Use of Water Buffalo for Environmental Conservation of Waterland[a] - Review -

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ABSTRACT : The aim of this paper is to propose the preservation of buffaloes not only as productive livestock, but also as a part of the biodiversity of wetlands and especially of the Greek wetlands. The water buffalo used to be an integral part of the biodiversity of many Greek wetland ecosystems, enriched their landscape, and provided invaluable services and products to the rural people and to the economy in general. Its total population before the 1950s was over 100,000 animals. Presently, it is found only in four wetland sites in Macedonia and Thrace and in the estuaries of Rivers Gallikos and Axios, with a total population of a few hundred animals. These wetlands are Ramsar Sites. Even this small population is threatened with immediate extinction because of the rapidly changing rural socio-economic conditions and the expansion of cultivated fields into wet meadows. Farmers and consumers are rapidly losing contact with this mammal and its products. This species possesses minimum requirements for treatment and is characterised by the ability of utilising roughage of variable nutritional value. These factors are promising to render buffalo breeding a valuable branch of the Greek livestock sector, which can also contribute to the maintenance of the wetlands. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 8 : 1324-1331*)

Key Words : Water Buffalo, Conservation, Wetlands, Grazing

INTRODUCTION

The number of water buffaloes in the world has increased steadily over the past three decades. The FAO and other agencies estimate that the present world buffalo population is somewhat over 140 millions, of which approximately 70% are riverine breeds and types (including Mediterranean types). While the developing countries' share in the global cattle population is currently 69%, they keep over 99% of the world's domestic buffaloes. Most buffaloes live in Asia, Egypt, Southern and South-eastern Europe. Latin America has also sizeable and increasing buffalo populations. The present total number of buffaloes is about 60% higher than it was at the beginning of the 1960s. During that period the share of buffaloes in the global population of bovine animals has risen from 8.5 to 10.0%. However, this reflects, to a certain extent, the recent reduction of cattle numbers in the developed regions where demand for beef has been falling accompanied by almost chronic surpluses of dairy products. In fact, the proportion of buffaloes to total bovine animal numbers in the developing regions has not changed by more than 13-14% since the 1960s (Krostitz, 1992; Gigli et al., 1996; Bomfim, 1997; Ganguli, 1997).

When FAO published a major work in 1974 (Ross Cockrill), reviewing for the first time the then existing information relating to the water buffalo (Bubalus bubalis), Sir John Grenfell Crawford, the Vice Chancellor of the Australian National University, introduced it by underlining that among all farming livestock which science had neglected, the domestic buffalo served as an outstanding example of general failure to recognise and exploit its production potential. Since then a world-wide interest has developed in this species, not only as a provider of animal protein for human consumption, but also because of a growing interest in the diversification of products of animal origin and the manufacture of typical regional products as well as a variety of renewed uses of these animals. Furthermore, the strong image linking the buffalo with nature and the environment's ecological equilibrium, particularly in some of the world's more marginal lands, shows this species as one of the most viable alternatives to intensive cattle husbandry systems which are more and more under accusation in an environment-conscious society (FAO, 1977; Boyazoglu, 1996; Bomfim, 1997; Ganguli, 1997).

Although cattle are found all over the world, the statistics show that the buffalo population is concentrated in no more than 29 countries and milk production is statistically recorded in only 19 of them. One can estimate that the recorded production of 38.6 million tons corresponds to 133.6 million animals. Actually, even where officially no buffalo milk production is reported in figures, milking buffaloes to obtain a minimum of milk needed for the family is a standard practice. In this connection, much beyond its

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immediate economic aspects, the role of buffalo is of a paramount importance in so far as it provides meat, milk, leather and work in many of the world's marginal rural areas. The buffalo is an insurance against environmental adversity and this explains why people and animals live in such a close symbiosis. Buffaloes are considered more resistant than cattle to most diseases and are often farmed with in more adverse environments, especially as far as accessibility is concerned. Only in few countries are buffaloes subjected to systematic prophylactic measures organized at a national level. Considerable research work has proved that buffaloes show efficient adaptation to warm shaded conditions but not to sustained direct solar radiation. These physiological and behavioral responses have a major impact on the productive and reproductive performance of buffaloes under natural climatic conditions in a specific location and/or a given artificial microclimate. On the other hand, these biological characteristics set the basis for proper management approaches and guidelines (FAO, 1977; Shafie et al., 1993).

The main characteristics of this species, namely its ability of utilizing roughage of variable nutritional value, its minimum need for treatments, its high disease resistance, the easy management practices needed, and, finally, the possibility for the production of traditional quality products (yogurt, cheese, butter etc.), are promising factors to render buffalo breeding a valuable branch of the livestock sector, which can also contribute to the maintenance of the wetland environments (NAS, 1981; Gigli et al., 1996).

Wetlands are important ecosystems throughout the world. The 1971 Ramsar convention defines them as areas of marsh, fen, peatland or water, whether natural or artificial, permanent of temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters (Maltby, 1986). Wetlands have been used for millennia for grazing, hay production, fishing and fowling. In this context, wetland ecosystems have produced important quantities of food from plants and animals, for people and their livestock on a sustainable basis.

In the industrialized countries during this century, the use of wetlands by man has led either to intensification or to abandonment, in the sense that the primary production is no longer exploited by man or by large mammals. Most wetlands, after drainage, are used intensively for arable farming or industry; of the remainder, many have been abandoned and their natural resources left unused. A number of these have been declared as conservation areas, nature reserves and national parks. This has led to a loss of wild plant and animal species; in many abandoned wetlands, the plant communities have undergone impoverishment towards shrub and woody species. This resulted in a decline of the hunting, touristic, fishing, scientific and conservation values of wetlands (Georgoudis, 1996).

The traditional uses of the vegetation of wetlands for grazing livestock, for hay production and thatching or as source of energy, maintained the vegetation of wetlands in early successional stages resulting in a mosaic of plant communities. Also, traditional harvesting practices were generally extensive, light and sustainable, resulting in wild plants and animals co-existence with this kind of exploitation by man. The problem of succession starts when extensive use of wetlands stops. This leads to the reduction of biological diversity, and ultimately the loss of other possibilities, i.e. conservation, fishing, recreation (hunting, touristic), education or research. The solution to this problem is to slow down, to stop or to reverse the successional processes, at least in some parts of the wetland. This maintains the plants and animals of early successional stages and thus the biological richness of the whole area (Georgoudis, 1995; Georgoudis and Pappa-Michailidou, 1995).

The present paper aims at studying the issues concerning the preservation of buffaloes not only as productive livestock, but also as a part of the biodiversity of the Greek wetlands. The objectives were: (a) to review the role of buffalo grazing in wetlands, (b) to examine the present situation in Greece with regard to population characteristics, production systems and the threats, and (c) to propose measures for the preservation of this species in Greek wetlands.

ROLE OF LIVESTOCK IN THE CONSERVATION OF WETLANDS

Livestock are important components of wetlands. They include buffaloes, cattle, horses, sheep, goats and geese, which cover a wide range of liveweights (from 10 to 1000 kg) and types of digestive systems. These physiological differences largely determine their behaviour in selecting habitat and food and, therefore, their impact on wetlands, especially on vegetation, water quality, fish and bird populations. On the other hand, the impact of livestock on wetlands can be aggravated or mitigated depending on the management practices applied.

Vegetation

Livestock grazing affects the canopy and species composition of wetland vegetation, but its impact depends on its intensity. If it is severe, plant reproduction is prevented and complete elimination of vegetation may result with adverse effects on the aquatic environment. According to Burgess et al. (1995), intensive grazing by cattle and horses can

mechanically damage mires and entrophication may be caused from both dung and urine thus altering plant communities.

Riparian vegetation, in particular, stabilizes the streambanks, regulates the temperature in the water, reduces sediment and nutrient transport and, if woody, it can remove nutrients from sub-surface flow and store them (Lowrance et al., 1985). Overgrazing of such a vegetation results in reduction of shade and cover which may rise water temperature and eliminate the sensitive fish species (Platts, 1979). Also, it may cause soil and streambank erosion, increased soil water evaporation and a rise in water temperature which will increase, with the additional light, the growth of algae and, therefore, lead to the destruction of fish habitats (Campbell, 1970; Skovlin, 1984).

Grazing, however, is beneficial to wetland vegetation if it is of light to moderate intensity, because it can increase species richness and diversity, thus creating favourable habitats to wildlife (Papanastasis, 1990; Burgess et al., 1995). Cattle grazing, for instance, improved species composition in the abandoned coastal marshes in Netherlands which had a high accumulation of organic matter (Bakker, 1978). Also, grazing by horses in Camargue in southern France resulted in the reduction of the species *Scirpus maritimus* and *Phragnites australis* in freshwater marshes, while annual herbs such as *Bellis annua, Hordeum maritimum* and *Plantago coronopus* were increased (Basset, 1980). This means that moderate livestock grazing can maintain early successional stages in wetlands thus restoring open habitats which allow the conservation of plant and animal communities associated with these habitats. In the seasonal wetlands of the Mediterranean region, in particular, even heavy grazing may be beneficial because it reduces the invasive emergent macrophytes in favour of the submerged macrophytes which attract waterfowl populations.

Water quality

Livestock can contaminate wetlands with their wastes by adding nitrogen and phosphorus compounds as well as pathogenic bacteria to the water. The latter include faecal coliform bacteria and streptococci (Meehan and Platts, 1978). Fish may be killed by the reduction in dissolved oxygen concentrations or the high ammonia concentrations caused by animal wastes. However, for such an event to occur, the quantities of faeces and urine added to the water must be high. According to Buckhouse and Gifford (1976), cattle did not cause faecal pollution in a semi-arid watershed of USA and they did not impair stream water quality when they grazed with a moderate intensity.

Water quality impairment can be also caused by the fine sediment originating from soil erosion due to overgrazing. Such a sediment diminishes productivity as well the water permeability of channels used by fish for spawning (Meehan and Platts, 1978).

Fish and bird populations

Although the effect of livestock on fish populations has not been thoroughly studied, the few studies available suggest that improper grazing decreases both the quantity and quality of fish in streams (Meehan and Platts, 1978; Platts, 1979). These adverse effects are attributed to the modification of streams which become wider and shallower and with less undercut banks under heavy grazing (Platts, 1979). No information exists on how livestock affect lake shores or fish populations in other wetlands.

As far as the effects of livestock on wetland birds are concerned, they depend on where a particular bird feeds or nests and on the grazing season (Skovlin, 1984). In general, the effects may be direct or indirect (Tsougrakis, 1995). Direct effects mainly refer to trampling of nests by large animals, such as cattle and rarely to egg consumption by sheep (Green, 1985; Beintema and Mueskens, 1987), while a kind of positive interaction (commensalism) is developed between livestock and some bird species, such as *Bubulcus ibis* and *Molothrus* spp. (Gordon et al., 1990). Deferment of grazing during the reproduction period can overcome damaging effects of livestock on nests.

Indirect effects are caused by changes in the structure and composition of vegetation. In general, livestock grazing increases the number of invertebrates, birds and vertebrates of the open habitats, while it decreases the species of the closed habitats. A case in point are the reedbeds which are dominated by *Phragmitus australis* and cover larger areas in several wetlands. These communities are poor habitats for both fish and most species of wetland birds. A reduction in cover of these macrophytes in the freshwater marshes of Camargue in sourthern France was found to increase the population of the two duck species *Anas crecca* and *A. strepera* by 2 to 11 times (Gordon et al., 1990). On the other hand, overgrazing of macrophytes, such as *Scirpus maritimus*, may result in the reduction of another duck species (*Anas platyrhynchos*) which feeds on its seeds (Duncan and D'Herbes, 1982).

Grazing management

It is clear up to now that livestock have multiple effects on wetlands which can be beneficial if overgrazing is avoided. Important is also the system of grazing. Planned grazing systems adapted to the condition of each wetland seem to be more effective in harmonizing livestock husbandry and wetlands than continuous grazing (Duncan and D'Herbes, 1982;

Papanastasis, 1990; Skovlin, 1984). Also, the kind of livestock species should be considered as well as their special breed. Sheep and goats do not like the water and they often develop worm and foot problems. Cattle, on the contrary, freely walk in the water as do horses. According to Gordon et al. (1990), some cattle and horse breeds have developed special morphological adaptations for grazing in water, such as inflated horns, broad hooves or small bodies so that they can easily walk in wetland habitats.

Among all livestock, water buffaloes are the most adapted species to the wetland environment. It is a grazer like cattle, but it can stay longer in the water and utilise more efficiently wetland vegetation, especially emergent macrophytes like *Phragnites australis*. Also, it is not affected by worm and foot problems. However, little research information, if any, is available on the role of water buffaloes in wetlands as compared to the other livestock species.

Grazing as a management tool in wetlands has received little scientific attention in the past. Apparently because of the detrimental effects of overgrazing on the environment, livestock have been removed out from most wetlands and other natural reserves, including forests and hostile policies to livestock husbandry have been developed (Papanastasis, 1984). However, there is no evidence that livestock are more harmful than wild herbivores of similar size and behaviour when they are kept at similar densities. Grazing is an ecological factor in natural ecosystems, very important to their function and productivity provided that it is well integrated in their management.

PRODUCTION SYSTEMS OF WATER BUFFALOES IN GREECE

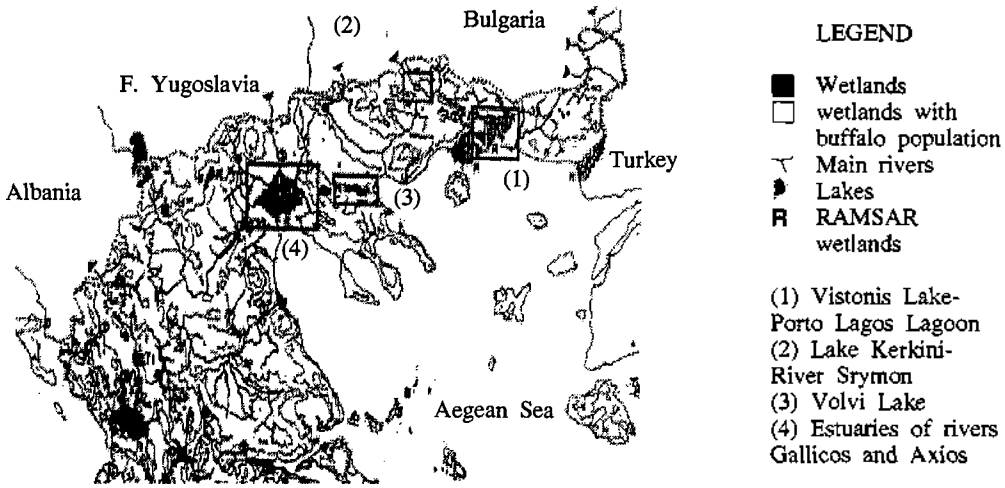
From the two main types of buffaloes - the Swamp and the River buffalo bred worldwide, the Mediterranean buffalo belongs to the Murrah group of breeds of the River type, but because of its isolation for many years, it has developed some unique characteristics. Mediterranean buffaloes, to which the Greek buffaloes belong, are stocky, well-built animals that combine both beef and dairy characteristics The Greek buffaloes are the last representatives of the Mediterranean sub-type of the River buffalo in the regions of Macedonia and Thrace. Their skin colour varies from brown to black and their coat colour from dark gray to black. The horns, nostrils and hooves are black. Most of the animals have white patches in the forehead, legs and tail, while no albino animals were observed (Mason, 1984; Shafie et al., 1993; Georgoudis et al., 1994; Georgoudis, 1996; Rossi, 1997).

In Europe and the Mediterranean, the buffalo population consists of 4,124,000 animals, including 1,917,000 buffalo cows. They are bred in Albania, Bulgaria, Egypt, Greece, Italy, Romania, Syria, Turkey and the former Yugoslavia. In Greece, the water buffalo is not mentioned as an indigenous farm animal in antiquity. Until the beginning of the 20th century, buffaloes were spread all over the country. The most important part of their population, which numbered about 100,000 animals, was kept in the swampy areas of Thrace, Macedonia and Thessaly (Dimitriadis, 1957; Zervas, 1975; FAO, 1977). According to the Statistical Service of the Ministry of Agriculture of Greece, 70,000-75,000 animals were kept in these regions at the end of the 50s. Because of the rapidly changing socio-economic conditions and the introduction of imported dairy cow populations, the number of buffaloes was reduced dramatically at the beginning of the 60s and at the end of the decade only 20,000 animals were left. By the end of the 70s only 1,000 animals remained and, as a result of this process, only few hundreds of head have been counted in some wetlands of northern Greece recently. According to our investigations, the Greek buffalo population consists of about 600 animals (table 1). This population is found only in four wetland sites in Macedonia and Thrace,

Table 1. Changes in the buffalo population in Greece (total number of animals)

Year	Number	Year	Number	Year	Number	Year	Number
1952	70786	1962	66235	1972	7858	1982	780
1953	71722	1963	59421	1973	7287	1983	589
1954	72959	1964	54959	1974	6468	1984	321
1955	75649	1965	46333	1975	4989	1985	738
1956	75688	1966	40097	1976	3828	1986	888
1957	75525	1967	37600	1977	2666	1987	714
1958	75321	1968	29798	1978	2048	1988	394
1959	75574	1969	21880	1979	1560	1989	740
1960	70605	1970	15380	1980	1056	1990	763
1961	67207	1971	10402	1981	930	1991	811
						1992	593

Source: Ministry of Agriculture, Statistical Service.



Map 1. Greek wetlands with buffaloes populations

namely in the Vistonis Lake - Porto Lagos Lagoon, in Lake Kerkini - River Strymon, in Volvi Lake, and in the estuaries of the Gallikos and Axios rivers near Thessaloniki. It must be noted that these wetlands are Ramsar Sites (Map 1).

Values of their biometrical parameters ranged as follows: males, wither height from 125 to 145 cm and live weight from 400 to 750 kg; females, from 120 to 140 cm and from 350 to 650 kg. Demographic parameters ranged as follows: age at first calving from 36 to 48 months; yearly birth rate from 65 to 85%; culling age of buffalo cows from 7.5 to 12 years. Reproduction is carried out through natural service. The average age of bulls at the beginning of productive life is about 18 months and at the end about 96 months. Calvings are not normally distributed during the year, but are mainly concentrated in late spring, summer and early autumn. Their breeding areas are fluvial wetlands. Buffaloes are usually stabled at night and graze during the day. While grazing, they are usually tended by the children of the family. Feeding is based on grazing, forages, byproducts, hay and concentrates. Their productive purpose is firstly milk and secondly, meat; in some areas buffaloes are not milked at all; draft is not requested. Genetic improvement is not carried out. Average milk yield of an unimproved buffalo cow ranges from 700 to 1000 kg and lactation length is estimated to be between 180-240 days (tables 2 and 3). There are no data available on milk composition, but this is supposed to be the same as that found in the literature (fat: 7.45%; protein: 4.36%; lactose: 4.83%; total solids: 17.96% - NAS, 1981). Buffalo cows are milked by hand twice a day. In the farms where buffalo cows are not milked, the total amount of milk produced is consumed by calves, which are weaned at the age of 7-8 months with an estimated live weight of 95-110 kg. In farms where milking is applied, calves consume 350-400 kg of milk and they are weaned at the age of 2-3 months, when they reach a live weight of about 75 kg. The slaughter age of the calves varies considerably, according to the farmer's individual needs, but the most common age is between 15-17 months and a slaughter live weight of 350-450 kg. No systematic production of specific milk products exists and only occasionally the milk is utilised for the production of cream, butter and yogurt. Buffalo's milk, when sold, receives a price 50-75% higher than that of cow's. On the other hand, buffalo calves are sold at prices lower by 10-15% than those of cattle.

Table 2. Morphological characteristics of buffaloes

	Male	Female
Birth weight (kg)	20-40	20-40
Live weight of adults (kg)	400-750	350-600
Wither height of adults (kg)	125-145	120-140
Age at which the buffalo reaches the adult weight (years)	5-6	5-6

Table 3. Reproduction parameters of buffalo cows

Age at first calving (months)	36-48
Average number of calvings during productive life	9
Number of calves born to every 100 buffalo cows per year	75
Percentage of calves dead before weaning	10%
Percentage of calves dead after weaning	3%
Average age of buffalo cows at the end of their productive life (months)	144
Yearly replacement rate of buffalo cows	10-20%
Duration of pregnancy (days)	310-320
Calving interval (days)	450

Following the criteria for the status of a breed (number of female breeding animals between 100 and 1000, FAO, 1992; number of reproducing animals in a stable population equal or less than 5000, EEC, 1992), the risk status of the remaining buffalo population in Greece should be considered as endangered to critical (Georgoudis et al., 1994). This small population is threatened with immediate extinction because of the evolution of agriculture, the expansion of cultivated fields into the old marshlands, and the lack of an appropriate conservation programme (FAO, 1990). Greek specialists in the fields of animal breeding and ecology have pointed out in relevant studies (Gerakis, 1990a,b; Georgoudis, 1993) the unfavourable survival perspectives of this small buffalo population, still existing in certain wetlands of northern Greece.

Buffaloes are kept in private family farms, where their breeding is not the only source of income and not the most important one. In Greece, there are no buffaloes bred in state farms. The technical support which buffalo production receives from the Government is similar to the one given by the Ministry of Agriculture to all livestock populations. No research programmes of special interest have been initiated for this production branch. In the last years, the only substantial reference to buffaloes has been in connection with surveys regarding the ecosystems and plants as well as animal production around the wetlands of northern Greece.

Milk, but also meat, are important in the area of Thessaloniki, while in the areas of Serres and Thrace buffaloes are not milked at all; nowhere are they used for draft purposes.

ENVIRONMENTAL EFFECTS ON GREEK WETLANDS

Livestock grazing in wetlands is an old and traditional practice in Greece. Most of these ecosystems evolved with the presence of farm animals including buffaloes, thus leading to a peaceful coexistence (Papanastasis, 1990). However, this coexistence has been already broken because of the expansion of cultivated fields in the old marshlands, which led to the reduction of the available grazing lands and finally, to the overgrazing of the remaining wetlands. In the meantime, buffaloes were replaced by cattle in the majority of wetlands due to socio-economic changes as it has been already explained in the previous chapter (Georgoudis, 1995; Georgoudis, 1996).

According to a recent inventory carried out by the Greek Biotope/Wetland Centre (Zalidis and Mantzavelas, 1994), there are 408 wetlands in Greece covering an area of about 200,000 ha. Of those, 114 are currently grazed by livestock with low (43%), medium (25%) and high (32%) stocking rates, while 112 were evaluated as having low (38%), medium (26%) and high (36%) value for livestock (Tsougrakis, 1995). These data suggest that about one third of the total number of Greek wetlands are important for livestock and most of them are currently grazed but with variable stocking rates. This means that there are both overgrazed as well as undergrazed wetlands.

A characteristic case of overgrazed wetland is the delta of Evros river, which is a Ramsar site with international importance for wetland birds. In this particular wetland, large numbers of cattle graze freely the whole year round, thus creating severe problems to the function of the ecosystem and damaging the breeding grounds of several species of birds. An opposite case is the National Park of Prespa with the Prespa lake which is also a Ramsar site with international importance for breeding of wetland birds. In this particular site, the function of the lake ecosystem is being threatened by the expansion of reedbeds, fens and bogs caused among other reasons (e.g. entrophication, cessation of burning, thatching etc.) by the reduction of grazing activities, too. In both wetlands, buffaloes do not exist, although they were there 30-40 years ago.

In order to stop the expansion of reedbeds in lake Prespa and improve the habitats for fish and wildlife, a project was recently (1997) initiated to re-introduce water buffalo, so that a sustainable management of Prespa ecosystem is implemented. In this project, the effects of buffalo grazing on various plant communities are recorded and its impact on fish and bird populations are evaluated. Results so far indicate that buffalo controls reeds and other emergent macrophytes of the lake much better than cattle that farmers currently use. Moreover, farmers started to get attracted by this interesting animal realizing its better adaptation to the Prespa environment that cattle. It is believed that the information collected from this project together with supporting policy measures on behalf of the Government will encourage farmers to promote buffalo as a farm animal for increased economic and environmental sustainability of wetland ecosystems in Greece.

In addition to this project several other research studies are needed to thoroughly investigate the role of water buffaloes in the wetlands. These studies may include:

1. Mechanisms of livestock/plant interactions
   - Effects on growth and survival of individual plants
   - Effects on plant reproduction, dispersal and recruitment
   - Effects on plant communities, their physical structure, species richness and diversity

- Effects of trampling

2. Effects of herbivores on faunal diversity
   - On fish populations
   - On avifauna
   - Direct effects/indirect effects
3. Selection of feeding habitat
4. Diet selection and feeding behaviour
   - Effect of animal species
   - Effects of size of the breed
   - Quantity of food eaten
   - Effect of body size
   - Effect of digestive system
5. Grazing management
   - Grazing system
   - Integration into production systems
   - Criteria for the choice of livestock species buffaloes and cattle
6. Comparative productivity and husbandry

CONCLUSIONS

Buffalo farming in Greece is not organised on a stable economic basis, and it is not supported by specific Government programmes in terms of production practices, genetic improvement, nutrition etc. The marketing of products is opportunistic and their value is appreciated only by few and older consumers. To avoid the extinction of this indigenous animal, it would be advisable to combine at first the preservation and then the expansion of buffalo breeding with the conservation and protection of the wetlands, where these animals traditionally lived.

The initiation of several projects is recommended to study the future of the water buffalo in the Greek wetlands. The exact potential of Greek wetlands to support again viable populations of this species must be evaluated. One has to explore various options and subsidise, if necessary, to ensure its presence in certain wetland ecosystems, e.g., as a tool for managing natural vegetation, and also as a touristic attraction. Finally, an interdisciplinary team (representing farm animal sciences, range management, wildlife management and limnology), must investigate the functional relationships of this species with the other wetland biotypes, e.g., feeding habits of the water buffalo and its position in the food web, and the positive or negative interactions with the key wildlife species of the wetlands.

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