On the development of a monitoring scheme of buffalo welfare at farm level

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ABSTRACT

In the present review some animal-related indicators, possibly relevant for a monitoring scheme of buffalo cow welfare at the farm level, are suggested. The indicators are discussed on the basis of their validity (meaningful with respect to animal welfare), reliability (reflecting the tendency to give the same results on repeated measurements) and feasibility (concerning time and money consume). The attention was focused on the following indicators: excessive thinning or fattening assessed with Body Condition Score (BCS) systems; cleanliness; lameness; resting, social, oral abnormal behaviours; injuries; stockmanship; animal-human relationship; positive indicators (diversity of lying postures, allogrooming, etc.). We have concluded that some of the indicators validated for cattle could be conveniently applied to buffaloes without changes (e.g. injuries and avoidance distance), while others should be appropriately adjusted to this species (e.g. BCS, cleanliness, housing factors). In addition, further studies are needed either to find reliable and feasible registration methods for some indicators (e.g. aggressive and resting behaviours) or to identify additional parameters specific for buffaloes (e.g. prevalence of buffalo cows injected with oxytocin during milking as an indicator of the quality of human-animal relationship).

Key Words: Buffalo, Welfare, Monitoring system.

RIASSUNTO
APPROCCIO AL MONITORAGGIO DEL BENESSERE NELLA SPECIE BUFALINA

Viene affrontata la complessa problematica della valutazione del benessere animale a livello aziendale, mettendo in evidenza le difficoltà relative alla individuazione di indicatori che riflettano effettivamente lo stato di benessere dell'animale, che siano ripetibili nel tempo e che risultino di semplice applicazione. Viene messo in evidenza che l'esigenza della messa a punto di un sistema di monitoraggio del benessere risulta particolarmente avvertita per la specie bufalina, sia per la profonda evoluzione che il sistema di allevamento ha subito nel corso degli anni, sia perché, a causa della carenza di studi e di sperimentazioni ad hoc, ai bufali continuano ad essere trasferite le acquisizioni relative ai bovini. In questo contesto, ai fini del monitoraggio del benessere a livello aziendale, viene proposto di far riferimento a una serie di variabili, alcune delle quali indicative del rapporto uomo-animale, che, com'è noto, influenza non solo il benessere, ma anche le prestazioni produttive degli animali. I parametri presi in considerazione sono: stato di iponutrizione o di eccessivo ingrassamento valutato con il metodo Body Condition Score (BCS), grado di pulizia degli animali, incidenza delle zoppie, comportamento degli animali durante la mungitura e il riposo, interazioni

sociali e aggressive, lesioni cutanee, distanza di fuga, grado di attenzione dell'allevatore per le condizioni di comfort degli animali, indicatori positivi di benessere (tipo di postura assunta durante il riposo, allogrooming, ecc.), caratteristiche dei ricoveri, per ognuno dei quali è riportato il tipo di informazione che può fornire, tenendo conto, in mancanza di specifici riferimenti alla specie bufalina, di quanto è noto per i bovini. Gli autori concludono che, sebbene alcuni indicatori validati per i bovini possano essere utilizzati senza modifiche per i bufali (per esempio, lesioni cutanee, distanza di fuga, comportamento sociale) od opportunamente adattati a questa specie (BCS, grado di pulizia, caratteristiche dei ricoveri), vi è la necessità di individuare ulteriori parametri specifici per i bufali (per esempio, incidenza di bufale trattate con ossitocina durante la mungitura quale indicatore della qualità del rapporto uomo-animale).

Parole chiave: *Bufalo, Benessere, Schema di valutazione.*

Introduction

In Italy buffaloes are present primarily in Campania and Lazio, whereas in other regions such as Puglia, Lombardia, etc. buffalo production has less importance.

Buffalo husbandry has long been considered characteristic of depressed regions and conducted for centuries with extensive rearing systems in low-lying swampy areas. However, the application of the most advanced rearing techniques (milking machines, loose yarding and cubicle housing systems, etc.), although perhaps not appropriate for buffaloes as developed for dairy cattle, and the consequent increase in milk production, has led to a renewed interest in this species (Zicarelli, 1994; Bordi *et al.*, 1997). The intensification of buffalo farming has exposed these animals to a rapidly changing environment that imposes physical and psychological stressors thus far unknown to this species.

Numerous studies have assessed the effect on cattle welfare of management stressors, such as handling (Boissy and Bouissou, 1988), loading and noise (Agnes *et al.*, 1990), space restriction (Maton and Daelemans, 1989; Fisher *et al.*, 1997), locomotion limitation and isolation (Le Neindre, 1993) and shipping (Kegley *et al.*, 1997). Less is known about the effect of stress on productive performance and the well being of buffaloes (Hussein *et al.*, 1997; Kanchev *et al.*, 1997). Lack of space resulted in evidence of stress in unweaned and weaned female buffalo calves as indicated by the alterations in a number of behavioural and physiological responses (Grasso *et al.*, 1999; Napolitano *et al.*, 2004). In addition, the development of a moni-toring system for assessing buffalo welfare at farm level is needed either to provide a certification system for comparing different husbandry systems, or as an advisory/management tool for the farmer.

Unfortunately, few studies have been conducted on this issue. Recently, the reliability of some animal-based parameters (avoidance distance, behaviour during milking, etc.) has been evaluated and could be used for assessing buffalo welfare at farm level (De Rosa *et al.*, 2003). At present, some monitoring systems have been developed in Europe. These include the animal welfare index TGI35L in Austria (Bartussek, 2001) and the related TGI200 in Germany (Sundrum, 2001), the ethical account in Denmark (Sorensen *et al.*, 2001), Freedom Food scheme (Main *et al.*, 2003) and Bristol Welfare Assurance Programme (Leeb *et al.*, 2004) in the United Kingdom, a decision support system for overall welfare assessment of sows in The Netherlands (Bracke *et al.*, 2002) and preliminary welfare assessment schemes for dairy cattle in France (Capdeville and Veissier, 2001) and in Italy (Tosi *et al.*, 2001). Some of these methods focus on design criteria, which comprise structural and technical elements (space allowance, feeding facilities, etc.) and management-related factors such as hygienic and climatic conditions. Others use animal-based variables (performance criteria) dealing with behaviour, health and physiology of the animals, or a combination of design and performance criteria to obtain a valid assessment of animal welfare (Johnsen *et al.*, 2001). According to Dawkins *et al.* (2004), design variables alone are not a good predictor of animal welfare and the assessment should be based on animal measures, as they are the results of the interaction between the animals and the environment. The indicators to be included in a scheme for on-farm assessment of animal welfare should be valid (meaningful with respect to animal welfare), reliable (reflecting the tendency to give the same

results on repeated measurements), feasible (concerning time and financial requirements) and used throughout Europe. On-farm welfare monitoring systems should provide a standard way of converting welfare-related measures into information that is easily understood by the consumer. This is also one of the main objective of European Cooperation in the Field of Scientific and Technical Research (COST) Action 846 "Measuring and Monitoring Farm Animal Welfare" (www.cost846.unina.it).

As no on-farm assessment protocol is currently available, in the present review some animal-related indicators, possibly relevant for monitoring the welfare of buffalo cows, are discussed on the basis of what has been proposed for dairy cattle (Winckler *et al.*, 2003) and focus on the applicability of the parameters, whereas the methodological aspects, albeit important, are only briefly considered. A short overview of specific housing factors possibly affecting buffalo welfare is also given.

Body condition scoring

In buffalo, as well as in cattle, body condition scoring (BCS) is used as a means to estimate the energy balance, body composition and body stores in place of live weight change. Although in the river buffalo milk production is quite remarkable (mean milk yield in Italy in a conventional 270 day lactation is about 2.2 tons with 8.3% fat and 4.7% protein) from a morphological and metabolic point of view the buffalo is more similar to beef cattle than to dairy animals (Campanile *et al.*, 1998a). Therefore, a BCS system derived from the one developed by Wagner *et al.* (1988) for beef cattle has been proposed by Campanile *et al.* (1998a). This method consists of assigning each buffalo cow a score from 1 (severely emaciated) to 9 (very obese) with 1-unit increments. The two systems (beef cattle vs. buffaloes) differ in their top scores. In particular, scores 9, 8, 7, and 6 of the buffalo scale correspond to scores 8, 7, 6, and 5 of cattle scale, respectively. The rationale behind this is that buffalo cows tend to accumulate more subcutaneous fat compared to beef cows when the animals are fed with more energy than required. In Italy, this system is often used in field conditions by nutritionists to

support decision making with respect to ration composition and feeding management. Although studied for similar methods applicable to beef (Evans, 1978) and dairy cattle (Ferguson *et al.*, 1994), for this system inter and intra-observer reliability have never been evaluated.

As reported for cattle, the inclusion of BCS for on-farm welfare monitoring is strongly suggested. This parameter should be used to assess manifest undernutrition (BCS < 4), with a high prevalence of thin buffaloes being associated with reduced levels of animal welfare. Buffalo overcondition (BCS > 7) usually is not associated with ketosis, as observed in cattle (Morrow, 1976; Gillund *et al.*, 2001). However, fat buffaloes after calving may show decreased fertility (Campanile, 1998).

Cleanliness

The evaluation of body cleanliness may give some information on animal comfort as well as stockpeople's attitudes and care for animals. In dairy cattle, the soiling of skin and hair may reduce thermoregulatory and antigermal properties of the skin, and cause inflammations of the skin (Winckler *et al.*, 2003).

A cleanliness index for dairy cattle using a five-point scale in five body areas has been developed by Faye and Barnouin (1985). A slight modification of this index was used in a recent study (De Rosa *et al.*, 2003) which in all cattle farms considered (n = 4) showed a high degree of reliability, whereas cleanliness reliability was very low for buffaloes in the sole farm where this variable was monitored. This latter result is likely to be due to the peculiar buffalo behaviour of wallowing which serves to gain protection against solar radiation and dermal parasites. In fact, it is worth noting that buffaloes present some morphological characteristics which are typical of the animals living in shaded, hot and humid regions. For instance, the melanin-pigmented skin of buffaloes is useful for defence against ultraviolet rays. Adult buffaloes have a sparse hair coat in comparison to cattle (394 and 2893 hair follicles per square centimetre in Egyptian buffalo and Friesian cattle, respectively; Hafez *et al.*, 1955), thus facilitating the dissipation of heat by convection and radiation. Obviously, also the number of sweat glands is very

limited in buffalo compared to cattle, determining a lower efficiency of sweating in buffalo than in cattle. Conversely, although the number of sebaceous glands is lower in buffalo than in cattle, the sebum secretion shows an opposite trend (152 and 21 mg/m² of body surface after 1 day from skin washing in Egyptian buffalo and Egyptian cattle, respectively; Hafez *et al.*, 1955), thus giving effective protection to the skin while the animals are in the mud. Moreover, according to Badrelin and Ghany (1954) and Hafez *et al.* (1955), skin and corneum layer in buffaloes (6 mm and 11 µm for skin and corneum layer, respectively) are thicker than those of cattle (4 mm and 5 µm for skin and corneum layer, respectively). This corneum layer protects the nearly bare body surface of buffalo from harmful mechanical and chemical agents, particularly when the animal is exposed to their effects in water and mud while swimming and wallowing. These latter behaviours are essential during the hot season to dissipate body heat. Therefore, the presence of mud on the buffalo skin may be considered a positive thing, whereas a thick and compact layer of dung on the body of the animals may denote a low frequency of litter renewal which may be also associated to high stocking density. As a consequence a modification of the method developed for cattle is suggested, taking into account the type of body covering.

Lameness and injuries

Although cleanliness can give some indication with respect to animal comfort, it may be less relevant than injuries and disease. In particular, lameness is a major welfare problem for dairy cattle and induces pain and discomfort of long duration. In these animals lameness can be assessed using different gait scores (Sprecher *et al.*, 1997; Breuer *et al.*, 2000; Winckler and Willen, 2001). For istance, Breuer *et al.* (2000) suggested a score ranging from 0 to 3, where 0 is assigned when the animal is not lame (normal gait), 1 is given when the cow is mildly lame (slight limp – no head bob), 2 is attributed when the subject was lame (clearly limp – head bob) and 3 is recorded when the cow is very lame (head bob and held leg up for a period of seconds). This condition may be caused by several different factors, such as unbalanced nutrition,

flooring, social behaviour and related time spent standing, etc. (Galindo *et al.*, 2000; Winckler and Willen, 2001). In particular, low ranking subjects spend more time in the passageways in slurry and on concrete floors where the hooves are more exposed to risk factors of sole and soft tissue lesions (Galindo *et al.*, 2000). Previous studies reported a significant correlation between lameness and claw disorders of cows and high inter-observer reliability (Winckler and Willen, 2001). However, in a study conducted in 3 buffalo farms (De Rosa *et al.*, 2003), lameness was virtually absent, a fact which may be attributed to either lower genetic predisposition, to lower feeding regimen, or to a different metabolism compared to cattle (Campanile *et al.*, 1998b). Although pathological conditions affecting the feet of buffaloes are rare, claw overgrowth and corkscrew claws have been observed in some buffalo farms (Cammarano and Marino, 2003). This latter claw abnormality has a genetic basis and bulls carrying this defect are usually excluded from reproduction.

Therefore, in a monitoring system for assessing buffalo welfare at farm level, the proportion of animals with poor claw conformation (corkscrew claws, abnormal angle of pastern, etc.) and claw overgrowth (long toes, excessive heel depth, etc.), as indicated by Whay *et al.* (2003) for dairy cattle, could be considered, whereas lameness, due to its low incidence, may be neglected. As suggested for cattle (Leeb *et al.*, 2004), a normal claw should be angled at 45°. Mild overgrowth shows the toes slightly elongated with one toe longer than the other.

Skin lesion and swellings reflect the impact of the surrounding environment on the animal's body. Alteration can be caused by contact with hard floors, pressure and hitting against feed racks and cubicle partitions, etc. For cattle many scoring systems have been proposed (Wechsler *et al.*, 2000; Leeb *et al.*, 2004). Leeb *et al.* (2004) suggested recording any hairless, redness, swelling and alteration on the body area. In particular, lesions larger than 3x1 or 2x2 cm and all lesions with completely broken skin should be noted. This system may be also used for buffalo cow without taking into account hairlessness due to the fact that adult buffaloes present a sparse hair coat.

Resting, social and oral abnormal behaviours

For buffaloes, little information is available on behavioural welfare indicators, as some of them, although common, have not been studied, and others are rarely detected. Heifers and adult dairy cows have been shown to develop or increase the time spent in stereotypies as a response to tethering (Redbo, 1990), restrictive allotments and decreases in the duration of eating (Redbo *et al.*, 1996; Redbo and Nordblad, 1997). Hovewer, in buffalo abnormal oral behaviours are not frequently observed. A possible explanation may be that dairy buffaloes are usually kept in loose systems, where structured feeds are offered, and confinement in tie stalls has never been applied to this species.

Conversely, as observed by many farmers and practitioners, aggressive interaction and subsequent injuries are a major problem in buffalo farming. In recent years, space allowance has been dramatically reduced as a consequence of farming intensification. Animals are not dehorned and are free to perform any agonistic behaviour. However, in restricted space social contacts are forced and flight opportunities markedly reduced for subordinate subjects (Grasso *et al.*, 2001; Napolitano *et al.*, 2004). In addition, one or more buffalo bulls are usually left in the herd since a specific and effective technique of artificial insemination is not available and males, in particular the older ones, tend to be more aggressive toward females and younger males. A further element of social disturbance is that primiparous buffalo cows are often not separated from multiparous subjects. Social rank is correlated with age, weight and seniority in the group (Grasso *et al.*, 2004). Primiparous cows occupy the lowest ranks with obviously more frequent problems of skin lesions and injuries at the udder.

Few studies on resting behaviour of buffaloes are available. Grasso *et al.* (1999) observed that buffalo calves kept in a restricted space (2.6, 1.5 or 1 m2/animal) lie and rest for a shorter time and, when lying, have a higher number of bent legs compared with animals kept in larger space (2.6 + 2.0 m² outdoor paddock/animal). A reduced space allowance may make it more difficult to perform the movements needed to lie down and this may explain their results. A crowded environment may reduce the ease with which animals change position from standing to lying by increasing the risk of falls. In addition, lying patterns may be restricted by other buffaloes that could cause the interruption of pen mate's resting by stepping on them. This latter hypothesis is also supported by data on leg position. According to Napolitano *et al.* (2004), a reduction in space allowance resulted in buffaloes assuming postures with a lower number of outstretched legs, possibly in order to reduce the chance to be trodden on. These animals also showed decreased levels of lying idle, which is likely to represent a fundamental form of resting.

The inclusion of aggressive and resting behaviours in a buffalo welfare monitoring protocol might be useful after appropriate research aimed at identifying periods when they are more apt to be expressed (e.g. before morning milking for resting and during feeding for aggressive behaviour) and when feasible registration methods have been determined (e.g. behaviour sampling and scan sampling).

Stockmanship and animal/human relationship

Numerous studies have demonstrated that stockmanship can affect behaviour and productivity of dairy (Hemsworth *et al.*, 2002) and beef cattle (Lensink *et al.*, 2001). Stockmanship includes a variety of facets that may impact animal welfare, including technical knowledge, early observation of disease and injury, good handling and empathetic behaviour (Hemsworth and Coleman, 1998). In recent years, a marked intensification of buffalo farming imposed a rapid change of the rearing techniques applied to this species. As a consequence, farmers and stockmen who used to employ a traditional and extensive system had to adjust their approach to intensive farming. In addition, the increasing number of buffalo heads induced people from other activities to become involved in buffalo farming. Both factors can have detrimental effects on the quality of the stockmanship. This can be assessed by using attitude questionnaires or through the direct observation of stockpeople's behaviour when interacting with animals (Hemsworth *et al.*, 2002; Waiblinger *et al.*, 2002). However, the observation of stockpeople can affect their behaviour towards the animals, while

answers to questionnaires may be unreliable. Conversely, behavioural tests aiming to assess the reactions of animals to humans may be more informative.

Avoidance distance is considered an indicator of the quality of the relationship between farm animals and stockpeople (Hemsworth *et al.*, 2000; Waiblinger *et al.*, 2003). It has been defined as the distance between observer and the point at which the animal moves to the side, away or forward (if withdrawal is blocked by a fence) when the subject is approached at a speed of one step/second (Waiblinger *et al.*, 2002).

In modern dairy farming systems human-animal interactions are frequent and the nature of the human contact can affect their subsequent behavioural response (Lensink *et al.*, 2000), welfare and milk production (Breuer *et al.*, 2000; Waiblinger *et al.*, 2002). Hemsworth *et al.* (2000) found a correlation between stockperson attitude, animal fear and productivity in dairy cows, thus indicating a possible opportunity to reduce fear of humans and increase milk production by targeting the attitude and behaviour of stockpeople. De Rosa *et al.* (2003) observed a lower avoidance distance in buffalo compared to cattle. This result can be attributed to the fact that buffaloes are generally recognized as being more curious than cattle. The different degree of curiosity of the two animal species could be interpreted in terms of neophobia or motivation to explore. However, this issue has never received scientific attention. The same authors observed a high degree of reliability for avoidance distance in buffaloes as measured in terms of Kendall coefficient of concordance (W).

Previous studies on animal behaviour during milking showed that stepping may be considered an indicator of agitation, whereas kicking is more related to aggressiveness (Hemsworth *et al.*, 2000; Munksgaard *et al.*, 2001). A step is defined as the lifting of a leg without the tip of the claw passing the other leg's dew claw while a kick is defined as a higher lift with a possible change of direction (De Rosa *et al.*, 2003). Animal restlessness at milking is a possible source of injury and may be caused by many different factors, such as pushing of adjacent cows, lameness, low mineral intakes, presence of hematophage insects, poor maintenance of milking machinery, etc.. However, Breuer *et al.* (2000)

found a correlation between human behaviour and cow restlessness during milking thus suggesting that at least a component of this animal reaction to milking may be interpreted as a response to the stockperson. In particular, these authors observed that the use of negative tactile interactions, loud harsh vocalisations and quick movements was negatively related to animal calmness, whereas the use of soft and quiet vocalisations and movements produced opposite results. The presence of aversive handlers during milking also induced increased heart rate, cortisol concentration and residual milk (Rushen *et al.*, 1999; Hemsworth *et al.*, 2000) which are all expressions of fear and stress. De Rosa *et al.* (2003) observed that stepping during milking was highly repeatable for both buffaloes and cattle, whereas for kicking a significant reliability was found only in two out of three buffalo farms. A positive correlation between stepping and kicking was found only in one out of three buffalo farms and one out of four cattle farms, thus indicating, in accordance with Rushen *et al.* (2001), that the different types of leg movements during milking need to be distinguished. However, these variables are time consuming, thus less feasible, and they can be influenced by confounding factors that are not indicative of quality of the human-animal relationship.

Buffaloes often tend to release the milk incompletely thus handlers make use of oxytocin injections to gather the residual product. Empirical data suggest that the prevalence of oxytocin injections is related to the quality of stockmanship with a higher number of injected animals correlated to a low quality of human animal relationship. This potential parameter could be highly feasible, repeatable, and conveniently used to monitor buffalo cow welfare.

Indicators of positive animal welfare

Although no scientific data on buffalo allogrooming are available, social licking in cattle can play a role as tension-reducing behaviour, as well as in reinforcing and stabilising social relationships, thus functioning as cohesive interaction along with head resting (Winckler *et al.*, 2002; Wasilewski, 2003). In this species, beneficial effects of allogrooming have been observed by

Table 1. Candidate animal related indicators for on-farm buffalo welfare monitoring.

Measure	Procedure [a]	Validity [a]	Reliability [b]	Feasibility	Confounding factors
Claw overgrowth	records of animals showing overgrowth claws (1)	not studied	not studied	high	-
Avoidance distance	measure of the distance between the assessor and the point at which the cow moved(3)	(2)	high (3)	high	space around the animal; reactions of neighbouring animals
Stepping during milking	number of steps (hoof lifted less than 15 cm off the ground) (4)	(4)	medium (3)	medium	lameness, insects, poor maintenance of milking machinery
Kicking during milking	number of kicks (hoof lifted more than 15 cm off the ground) (4)	(4)	medium (3)	medium	lameness, insects, poor maintenance of milking machinery
Body condition scoring	1 to 9 scale using 1-unit increments; several regions are scored from brisket to pin and back bones on appearance and palpation (5)	(5)	not studied	high	stage of lactation, parity
Cleanliness	0 to 2 scale using 0.5 increments; five body areas of hindquarters are scored (6)	(7)	low (3)	high	buffalo specific behaviour
Injuries	prevalence of lesions larger than 3x1 or 2x2 cm and any lesions with completely broken skin (1)	(8)	not studied	high	-
Oxytocin	prevalence of injected animals	not studied	not studied	high	stage of lactation, parity

[a] Studied in cattle.
[b] Kendall coefficient of concordance (W): greater than 0.6 = high; between 0.4-0.6 = medium; lower than 0.4 = low.

(1) = Leeb et al. (2004); (2) = Waiblinger et al. (2002); (3) = De Rosa et al. (2003); (4) = Rushen et al. (1999); (5) = Wagner et al. (1988); (6) = Faye and Barnouin (1985); (7) = Oltenacu et al. (1990); (8) = Wechsler et al. (2000).

Wood (1977) and Sato (1984), who found a positive correlation between being licked vs. milk production and weight gain, respectively.

More comfortable lying postures (sternal recumbency with the head tucked against the flank and lateral recumbency with a higher number of outstreched legs) may be a sign of reduced vigilance and/or thermal comfort and are likely to be assumed only if the animal confidence in the predictability of its environment is high (Grasso *et al.*, 2003).

In cattle, a high degree of synchronisation within the herd may indicate a positive welfare state, in particular for subordinate animals (Metz, 1983). Theoretically, also among buffaloes low ranking animals may be able to meet their basic feeding and resting requirements performing these behaviours when the competition for a particular resource is low (e.g. feeding at night and resting while the majority is involved in ingestive activities), however their welfare state would be improved if they could choose when and where (i.e. along with the other members of the group) perform such behaviours, thus allowing each subject, including the low ranks, to be fully integrated herd members.

As already stated for resting and aggressive behaviours, periods of increased expression and feasible methods should be identified before the inclusion of these behaviours in a buffalo welfare monitoring scheme.

A positive indicator of welfare could also be the quality of the human-animal relationship, however this parameter is treated elsewhere in this paper.

Housing factors

The welfare of farmed subjects is not simply limited to the animal's functioning and performance. They should also be able to develop normally and express natural adaptations in relation to their innate natures. The provision of barren housing systems irrespective of animal's natural behaviour and needs may reduce the welfare of livestock such as buffaloes, which have been subjected to intensive farming in recent years. In particular, in order to improve milk hygiene and to reduce the time for cleaning the udder at milking and disease transmission, potholes and pools, typical of the traditional system, have been abolished

or in some cases replaced by spray systems. Tripaldi *et al.* (2004) observed that the provision of a housing system enriched with potholes and spontaneous vegetation, thus closer to natural conditions, was able to improve the welfare of buffalo cows. These animals were able to express some species-specific natural behaviours, such as wallowing and grazing, and showed a lower adrenal cortex response to exogenous ACTH injection. Accordingly, a higher level of fertility was observed in buffalo cows allowed to enter a pool compared to animals provided with showers to facilitate thermoregulation (Di Palo *et al.*, 2001). In addition, Zicarelli *et al.* (2001) observed a reduced calving interval and a higher conception rate in animals provided with a pool. Therefore, for on-farm buffalo welfare monitoring the provision of systems aimed to alleviate heat stress, particularly those allowing the expression of proper natural behaviour, should be considered in a positive light.

Conclusions

Due to reduced distribution in Europe, the scientific interest in buffalo welfare has been markedly lower than in cattle. Table 1 shows some candidate animal based parameters which represent a good starting point for the development of a buffalo welfare monitoring scheme. Resting and social behaviours and positive indicators are not reported in the table as, currently, no feasible procedures are available. However, our list does not pretend to be exhaustive as important health variables (e.g. infectious diseases, mastitis and prolapses) relevant to buffalo welfare are not considered in the present paper. Their prevalence is low and data collection should rely on farm records, which often suffer from insufficient record keeping. In conclusion, some of the indicators validated for cattle could be conveniently applied to buffaloes without changes (e.g. injuries and avoidance distance), whereas others should be appropriately adjusted to this species (e.g. BCS, cleanliness, housing factors). Further studies are needed to identify additional parameters specific for buffaloes (e.g. prevalence of buffalo cows injected with oxytocin during milking as an indicator of the quality of human-animal relationship).

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