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Impact of climate change on livestock health and adverse effects of livestock rearing on environment as well as on human health

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Abstract

This review article is highlighting the impact of changing climate on animal health particularly livestock and various dangerous effects of livestock rearing on environment as well as on the health of the people. The Asian continent, because of its size and diversity, may be affected significantly by the consequences of climate change. Animal health may be affected by climate change in four ways: heat-related diseases and stress, extreme weather events, adaptation of animal production systems to new environments, and emergence or re-emergence of infectious diseases, especially vector-borne diseases critically dependent on environmental and climatic conditions. On the other hand, there are various global problems related to the livestock rearing that are posing a greater risk to environment and public health such as impaired air quality due to livestock rearing, livestock mortality burial issues, food contamination of livestock origin, environmental ill effects of meat production and diseases transmissible from livestock to human beings. In order to avoid the destruction of global environment and prevent it from further deterioration different nations of the world should unite together to take some necessary steps. Livestock farmers and Scientists of the world should take every step to counter the hazardous effects of livestock rearing on the environment and human health because without livestock rearing no country in the whole world can sustain the life of their population.

Key words: Animal health, Climate change, Environmental pollution, Zoonotic.

Introduction

Climate system is constituted by atmosphere, land, ocean, ice and biosphere. Climate change is the sum total of all atmospheric phenomena at a place, over a particular period of time in a year. Governing parameters of climate are latitude, altitude and local geographical features (Obando and Makokha, 2005). Climate change is the long term significant change in the expected patterns of average weather of a specific region over a specified period of time and these changes are largely

attributed to man. Major factors responsible for climate change are deforestation, urbanization, industrialization, automobiles, burning of fossil fuels, coal mines, gas pipe lines and landfills that are producing methane, fertilizers. Various indicators of climate change are like earth's temperature has increased from 1.2^{o}F to 1.4^{o}F since 1 900, sea level is rising globally by 25 cm, shrinking of glaciers, thawing of permafrost, changes in range and distribution of plants, ozone layer depletion, ocean currents, ocean acidification, desertification, eutrophication, warming of lakes & rivers and increase in frequency of floods & droughts globally (Hammond *et al.,* 2009). Due to climate change frequency of tropical cyclones/typhoons and tsunami have also become more intense.

Climate change is considered as the most serious long-term threat to agriculture. Evidence from the Intergovernmental Panel on Climate Change (IPCC, 2007) is now overwhelmingly convincing that climate change is real, and poorest people will be the worst affected. The IPCC Report gives detailed projections for the 21st century and these show that global warming will continue and accelerate. The best estimates indicate that the earth could warm by 3°C by 2100. As, rural poor communities rely greatly for their survival on agriculture and livestock keeping that is amongst the most climate-sensitive economic sectors. With increases of 1.5°C to 2.5°C, approximately 20-30% of plant and animal species are expected to be at risk of extinction with severe consequences for food security in developing countries (FAO, 2007). Lack of water and increased frequency of drought in certain countries will lead to a loss of natural resources. The faster climate change occurs, the greater will be the risk of damage to the earth and the extent of such damage may exceed our ability to cope with the consequences. Numerous studies and reviews have addressed the effect of climate change on the physical environment and on human health over the past two decades. However, studies of the actual and potential effects of climate change on animal health remains sparse. Climate change will have far-reaching consequences on dairy, meat and wool production, mainly arising from its impact on grassland and rangeland productivity (NRMED, 2010). Heat distress suffered by animals will reduce the rate of animal feed intake and result in poor growth performance (Rowlinson, 2008). Local and rare breeds of the livestock will be lost as a result of the climate change and in turn disease epidemics. Biodiversity loss has global health implications and many of the anticipated health risks driven by climate change will be attributable to a loss of genetic diversity (Livestock Thematic Papers, 2007-2010).

Climate change especially global warming is a major factor that is likely to affect significantly the future of animal production, health and welfare in the Asian region. Climate change is anticipated to have far reaching effects on the sustainable development of developing countries including their ability to attain the United Nations Millennium Development Goals by 2015 (UN, 2007). Many developing countries governments have given adaptation action a high, even urgent, priority to this issue. Scientists suspect that increasing temperatures, in combination with changes in rainfall and humidity, may have significant impacts on domestic animals, birds, wildlife and human diseases (Hofmeister *et al.,* 2010). Because of expanding human populations, these changes could aggravate already limited water resources and increase habitat destruction, providing yet more opportunities for infectious diseases to cross from one species to another. In Asia, the major impacts of climate change will be on epidemics of malaria, dengue, and other vector-borne diseases of both animals and human beings (Martens, *et al.,* 2004). Increase in the frequency and

duration of severe heat waves and humid conditions during the summer is likely to increase the risk of morbidity and mortality in livestock.

Throughout the world livestock are reared for the milk, meat, wool and draught purpose and harmful environmental effects of livestock rearing are becoming increasingly serious at all local, regional, national and global levels. The presence of livestock in the farms leads to a buildup of animal waste. The enormous volumes of waste cannot be assimilated by natural processes, and therefore require special treatment and major of systems used to treat animal waste are inadequate. Manure storage facilities also releases noxious, dangerous, offensive, odorous gases, dust, microorganisms, endotoxins in the air and their runoff into surface waters. Such outdated and improper treatment of animal waste can lead to serious environmental pollution problems (Yelm Worms, 2011). Improper collection and disposal of untreated animal waste can harm groundwater and human health. Livestock rearing causes significant emissions of nitrate, phosphate, heavy metals, and antibiotics in manure and liquid effluents. Faulty, continuous and improper use of antibiotics promotes development of antibiotic resistance in bacteria that are present in animal waste and environment (Kristiansson, *et al.,* 2011). There are indoor health effects on man and livestock from indoor exhausted gases like ammonia, hydrogen sulphide and bioaerosols that ultimately have impacts on the local, regional and global environment leading ultimately to global warming. There is also a risk of airborne transmission of infectious agents such as virus and other microorganisms between farms. These environmental problems are enhanced by high animal densities; insufficient distances between farms and location of farms very close to residential areas. This review article is highlighting the impact of changing climate on animal health particularly on livestock and various dangerous effects of livestock rearing on environment as well as on the health of human beings.

Change in climate and its impact on livestock

In pastoral and agro pastoral systems, livestock is a key asset for poor people as it fulfils multiple economic, social and risk management functions of the these people. The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors such as rapid population and economic growth, rising demand for food (including livestock) and products (Conant and Paustian, 2002), conflict over scarce resources (land tenure, water, biofuels, etc.) that are affecting livestock production systems. For rural communities, losing livestock assets could trigger a collapse into chronic poverty and have a lasting effect on their livelihoods. The direct effects of climate change will include higher temperatures and changing rainfall patterns, which could translate into the increased spread of existing vector-borne diseases and parasites, accompanied by the emergence and circulation of new diseases. In some areas, climate change could also generate new transmission models (Livestock Thematic Papers, 2007-2010).

Impact of climate change on general health of the livestock includes increased premature death; increased incidence of cardio-respiratory diseases, increased mortality, disease & injury due to heat waves, droughts, and fires etc. Climate change also increases burden of gastrointestinal diseases that are associated with floods and increased malnutrition consequently affecting the growth and development of the livestock and even young ones of human and animals (Baylis and Githeko, 2011).

Climate change is causing new transmission models & generation of different host species, reduction in immunity and occurrence of photosensitization. It is also causing the expansion of vector population into cooler areas i.e. high altitude area and causing the vector borne diseases e.g. blue tongue, encephalitis, trypanosomiasis and fascioliosis. Climate changes poses changes in spatial distribution of pathogens like haemorrhagic septicemia, anthrax and black leg (Baylis and Githeko, 2011). Climate change affects ecological distribution of the diseases like fungal infections are greatly influenced by change in temperature & humidity, change in rain fall pattern is leading to large outbreaks of diseases, emergence of new diseases with a warmer climate. Impact of climate change on production capacity of the livestock involves far reaching consequences on dairy, meat & wool production via impact on grass and range productivity.

Impact of climate change on reproduction of livestock includes higher embryo mortality & abortion rate, reduced conception rate, altered progesterone production & metabolism, reduced placental development and lowering of conceptus weight in female animals. Summer infertility problem which already exists in buffaloes is further aggravated by climatic changes. In male climate change effects spermatogenesis & testosterone level is lowered. It also leads to decreased sperm motility, increased sperm abnormality, decreased sperm output and lowered libido.

Indirect impact of climate change that are in turn affecting the livestock population of a country includes affects on availability of fodder e.g. changes in feed resources, decrease carrying capacity of pasture land, desertification and scarcity of water resources. It also affects quality of fodder that ultimately affects rumen fermentation and there is also decrease in production of fodder (Glover, *et al.* 2008). Climate change also shows its affect on water resources like monsoon rains become harder & less predictable; there is also shallowing of rivers causing shortage of drinking water for the livestock (IPCC, Climate Change, 2001).

Therefore it can be concluded that, climate directly affects livestock general health, diseases, production and reproduction whereas, it has indirect effect on the livestock health by showing its impact on fodder production, fodder quality and water resources. Direct effects of climate change involve heat exchanges between the animal and the surrounding environment that are related to radiation, temperature, humidity and wind speed. Under present climatic conditions, the lack of ability of animals to dissipate the environmental heat determines that, in many areas of world, animals suffer heat stress during, at least, part of the year. Heat stress has variety of detrimental effects on livestock (Fuquay, 1981), with significant effects on milk production and reproduction in dairy cows (Johnson, 1987; Valtorta *et al.*, 1996). Extreme heat waves, may affect beef (Ingram and Mount, 1975) and dairy cattle. Climate change will have a substantial effect on global water availability in the future that will affect livestock drinking water sources, livestock feed production systems and pasture yields. As climate changes and becomes more variable, niches for different species alter from time to time (Parmesan and Yohe, 2003). Rising temperatures increase lignifications of plant tissues and thus reduce the digestibility and the rates of degradation of plant species.

Change in environmental temperature and its impact on livestock

All animals have a range of ambient environmental temperatures termed as thermo neutral zone. This is the range of temperatures that are conducive to health and performances of the livestock animals. The upper critical temperature is the point at which heat stress effects begin to affect the animal. Number of environmental factors that contribute to heat stress includes high temperature, high humidity and radiant energy (sunlight). Heat stress can be simply defined as the point where the livestock cannot dissipate an adequate quantity of heat to maintain body thermal balance. The environmental conditions that induce heat stress can be calculated using the temperature humidity index (THI) (Berman, 2005.). The severity of heat stress experienced by an animal depends on a number of factors. The key ones include: The actual temperature and humidity, the length of the heat stress period, the degree of night cooling, ventilation and air flow, the size of the animal. Species that are indigenous to a region are better able to maintain a more constant core body temperature than non-adapted animals that is brought about through anatomical and physiological adaptations. At high ambient temperatures, there is an increase in water consumption and a concomitant decrease in feed consumption (Fox and Tylutki, 1998). In cold climates, feed consumption increases during extremes of cold making exposure to the livestock against different disease conditions via the food chain These changes in food and water consumption, which mark the principal metabolic shift in animals in response to environmental fluctuations, may contribute to toxicological differences in pesticides between the world's regions. Heat distress on animals reduces rate of animal feed intake leading to poor performance. Due to heat distress high producing animals are more likely to be affected than low producing animals. There is decrease in milk production for cows under heat stress (decrease in milk production can range from 10 to >25%), and decrease of egg production and feed nutrient utilization efficiency in poultry birds. Alterations of temperature and precipitation regimes may result in a spread of disease and parasites into new regions or produce an increase in the incidence of disease, which, in turn, would reduce animal productivity and possibly increase animal mortality (Baker and Viglizzo, 1998). Vector-borne diseases could be affected by the environmental temperature variations as there is expansion of vector populations into cooler areas e.g. malaria in human beings and livestock tick-borne diseases; more temperate zones (such as bluetongue disease in northern Europe); and changes in rainfall pattern during wetter years, that could also lead to expanding vector populations and large-scale outbreaks of disease (e.g. Rift Valley fever virus in East Africa). Temperature and humidity variations also have a significant effect on helminth infections. Trypanotolerance, an adaptive trait which has developed over the course of millennia in sub-humid zones of West Africa, could be lost, thus leading to a greater risk of disease in the future (Thornton and Herrero, 2008).

Climate change impact on crop and livestock practices

Changes in crop and livestock practices could produce effects on the distribution and impact of malaria in many areas, and schistosomiasis and lymphatic filariasis in irrigated areas. Climate change impact on livestock feed-grain availability and its price has been considered in several studies by many researchers (Adams *et al.*, 1990; Bowes and Crosson, 1993; Rosenweig and Parry, 1994). The indirect effects of climate driven changes in animal performance mainly results from

alterations in the nutritional environment. Researchers have suggested that changes in climate would affect the quality and quantity of forage produced (Baker and Viglizzo, 1998). The impact of climate change on pastures and rangelands may include deterioration of pasture quality towards poorer quality subtropical C_4 grasses in temperate regions as a result of warmer temperatures and less frost; however, there could also exist potential increases in yield and possible expansion of area if climate change were favorable as a result of increase in CO_2 (Campbell *et al.*, 1995). As a consequence, productivity of grazing livestock could be altered.

Livestock rearing and its hazardous effects on environment and human health

Researchers have expressed concerns over air quality for residents living near confined animal feeding operations (CAFOs) (Susanna *et al.*, 2005, Wing *et al.*, 2008). These include odors, regarded as a nuisance issue, and impaired air quality, which can be a more serious health hazard. Both have similar causes, and in some cases offensive odors is an easily identifiable indicator of poor air quality. For example, ammonia, which is a potentially dangerous air emission, also has a distinctive odor. Gases such as ammonia and hydrogen sulfide and the associated odors are perhaps the most recognizable CAFO air emissions, but other emissions include volatile organic compounds, particulate matter, and microbes (Susanna *et al.*, 2005, Heederik *et al.*, 2007). These emissions can pose serious potential health risks not only to CAFO workers, but to neighboring homes and communities as well (Susanna *et al.*, 2005).

Hydrogen sulfide (H_2S)

Hydrogen sulfide (H_2S) is a colorless, flammable gas that smells like rotten eggs at low concentrations. Because H_2S has a specific gravity heavier than air, it stays close to the ground and can accumulate in enclosed, poorly ventilated, and low-lying areas. The odor detection threshold for H_2S ranges from 0.5 ppb to 30 ppb for 83% of the population, while the irritant threshold ranges from 2.5 to 20 ppm. Thus, the odor threshold for H_2S (as well as other sulfur-containing compounds) is 3-4 orders of magnitude (that is 10^3 and 10^4 times) below the level that causes classical irritant symptoms. The scientific literature on H_2S suggests that health symptoms can occur with chronic exposure to H_2S concentrations far below the levels at which acute irritation or toxicity occur. Health effects included eye, respiratory or neuropsychological symptoms. Acute exposure to H_2S at levels in the low ppm range (1 to 7 ppm) can also induce health symptoms including headache, increased airway resistance, coughing, throat irritation and eye pain. At 30 ppm, H_2S becomes neurotoxic and induces nasal lesions in olfactory mucosa. At 200 to 1000 ppm, brief exposure to H_2S can be fatal. Levels of H_2S inside CAFOs (e.g., 1 to 2 ppm) tend to be above those that have been reported in other settings to elicit health symptoms with chronic (and in some cases acute) exposure. Fatal cases of H_2S poisoning have occurred in both humans and animals during processing of manure.

Ammonia (NH_3)

Ammonia is a colorless gas at ambient temperature and pressure. At concentrations above 0.7 ppm, it has a pungent, sharp, repellant and acrid odor. The eye irritation threshold (irritation just barely noticeable) for ammonia is 4 ppm (3

mg/m^3). Decrements in baseline Pulmonary Function Tests (PFT) have been reported in workers exposed to NH_3 at concentrations of 7 ppm in tandem with other aerial contaminants. Ammonia is released from the natural decomposition of organic material, including manure as well as dead animals and plants. Ammonia concentrations up to 200 ppm have been found in some animal (e.g., poultry) confinement facilities, but typical levels are much lower (5 to 70 ppm). Comparison of ammonia concentrations measured in animal feeding facilities with human responses to these concentrations suggests that health symptoms (mainly nasal or respiratory irritation) can occur in some of these facilities.

Volatile organic compounds (VOCs)

An overview of studies of VOCs emitted from animal facilities indicates that hundreds of compounds are present. In a recent analysis of VOCs emitted from swine facilities in North Carolina utilizing gas chromatography and mass spectrometry (GC/MS), over 3 00 compounds were identified. Many more compounds were present, but the GC peaks were too small to allow identification. The compounds identified by GC/MS were diverse and included many acids, alcohols, aldehydes, amides, amines, aromatics, esters, ethers, fixed gases, halogenated hydrocarbons, hydrocarbons, ketones, nitriles, other nitrogen-containing compounds, phenols, sulfur-containing compounds, steroids and other compounds. Acids, phenolic compounds and aldehydes were present in the highest concentrations. The magnitude of total VOCs associated with animal feeding operations and/or waste management systems varies widely from as low as 0.60 mg/m^3 in a recently cleaned swine facility to 108 mg/m^3 from the headspace of a chamber containing slurries produced by weaner pigs. Exposure to low concentrations of hundreds of compounds simultaneously can produce high levels of odor and irritation downwind of CAFOs. Introduction of these volatile organic compounds into the upper and/or lower respiratory tract has been found to produce many systemic responses in both human and animals including altered respiration.

Particulate matter including bioaerosols

Particulate matter including bioaerosols released in the livestock urban settings have increased mortality risk, especially among the elderly and individuals with preexisting cardiopulmonary diseases, such as chronic obstructive pulmonary disease, pneumonia and chronic heart disease. This effect can begin to occur when ambient particles <10 microns in size reach a level of 30 to 150 $\mu g/m^3$, (EOH, 2012).

All of the emissions described above can induce odor sensations. Health complaints associated with odorous emissions from animal facilities include eye, nose and throat irritation, headache, nausea, diarrhea, hoarseness, sore throat, cough, chest tightness, nasal congestion, heart palpitations, shortness of breath, stress, drowsiness and alterations in mood. These symptoms typically occur at the time of exposure and remit after a short period of time. Health symptoms may persist for longer periods of time as well as aggravate existing medical conditions in sensitive individuals such as asthmatic patients.

Livestock mortality burial and environmental health

Mortality losses are a normal part of livestock and poultry production. One option for disposal of these mortalities is burial. Buried livestock mortalities undergo a decomposition process, during which nutrients, pathogens, and other components of the animal carcass are released into the environment (Bernard *et al*., 2004). Very little research has been done on this topic. Most of the existing research focuses on poultry mortality pits. Burial of livestock mortalities is not a common practice as most producers prefer to use the services of a licensed collector for lifting the carcass of dead livestock animals. The potential for contamination exists when livestock mortalities are buried and therefore, organic and inorganic substances are released during their decomposition. Elevated levels of biochemical oxygen demand (BOD), ammonium-nitrogen (NH_4-N), total dissolved solids (TDS), and chloride (Cl^-) have been found within or very near to burial trenches. Elevated chloride levels are generally the best indicator of burial-related groundwater contamination. It is uncommon to find burial-related contamination more than a meter or two from the source. There is currently no evidence of environmental problems being caused by livestock mortality burial (Bernard *et al*., 2004). The potential for pollution of groundwater is high around dead bird disposal pits. High concentrations of ammonia and total dissolved solids have been measured in nearby groundwater by some of the workers (Freedman and Fleming, 2003).

Environmental impact due to livestock meat production

The environmental impact of meat production includes pollution and the use of resources such as fossil fuels, water, and land. According to 2006 report by the Livestock, Environment and Development Initiative, the livestock industry is one of the largest contributors to environmental degradation worldwide, and modern practices of raising animals for food contribute on a "massive scale" to air and water pollution, land degradation, climate change, and loss of biodiversity (Steinfeld, 2006). Animals fed on grain need more water than grain crops. Relatedly, the production and consumption of meat and other animal products is associated with the clearing of rainforests, resource depletion, air and water pollution, land and economic inefficiency, species extinction, and other environmental harms. Although it requires less land for the livestock rearing but as the livestock need large quantities of feed for more meat production efficiency and therefore, growing of cereals for feed requires substantial areas of land. Free-range animal production requires land for grazing, which has led to encroachment on undeveloped lands as well as clear cutting of forests. Such expansion has increased the rate of species extinction and damaged the services offered by nature, such as the natural processing of pollutants (FAO, 2006). Raising animals for human consumption accounts for approximately 40% of the total amount of agricultural output in industrialized countries today and livestock is the world's largest land user. Grazing occupies 26% of the Earth's surface, and feed crop production uses about one third of all arable land (FAO, 2006). Because of this enormous requirement for land use, land degradation such as deforestation, desertification, and soil quality decline, which are already major global problems, are becoming more significant. Extended heavy grazing also contributes to the disappearance of edible plant species, and the successive overgrowth of other inedible plants and bushes (Sapp and McDonald, 2001). Overgrazing is also associated with both soil quality decline and deforestation as farmers and ranchers encroach on

forested areas in search of plots of land on which they have to feed their animals (National Research Council, 1994). Producing a certain quantity of food in meat requires much more water than producing the same amount of food in grain.

The production of protein from grain-fed animals requires eight time as much fossil fuel energy as the production of plant protein. According to an article in Environmental Health Perspectives, typical feedlot husbandry of cattle requires an input of 35 kcal of fossil fuel to produce one kcal of food energy in beef, far more than that required for comparable plants (Horrigon, 2002) that however, reflects the situation in the developed world and does not take into account the situation in most third world countries.

Hazardous effects of livestock and livestock related food products on human health

Livestock food originated contamination is an indirect cause of public health risk in developed as well as developing countries of the world. Food contamination refers to foods that are spoiled or tainted because they either contain microorganisms, such as bacteria or parasites, or toxic substances that make them unfit for consumption (IMS & Research Methodology, 2010). Many bacteria can contaminate food. The most common of these are *Campylobacter jejuni*, *Clostridium botulinum*, *Escherichia coli* (*E. coli*), *Salmonella typhimurium*, *Shigella*, *Staphylococcus aureus* (Rao, 2006). Spoiled milk is also mostly caused by bacteria such as *Lactococcus cremoris*/*Enterobacter aerogenes* that cause the milk to form long white strands. Water contamination is usually due to the presence of three bacteria, *E. coli, Clostridium perfringens,* and *Enterococci*, the bacteria normally found in the feces of many animals. Parasites are organisms that live in or on a host, and obtain nourishment without benefiting or killing the host. They enter the body through the mouth when contaminated animal food is swallowed. There are many different types and range in size from single-celled, microscopic organisms (protozoa) to larger, multi-cellular worms (helminths) that can be seen without a microscope. Parasites that contaminate food of livestock origin include *Entamoeba histolytica*, *Giardia duodenalis, Cryptosporidium parvum, Cyclospora cayetanensis, Toxoplasma gondii, Trichinella spiralis, Taenia saginata* & *Taenia solium* (Doyle, 2003). There are certain zoonotic conditions like tuberculosis, antrax & brucellosis etc. that can transmit to human beings when they come in contact with the diseased livestock and their products.

CONCLUSION

The quality of life on earth is linked to the overall quality of the environment. This article have attempted to demonstrate how complicated it is to evaluate and foresee what will be the impacts of climate and environmental changes on animal health in such an enormous continent as Asia, which is characterized by large and growing populations, high animal densities and very diverse climate zones, landforms, cultures and practices. This review also highlights various global problems related to livestock rearing that are posing a greater risk to environment and public health like impaired air quality due to livestock rearing, livestock mortality burial issues, food contamination of livestock origin, environmental ill effects of meat production and zoonotic diseases transmissible from livestock to human beings.

Climate change could affect animal production and well-being, especially because of increases in air temperature. The already changing pattern of some animal and human diseases (particularly arthropod borne diseases) highlights the urgent need to undertake action in response to a series of events that may be attributed, among other factors, to climate variability. Moreover, it is noteworthy that some developing countries in Asia are not yet ready to face such a threat and need to be part of a 'win-win' process with the support of international organizations such as the Office International Des Epizootics (OIE), Food and Agriculture Organization (FAO), World Health Organization (WHO) and World Bank. In order to avoid disastrous destroy of global environment and prevent it from further deterioration, it is a vital matter of immediate urgency to keep and control the changing atmosphere of earth. The livestock farmers and the people of different nations should also be aware of the disastrous consequences that the environment and public health can face due to livestock rearing.

Authors' contributions: ***Anita Kirrolia*** *(PhD Research Scholar), contributed in preparation and writing of the manuscript;* ***Dr. Vikas Nehra*** *(Assistant Scientist), contributed in reviewing of the literature, final editing and corresponding author of manuscript.*

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