubalus bubalis* are used for 9–10 lactations, each of them being 270 days long (Thomas, 2004). Average annual productivity is 2000 kg (Borghese and Moioli, 2002).

According to reports from Bangor University in the United Kingdom, consumption of buffalo milk reduces effects of eczema. It can be also used with some types of cow's milk intolerance. Buffalo milk production is not restricted by the system of milk quotas (www.calu.bangor.ac.uk), which means that commercial production of milk is not administratively limited.

Technological value

Milk proteins, casein and whey proteins are synthesized in the mammary gland and are known as genetic markers. Chemical composition and physicochemical traits of milk depend on various genetic forms of these proteins. They determine technological value of milk, especially its suitability for cheese making (Sitkowska and Neja, 2008).

According to Ambrosio et al. (2008), the main ingredients of water buffalo milk are:

A. caseins
– alpha S1-casein (αs1-CN)
– alpha S2-casein (αs2-CN)
– beta-casein (β-CN)
– kappa-casein (κ-CN)

B. whey proteins
– beta-lactoglobulin (β-LGB)
– alpha-lactoalbumin (α-LAB)

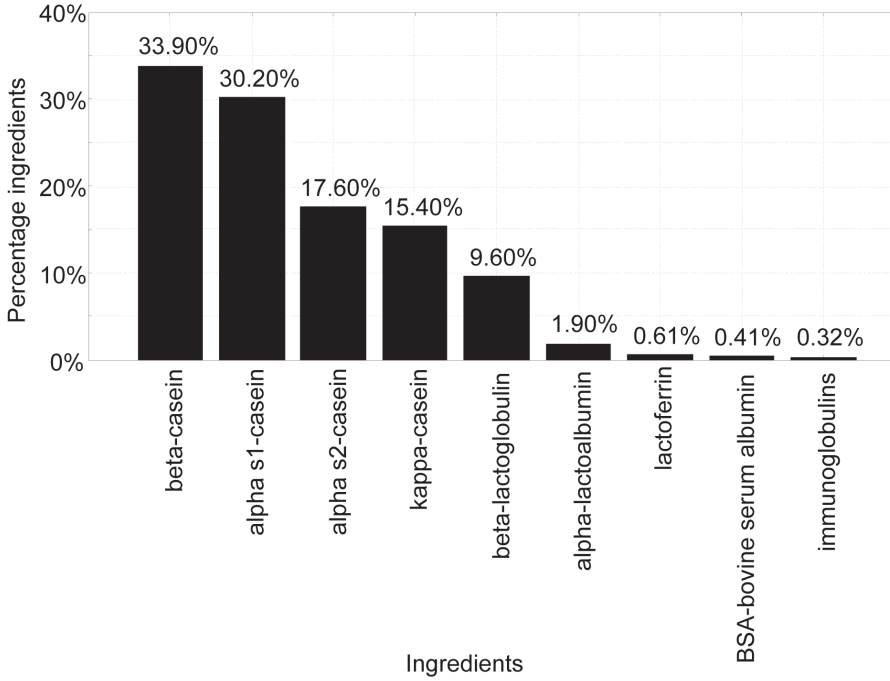

Figure 1. Composition of buffalo milk (Urech et al., 1999; Högberg and Lind, 2003)

Cheese is a food product made from milk. The wide range of cheese types is the result of continuous development of cheese production technology, as well as high qualifications of contemporary cheese-makers (Murtaza et al., 2008). The milk of *Bubalus bubalis* is used to produce the following types of cheese:

♦ soft (water content >45%): Mozzarella in Italy; Karish, Mish and Domiati in Egypt; Madhfor in Iraq; Algab in Syria; Vladesa in Romania;

♦ semi-firm (water content 40–45%): Beyaz peynari in Turkey;

♦ firm (water content <40%): Braila in Romania; Rash in Egypt; White brine in Bulgaria; Akkawi in Syria (Borghese, 2005 a).

The most common cheese of buffalo origin is mozzarella. It falls into the "pasta filata" category. Its consistency is soft and juicy; the taste is pleasant, fresh, slightly tart and nutty. It is produced from whole raw milk with addition of natural whey cultures (NWC). Buffalo mozzarella is known worldwide as "Mozzarella di Bufala Campana". It is highly valued for its specific taste as well as culinary and dietetic characteristics. It is produced only in Campania (southern Italy) according to an old, traditional recipe. In 1996 this product was given the DOP (Product of Designated Origin) status (Mauriello et al., 2003). Good stretchability after melting is a typical characteristic of this cheese; therefore it is often used for Italian pizzas and caprese salads, as well as many other dishes (Borghese, 2005 a). Research carried out by Sameen et al. (2008) showed that buffalo mozzarella contains more fat, protein

and substantially more calcium in comparison to mozzarella produced from cow's milk. In Italy, mozzarella is not the only buffalo milk product. Other cheeses made from buffalo milk include treccia, ricotta, crescenza, robiola and caciocavallo. Common products include also butter and yoghurts as well as cream, condensed milk, flavoured milk, and ice-cream. In Asia and Europe it is customary to drink fresh and sour buffalo milk (Thomas, 2004; Borghese, 2005 a).

Buffalo meat

Water buffalo meat is a very good alternative for beef. The meat of *Bubalus bubalis* is of higher nutritional value as it contains 40% less cholesterol, 55% less calories, 11% more protein, 10% more minerals and 2% more vitamins in comparison to bovine meat. Furthermore, until now Bovine Spongiform Encephalopathy (BSE) has never been observed in water buffalo (Jorge, 1999; Dosi et al., 2006).

Buffalo meat is eaten mainly in Italy, Asia and South America. One Italian company produces many typically Italian buffalo meat products: bresaola (salted rump lean muscle), salami, sausages, cacciatorini (very small salami), ham, dry meat, etc (Borghese, 2005 b).

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Accepted for printing 22 IV 2010

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Biologia gatunku *Bubalus bubalis*

STRESZCZENIE

Hodowla bawołów wodnych nie wymaga wysokich nakładów ze względu na ich niskie wymagania dotyczące pożywienia i schronienia. Te prymitywne zwierzęta są dobrze przystosowane do ekstensywnego chowu dzięki odporności i umiejętności dobrego wykorzystania składników pokarmowych. Bawoły mogą stanowić dobrą alternatywę dla właścicieli terenów podmokłych, na których hodowla bydła nie jest możliwa. Bawole mleko, posiadające specyficzny smak i walory zdrowotne, można wykorzystać do poszerzenia asortymentu produktów mlecznych.