Ann. Anim. Sci., Vol. 15, No. 2 (2015) 307–321 *DOI: 10.1515/aoas-2015-0013*

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THE EFFECT OF SEASON AND METEOROLOGICAL STRESS FACTORS ON BEHAVIOURAL RESPONSES AND ACTIVITIES OF DONKEYS (*EQUUS ASINUS*) – A REVIEW

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Abstract

The review examines the adaptation of donkeys to arid conditions, and the impact of meteorological stress on performance and welfare in donkeys. The impact of season, including meteorological and nutritional factors, on the behavioural responses and welfare of donkeys was also reviewed. Season influences the adaptation and behaviour of donkeys as they are subjected to uses, and the modulating role of feed availability on the grazing behaviour of donkeys was also examined. It is concluded that season, as influenced by meteorological stress conditions, modulates the behaviour, welfare and grazing of donkeys.

Key words: season, behavioural responses, donkeys, meteorological factors

The donkey is indigenous to the African continent and its ancestor is believed to be the Nubian wild ass. Domestication of the wild ass took place through a gradual process of management of wild populations across much of its habitat (Blench, 2012). Small farmers, transporters and women in Africa are increasingly using donkeys for cultivation, transport and income generation (Fernando and Starkey, 2000). It is suggested that donkeys will continue to be important in countries with large rural sectors without access to affordable motor power (Starkey and Starkey, 2004). Donkeys were used by humans more than 5,000 years ago, to help them survive the harsh Saharan terrain in Northern Africa (Kimura et al., 2011). They provide greater mobility with which to face erratic rainfalls and are of value in carrying firewood, loads, including water, household structures, goods and children (Marshall and Weissbrod, 2011). In Nigeria, there is a thriving trade in donkeys reaching southern markets,

and this is probably replicated along the West African coast (Blench et al., 2004). In Western Europe and North America, donkeys are used as pack animals for tourism companies, located in the mountainous regions. Donkeys have been used in India to carry arms and ammunition to the difficult terrains that mechanized vehicles cannot reach easily (Singh et al., 2005). Donkeys are used for human therapeutic purposes, and by people who have disabilities and discomforts (Karatosidi et al., 2013). In children with severe IgE-mediated bovine milk-protein allergy and hyperlipidaemia, donkey milk serves as a viable substitute for cow's milk (Nikkhah, 2012; Salimei and Fantuz, 2012). Thus, the Ragusana and Martina Franca breeds from Sicily, Italy are used to produce milk for human consumption (Caldin et al., 2005). Donkeys are used mainly in transportation; conveying farm produce to the market or pulling of carts, and in farm cultivation (Starkey and Starkey, 2004). They produce milk for infants, who are allergic to bovine milk (Mansueto et al., 2013) and in animal-assisted therapy and activity in humans (Borioni et al., 2012). In Nigeria, donkeys are used predominantly in the transportation of goods and agricultural produce to the market (Blench, 2004).

Behavioural observation of animals in its natural environment is a vital key to the practice of husbandry, as deviation from the normal is a reflection of some form of stress or disease (Ayo et al., 2002). Early detection of such dysfunction is based on a sound knowledge and background of the normal behavioural responses, which are essential in correctly predicting problems associated with husbandry practices. Behavioural responses are the first line of defence to environment challenges (Daly and Johnson, 2011). The environment influences animal behaviour and acts to shape behaviour of an individual animal (Breed and Sanchez, 2012). Behaviour generally has been used to measure stress, health and productivity, which are prerequisites for animal welfare, but an abnormal behaviour indicates lack of adequate welfare (Hemsworth et al., 2009). Behavioural activities exhibited by the donkeys include grazing, drinking, defaecating, standing, grooming, lying down, walking, urinating, mutual grooming, aggression (kicking and biting), vocalisation, sniffing and flehmen (D'Alessandro et al., 2007; Minka and Ayo, 2007 a).

The aim of the present review was to determine the effect of season and meteorological stress conditions on behavioural responses, welfare and activities of donkeys.

Adaptation of donkeys to arid conditions

Donkeys have evolved to live in some of the most unfavourable ecological zones. They are adapted to feeds that are high in cellulose and low in protein. Donkeys are well adapted to low humidity and high temperature (Smith and Pearson, 2005). The domestic donkey performs hard work under different agroclimatic conditions and withstands shortage of feeds. Hardiness, including ability to survive under harsh environmental conditions and low-market value, have made the donkey the cheapest and suitable means of transportation in developing countries. Donkeys, unlike cattle, are adapted to tough desert conditions and have an easier time surviving in drought-prone areas than do other livestock because of inherent tolerance for dehydration, low sweat rate and good thermoregulatory mechanisms (Singh et al., 2005; Rossel

et al., 2008). They have longer working life than other animals; they are relatively resistant to diseases, have excellent stamina, and their adaptable grazing behaviour allows them to consume harsher types of vegetation, such as bark and leaves from trees (Ashley et al., 2005; Merrifield, 2008). Donkeys are surprisingly well adapted to heavy burdens of internal parasites; and are known to be very resistant to most livestock diseases, which affect horses (Youseph et al., 2005). However, unkempt donkeys are prone to diseases such as ulcerative lymphangitis, inflammation of the tongue, interdigital dermatitis, ear sore, fistulous withers and lameness (Bale et al., 2003). They have higher threshold for thirst than other equine species in terms of water intake and latency to drink, when fluid deficits develop (Grinder et al., 2006). Donkeys are not well adapted to damp areas, but can easily live in marginal desert lands and are adapted to areas that are arid, at least seasonally (Anonymous, 2011). The most limiting factor for survival in semi-arid and arid areas and during drought is water. Donkeys survive better than cattle in these areas and during drought. They have the ability to tolerate thirst and this allows them to have access to more remote sources of forage, inaccessible to cattle in rangeland (Smith and Pearson, 2005). Nengomasha et al. (2000) reported that donkeys with limited access to water (2 to 3 days) lose less water through faeces than their counterparts with *ad libitum* access to water.

Effect of meteorological stress on performance of donkeys

High environmental temperatures disturb the thermoregulation system and can adversely affect the health, reproduction and performance of equids (Dey et al., 2010). Meteorological stress factors that impose strain on animals include high ambient temperature, solar radiation, windspeed and relative humidity (Silanikove, 2000). Ungulates in arid region must contend with high solar radiation, high ambient temperatures, inadequate water and cover, unpredictable food resources, and the challenges these factors present for thermoregulation and water balance (Cain et al., 2006). The daily heat stress affects the performance and normal function of the animals (Mader et al., 2009; Kumar et al., 2011). The adverse effects of high ambient temperature on productivity and well-being of animals have been well documented (Zumbach et al., 2008). Individual susceptibility to thermal environmental stressors is influenced by several factors, including species, condition scores, temperament, sex and previous exposure (Brown-Brandl, 2009). For example, heat stress occurs in animals when there is an upset in the equilibrium between heat production within the body and its dissipation (Kumar et al., 2011). Ambient temperature is ecologically the most important physical or environmental stressor (Horowitz, 2002). Extreme hot and cold ambient temperatures affect animals, which are evident in fluctuations of physiological responses to combat the thermal environmental stress (Pandey et al., 2012). Heat loss mechanisms include evaporation, heat loss, skin blood flow, and cardiovascular support for thermoregulation and exercise (Sawka et al., 2011). In the Northern Guinea Savanna zone of Nigeria, the early rainy season, characterized by high ambient temperature and relative humidity has been described to be thermally stressful to donkeys (Ayo et al., 2008).

Welfare of donkeys

The well-being of animals is defined by a range of parameters, including health, physiology and behaviour (Earley et al., 2010). Working animals, including donkeys provide an essential transport resource in developing countries around the world. Consideration of health and behaviour is critical when assessing welfare. Recently in the developed countries, there has been gradual introduction of intensive and semi-extensive production system, especially in high productive dairy breeds. Understanding the behaviour of the donkey may be useful in planning strategies and extension programmes to improve the physical and psychological welfare of the donkey (Murugan, 2006). In developing countries, equids often carry out tasks under impoverished conditions for long hours each day. As a result, studies have shown that they have many physical and clinical problems, such as wounds, poor body conditions, high parasite loads and dental diseases (Burn et al., 2010). Despite growing information on working equine health, little is known about the animal welfare implications of the myriad physical conditions the animals are subjected to (Broster et al., 2009; Regan, 2009). Equids kept in stalls are denied the chance of social interactions and the performance of natural behaviour is reduced. Inadequate environmental conditions may, therefore, compromise behavioural development (Rivera et al., 2002). In the tropics, animals are predominantly kept outdoors and they are exposed to direct solar radiation during the day; and other thermal stressors, including high ambient temperature, high humidity and rainfall exert significant effects on their performance (Hetem et al., 2011; Nwosu and Ogbu, 2011). Individual susceptibility to thermal environmental stressors is influenced by several factors, including species, condition scores, temperament, sex and previous exposure (Brown-Brandl, 2009). For example, heat stress occurs in animals when there is an upset in the equilibrium between heat production within the body and its dissipation (Kumar et al., 2011). Ambient temperature is ecologically the most important physical or environmental stressor (Horowitz, 2002). Extreme hot and cold ambient temperatures affect animals, which is evident in fluctuations of physiological responses to combat the thermal environmental stress (Pandey et al., 2012).

The understanding of the behaviour is useful in planning strategies to improve the welfare of the animals (Murugan, 2006). Improper husbandry and handling practices are linked with the occurrence of unwanted behaviour in working equids (Popescu, 2013). This is because animals display consistent individual differences or variations in their behavioural and physiological responses to various challenges imposed on them (Van Reenen et al., 2013).

Feeding is an important aspect in the management of any farm animal. It requires knowledge of the feeding behaviour and nutrient requirement of animals for specific production and function (Aganga et al., 2000). Donkeys fed fibrous forage require 80 to 95 kg digestible energy per kg body weight per day (Wood et al., 2005), which is significantly lower than the requirements for a similar-sized pony. The daily dry matter intake of the donkey is significantly lower than that of a horse. Donkeys are normally maintained on forages with low protein content. Field research by Smith and Wood (2008) has shown that the donkey's requirement for crude protein is approximately 40 g/100 kg body weight per day.

The donkeys have evolved to thrive on highly fibrous, poor-quality foodstuffs, and are grazers as well as browsers. According to Burden (2011), they have different nutrient requirements with significantly lower energy and protein needs, when compared with horses. The donkey is different from horse in its ability to thrive on highly fibrous feeds (Burden et al., 2013). The limited availability of feed, together with the constraint that the traditional management system imposes on the natural foraging behaviour of donkeys, often leads to poor nutrition in donkeys (Carretero-Roque et al., 2005). It has been observed that donkeys have a greater digestive efficiency than horses and, thus, feeding them as if they are small horses leads to excess energy intake, resulting in obesity (Wood et al., 2005). Donkeys in their natural habitat (arid and semi-arid environments) spend more than half of each day's time grazing and feeding mostly on poor-quality scrub (Taylor, 1997). The digestive system of the donkey is more efficient than that of the horse, but there is no marked structural difference between the gastrointestinal tract between the two. A donkey needs less feed than a horse or pony of similar height and weight (David and Wood, 2008). In temperate regions, the forage available is often too abundant and rich, over-feeding may result in increased weight gain and obesity, leading to metabolic disorders such as laminitis (Morrow et al., 2011), gastric ulcers (Burden et al., 2008), equine metabolic syndrome (DuToit and Trawford, 2010) and hyperlipidaemia (Burden et al., 2011).

Behavioural response of donkeys to meteorological stress factors

The hypothalamic-pituitary-adrenal axis (HPA) and the sympathetic adreno-medullary system play a vital role in the metabolic preparation of the body to perform behaviour (Tsigos and Chrousos, 2002). Animals under heat stress must alter their behaviour and physiology to increase heat loss, reduce heat production and restore homeostasis, and this is done at the expense of productivity (Huynh et al., 2005). There may be species differences in the magnitude of the behavioural responses in animals (Bonilla-Jaime et al., 2006). For example, the donkey's reluctance to exhibit pain outwardly is a behavioural survival mechanism to reduce predator attention (Merrifield, 2008). Donkeys in the tropics are able to maintain homeothermy by compensatory mechanisms in order to keep their physiological values within the established normal range (Minka and Ayo, 2007 a). Stress responses in donkeys are always conducted on the basis of irregular behavioural phenomena that may be difficult to interpret as observed in previous works (Minka and Ayo, 2007 a; Ayo et al., 2008). Behavioural adaptation to environmental challenges by domestic animals, including the capacity to learn new responses to challenges, tends to provoke behavioural responses (Cooper and Albentosa, 2005). Behavioural and learning processes in equids are likely to affect the usefulness of the animal as a domesticated species (Murphy and Arkins, 2007). Endothermic animals such as equids usually keep their body temperature within a narrow limit with changing environmental conditions (Singer, 2007). However, this occurs at a high energetic cost. Endothermic animals can, therefore, face a two-fold challenge. In harsh environmental conditions, the availability and quality of food are limited, but the energy requirement to maintain body temperature is high (Arnold et al., 2006). Sweating has a variety of functions in mammals, including pheromone action, excretion of waste products and main-

tenance of the skin surface. In donkeys and horses, it also has an important role in thermoregulation (Jenkinson et al., 2006). Donkeys were observed to shiver during the early morning hours of the harmattan season, when ambient temperature values fell below 20°C (Ayo et al., 2014). Ambient temperature and temperature humidity index affect diurnal fluctuations of respiratory rate, heart rate and rectal temperature with higher values in the afternoon, which is indicative of the influence of thermal environmental factors on physiological parameters (Ayo et al., 2014). Continuous packing for 4 h has been reported to induce a transient increase in rectal temperature (Olaifa et al., 2012) and respiratory rate in donkeys (Pal et al., 2002). Donkeys have wooly hair which insulates them from desert heat and cold and a lean body mass that is fuel efficient and easily cooled (Smith and Pearson, 2005). Equids without access to shade showed greater rectal temperature, respiration rate, and skin temperature and exhibited more sweat than those in shaded area (Holcomb et al., 2014). Research indicates that individually housed equids prefer shade when it is available in hot, sunny environments (Holcomb et al., 2014). Equine social behaviour showed improved performance of horses using shade in summer (Heleski and Murtazashvili, 2010). Minka and Ayo (2007 a) observed that shading has a significant effect on the behavioural responses of the donkeys during the hot-dry season. In the experiment, donkeys spent more time lying down in shaded area than in unshaded area, due to the direct effect of solar radiation on the topsoil of the unshaded area, donkeys are uncomfortable to sit for a long period; the speed of the donkeys in shaded area was also higher than in the unshaded area (Minka and Ayo, 2007 a).

Heat stress is always a potential problem, which causes obvious discomfort, tremors and rapid shallow breathing in donkeys (Fielding and Krause, 1998). Laedwig (2000) reveals that animals, like donkeys, under intensive housing conditions, exhibit chronic intermittent stress response, occurring in situations such as standing up or lying down in inadequately designed cubicle or tether stalls. The response of the donkey to a stressor also depends on temperament and early experience. Desert mammals often tolerate scarcity of drinking water and food for prolonged periods. Animals reduced their mass-specific resting metabolic rate and total evaporative water loss by 16.2 and 25.7%, respectively, and maintained a digestive efficiency of about 70%, during water scarcity (Ostrowski et al., 2006). Adaptive heterothermy and selective brain cooling are regarded as important thermoregulatory adaptations of mammals, and especially large ungulates, living in warm arid environments (Mitchell et al., 2002). Behavioural and the physiological responses can be stimulated or triggered in anticipation of homeostatic needs. Animals display consistent individual differences in their behavioural responses to a variety of challenges. The differences are a reflection of the existence of underlying traits, which may affect the individual's adaptive capacities, health and life outcome (Boissy et al., 2005).

Behavioural activities of donkeys

Scientists are continuously trying to achieve a clearer understanding of equine learning behaviour and its implication in training, since behavioural and learning processes in equids may influence the usefulness of the animal as a domestic spe-

cies (Murphy and Arkins, 2007). Since behaviour is a response of an animal to the environment, the more restrictive an environment is, the more limited are the choices available to the animal. Animals in natural conditions are regarded as showing the normal behaviour of that species (Christensen et al., 2002). Donkeys in their natural habitat, that is, arid and semi-arid environment, spend more than half of each day grazing on poor-quality shrub (Taylor, 1997). Behavioural indicators tend to be advantageous because behavioural changes are usually the earliest signs that can be found to indicate sub-optimal conditions (Keeling and Jensen, 2009).

Equine physical and digestive well-being is often enhanced when allowed to graze on pastures (Bott et al., 2013). The behavioural observation of jennies performed in the presence of their foals indicated that maintenance behaviour (grazing, drinking, resting and grooming) differed significantly with time of foaling (D'Alessandro et al., 2007). Free-ranging mares of two species of equids (Donkeys and Shetland ponies) modify their foraging behaviour to meet the increased nutritional requirements induced by lactation (Lamoot et al., 2005 a). Preliminary studies of the Caballo Fino Chilote stallion showed that the stallion spent 55.89% of their time grazing, which is the most predominant behavioural activity (Tadich and Pulido, 2010). Herbivores of arid regions are frequently faced with inadequate food quality and quantity. The time and energy devoted to foraging is vital to balancing their energy budgets. For desert ectotherms, a low metabolism should be advantageous, reducing their total energy requirement, but extreme ambient temperatures can strongly constrain the activity of these animals (Lagarde et al., 2003). The percentage time spent by the donkeys grazing during the summer period was found to be significantly lower than that of the winter and other seasons (Lamoot and Hoffman, 2004; Bi et al., 2007). In the aforementioned studies, grazing time was lower in the summer, but higher during the winter period of the year. Duncan (1985) and Xia et al. (2013) observed that the Camargue horse and the Asiatic wild ass, respectively increased their grazing time in winter in an attempt to maintain a high-quality diet. Therefore, increased grazing time may be related to a decrease in quantity and quality of grass availability (Lamoot et al., 2005 b; Xia et al., 2010).

In another study, Souris et al. (2007) reported that grazing activity in Przewalski horse decreased to a minimum in July/August; and there was an increase again towards the end of the study in September, whereas resting followed the opposite trend. The percentage time spent grazing in feral goats (*Capra hircus*) remained high throughout the daytime in winter compared to summer period (Shi et al., 2003). A study revealed that zebra increased their foraging efficiency by increasing the number of bites and reducing grazing time in wet season, compared to the dry season (Havarua, 2011). The grazing efficiency of ungulates may be influenced by factors such as the time of day, ambient temperature, relative humidity, temperature-humidity index, season, vegetation type and reproductive status (Scaglia and Boland, 2014). High ambient temperature and temperature humidity index during the rainy season may contribute to the decrease in grazing time or activity. Indeed, Hagemoen and Reimers (2002) suggested that the low or decreased grazing activity during the summer period may be a result of attacks by biting flies. Defoliation may be more intense as quantity and availability of forage become limited during the dry season

(Fynn and O'Connor, 2000). Conversely, defoliation may be less intense during wet seasons, when green forage is abundant (Ilius and O'Connor, 2000). The dry season in general is, therefore, associated with an increase in grazing pressure on limited forage and with higher herbivore selectivity. The behavioural pattern of Alpine deer in China showed that grazing/ruminating decreases during the winter period, when compared to other seasons (Xiuxiang et al., 2008). Brinkmann et al. (2012) observed that limited quality of forage and the energy requirement needed to maintain optimum body temperature lead to an increase in grazing time. Thus, the donkeys, apparently, sustain the ability for seasonal adaptation to unfavourable environmental conditions, by increasing their grazing time and alteration in their metabolic rate.

Ruminants are confronted during winter with a nutritional bottleneck as a result of cessation of forage growth and low digestibility of the remaining scarce forage because of high content of crude fibre (Arnold et al., 2006). Adaptation to seasonal fluctuation of forage in ruminant is controlled by endogenous biological rhythm related to the natural photoperiod that enables the anticipation of seasonal environmental changes (Lincoln et al., 2005), whereas equids can survive in extraordinary poor forage with the help of cellulose-fermenting symbiotic organisms in their hind-gut (Meyer, 2002). Donkeys are able to absorb more nutrients per day not only from food with a high-fibre content, but also from a whole range of forage qualities (Menard et al., 2002; Houpt, 2005). Thus, donkeys are true grazers and are able to adapt their foraging behaviour to unfavourable environment (Moehlmann, 1998). In a study performed by Lamoot et al. (2005 b), donkeys spent significant portion of their time resting during the summer compared to the winter period. Resting normally reduces or minimizes energy expenditure of animals, which is a physiological response to high ambient temperature (Arnold et al., 2006). During the rainy season, donkeys can easily meet their metabolic and nutritional requirements because of abundance of high-quality forage. This indicates that environmental factors affect the resting behaviour of horses (Waring, 2003).

Grooming occupies a small, but vital part of the daily behavioural activities of donkeys and horses. Grooming assists equids to maintain the health of the integument. It also helps in developing and maintaining social bonds between equids (Feh, 1999). Grooming methods used by donkeys include shaking, rubbing, scratching, rolling, tail swishing and nibbling (McGreevy et al., 2004). Allogrooming or autogrooming duration is not directly related to tick population, suggesting that the most important function of this behaviour is a social one, rather than the removal of ectoparasites (Yamada and Urabe, 2007). Thus, social grooming was observed more frequently in feral horses than domestic stallions (Christensen et al., 2002). Kimura (1998) also observed seasonal influence on grooming activity with the highest occurrence of mutual grooming during the summer due to the shedding of the coats and presence of insects. Haflinger horses showed no season variation in walking/locomotion (Lamoot and Hoffmann, 2004). Locomotion was constant over the entire period of behavioural study of Przewalski horse group, performed in the great Gobi desert (Souris et al., 2007). Locomotion is most typically expressed as movement from one place to another. Feral horses spend a large portion of their time budget on lo-

comotion (Ransom and Cade, 2009). Walking assists animals to determine what is edible (French, 1989). Locomotion was the most frequently engaged behavioural activity of donkeys in the coastal Savannah zone of Ghana (Canacoo and Avornyo, 1998).

Equids are typical inhabitants of semi-arid to arid rangelands and need regular access to fresh water. However, their water needs are difficult to study under free-ranging conditions (Kaczensky et al., 2010). The fact that Asiatic wild asses may only have to drink every other day during the hot season and less frequently in spring and fall explains why Asiatic wild asses can travel larger distances, and can make use of pastures farther away from water than Przewalski's horses (Kaczensky et al., 2008). Horse daily water requirement ranges from 20 to 70 litres depending on body weight, air temperature, relative humidity, level of activity and health (NEWC, 2005). Young horses consume an average of 30 litres of water per day and those in cool environment consume less (Georgen, 2001). Water intake of stable horses is 2–4 litres per kg of dry matter of food consumed (Houpt, 1987). Aganga and Tsopito (1998) reported that feral and domestic donkeys normally drink water once per day. The presence of dew and the high moisture content of the forage during the rainy season may be responsible for the consumption of less water during the rainy season. Equines primarily select herbaceous plants, but they are also able to modify their foraging behaviour in response to modifications in the availability of these more nutritional feed resources (Ferreira et al., 2012). Eliminative or excretory behaviour is expressed as urination and defaecation in donkeys. Stallions deposit faeces and urine as a marking behaviour and also to establish faecal piles on fresh excrement of mares (Kimura, 2001).

Concluding remarks

High ambient temperatures, high direct and indirect solar radiation, and humidity are environmental stress factors that affect the wellbeing and behaviour of donkeys. Physiological, hormonal, and behavioral thermoregulatory responses are used to combat stress in donkeys. Factors such as nutritional imbalance and nutritional deficiency may aggravate the impact of heat stress. Heat stress is a major problem on animal productivity in the tropical and arid areas. Welfare of animals can be determined by measuring parameters such as changes in hormone level, body temperature, and normal behaviour. The observation of equids in their natural environment is an important key to the practice of husbandry, as deviation from the normal behaviour is an indication of some form of stress. Early detection of such deviations based on a sound knowledge of the normal behaviour of the animal is essential in correctly forecasting veterinary problems, and making adjustments in husbandry practices. Consideration of both health and behaviour is important when assessing welfare. For veterinarians and equine scientists, understanding the fundamental aspects of the behaviour of donkeys is important to evaluation of health and welfare. Physiological conditions, environmental stimuli, and social situations influence specific behavioural responses. Behavioural activities engaged by donkeys include grazing, resting, grooming, alert, defaecation, urination, kicking, flehmen. Grazing is the most predominant behavioural activity of donkeys.

Conflict of interest

The authors have not declared any conflicts of interest.

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Received: 19 VIII 2014
Accepted: 30 XII 2014