EFFECTS OF CLIMATE VARIABILITY ON THE HARVESTING AND PRESERVATION OF MOPANI WORMS

Mamakwa Sanah Mataboge,
Fumulani Mavis Mulaudzi, Friedeburg Anna Maria Wenhold
University of Pretoria
sanah.mataboge@up.ac.za

Phillip Obed Yobe Nkunika
University of Zambia
pnkunika@unza.zm

Nomusa Rhoda Dlamini
Council for Scientific and Industrial Research
NRDlamimi@csir.co.za

Robyn Gwen Alders
University of Sydney
robyn.alders @sydney.edu.au

ABSTRACT

*The effects of climate variability on the harvesting and preservation of Mopani worms are addressed in this review. Human consumption of insects has occurred for millennia and has recently received increased attention in the literature. Given the intimate link between the larvae of lmbrasiabelina (i.e. the Mopani worm), Mopani woodlands and rainfall, climate change and weather variability will likely have negative effects on Mopani worm availability, harvesting, preservation and nutritional status of global communities including sub-Saharan-African (hence forth **SSA)** countries. The literature review presented in this article covered the period between 1982 and 2015 relating to the search for alternative nutrient food sources which was veiy prominent during the period of variable climatic conditions. Both qualitative and quantitative literature was read. Intensive data mining of reports and publications using Google search engine was carried out, using the words Mopani worms, harvesting and preservation as key search words. Climate variability effect on the Mopani woodlands, Mopani worms developmental stages, harvesting, preservation, economic development and nutrition are discussed. The recommendations made are that the negative effects of climate variability on Mopani woodlands and Mopani worms need to be mitigated to ensure food security and sustained economic development.*

Keywords: climate variability, food security, harvesting, Mopani worms, rainfall and preservation.

INTRODUCTION

Climate change and weather variability is a global phenomenon which has had a devastating impact in SSA countries that rely on rainy seasons for food security and public health. Of the past 115 years, Southern Africa experienced the worst recorded drought in the year 2015 cropping season (South African Broadcasting Company [SABC] NEWS 14.01.2016). Climate change and weather variability are linked to droughts which have a considerable negative impact on commercial and subsistence farming. In **SSA,** rainfall patterns have become less predictable, precipitation has decreased on average, and temperatures are increasing (Holmgren and Oberg, 2006). The upward trend of the already high temperatures and the reduction of precipitation levels increasingly result in reduced agricultural production in SSA (Mano and Nhemachena, 2007). This might have a negative impact on the availability of indigenous food resources such as plants and insects. Climate variability of low rainfall and hot or cold temperatures has a negative effect on the survival of several woodlands, excluding the Mopani trees which withstand the moderate rainfall, high to lowest temperature ranges including minimum frost conditions (Whitecross *et al.,* 2012) The green leafy Mopani trees are habited by Mopani worms which are the larvae of the moth *Imbrasiabelina* and are widely consumed for their nutritional benefits by rural populations (Makhado and Potgeiter, 2009).

The moth, also known as *Gonimbrasiabelina,* lays its eggs on the Mopani tree, *Colophospermummopane* during the rainy season and the caterpillars, Mopani worms, feed on the leaves. Consequently, the availability of the Mopani trees and fresh leaves determines the occurrence and abundance of Mopani worms. The decrease in the number of Mopani woodlands negatively impacts on Mopani worm availability and harvesting, thus affecting the nutritional status of those who rely on them as a stable source of protein. Globally there are more than 800 million of current 7.4 billion people are hungry people and in need of sustainable food supply (WFP, 2015). The global population is expected to be 8.9 billion by 2050 and there are no records of sufficient food to cater for the expected increase this may worsen food shortage (UNDESA report, 2015).

Climate variability has affected a number of low to middle income countries, with one of the regions hardest hit is being SSA. The food security in low income countries among others as classified by World Bank according to 2012 GNI per capita include Mozambique, Tanzania, Zimbabwe in (Annexure 1. accessed from http://data.worldbank.org) are threatened by severe drought, floods and storms (Dhaka *et. al.,* 2010). The Intergovernmental Panel on Climate Change (IPCC) called Africa 'one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity' (IPCC WGII, 2007). Insects are increasingly being recognised as critical to improving food and nutritional security. Insects can be healthy, nutritious alternatives to mainstream staples such as chicken, pork, beef and fish. Globally, there are about 1 900 to 2 000 insects consumed as sources of protein and micronutrient.

Among these insects are Mopani worms which contain 54% protein nutrients (Yen, 2008; Rumpold and Schlueter, 2013; Kwiri, 2014). Mopani worms contain amino acids and fatty acids, therefore can mitigate protein energy malnutrition. Many insects are also high in calcium, iron and zinc. Insects already form a traditional part of many regional and national diets in developing countries and Southern Africa (Food and Agriculture Organisation [FAO], 2013). The Mopani worm is reported to be the most widely consumed insect in SSA (Illgner and Nel, 2000). The Zimbabwe-Botswana Mopani belt is known in Southern Africa as a high production area of Mopani worms. Most people in this belt eat Mopani worms either as a staple protein source or as a delicacy for the elite population.

Entomophagy (the eating of insects) can mitigate malnutrition in children under five years old (Kwiriet *al.,* 2014). Protein energy malnutrition, among other diseases, adds to the high mortality and morbidity rate among children under five years of age in SSA countries. The reduction of child mortality was reported not to be attained without implementing sustainable nutritional intervention during reflections on attainment of the Millennium Development Goals (MDGs) in some low income countries (Higgins, 2013). Malnutrition is a global problem and was reported that stunting affected 165 million children in 2011 while 52 million children suffered wasting with the highest prevalence in South Asia and SSA (Black *et al.,* 2013). Stunting is the anthropometric measurement as height for age of below fifth percentile or -3 Z score as compared to children of the same age according to Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS) (Lewit and Kerrebrock, 1997). Wasting is loss of muscle and fat tissue by children under five years of age on shoulders, limbs, buttocks and developing distended abdomen (Department of Health [DoH], 2009).

Moreki *etal.* (2012) stated that malnutrition undermines the health of children and lactating mothers in developing countries. Hence, the consumption of insects such as Mopani worms presents an affordable source of protein and minerals. In the implementation of Integrated Management of Childhood Illnesses (IMCI), Mopani worms are recommended as an affordable protein source for families with malnourished children (Department of Health [DoH], 2014) as it is cheaper.

Agriculture is the mainstay of food security in most African economies. Negative developments in agriculture due to climate change would adversely affect livelihoods that depend on crop production for food security (Dube and Phiri, 2013). However, insect farming as a new agricultural endeavour in SSA countries is an attractive preposition with manageable challenges. The presence of drought or heavy rains that might interfere with harvesting of Mopani worms may have a negative effect on farming and harvesting of Mopani worms. Mopani woodlands degradation is caused by several factors such as fire, construction of huts by indigenous communities and exporting root ornaments (Mashabane *et al.,* 2000). The lack of the woodlands management policies might negatively affect developing communities as the availability of the Mopani worms might be negatively affected due unsustainable harvesting, preservation and policies regarding deforesting in addition to climate variability. One of the solutions to ensure sustainability of Mopani woodlands and Mopani worms availability to ensure food security is among others modern farming practices such as coppicing of the stems (Mapaure and Ndeinoma, 2011). The aim of this review is, therefore, to explore and describe effects of climate variability on the harvesting and preservation of Mopani worms.

METHODOLOGY

This article presents a review of literature on the effects of climate variability on the harvesting and preservation of Mopani worms.. An *integrated literature review* method was used to explore the effects of climate variability on harvesting and preservation of Mopani worms. The integrated literature review method was used as we intended to get the relationship of the three concepts: Mopani worm availability, harvesting and preservation and the phenomenon of climate variability. The five steps of the integrated literature review method included problem formulation, (2) data collection or literature search, (3) evaluation of data, (4) data analysis, and (5) interpretation and presentation of results (Russel, 2005).

An assumption to create a problem was stated that climate change would have an effect on the Mopani worm availability, harvesting and preservation. Literature search was enabled by the use of primary concepts: Mopani worms, harvesting and preservation and climate change. Our first search combined all the keywords into one search. As subtitles emerged from the main studies, secondary concepts were identified namely: Mopani trees, child nutrition and poor communities livelihoods were used as search words. This was followed by on the pairing of "climate change and variability" with each subsequent term. Every article and report was selected and validated carefully for the period 1982 up to 2015. Search sites were News reports, Pubmed, Web of Science reports on climate and woodlands, news reports and news papers, Department of Health [DoH] and Google Scholar. Climate change is a long occurring phenomenon, literature search was dated three decades back to get a comprehensive description of climate variability on Mopani worms, harvesting and storage. Exclusion criteria included articles that discussed woodlands with no focus on Mopani woodlands and other insects harvesting and preservation but excluded Mopani worms. Qualitative and quantitative studies were reviewed as there was a need to explore and expose the effect of climate variability through the years and its effect on Mopani worms as represented by statistical data and subjective reports by communities in quantitative and qualitative reports respectively. The evaluation of data was followed by a comparison of the findings of different studies. Convergent findings were assigned subheadings, discussed together and interpreted as to how they compare and relate to climate change and variability effect on Mopani worms harvesting and preservation. The findings were interpreted, skimmed and summarised. Discussions of findings related to effect of climate variability on communities' health and economic development are presented in this article. Furthermore, the findings denoted the extended relationship of climate variability, Mopani worms harvesting and preservation among communities.

FINDINGS

The findings of this article are discussed under the following headings: climate variability and Mopani woodlands; climate variability and availability of Mopani worms; harvesting, preservation, safety and nutritious value of Mopani worms; effects on commercialization and effects on nutritional status

Climate variability and Mopani woodlands

Mopani trees survive most low altitudes of 400-700 meters above sea level and rainfall as low as 200-mm. The drought induce chemical components changes, especially the soil sodium levels, thereby affecting the characteristics of the soil and the Mopani woodlands (MacGregor and O'Connor, 2002). A study conducted on the semi-arid Mopani Savana veld to assess the effects of over a decade period when drought prevailed in 1981-1993 confirmed that Mopani trees were not affected compared to other trees as they could withstand protracted drought conditions (O' Connor, 1999). The findings of the study by O' Conor (1999) revealed that most of the litters from disappearing woodlands were from *Colophospermummopane* trees which survived while the mortality of other species of shrubs was observed.

The challenge posed by climate variability is the preservation of Mopani trees to ensure sustenance of harvesting and availability of Mopani worms for consumption by the vulnerable poor communities. For instance, Gullan *et al.* (2005) have stressed that the years of reduced Mopani worm harvest are associated with climate induced-drought than with unsustainable harvesting of the Mopani worm. Furthermore, Phiri *et al.* (2014) state that climate variability and reduced rainfall account for reduced Mopani worm availability and harvesting. Chikodzi *et al.* (2013) state that climate variability poses a threat through drought, cyclones, heat waves and other severe weather conditions. However presents unique opportunities for innovation, development and employment through the use of new agricultural interventions to mitigate the effects of climate change and Mopani harvesting. Variability in the climate has provided new technological development of farming methods to sustain Mopani worms.

Climate variability and availability of Mopani worms

Mopani worms would survive in similar climate variability as the Mopani woodlands which are high and low temperatures (Whitecross *et al.,* 2012). The effect of climate change on herbivorous insects, like Mopani worms, can be direct through its impact on their physiology and behaviour or indirect where the insects respond to climate-induced changes mediated through other factors, notably the host plant (Bale *et al.,* 2002). Bale *et al.* (2002) also review life-history strategies of insects, where there is evidence that insects may take from 2 up to 14 years to complete their life-cycle, depending on prevailing conditions including climate variability. The developmental stage that lasts the longest is the pupae. This demonstrates that insects may delay certain developmental stages in response to climate conditions. For Mopani worms, there is need to understand its life cycle and factors that contribute to pupae surviving and emerging as moths, and also the length of time the pupae can remain underground, and still remain viable when conditions are suitable.

During the summer months or rainy seasons, the Emperor moth, *Imbrasia-belina,* lays its eggs on the Mopani tree leaves (C. *mopane).* However, if the Mopani tree is not available, other trees are used such as the Marula tree, *Sclerocaryabirrea.* The Mopani tree is always the preferred tree. The young Mopani worms emerge from the eggs and immediately begin feeding on the Mopani leaves and moult four times until they reach their maximum size (Potgieter, Makhado and Potgeiter, 2012). The mature Mopani worms move down the tree and burrow a 15cm deep hole on the ground, where they pupate. The pupae are a winter stage and can last for one to six months, depending on the generation. The moths emerge in summer and live for only two to three days, during which they do not feed, but their only function is to mate and produce eggs (Potgeiter *et al.,* 2012). The different stages of the life cycle of *I. belina* provide food for numerous natural predators. Therefore life cycle of the Mopani worms ensures its survival during variable climate conditions.

Harvesting, preservation, safety and nutritious value of Mopani worms

Harvesting of Mopani worms is seasonal and happens during rainy seasons when Mopani woodlands are leafy, greeny and habited by Mopani worms. During the Mopani bounty period harvesters register and need to abide with stipulated harvesting guidelines in order to avoid extinct of Mopani worms. Therefore, property rights allow for controlled harvesting by regulating the numbers of harvesters, amount and period of harvesting (Mufandaedza *et al.,* 2013).

Women and children make up 96% of harvesters. Torrential rainfall which might affect the amount to be harvested is not welcomed during harvesting period as most time should be spend in woodlands. Furthermore, wet days, due to torrential rainfall, interfere with the sun drying process, as such heavy rainfall leads to spoilage of the harvested Mopani worms and renders the Mopani worms not suitable for human consumption. Even though the presence of spore forming bacteria such *Bacillus licheniformis, Bacillus subtilis* and *Bacillus megateriumwas* reported in meal worm larvae *(Tenebriomolitor)* and their fermented and dried products, spoiled Mopani worms are not suitable for human consumption (Klunder *et al.,* 2012). Meal worms are used in Europe to formulate food and feed ingredients and increase the shelf live. The *Bacillus* species identified in meal worm products are found in the soil and generally not considered pathogenic. However, they can cause spoilage if they proliferate due to moist and wet weather conditions that interfere with the drying process.

Favourable climate with alternating rainy days and dry sunny days is needed as the harvested Mopani worms have to undergo the drying process in order to preserve their nutritional value, prevent deterioration and ensure suitability for consumption. The processing, normally done by women and children, is labour intensive and the initial steps involve the removal of the undigested material (degutting) prior to sun drying (Kwiri *et al.,* 2014). The South African (Pietersburg/Polokwane) analytical data from the early 1908's on Mopani worms highlighted high crude protein content (on a dry basis) (Dreyer and Wehmeyer,1982), but pointed to the relatively low digestibility thereof. This was attributed to the fibre remaining in the worm during traditional degutting. As reported by Madibela *et al.* (2007), degutting improves crude protein content by 10% which is calculated to be 521.4 g/kg before the degutting process. Traditional drying as a preservation method has been proven not to affect the protein composition of the Mopani worms. However, as sun drying takes long, in some practices, the Mopani worms are roasted on charcoal, sometimes oven dried, processed into powder or paste as an alternative drying method to avert spoilage (Madibela *et al.,* 2007; Klunderet *al.,* 2012; Thomas, 2013). Even though Motshegwe *et al.* (1998) contest that the chemical quality of the nutrients of Mopani worms has been investigated, it is irrefutable that the recent preservation methods may have an effect on nutrient components. There is, therefore, a need for further research (Madibela *et al.,* 2009). The drying process preserves the Mopani worms and extends their shelf life and availability throughout the year. The dried Mopani worms are stored in sacks, tins or baskets, for either home-consumption, or taken to the market for sale (Thomas, 2013).

Effects on commercialization

Conducive climate variability characterised by rainfall and Mopani bounty seasons economically profit some countries which have commercialised Mopani woodlands such as Botswana and Zimbabwe. These two countries have large Mopani tree farms and are the key suppliers of Mopani worms in Southern Africa (Madibela *et al.,* 2009). The Zimbabwe- Botswana belt benefits Botswana more than Zimbabwe as Botswana's economic policies integrate Mopani woodlands' protection and sustenance. The economic inputs are estimated to be US$33.3 million in Mopani trading countries such as Botswana and creates employment for 10 000 people (Styles (1995) as cited in Ghazoul, 2006). The woodlands are situated alongside the Pongola and Luangwa rivers within tropical summer rainfall ecoregion and temperature ranges of 4-46^{2}C (Low and Rebera, 1996).

A common practice has been that the dried Mopani worms are sold to street vendors who make this high protein source more accessible to the community as it is still the cheapest source of protein (Chaly, 2009). Due to the commercialization of the Mopani woodlands, there is recently restricted access to the harvesting areas which are owned by farmers. Duringthe Mopani bounty period characterised by green leafy Mopani trees during rainy season where the larvae appears in large numbers, the harvesters get permission to harvest an agreed amount that they can sell to other countries (Gonda *et al.,* 2010). With the challenges brought about by climate variability, it would become cumbersome for some people in SSA to afford harvesting fee or high priced Mopani worms which underwent technological processing such as powder or paste for consumption. The most affected might be those who are living below the bread line while the city elites consume the Mopani worms as a snack (Gonda, 2010). Further unavailability may be related to emerging markets as in Botswana Mopani worms is exported to South Africa for animal feeding (Mpuchane *et al.,* 2000).

It is evident that Mopani worm harvesting benefits women and children in many ways as they form 96% of the harvesters. Women are economic harvesters and they sell the Mopani worms to the community. On the down side, most harvesters leave their households to stay in the field where Mopani trees are available during rainy periods, usually in November or December and March or April (Stark *et al.,* 2003). In December 2001 to January 2002 no harvesting occurred in Zimbabwe due to drought and lack of support by the government (Stark *et al.,* 2003). Without government support, most agricultural practices are negatively affected as seen during drought seasons or periods where even animal farmers lose high numbers of livestock due to lack of water and grazing land.

Even though drought period usually has negative effect on farming produce, in Zimbabwe it facilitated the inception of new Mopani farming intervention. The positive outcome from lessons learned during drought period was that household Mopani tree farming was initiated. This afforded women an opportunity to continue with their household chores and parenting responsibilities while developing as commercial Mopani worms traders in Zimbabwe. The majority of the project beneficiaries were women and children who became active household Mopani tree farmers however it was not without competition (Stark *et al.,* 2003).

The new household agricultural practices widened the market and Zimbabwe has seen a rise of males who are Mopani worm farmers and harvesters. Almost 3,4 of males in an area called Kapeni and Ndiweni in Zimbabwe were Mopani harvesters. This brings in competition within a context that has been managed by women and children. As such, it may keep most women out of the market (Stark *et al.,* 2003). Cultural and traditional factors play a role in land ownership and mostly disadvantages women. Males will possibly gain more land for household Mopani farming as compared to women. (Chagumaira *et al.,* 2014)

Climate variability needs to be favourable for farming including Mopani woodlands sustenance as most families in SSA rely on farming for food produce. During a study conducted in Zimbabwe on the Hangwe community, the key interview informants revealed that 75% of the population survive on agriculture as such land and water preservation become the priority need for their survival. One of the firewood sources in the study setting was Mopani trees. The need for wood by city residents during electricity shortage put pressure on tree cutting for fire as it generates money for local people while destroying the Mopani worms' habitat (Nhemachena *et al.,* 2014). The informants further needed training in technology, drilling of water and fencing of the agricultural sites. The fencing would protect the Mopani trees from being used as firewood and ensure the woodlands' sustenance for food security, work creation and economic development.

Effects on nutritional status

The occurrence of drought or heavy rains that might interfere with harvesting may have negative effects on the harvesting of Mopani worms, consequently having adverse effect on human nutrition, economic status of Mopani farmers as well as animal feeding. The nutritional potential of edible insects for humans is often presented as an option in the fight against protein energy malnutrition, especially in resource-poor settings where intake of animal source foods may be suboptimal. From roughly 2000 edible insect species world-wide, the number reported to be consumed in South Africa ranges from 15 to 36 species (Rumpold and Schlueter, 2013).

Despite analytical data for edible insects being published, a recent review of international food composition data concluded that most of these publications do not fulfil the requirements for inclusion in food composition tables, because they express nutrient content on dry basis (Nowak *et al.,* 2016). It follows that using such figures for estimating the nutrient contribution of edible insects in the diet, is of limited value in terms of determining their role in human nutrition. Furthermore, utmost care should be exercised when interpreting published food composition figures, as these are very often presented as dry matter, whilst foods are consumed and presented in food composition tables on a fresh weight basis. Despite these limitations to the analysis of insect nutritional content, the nutritional composition of insects suggests that the crude protein, amino acid and fatty acid content may contribute to meeting the nutritional needs of populations who consume these regularly and in sufficient quantities. This is the reason for their inclusion in the list of foods to be considered in the management of protein energy malnutrition in Mopani woodlands (Madibela, 2009). On the other hand, Payne and co-workers, namely: Scarborough·, Rayner and Nonaka (2016) recently warned against premature generalisations, when they compared the nutritional profiles of edibles insects to meats and meat by-products. They concluded that the nutritional profiles of insects vary greatly. Several insects are potentially superior to meat in the fight against undernutrition (that is protein energy malnutrition), but that in the context of overweight and obesity, this may not be the case (Payne *et al.,* 2016).

Furthermore, Climate variability, specifically water availability, is important in determining the nutritional values of some food. Hence, footprints of water and energy in the food system are a global concern (Khan and Hanjra, 2009). Ecological considerations have recently often been included in reflections on sustainable diets. In this regard, the role of water is receiving ongoing attention, for example in South Africa where a number studies are currently underway infield laboratory in the context of food insecurity and water scarcity. Nutritional water productivity or the water footprint of a food or diet may become increasingly important globally and especially in water scarce countries (Wenhold *et al.,* 2007).

The need for sufficient water for food production goes beyond ensuring food availability but the quality of the produce. The relatively novel concept of "nutritional water productivity" links the agro-economical or environmental considerations with human nutrition. It quantifies nutrition output per volume water input, and is expressed as nutritional units (e.g. grams of protein) per cubic meter of water used in the production of a particular food. Typically, the protein water productivity of animal source foods is considerably lower than of plant crops (Wenhold *et al.,* 2012; Wenhold *et al.,* 2007). Whilst such figures relating to Mopani worms are not yet available, it seems likely that for edible insects as a group these will be more favourable than for conventional livestock, apart from producing less greenhouse gases (Nowak *et al.,* 2016).

Unemployment, food insecurity and hunger in relation to population growth will be exacerbated by climate variability characterised by protracted drought periods, minimal agriculture produce and Mopani worm availability. In addition, poverty levels are heightened andaffects women more than men as women rely more on agriculture and edible insects which are climate dependent than men.

Worldwide, 1.2 billion people are extremely poor living on less than US$1.25 per day WFP (2015) hence most people do not meet their daily nutritional needs due to lack of purchasing power. However, edible insects such as Mopani worms are available in their environment at a cheaper price than chicken, beef and fish mostly during the years with good rainfall. On the other hand, the effect of climate variability characterised with lack of rainfall and long drought periods created competition between Mopani worms and other available indigenous foods. The consumption of alternative indigenous food was practiced by the population that previously fed mainly on Mopani worms during drought periods by families in Zimbabwe and South Africa in 2008. During drought periods and the lack of Mopani worms, Zimbabweans baked their own bread and prepared porridge from *Hacha* fruits, while in South Africans alternative indigenous available fruits were eaten to buffer starvation (Woittiez *et al.,* 2013; Shackleton and Shackleton, 2004). However, these indigenous foods did not meet the protein portions provided by Mopani worms and would possibly lead to malnutrition among women and children.As pointed out by Downing *et al.* (1997), there is a need for strategies to reduce the vulnerability of the populations and natural resources to climate change using a broad spectrum of capacity to respond to environmental, resource and economic threats. In this case, one strategy would be to ensure the survival of the Mopani tree and research to understand the life cycle of the emperor moth, *I. belina,* as a means to create a sustainable supply of Mopani worms, even under adverse conditions to curb malnutrition.

RECOMMENDATIONS

Climate change is worsened by the economic activities undertaken in SSA countries and this affects the sustenance of Mopani woodlands. It is therefore recommended that mitigation interventions to reduce the impact of climate change related to negative outcomes of greenhouse gases due to chemical emissions from industrial practices, need to be an urgent agenda for SSA. The recommendations in agriculture research were that there is lack of climate change awareness by the people, and there is a need for awareness campaigns to be initiated. The findings in this study reiterated this recommendation. It is imperative for the population whose livelihood is dependent on the climate to be trained on sustainable means of farming and preserving their natural resources as sources of food. A multifaceted and context informed interventions are mostly advocated for.

CONCLUSION

From a human nutrition perspective a whole diet consumed over time, not the composition of individual foods, should be investigated. The harvesting of Mopani worms need to continue by implementation of new farming practices and mitigate climate change to ensure adequate protein availability from affordable sources. Cultural acceptability, typical portion sizes consumed, as well as the frequency of consumption and seasonal effects also need to be considered when the nutritional role of a food is evaluated. A review of South African food consumption surveys has shown that the total protein intake appears to be adequate, yet the animal source fraction thereof is often low. Furthermore, dietary diversity is often lacking (Faber and Wenhold, 2007). An evaluation of the nutritional contribution of the Mopani worm should include these considerations.

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