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Review

SITUATION AND PERSPECTIVES OF BUFFALO IN THE WORLD, EUROPE AND MACEDONIA

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The Asian buffalo or the Water buffalo is classified in the genus *Bubalus,* species *bubalis.* Taming occurred at recent times (5,000 years ago) compared to taming of *Bos Taurus* and *Bos Indicus (*10,000 years ago). Asian buffalo includes two subspecies named also types: the River and the Swamp, the morphology and the purposes of which are different as well as the genetics. The River buffalo has 50 chromosomes of which 5 pairs are submetacentric, while 20 acrocentric. The Swamp buffalo has 48 chromosomes, of which 19 pairs are metacentric. The two subspecies are inter-fertile and give progeny with 49 chromosomes. Male crossbred progeny has sometimes showed fertility problems while female progeny has showed longer calving intervals only in case of further backcross. Morphology of the two types differs considerably. Swamp buffaloes are less heavy, the adult male weight ranging between 325 and 450 kg, while River type weighs between 450 and 1000 kg. While the Swamp buffalo is reared mainly for draught purposes, although it also gives valuable milk production of up to 600 kg milk per year, the importance of the River buffalo depends on the high quality and quantity of the milk that it produces. Each subspecies shows a lot of breeds. Buffalo (*Bubalus bubalis*) population in the world is actually about 172 million head: 168 million are in Asia (97%); 4 million are in Africa, practically only in Egypt (2.3%); 4,1 million in South America (2.4%); 40,000 in Australia (0.02%); 500,000 in Europe (0.3 %).

Key words: buffalo; *Bubalus bubalis*

СОСТОЈБАТА И ПЕРСПЕКТИВИТЕ НА БИВОЛОТ ВО СВЕТОТ, ВО ЕВРОПА И ВО МАКЕДОНИЈА

Азискиот бивол, или воден бивол, е класифициран во родот *Bubalus,* видот *bubalis*. Времето на негово појавување е неодамнешно (пред 5.000 години), споредено со времето на појавување на *Bos taurus* и *Bos indicus* (пред 10.000 години). Азискиот бивол има два подвида, односно типови: речен и мочуришен; морфологијата и значењето на секој од нив се различни, како и генетиката. Речниот бивол има 50 хромозоми, од кои 5 пара се субметацентрични, додека 20 се акроцентрични. Мочуришниот бивол има 48 хромозоми, од кои 19 пара се метацентрични. Двата подвида се интерфертилни и даваат потомство со 49 хромозоми. Машкиот потомок понекогаш покажува проблеми во плодноста, додека женскиот потомок покажува подолги интервали на телење само во случај на понатамошно вкрстување. Морфологијата на двата типа значително.се разликува. Мочуришните биволи имаат помала маса, кај возрасниот мажјак се движи меѓу 325 и 450 kg, додека речниот тип тежи меѓу 450 и 1000 kg. Додека мочуришниот бивол се одгледува главно за влечење, иако годишно дава значителна продукција на млеко (до 600 kg), значењето на речниот бивол се заснова на висок квалитет и квантитет на млеко кое го продуцира. Во рамките на секој подвид има многу раси. Популацијата на биволот (*Bubalus bubalis*) во светот денес брои околу 172 милиони грла: 168 милиони во Азија (97%); 4 милиони во Африка, практично само во Египет (2,3%); 4,1 милиони во Јужна Америка (2,4%), 40.000 во Австралија (0,02%); 500.000 во Европа (0,3%).

Клучни зборови: бивол; *Bubalus bubalis*.

FAR EAST STRATEGIES

China

According to statistical data (FAO, 2005), the total number of buffaloes in China in 2005 was 22.745 million, the third largest population of buffalo in the world. In the aspect of scientific research, compared with other breeds, buffalo started relatively late.

China has a huge variety of buffalo genetic resources, unknown to most buffalo experts but the Chinese. They are all of the Swamp type, with a long history of domestic livestock, and provide a good deal of products to the farmers.

In China each region has different types of buffaloes, to the extent that it is possible to say that buffaloes have adapted themselves to a range of climates, heights and temperatures as wide as the different cattle breeds fit the various continents and countries. Therefore, in China there are buffalo breeds that can be found only in the lowlands, while other breeds live only in the mountains.

As for all Swamp buffaloes also all Chinese buffaloes are used for draught, often as the only purpose. Exceptions are given by the Wenzhou breed, which is regularly milked and produces 1,020 kg milk in 278 days and by the Jianghan (800 kg milk in 8–12 months). Also the Fuan breed is sometimes milked, producing averagely 2.6 kg milk/day, in a lactation of extremely variable length: 150 to 300 days (Zhang Chunxi and Li Zhongquan, 2001).

China imported the Murrah buffalo from India in the late 1950s and the Nili-Ravi buffalo from Pakistan in the late 1970s. Since China imported two breeds of exotic dairy type buffaloes, experiments such as feeding observation, buffalo frozen semen, artificial insemination and crossbreeding. had been conducted, and good results were gained. Especially in the past 20 years, great development and breakthroughs in scientific and technological research on buffaloes were achieved. In the area of breeding improvement, genetics and breeding, physiology and biochemistry, feed and nutrition, reproductive technology, embryo biotechnology, dairy processing and disease prevention and treatment, plenty of scientific and technological achievements were gained, and abundant scientific data were accumulated (Liang Xian-wei, 2004). According to reports, through the crossbreeding system applied in upgrading the two breeds such as the crossbred Murrah F_1, F_2 and the crossbred Nili-Ravi F_1, F_2, the milk performance has obviously been improved in the crossbred. The average milk yield per lactation in the Murrah crossbred F_1 and F_2 are 1240.5 kg and 1423.3 kg respectively, which is higher than in the local buffalo of 1092.8 kg (this data comes from the selected herd, normally the local Swamp buffalo produces 500–800 kg per lactation) by 13.5% and 30.2% ($p < 0.01$). In the Nili-Ravi crossbred F_1 and F_2 milk yield per lactation are 2,041.2 kg and 2,325.6 kg, which are improved by 88.6% and 115.2% respectively ($p < 0.01$). The triple-crossbred and their *inter se* crossing offspring are 2,294.6 kg and 1,994.9 kg respectively, which have increased by 109.98% and 82.55%, compared with the local buffalo ($p < 0.01$) (Yang Bingzhuang et al., 2003), as reported in table 1.

Table 1

Comparison of milk performance in different buffalo breeds (kg/day)
(Yang Bingzhuang et al., 2003)

Breed	Lactation	Lactation length (days)	Milk yield	Average milk yield per day	Highest daily milk yield (kg)
L	70	280.4±20.2	1092.8±207.4	3.79	6.6
M	237	324.7±73.9	2132.9±78.3	6.57	17.40
N	164	316.8±83.6	2262±663.9	7.14	18.40
MLF_1	157	313.7±96.7	1240.5±479.8	3.95	7.57
MLF_2	118	313.9±90.1	1423.3±534.5	4.53	8.30
NLF_1	45	326.7±96.4	2041.2±540.9	6.25	16.65
NLF_2	55	321.4±118	2325.6±994.4	7.22	19.35
$NMLF_2$	168	317.6±78.4	2294.6±772.1	7.22	18.80

L = Local; M = Murrah; N = Nili-Ravi;

The body size and body weight in the crossbred are bigger than in the local buffaloes, therefore the meat yield performance in the crossbred is better than in the local buffalo.

According to the data in the Guangxi Buffalo Research Institute, a fatten experiment was conducted on triple-crossbred and ½ Santa Gertrudis in the same conditions. The results showed that the dressing percentage at 18 months was 53.0% and 59.9% respectively, the net meat weight was 43.2% and 42.1% respectively, the bone meat ratio was 1:4.5 and 1:4.4 respectively, the quality of the buffalo meat was equal to the bovine meat. The result showed that Murrah F_2, had the biggest drawing ability (198.3 kg) and the next was Murrah F_2 (166.3 kg) and the last was the local buffalo (111.8 kg) Meanwhile the swamp buffalo can be crossed with the River buffalo with high milk yield to create the high milk yield cow (Yang Bingzhuang et al., 2003).

India

India has about 95 million animals which is 56.5% of the world buffalo population. India is the first country in the world for the number of buffaloes and milk production (about 84.4 million/tons, of which 54 are buffalo milk).

India is also the first country in Asia for scientific and technological development in the buffalo nutrition, production, reproduction, biotechnologies and genetic improvement. Moreover, India realized national programmes as the "green revolution" (to increase crop production for animals), the "white revolution" (to increase milk productivity and satisfy the human need of proteins) and finally the "red revolution" (to increase meat production and industry), particularly on buffalo.

The strategy of the Indian country is the genetic improvement of the local breeds through animal recording and selection. In fact India posseses the best River milk breeds of Asia, e.g. Murrah, Nili-Ravi, Surti and Jaffarabadi, which had their origin in North-Western states of India and have high potential for milk and fat production besides being used for work and surplus stock used for meat production (Sethi, 2003). Indian Murrah is the most diffuse in the world from Bulgaria to South America and all over the Asian countries.

Buffaloes are well adapted to a hot and hot humid climate and play a distinct role in the economy of the farmers, which is primarily based on agricultural production systems. They provide high quality milk, meat and source of draught power to small holders of the countries of these regions. In fact these animals are considered an asset financially as they serve as an instrument of insurance against the risk of crop failure due to natural calamities (Dhanda, 2004).

Pakistan

In Pakistan the buffalo is the main dairy animal in the country. Out of the 23 million head of the buffalo in Pakistan, 76% of these are only in Punjab (24% in other provinces of the country such as Sind, N.W.F.P., Baluchistan); Punjab supplies 73% of the total milk and 71% comes from buffaloes which are part of the traditional small mixed farming system integrated with crop production. The herd size is very small; 85% of buffaloes are raised in herds of one to five. There are 0.5 million landless farmers keeping dairy animals and contributing a significant (70%) share to the total milk production (Raza et al., 2000). The most common breeds present in Pakistan are the River Nili-Ravi and the Kundhi; their production performances are respectively about 2070 kg in 312 days of lactation and 1825 kg in 277 days of lactation (Mudgal, 1999).

In Pakistan the first strategy is also the genetic improvement in the Nili-Ravi and the Kundhi breeds through animal recording and selection and progeny testing trials. Recording of buffaloes is mainly done in the seven institutional herds, particularly in the Livestock Research Institute, Bahadurnagar, and on a few military farms. Apart from these, buffaloes at a farmer level are recorded under the progeny testing programme which has been carried out since 1980. The Government facilitates vaccination against contagious diseases at nominal prices. About 5–10% of breedable females are artificially inseminated while the rest are mated naturally with bulls of a good type (Khan et al., 1999; Khan, 2000).

Philippines

In the Philippines there are 3.2 million Carabao buffaloes, 99% is with small farmers that have less resources, low income and have less access to other economic opportunities.

Thye Carabao Development Program is a massive programme started in 1993 to improve the native Swamp buffalo locally known as the Carabao to develop meat, milk and draught. The elite herd of the Riverine buffalo is now established in the Philippine Carabao Center, the Science City of Muňoz importing about 3000 Murrah buffaloes with pedigree performance records from Bulgaria. Each female crossbred when raised for milk can produce about 1,350 kg of milk per lactation (Cruz, 2003). The crossbreeding of Bulgarian Murrah (producing 1,800 kg per lactation) with a Swamp population (producing 400 kg per lactation) obtained F_1 with 1,100 kg and F_2 with 1,350 kg mean production respectively.

The Nueva Hecija Federation of Dairy Carabao Cooperatives (NEFDCCO) is a federation that collects 25 cooperatives in the Nueva Hecija area, which aims are milk collecting, milk industry organizing and product selling. Because the main purpose of the project is to deliver a mechanism for the Philippine group to select the parents of future generation of the Carabao, it will be necessary for them to evaluate their livestock and design breeding programs that will deliver rates of genetic improvement in the range of 1.2% – 2.0% per year compounding. The difficulty in communicating the value of genetic improvement is that it is small per year and will not be delivered with precision every year (Phillips, 2004).

Vietnam

Swamp buffaloes in Vietnam are mainly raised by smallholder farmers with small herds (four to eight head) partly for draught power and partly for meat. The traditional management dominates the buffalo production systems. Buffaloes play an important role in agriculture and in the life of Vietnamese farmers. They are the main source of draught power for land preparation and transportation in the rural area, and supply a huge amount of fresh organic manure for cultivation. The local buffaloes are of the Swamp type with a total population of nearly 3 million. In general, Vietnamese Swamp buffaloes have small body size, slow growth rate, late maturity, long calving interval and low milk yield, but are adapted very well to their ecological conditions and they have good disease resistance. In the 1970s dairy Murrah buffaloes were imported from China, Bulgaria and India to improve productivity of local buffaloes. Murrah buffaloes were well adapted and raised in many places in their country. The male Murrah buffaloes were used to cross with female Swamp buffaloes. The crossbred F_1 have improved the body size, growth rate, draught power, milk yield and also reproductive performance, but at present the numbers of crossbred buffaloes are still small (Mai Van Sanh, 2004). Murrah buffaloes and cross-breeds (Murrah × Swamp) are mainly raised in the research station in small numbers, consequently their performances are recorded and documented accurately. They are distributed in the north, central and south provinces of Vietnam. There are some good demonstrations of raising Murrah buffaloes for work and milk in village conditions in the Northern provinces. Diluted semen and frozen semen of Murrah bulls were successfully produced for artificial inseminations (AI) through financial and technical support of the Indian Government, but they were poorly developed (Nguyen van Thu, 2000b). The Buffalo milk production of Vietnam is reported in Table 2.

Table 2

Milk production of buffaloes in Vietnam
(Nguyen van Thu, 2000a)

	Swamp (in the South)	Swamp (in the North)	Murrah	F_1 crossbred
Lactation period (days)	–	210–360	236± 57.31	292±27.5
Milk yield (kg/day)	1.50	1.20–3.45	5.55	3.50

Sri Lanka

The estimated number of buffalo owners in Sri Lanka is around 100,000 (Bandara, 2000). The population of buffaloes, decreased from 0.89 million in 1981 to 0.75 million (–15.45%) in 1997 with great reduction in the wet (–20.42%) and wet-intermediate zones (–33.26%). The reasons for this are the increase in population pressure creating a high demand for land for residential and commercial purposes, especially in the wet zone, urban and peri-urban areas and increased mechanization

of paddy cultivation practices and colonization of vast tracts of dry zone resulting in the dwindling of communal grazing grounds for free-ranging cattle and buffaloes. While there has been a decline of population, there has been a steady increase in the exotic River crosses in the population.

The indigenous buffaloes which require long years to reach sexual maturity and are capable of producing only about 1–2 litres of milk over a very short lactation period of 3–5 months, have crossbred with exotic riverine dairy buffaloes since 1950s. As a result a significant shift in the genetic composition of the buffalo population has been recorded. According to more recent reports on the national scale the percentage of herds carrying cross-bred buffaloes has increased from 26.5% in 1985 to 30, 4% in 1999 (Abeygunawarardena and Abeyratne, 2001).

Bangladesh

Bangladesh had 772,764 buffalo head possessed by 270,228 holding representing 1.52% of the total holding of the country. The average buffalo head per holding was 2.67 (Faruque, 2003).

Bangladesh has about 100,000 adult female buffaloes that are being used for draught or dairy purposes. These buffaloes are found in the Bramhaputra-Jamuna flood plain of central Bangladesh, the Ganges-Meghna, flood plain of southern Bangladesh and institutional herds. Bangladesh has milk/dairy buffaloes of the Swamp, crossbred and River types as the Murrah and the Nili-Ravi. The occurrence of crossbred dairy buffaloes indicates that the genetic improvement programme has been run and is still being run to date.

Recent studies indicate that Bangladesh possesses several types/breeds of buffaloes (Faruque, 2003). The Indigenous river type (433,000 head) is bred in the western and central part of the country; the Bangladesh (4,500 head) is bred in the central and southern west; the Indigenous swamp type (37,500 heads) is present in the eastern part of the country. Among the Crossbred type there were an Indigenous × Nili Ravi population (40,000 head) present in the southern part of the country and a phenotypes combination of the Swamp type and the Nili-Ravi (207,569 heads) bred in the south west and the southern part of the country.

Thailand

Thailand had the second largest number of the Swamp buffaloes in the world in the past. However, this buffalo population drastically declined from 4.7 million in 1990 to 1.9 million in 1998.

The number of buffaloes has decreased every passing year; the present number is about 1.7 million and tends to decrease gradually. As the reproductive efficiency is low due to the longer production cycle, the last longer period of reproduction could be two calves in 3–4 years. Such 1.7 million heads of buffaloes belong to 517,941 households. If the situation forced the buffaloes to decrease only due to several enforcement, the national buffalo population would be declined absolutely (Suthikrai, 2002).

Approximately 83% of the Thailand buffaloes live in the northeast where most agricultural production is under rain fed conditions. Genetically Thai buffaloes are of the Swamp type. The majority (90–95%) are grey to black in colour, while the rest are white. Most of the buffaloes are raised by small farmers in the rural areas.

Buffalo breeding in village conditions is generally random mating. In fact, in the plantation season the buffaloes are tied up and fed with rice straw for almost four months resulting in a lack of opportunity to be bred during the plantation time. The animals, males and females, are grazed together in the paddy fields after the harvesting season. Consequently, unplanned breeding occurs during the harvesting time when the villagers let the buffaloes graze together. It is obvious that in general, there is no recording system approach to the farmer level as in the Government farms (Ancharlie Na-Chiangmai, 2000).

A programme on the genetic improvement of Swamp buffaloes for use as dual purpose animal (meat and draught) is in place. This programme has been directed to solve two basic problems, the decrease in number and the reduction in mature body weight and size of buffaloes under small farm production. Reproduction and growth performance of buffaloes at the matured herd were evaluated as the result of genetic improvement programmes during 11 years (1983–1993). With regard to the reproductive performance, the age at 1st calving was reduced to 3.5 years, the calving interval to 487 days, the conception rate was in-

creased to 80.5'%, the calving rate to 76.9% and the calf crop to 70% (Pakapun Skunmun, 2000).

Indonesia

The number of households showed the potential of buffalo farms in Indonesia by 489 thousand households in 1993; otherwise, in 1983 the number was more than 593 thousand households. On the other hand, the total population of buffaloes in Indonesia during that period did not follow the declining in the number of households with buffaloes. In 1985 the total population of buffaloes was 3,245, as well as in 1993 its population was 3,238. This statistic shows the number of households in the period of 1985–1993 which was declining, but there were no significant changes in the number of buffaloes. And thus, it indicates that the rural buffaloes maintained by small farmers in Indonesia still have a potential contribution to the development of dairy industry in Indonesia. The buffalo breeds have been typed as the Swamp and the River subspecies, and most of the Indonesian buffaloes are included in the Swamp one that consists of many types and varieties of single breeds. There are varieties of the Swamp breed in many different localities with divergence in the size, weight, colour, marking and horn dimension. The Swamp buffalo is generally considered to be an working animal, but it also has a considerable capacity for milk production. The Swamp buffaloes are used for draft power in most areas and beef in Java lowland areas and the Sumatra uplands.

Most of the rural buffaloes maintained by small farmers in Indonesia produce less than 1,000 kg of milk per lactation. The primary objective of a new pilot program will be the awareness of stakeholders and the increasing availability of animal protein for improving the human nutrition. This goal could be achieved by increasing the buffalo production of milk and meat through the improvement of genetic capacity of buffalo, producing F_1 and backcross buffaloes from the Swamp and Mediterranean Italian River buffaloes, to be used to increase buffalo milk production in Indonesia while maintaining and improving a nucleus of purebred Swamp buffaloes (Borghese and Mazzi, 2005).

NEAR EAST STRATEGIES

Turkey

The Water buffalo is called with different names like Dombay, Camiz, Camis, and Komus in Turkish. According to 1974 FAO statistics, there were 1 million buffalo head in Turkey. Since 1984 to 1997, the decrease in buffalo breeding population was of 65% and the reason for the decreasing of Water buffaloes was the preferences of cattle to buffalo in Ege and Marmara Regions, where a great number of buffaloes were found. In Turkey, all improvement efforts for genotypes were only practiced for cattle. Buffalo population is about 110,000 head (Borghese, 2004), only of Anatolian breed.

In 1988 it was investigated that the average milk yield of the buffaloes raised in controlled herds at the first lactation period was 813.12 ±36.21 kg; it was reported, at the first, second and third lactation period, the average milk yield was 983.4±58.45 (442–1715) kg respectively, it was also reported that the average milk yield of farmers in village conditions was 1,009.89±21.13 kg. The average lactation period was 224.80±6.42 (121–368) days. The dry period was 188.04±11.17 (64–552) days. Milking was made generally by hand. The milking machine was only used around Istanbul. The average dairy yield of the buffalo cow was 5.08±1.709 kg.

The buffalo milk composition was protein 4.18±0.070%, total solids 17.71±0.352%, and fat 8.111±0.205 %. The fat-free solid content of buffalo milk was 11.91±0.168%. The water content of milk was 82.29±0.352%. The milk production of the Water buffalo is famous and favoured especially for famous unique Turkish desserts. It was one of the biggest motivations for the farmers to keep and raise water buffaloes near big cities (Soysal and Kok, 2004).

In 2002 Italian semen was introduced to improve the genetic and milk productivity in Ilikpinar village (Hatay) on the local population. In the first trial carried out, a pregnancy rate of 45% was achieved by using the Italian semen (Sekerden et al., 2003).

The Project, as a collaborative project of 2 countries (Turkey and Italy), came into force by using semen originated from 2 Italian bulls which was provided by FAO Inter-Regional Cooperative

Research Network on Buffalo. When aids (900 doses semen and chemicals for 80 buffalo cows) provided by FAO were exhausted, in order to continue with the Project, financial support was taken from the Scientific and Technical Research Council of Turkey. So, 600 doses of buffalo semen from 4 bulls were purchased. The conception rate was 78% in the last insemination time.

In F_1 (Mediterranean Italian × Anatolian) the milk yield average was 1203.0 lt. The lactation yield average of 81 Anatolian buffaloes was calculated as 961.59±342.13 kg (Sekerden, 2009).

The milk production of the Water buffalo is renowned and favoured particularly for the production of the famous Turkish desserts. This was one of the highest motivations for farmers to keep and raise water buffaloes near big cities (Soysal and Kok, 2004). A semi-hard cheese called "peyaz peyneri" is made from buffalo milk. Ayran is a drink with water and buffalo yogurt. The meat production is all converted into sausages. The price of buffalo meat is 10 percent less than the price of beef.

Azerbaijan

The most valuable buffalo gene fund of U.R.S.S. was in Azerbaijan. In the transition period following the fall of the Soviet Union no research facilities or governing farm activities existed to assist buffalo breeders. As a result, the number of buffaloes in many regions of Azerbaijan fell drastically. Valuable breeds of buffaloes were slaughtered for meat. In order to prevent this shortage, the President of Azerbaijan Heydar Aliyev issued a decree on the Preservation of Local Livestock Gene Pools in Azerbaijan. The Azerbaijan Association of Buffalo Breeders founded in December 2001 played a big role in passing this law.

There are about 300,000 buffaloes in Azerbaijan, including 140,000 female buffaloes with an average milking rate of around 1,200–1,600 kg (8–10% fat content) with 305 days per lactation. On state supported buffalo breeding farms, there are 920 buffaloes, including 250 female buffaloes (Farajev and Bashirov, 2002).

The main problem hampering the development of buffalo breeding in Azerbaijan is the absence of high quality reproductive buffaloes and a lack of artificial insemination facilities. Financial assistance, such as that provided from Italy, was useful to introduce oestrous induction and artificial insemination techniques, to develop milking and cheese industry management (Borghese and Mazzi, 2005) to improve the local Azeri breed.

Iran

In the 1930s there were 1 500 000 buffaloes in Iran. By 1995 this number decreased until now, to 470 000. The buffalo is a native animal of Iran, with over 80% of its population concentrated in the north and north-west (Azerbaijan province) and 18 % in the south of the country (Khuzestan). Some of the main reasons for this decline may be industrialization, the increasing demand for buffalo meat and a lack of replacement of the slaughtered animals and farming diversification and income. Official neglect and pro-Holstein propaganda have caused a significant decrease in buffalo numbers in Iran in recent decades (Mohsen pour Azary et al., 2004).

The buffalo farming system in Iran is based on smallholders (99 %); most of the herds have an average of five animals; a few herds have between 20 and 50 buffaloes and some of them have 300 buffaloes. Smallholders manage their animals according to the opportunities offered by the environment such as pasture, stubble, shrubs and grass. Most of them obtain their feeding by grazing along water sources.

In Khuzestan buffaloes are raised outdoors throughout the year living also in the marshes, but in the north-west (Azerbaijan) they are housed in autumn and winter.

Buffalo farming in Iran can be considered to be at a good level since the owned or rented properties are of a large size and the land available for buffalo farming is also extensive. Buffalo farming has been a traditional activity for many decades (Kianzad, 2000).

There are two breeds in Iran, Khuzestani and Azeri that produce about 1 865 kg and 1 200 kg of milk, respectively, with a lactation period of 210 days. The mean calving interval is about 420 days.

Products: milk, yoghurt, fresh cream, fresh cheese, butter, ice-cream, rice pudding, churned yoghurt, dried whey, ghee. In Iran the price of buffalo milk is twice that of cow milk. Buffalo skin is

used in the leather industry. Buffalo manure is used for fuel in rural areas.

A development project is starting, introducing Italian buffalo semen from COFA in order to improve genetic and milk production.

Iraq

In Iraq, according to data provided by Khalid Al-Fartosi (2009), there are 120,000 total River Khuzestani or Iraqi buffaloes, 75,000 adult females with 1600–1870 kg as lactation milk yield, in a 258 days lactation period. Presently water buffaloes in Iraq suffer from some problems dealing with diseases, products and management, because of the war.

Buffaloes are bred in the marshes and swim far and wide for feeding on papyrus, reeds, common ash and other plants. When the flood water is high their owners have to go out and collect these plants in order to feed the buffaloes on platforms.

Buffaloes in towns rarely graze on natural pasture; they are fed mostly on concentrates, green forage, straw and agricultural by-products.

Now the Ministry of Agriculture is working on a buffalo development project supported by Italy.

AFRICA STRATEGIES

Egypt

The total number of buffaloes in Egypt is about 3.950 million (Soliman, 2009), of which 42 % are dairy cows, 6 % buffalo bulls, 32 % heifers less than two years old and 20 % male calves less than two years old. The aggregate share of buffalo milk, from all types of production systems is about 81 % of the total milk production in Egypt.

There are different research institutes at the Ministry of Agriculture and at the University in Giza (Cairo) involved in developing project concerning buffaloes and buffalo products. The breed is the River Egyptian. The buffaloes are spread along the river Nile, in the Delta Region and at the Fayum Oasis .

The age at the first calving is 34–41 months.

According to Soliman (2009) data, in Egypt there are two different farming systems, traditional and progressive, with different production standards, according to the following Table 3.

Table 3

Different production standards in Egypt
(Soliman, 2009)

Milk yield for lactation	Traditional mixed small farm system	Progressive farm system
Total milk/head/season 1	1650	1850
Total milk/head/season 2	1790	2000
Total milk/head/season 3	1950	2400
Total milk/head/season 4	1870	2350
Total milk/head/season 5	1800	2200
Grand average milk yield per milking head	1850	2250
Average lactation length (days)	180	250

Products: The following cheese kinds are produced with the addition of cow milk such as Domiati, Karish, Mish, Rahss.

EUROPE STRATEGIES

Romania

The buffalo population in Romania was more than 200 000 head in 1996. Actually it is about 100 000 of the Mediterranean breed, sometimes crossbred with the Bulgarian Murrah (Borghese and Mazzi, 2005).

The average milk production is 1 200 kg per lactation (270 days). Buffaloes are still used today on small private farms for draught and the goal of the selection process is to create a dual-purpose type of animal (milk and meat), realizing good daily gains (600–800 g), in order to slaughter the males at 22 months with 460 kg of live weight. At present the calves are also fattened to be slaughtered at four months (100 kg of live weight).

The animals are housed and tied during the winter due to the unfavourable weather conditions and fed with hay, bran, concentrates, silage, grazing on pasture in the warm season.

Products: Vladaesa cheese, Braila cheese.

Bulgaria

In Bulgaria a new buffalo population, named the Bulgarian Murrah, has been created through the import of the Indian Murrah in 1962 and later in 1975 by crossing them with the indigenous Mediterranean. This activity was performed systematically under the scientific management of the Buffalo Research Institute in Shumen and the National Animal Selection Centre.

Buffaloes were raised on the State farms, kept tied in closed sheds, machine milked and fed maize silage, alfalfa or grass hay, straw and concentrates.

The animals were managed in separate groups according to physiological conditions such as suckling calves, females of four to twelve months, heifers, pregnant heifers, dry cows and milking cows.

After the changes in the political and social-economic system in 1989, buffaloes were transferred to the new private farms, where scientific and genetic activities were limited and the animal numbers have drastically decreased.

Actually, there are only 9 200 head, of which 5 880 are cows of the Bulgarian Murrah in Bulgaria. These animals are submitted for milk recording and to artificial insemination.

Milk recording, selection, artificial insemination and progeny testing are coordinated by the Buffalo Research Institute.

Products: White brine cheese, typical yoghurt.

Germany

In Germany there are now 2111 buffaloes in 14 different regions, particularly in Sachsen (434), in Baden-Württemberg (389) and in Brandenburg (287) (Thiele, 2009). The population started with 625 head imported by Italy and Bulgaria in 2001, showing a quick increasing linked to a rich market of high quality products, coming from milk and meat processing as mozzarella and other cheeses, cream, yogurt, sausages, meat boxes, and also beauty products.

Macedonia

The buffalo farms in Macedonia are very few, 4 or 5 at all perhaps, and the total population is very reduced, probably less than 100 animals, but nobody knows exactly the reality. There is a farm in Debreshte village (near Ropotovo), with some local dairy cows and 12 buffaloes of the Mediterranean breed, small and compact, bred on natural pasture. The first problem of the farmer is that they have no male and very high consanguinity. The proposed solution is the introduction of artificial insemination by Italian semen to increase the milk production, actually very low, and to introduce a different and better genetic basis.

In Mojanci village (near Kočani) there is a family farm with 8 buffaloes in the farmyard close their house, of the same Mediterranean breed, but the animals were bigger than in the previous farm. The farmer produces simple cheese that is sold in the local market.

The reality is that a programme to save and develop buffaloes in Macedonia is a priority to maintain biodiversity, to conserve the buffalo genetic that was introduced 5 centuries ago with the Turkish invasion, to develop animal farms and typical products for the local market and as a basis for the tourist economy. The project presented by the Animal Science Institute to the Agricultural Ministry will be effected with the cooperation of Italy.

United Kingdom

There are a maximum of 2500 breeding females in the UK and probably a maximum of 1200 milking animals and maybe less.

As for milk yields, the average is 1500 kg per year. This was due to the poor quality buffaloes imported from Romania and also some mis-information through ignorance of the nutrition of buffaloes.

An imported way of bulls too have been from the North of Romania. The best animals are without doubt those that show signs of the Bulgarian Murrah ancestry, and indeed the sires of over half of foundation animals were Bulgarian (from AI).

Lactation length is about 300 days in the best (with perseverance) but considerably less in some, particularly heifers. Calving interval is usually a bit over 365 days (Wood, 2009).

Greece

In Greece, due to the rapidly changing socio-economic conditions, including the mechanisation of the agricultural sector and the substitution of

buffalo milk by milk produced by imported dairy cattle, the number of buffaloes has declined dramatically over the last decades. As a result, from 75 000 animals counted at the end of the 50s, today only few head remain. Now there are 2503 buffaloes in Greece (Ligda, 2009). The animals are River buffaloes of the Mediterranean breed and are spread in the geographical areas of the Thessaloniki district (Kalochori, Apollonia), Serres (Omalo, Chrysochorapha), Rodopi (Dialambi). The buffalo population is distributed in 28 private herds.

The coat colour is dark gray to black (sometimes spotted).

Lactation length varies from 210 to 280 days with an average lactation milk of 700–1000 kg while the age at the first calving is 36–48 months.

The age at slaughter for the young stock is 15–17 months and the weight at slaughter is 350–400 kg.

The cows are milked twice a day at the farm by hand. The distribution of calving is regular during the year, but higher frequency is observed mainly at the end of spring, summer and autumn.

The calf is suckling for 7–8 months, with a live weight at weaning of 75–90 kg, and 2–3 months where the owners sell the milk.

The riparian zones of the Strimonas River and Kerkini Lake are used for grazing during the whole year. However, during the period from November to April, grazing is not sufficient and complementary feeding is given to the animals (straw of wheat, clover, corn and maize silage).

Buffaloes are not used for draught, but only for milk and meat production. The dairy products obtained from buffaloes are yogurt, white cheese in brain, butter, kaimaki and cream.

Each farmer has his own bulls available for natural service in the fields and used in proportion 1 to 8–15 cows. Artificial insemination is not applied. Efforts for buffalo production are made by researchers of the Greek Focal Point for the Preservation and Conservation of the Animal Genetic Resources, at the Aristotle University of Thessaloniki, with the support of the Ministry of Agriculture to rehabilitate buffalo production and to let buffalo farming, at present under protection, to become an economic viable activity.

GENETIC IMPROVEMENT IN ITALY

In the past fifty years, buffalo numbers in Italy have increased 17 fold; in particular the number of buffaloes raiseds from 101.000 head in 1993 to 276.000 in 2004, showing a percentage increasing of 173% (ANASB, 2004). Actually there are 370,000 head with 180,000 dairy buffaloes. It is therefore the livestock that has registered the highest increase in number. The reason for this increase lies in the fact that from a rustic triple–purpose animal, the buffalo has become a dairy purpose animal. All produced milk is in fact processed into mozzarella cheese, and the increased demand for this cheese, both on the national and international market, together with the milk quotas (i.e. taxes on surplus cow milk production) imposed by the European Union, have favoured the increase of buffalo production (Moioli, 2005). The Italian Ministry of Agriculture is responsible for the milk recording and selection activity through two specific organizations, the Italian Breeders' Association (AIA) and the Buffalo Breeders' Association (ANASB) which provide the technical staff for performing these activities. Recorded buffaloes are raised in 290 herds in 36 Italian districts (the average herd size is 161.3). The numbers for milk recorded buffaloes (ANASB, 2009) are 46,799, i.e. 26 percent of the buffalo population, the average lactation milk production is 2,221 kg (270 days), the fat content is 8.24 percent and the protein content is 4.66 percent. Fat and protein content analysis is compulsory in the Italian milk recording system because the two results are included in the estimation of the genetic merit of milk, giving the highest importance to the protein content, due to the conversion of the milk into mozzarella cheese. In fact the aim of the selection, pursued by the Central Technical Commission of ANASB, is to improve the mozzarella cheese production by a selection index called PKM (Production kg Mozzarella). This index is estimated by considering the produced kilograms of mozzarella cheese in each lactation, taking into account kg of milk, fat and protein contents as in the following formula (ANASB, 2005):

$$\text{Mozzarella (kg)} = \text{Milk (kg)} \times (3.5 \times \%\,\text{proteins} + 1.23 \times \%\text{fat} - 0.88) / 100$$

It has to be specified that the length of lactations is normalized to 270 days even if it endures

120 days or 700 days, excluding from normalization productions higher than 6.000 kg.

Several environmental factors may affect milk production and reduce or increase the gene expression, which is a quantitative character. It is therefore fundamental, in order to evaluate the genetic effect in the expression of a quantitative character, to consider its hereditability. The hereditability values utilized in this genetic program have been estimated from scientific researches performed on the Italian buffalo population. In fact it does not exist a large bibliography in this sense in buffalo species, contrarily to other species. Actually in Italy the estimated hereditability values are relatively low for PKM, milk production, fat and protein contents (0.14, 0.17, 0.13, 0.15, respectively), but the great variability in the production of recorded animal allows to suppose the possibility of carrying out a real selection. This genetic program aims to estimate the genotype of the subject starting from its phenotype (milk production, protein kilograms, etc.). This index, expressed as positive or negative deviation from the mean, is evaluated as the aptitude of the subject to transfer its productive potentialities to the progeny, furnishing an estimation of the future utility to the selection.

It has to be taken into account that the productive performances of a subject are the results of the casual combination of half paternal and maternal genes, together with the environmental factors. Therefore it may be useful to know the genetic value of the animal before its reaching the productive maturity. In this sense the Pedigree Index (PI), an estimation of the genetic value based on its parents, can be utilize. If the identities of the father and the mother are known, the PI will be the average of the genetic value of its parents as in the following formula (ANASB, 2005):

$$PI = \frac{\text{Father genetic value} + \text{Mother genetic value}}{2}$$

The selection activity started in the 1980s. Five progeny testing cycles were performed from 1987 to 1994, testing comprehensively 43 bulls, and providing 17 positive bulls. The genetic value of these bulls has been tested on a minimum number of 10 daughters and 47 lactations (Bull called Bravo), to a maximum of 82 daughters and 194 lactations (Bull called Napoli). Two more progeny testing cycles were performed from 1998 to 2002. In these two last cycles eight bulls were put on-test. 14,477 semen doses were produced and 3,718 buffaloes were inseminated. The remaining available doses are 6,350. In 2003–2004 a further cycle was initiated during which four new bulls have been progeny tested.

The keeping of bulls and semen collection are performed in two different AI stations (COFA and Chiacchierini). The bull and cow genetic merits for milk and mozzarella production are published in special catalogues that are produced by ANASB twice yearly (ANASB, 2005). In the catalogue, the top one percent of Italian buffalo cows with the highest genetic merit for mozzarella and milk production are listed.

In the last decades several studies have been carried out in order to improve the efficiency of artificial insemination. In fact, different methods for oestrus synchronization have been tested and good results were obtained, with a 35 to 50% pregnancy rate. The synchronization of oestrus can be defined as the management techniques which utilize hormones in order to control the oestrus cycle. Its aim is to coincide the ovulation with the time of artificial or natural insemination and allow to concentrate the deliveries in some periods of the year. Because of the low intensity of the oestrus behaviour in buffalo it is necessary to inseminate animals after the hormonal treatment of this type. The methods to evaluate the response to the synchronization include the percentage of animals which show signs of oestrus on the total number of treated animals, conception rate (CR) and pregnancy rate. Several treatments have been tested in buffaloes. Treatments with progesterone and its analogues allow oestrus induction in cyclic animals (51.1% CR), but also in non cyclic animals (39.5% CR), because of their action on the pituitary gland and gonadotrophines production (Barile et al., 2004). On the contrary, treatments based on the use of GnRh and prostaglandins have shown good results in cyclic animals, inducing a high percentage of synchronized ovulations (44.9% CR; Barile et al., 2004). Furthermore other biotechnologies are actually studied in order to obtain genetic improvement by maternal lineage. Superovulation and embryo transfer resulted in the low number of embryos (about 2.1/buffalo), but encouraging results have been reached in some experiments performed in Brazil in the last years. In this case the use of bovine somatotropin may represent a valid tool in order to improve the techniques.

The most efficient method actually studied in order to exploit the maternal lineage, is represented by the Ovum Pick-up together with in vitro embryo production. In vitro embryo production procedures are applied worldwide with different goals for a variety of livestock species, exotic, wild and endangered animals. Actually a similar efficiency to that recorded in cattle has been reached in buffalo species and further improvements may be obtained. The possibility of obtaining embryos from in vitro technology has drawn the attention of animal scientists and entrepreneurial groups, especially when a non-invasive procedure for recovering oocytes from antral follicles in live animals became a practical and effective approach (Kruip et al., 1994). Collection of oocytes by means of ultrasound guided follicular aspiration is routinely performed with success in large prepuberal and adult ruminant species under various physiological and pathological conditions (Meintjes et al., 1993; Neglia et al., 2003). The OPU technique results in resetting the follicular population and subsequently increasing the follicular wave frequency. It follows that the occurrence of follicular atresia is highly reduced. In fact follicles are punctured before they become atretic. Because of its high milk production, the Mediterranean Italian buffalo is in a high demand around the world, as well as important for the local economy. Special efforts are needed to rapidly propagate superior males and females. The application of the OPU technology, together with the multistep embryo production in vitro, could be a way of meeting this need. The application of the OPU technology to the buffalo, together with an improvement of the multistep process of in vitro embryo production, can enhance genetic progression through the maternal lineage, thus overcoming the reduced level of efficiency linked to more traditional approaches. However, in vitro embryo production in the buffalo species has always been associated with a lower efficiency compared to the bovine species, although recently some encouraging improvements have been reported (Gasparrini et al., 2000).

PROPOSALS FOR GENETIC IMPROVEMENT

Breeding and official selection activity in any country depends on the economic importance of the considered livestock, therefore of the products that can be obtained from it.

The first step in the breeding and selection activity with regard to any dairy livestock is the milk recording of the productivity of each yielding animal. The results, when appropriately merged with the genealogy data, allow a definition of the milk genetic merit of each animal, in particular of the bull, for which we have no other milk record except the production of his progeny.

The importance of animal recording for the activity of selection is well recognized all over the world and is demonstrated by the fact that in most countries such activity is at least partially financed by governments, which consider it an important means for the improvement of animal production. An international non-governmental organization, the International Committee for Animal Recording (ICAR) has been active for over thirty years in the field of promotion and standardization of animal recording. The ICAR comprises 20 member countries and has obtained excellent results particularly in the dairy cattle sector, where one of its groups, entitled Interbull, regularly produces milk genetic merits of bulls that are comparable among different countries representing the most important dairy breeds such as are the Holstein Friesian and the Brown Swiss. What keeps buffaloes far behind the results obtained by dairy cows is the cost of the whole organization of milk recording, genealogy data registration and the selection activity. A specific seminar, jointly organized by the FAO and the ICAR in the year of 2000 (Workshop on animal recording for improved breeding and management strategies for buffaloes; Moioli, 2000), made clearly evident the major constraints affecting the implementation of the milk recording activity, which can be briefly summarized as follows: 1. Lack of finance; 2. Farmers are reluctant to reveal to other people the levels of production of their animals; 3. Identification of the animals is expensive; 4. Recording costs increase proportionally to the distance between herds, and buffaloes are mostly raised by smallholders (two to five animals) scattered over wide country areas. These constraints illustrate why the percentage of recorded buffaloes in countries where buffalo seem to be more important than cattle are so low (Moioli, 2005).

The highest proportion of milk recorded buffaloes, in fact, is found in Italy (26%), in Iran is 5.7 %, while in other countries the recorded buffaloes are about 1% of the total dairy females (Turkey, Egypt) or less.

The productivity in other countries is lower than in Italy, considering that only in Italy there was a very long work of recording, selection and genetic improvement, health, feeding and livestock system rising. Also milk composition was improved in Italy in few years, with a mean protein percentage from 4.4 to 4.7 and fat percentage from 7.3 to 8.2 without any selection of this character.

Moreover the possibilities of genetic improvement for the milk quantity and quality will be higher, if the selection pressing will be increased reducing the number of bred females. So, just now in Italy there are many females producing more than 5,000 kg milk for lactation (270 days).

Therefore the selection will be directed for the improvement of the yield of mozzarella cheese, not only for milk production, because the farm income actually is resulting first from mozzarella cheese, then from selling pregnant heifers, at last from beef (Borghese, 2004).

A consistent number of recorded buffaloes is obviously found in countries with the highest presence of buffaloes (India, Pakistan and Egypt) which signifies that these countries have also taken steps towards implementing an organized milk improvement activity, on a solid scientific and technical basis.

Therefore the animal recording could be considered the selection basis. However it is impossible to have a rapid increase of the milk production in the Swamp breeds through the animal recording only. We can obtain more rapid results introducing high quality semen for crossbreeding schemes in the Swamp population or in the River population in some countries, as Macedonia, where the risk is the buffalo disappearing.

One of the purposes of the proposed breeding schemes would be to produce F_1 crossbreds and backcross buffaloes from the Swamp introducing the River buffaloes, characterized by a tested genetic value. These schemes will promote the increase of buffalo milk production, while maintaining and improving a nucleus of purebred Swamp buffaloes.

A project will start with the constitution of a Pilot Centre in the Hosting Country. The aim of the proposed breeding schemes is to produce F_1 and backcross buffaloes from the Swamp and the River buffalo to be used to increase the buffalo milk production while maintaining and improving the nucleus of purebred the Swamp buffaloes.

Because the fertility of the buffaloes produced from crossbreeding of the River × Swamp buffalo has never been carefully studied, and because a reduced fertility of F_1 males is referred in literature (Dat et al. 1994), karyotyping will be performed on all F_1 and backcross progeny at each stage of the trial so to evaluate fertility parameters.

The nucleus of purebred Swamp buffaloes will be recorded for milk productivity to define the optimal breeding strategies to increase milk production in the purebred Swamp. The breeding scheme is described below.

To realise the backcross River × Swamp, frozen buffalo semen from the Mediterranean Italian bulls in the progeny test will be imported from the Reproduction Centre COFA in Cremona, Italy, according to ANASB (Italian Buffalo Breeders Association) indications.

Because ovulation in the buffalo can not be predicted from oestrus behaviour signs because they are not often shown or showing a large variability, oestrus synchronization and fixed time protocols of artificial insemination will be utilised to increase the conception rate.

As described above, the results of the work carried out in our Institute showed that the use of a progesterone pessary (PRID) associated with a follicle stimulating hormone as PMSG and with an analogue of prostaglandin, can be able to control ovulation and induce a good synchronization rate. This treatment allowed the use of AI in the low breeding season too, obtaining similar conception rates either in autumn or in spring (Barile et al., 1997, 1999). It was also possible to observe, by the determination of the preovulatory peak of LH, that the fixed time for AI was near to ovulation (Barile et al., 1998). In fact, utilising 2 AI schedules at 72 and 96 hours after PRID removal during the spring season we have obtained a conception rate ranged from 45.1% to 64.5% in different years (Barile et al., 2001a, 2001b, 2003). Using the PRID regime, it is possible to synchronise oestrus in cycling heifers too, increasing the effectiveness of AI programmes in buffalo heifers (Barile et al., 2001c; Pacelli et al., 2001); in this case 48 and 72 hours from the PRID removal are appropriate fixed time for AI.

In the Pilot Centre a great attention will be required in the feeding and management of F_1 generation (49 chromosomes) from which we could aspect intermediate performances between parents.

The male will be reared with mother milk until 3 months and gradually weaned using a pre-starter meal containing milk powder and high quantity of protein and fat, to create a F_1 genetic basis to use in the future for natural mating. The less valuable males will be used to produce meat and a selection line with this purpose will be pursued to increase the buffalo meat productivity as realized in India (Ranjhan, 2004) and in Italy (Borghese, 2004).

The same care will be used in the livestock of the female buffaloes, that will be weaned at 4 months, and after the heifers will be controlled and studied, with the purpose to realize the earliest puberty to increase the reproduction efficiency and the genetic improvement.

After puberty all the F_1 heifers will be inseminated with Italian buffalo semen to increase the Mediterranean Italian percentage, until 75% in F_2, and following more with the purpose of backcross to the River, to create a genetic Mediterranean Italian basis in the Pilot Centre to spread out the genetic improvement in all the Country.

The insemination with the Italian buffalo semen will be continued on Swamp buffaloes in the field creating a F_1 generation that could be crossed inter se: we will obtain a progeny with 48–49–50 chromosomes and the goal will be the diffusion of F_1 in the villages for the smallholders to be used as a draught animal in fields but with a higher milk production for the family in comparison with the poor production of indigenous breed.

The final results of a similar breeding scheme project in any Asian country, interesting to develop the Swamp type will be: 1. the constitution of a purebred Swamp nucleus; 2. the genetic improvement of Swamp population; 3. the increasing of animal products in F_1 Mediterranean Italian × Swamp; 4. the creation of a new breed by backcross; 5. the spread out of genetic improvement and of the animal products in smallholders and in small scale buffalo farms.

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