the SUSTAINABLE HARVESTING of EDIBLE INSECTS in SOUTH AFRICA, with REFERENCE to INDIGENOUS KNOWLEDGE, AFRICAN SCIENCE, WESTERN SCIENCE and EDUCATION

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Abstract

In our ongoing research on edible insects in the Limpopo Province of South Africa, we have found evidence of the unsustainable harvesting of edible insects and the food plants of certain insects. The decline in the edible insect industry, together with the need for food security provides a strong incentive to investigate possible causes of problems using different knowledge systems. Any solution to these problems needs to take Indigenous Knowledge Systems (IKS) into account if it hopes to be successful and sustainable. We have found that different communities have different explanations for the same phenomena. Some of these explanations correspond with the explanations for the same phenomena in Western science. Where areas of overlap between IKS and Western science exist, these can be used in education in such a way that recommendations for sustainable harvesting can be developed with reference to African science. In this process, the area of overlap between the systems may grow as information from one system is incorporated in another. In this contribution the overlapping roles of IKS, African science and Western science are explored in the teaching of the sustainable harvesting of Indigenous resources for food security and conservation. This creates opportunities to teach relevant science in such a way that the concerned communities can benefit through better food security and the conservation of culturally important plants and animals.

Introduction

Evidence exists that the harvesting of the "mopane worm" (*masonja* in Sesotho) has declined in the last 20 years. This is affecting the nutritional, cultural and economic uses of these insects, and provides an incentive to search for solutions. The problem involves real issues such as conservation and food security, but the solutions must also consider practical and theoretical issues from Indigenous Knowledge Systems (IKS), African science and Western science, which might all provide different interpretations of the problems and different potential solutions.

Masonja, the "mopane worm"

The "mopane worm" (*Imbrasia belina*) is the edible caterpillar of the Mopane Emperor Moth (Family Saturniidae; Order Lepidoptera), referred to by various names in different cultures, such as *masonja* by the South Sesotho speaking people. These caterpillars are known to be highly nutritious and healthy to eat (Dreyer, 1968; Dreyer & Wehmeyer, 1982) and form the basis of a multimillion dollar industry in areas including Zambia, Zimbabwe, Botswana and the Limpopo Province of South Africa. They are definitely the most important edible caterpillars in southern Africa. Some traditional healers use them for medicine and a huge controversy recently erupted because some people are now advocating that they can be used to cure HIV AIDS (Makhabele & Eybers, 2006). Although there are traditional healers using them for medicine, no Western research has been done on their medicinal properties. The fact that they are a nutritious cultural food means that they could be useful in maintaining health in any patients, including those with HIV AIDS. However any further medicinal properties have not been demonstrated in Western science and any special properties in traditional medicine are not in the public domain. Like all members of the Order Lepidoptera (and all other Orders of holometabolous

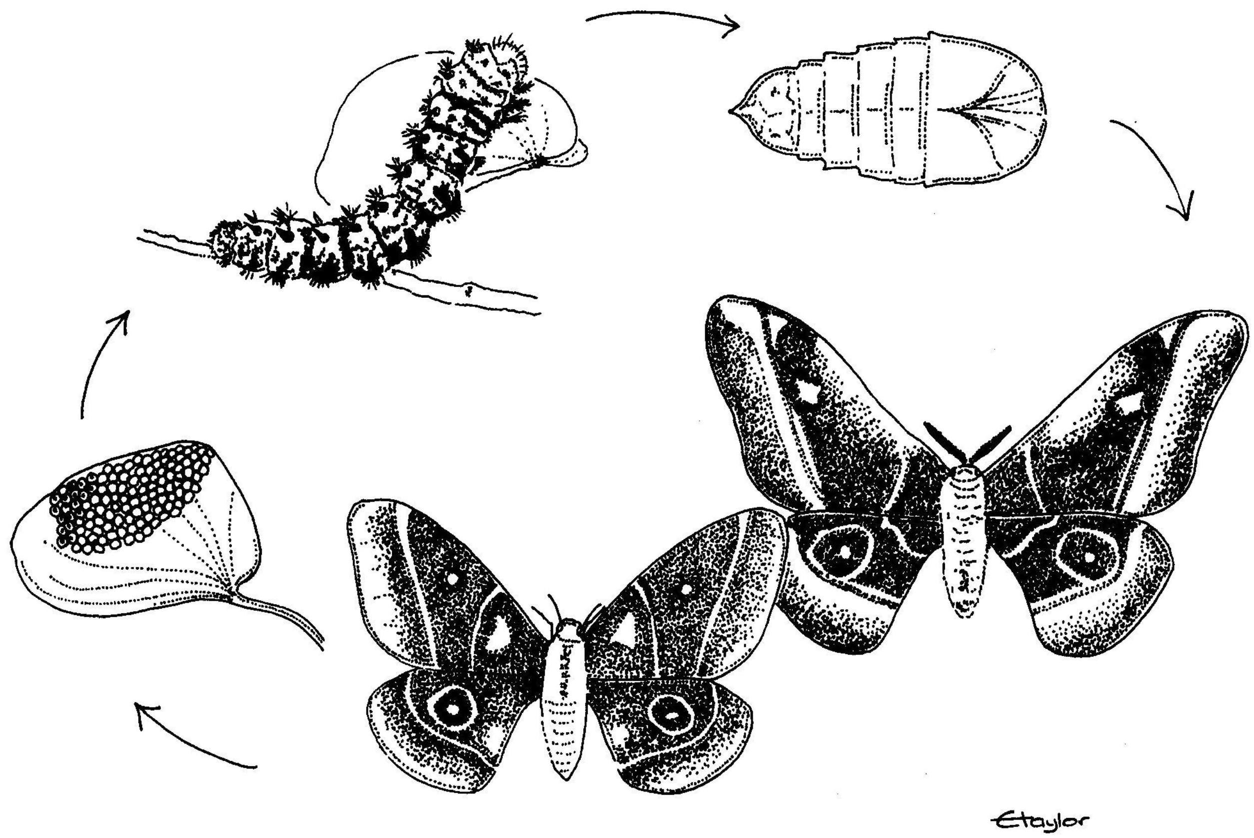


Figure 1. Complete metamorphosis: Life cycle of the mopane worm (*Imbrasia belina*)showing the sequence of the four different stages in the life cycle: eggs, larva (caterpillar), pupa and the adult male and female moths. If any stage in the life cycle is eliminated in a region the life cycle will be broken and a local extinction will occur (Artwork: E. Taylor).

insects) they have complete metamorphosis with four stages in the life cycle (egg, larva, pupa and adult) (see Figure 1).

This type of life cycle is similar to that of the Chinese silk moth, *Bombyx mori*, often used as an example of an insect with complete metamorphosis in Western text-books. Knowing the life cycle is obviously important for sustainable management because if any stage is completely removed the life cycle will be broken and local extinction will occur. This will cause the industry to shrink or collapse in the affected area. There are now areas in southern Africa where the last harvest was about 20 years ago and areas where *masonja* no longer occur (Greyling & Potgieter, 2004; Toms & Thagwana, 2005). Environmental fluctuations do cause fluctuations in populations of these insects, but it is probable that other factors such as over-harvesting fuelled by demand, price, economic realities, and increased commercialisation has also played a role (Greyling & Potgieter, 2004).

IKS and sustainable harvesting.

Several researchers have reported cases of apparent decreases in the availability of *masonja*, where the possibility of over-harvesting needs to be considered and investigations into the IKS of sustainable

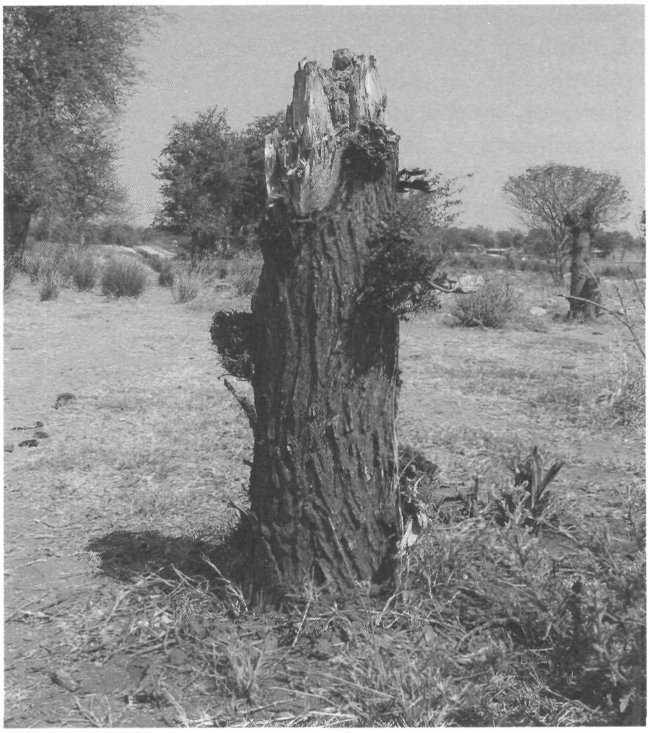


Figure 2. Example of mopane tree cut down for firewood at a height of about 1m. The shoots on the side of the stump have been browsed by goats (Photograph: Dave Balfour).

harvesting could prove fruitful. It can be argued that sustainable harvesting existed in the past but unsustainable harvesting is now prevalent in some regions. One of the contributing factors is probably an increase in human populations, but this is not the only consideration.

When we started investigating the sustainable harvesting of edible insects, we soon realised that the sustainable harvesting of edible insects would not be possible without paying attention to the sustainable use of their host plants. One of the areas for concern is the deforestation of regions in which the food plants occur. The favourite food plant of *masonja* is the mopane tree (*Colophospermum mopane*). The sustainable harvesting of these trees is important because they are used for firewood, fencing, housing, traditional art, browsing for herbivores like kudu and elephant (for hunting or tourism) and as host plants for culturally important insects. The problem of deforestation is taken seriously by the traditional leaders and a large notice at the side of the road in one of our study areas reads: "DO NOT DEFOREST. Care for the environment". However, directly opposite this sign, on the other side of the road, is a roadside stockpile of firewood available for any passing customer. Although the deforestation process is not being adequately monitored, it is already clearly evident if we look at some affected areas such as between Giyani and Phalaborwa, using "Google Earth" or "landsat" images. There are now regions in the Limpopo Province of South Africa where as much as 10 tonnes of mopane wood is being harvested per day. Much of this harvesting is being done in a secretive way and the total impact is unknown. Unfortunately some of the trees that are being removed are more than 100 years old and they are being removed in a way which will lead to the death of the roots because they are being taken out at waist height, knee height or ground level and any shoots may be eaten by goats (see Figure 2). This leads to the loss of browsing for herbivores and the loss of a sustainable source of fire wood, building material and curios for example. It also contributes towards global warming through deforestation and carbon dioxide production.

The problem is serious, because one of the major reasons for wood harvesting is to provide fuel for cooking fires in the city of Thohoyandou, one of the poorest cities in South Africa. Wood fires are traditionally used for cooking and many people are making a living out of the harvesting and sale of wood since viable alternatives to this fuel are not readily available. A "traditional Western conservation" solution to this problem could be to prohibit the harvesting of wood, and this has been done in certain areas. One of the results is to drive the harvesters underground. The IKS reality is that wood is needed and harvesting will continue, so a negotiated solution is required. If one starts to think of the problems associated with reforestation that could be needed after extensive damage has already occurred, it becomes obvious that the best solution is to limit the damage to the trees by using appropriate coppicing practices. To replace mopane trees after the damage is done, it could take at least 10 to 20 years before the new trees could carry a caterpillar crop, but the affected communities would not want to wait that long. In contrast, by saving the existing trees through the use of appropriate coppicing heights, not only will wood be regenerated, but *masonja* as a food source can also be conserved and utilised while new wood is growing.

Evidence of problems and possible causes

Evidence of the unsustainable use of trees (deforestation) comes from various sources such as visual observations (e.g., Figure 2), sale of wood at the roadside, public notices discouraging deforestation, newspapers and satellite images from "landsat" and "Google Earth". One of the causes of deforestation is the reallocation of woodland to agriculture, but much of the deforestation leads to bare land with little use in this arid part of the world where any agricultural production is restricted by low rainfall and the general lack of water. Evidence of decline in the edible insect industry comes from increased commercialisation (Kozanayi & Frost, 2002) and the reduced availability of prepared products and the fact that there are regions where the edible insects used to occur where they no longer occur. In one case they have not been collected for about 20 years. Another problem is the harvesting of immature caterpillars which are often found at the markets. Harvesting of immature caterpillars increases the load on the populations because it increases the harvest time and this increases the possibility of local extinctions. In Zimbabwe there are reports of the non-availability of insects in traditional harvesting areas leading to pressure to harvest in national parks (Koro, 2002). Over and above these problems, there are natural fluctuations in populations and the harvesting of these resources will have more severe consequences during a drought or any period when there is a natural decline in the population. Once a local extinction has occurred, reintroduction of caterpillars can potentially take place, but only after the appropriate stock becomes available and the local communities are ready to participate. An appropriate community-based education programme on culturally acceptable methods of sustainable harvesting is a prerequisite.

What is an appropriate coppicing height?

As an alternative to destructive harvesting of the trees, in which deforestation occurs, it is possible to coppice the trees and leave the trunks to produce new growth. Some evidence of this alternative exists in our research but further investigations are needed. It appears that there is little knowledge about coppicing heights in IKS and insufficient research to come to any conclusion in Western science (Kaschula et al., 2005). In the affected communities there is an obvious problem and a need for a quick solution. It may take many years to investigate this problem with slow growing trees in Western science, but guidelines are needed now and African science can be expected to produce guidelines for this urgent African problem. It is proposed that a "guestimate" should be used as a preliminary recommendation and that this could be modified as research results become available. It is proposed that this is a legitimate process in African science, where solutions are required by the people now and refinements can, and should, come later. It is obvious that cutting the trees down at waist height or below leads to browsing by goats which will lead to the death of the tree. Thus, the coppicing height needs to be above the height at which goats can browse. For the good of the tree, it is probable that the higher the coppicing the better. However, there is also a need to consider the reality of the needs of the harvesters. Anything above 2m would be difficult to manage. For this reason it is tentatively proposed that the coppicing must be done as high as possible, preferably at least 2m from the ground. This is a legitimate process in African science because in African science there are no non-interpreted facts (Wallner, 2005, p. 51). In African science the consequences of this proposal could be observed, but only if it was accepted by one or more communities. In Western science more research would be needed to find a more precise optimal coppicing height, but what is really needed is a guideline more than a fixed researched result which would differ in different regions with different environmental conditions.

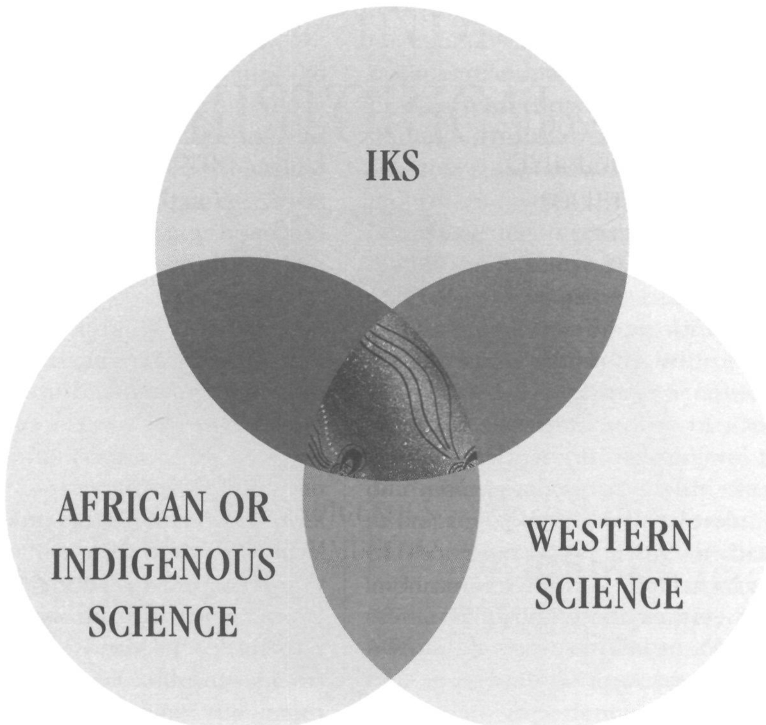
Different IKS in different communities and different regions

During our research we have found that different communities have different IKS. In some communities in the Limpopo Province of South Africa the life cycle of *masonja* is well understood, and the knowledge of the life cycle corresponds strongly with the life cycle as understood in Western science. However, there are also areas where the majority of the people, including science and biology teachers, did not know or understand the implications of the life cycle of the mopane worm (Toms et al., 2003). Recent surveys have shown that there are regions where more than 90% of the learners we questioned did not know this life cycle. This was especially surprising because this caterpillar forms the basis of a multimillion rand industry. This illustrates the point that different people can have different IKS, even though they may live in the same region or the same community. For example, a biology teacher at Phalaborwa (on the border of the Kruger National Park) in the Limpopo Province, who did not know the life cycle, failed to associate the moths with *masonja*. She had no idea that the moths had to lay eggs for the *masonja* to be able to emerge. Although she also likes to eat *masonja*, she regarded the large mopane moths as an annual nuisance and used an aerosol insecticide on them when they entered her house. Later in the season, she wondered why the *masonja* crop on the mopane trees in her garden was so poor. If the trees in your garden do not yield an adequate crop, or if the *masonja* have been absent for several years, the next step could be to cut the trees down for fire wood. The fact that this biology teacher did not see the connection between the different stages of the life cycle clearly illustrates some of the potential advantages of our research and the feedback to the communities. When human populations and utilisation levels are or were low, it is/was easy to live in harmony with nature because many of the IKS beliefs are/were in harmony with nature. Those parts of the IKS that were not sustainable did not matter because the population pressures were low and this allowed nature time to recover.

However, there are now cases where certain practices are not sustainable or in harmony with nature. In the case of the mopane worm mentioned above, knowing that the moths are an essential part of the life cycle, and that they only live for a few days, people must be encouraged to conserve them. Thus, a combination of IKS, African science and Western science can contribute towards a sustainable solution for this problem. Similarly, the deforestation of parts of the Limpopo Province is by no means sustainable or harmonious with nature, there is a challenge for IKS, African science and education using IKS to conserve the natural resources and restore the harmonious relationship that existed in the past. In regions where the life cycle is not known, and the implications of the life cycle are not understood, various myths and legends may exist, and some of these also have positive or negative implications. One of these is the myth that when the caterpillar buries itself in the ground (to pupate) this is part of a death process (Toms et al., 2003). If the caterpillars die when they bury themselves there is no reason to hold back with the harvest and any caterpillars left in the trees will die. This myth can directly lead to over-harvesting. If all the caterpillars, or any other stage in the life cycle, are harvested, the life cycle will be broken and a local extinction can occur.

Science and IKS in sustainable harvesting

It is essential to know about the life cycle and metamorphosis of *masonja* to understand the consequences of the life cycle for any form of heavy sustainable utilisation. Knowledge of the life cycle is part of the IKS (and African science) of certain

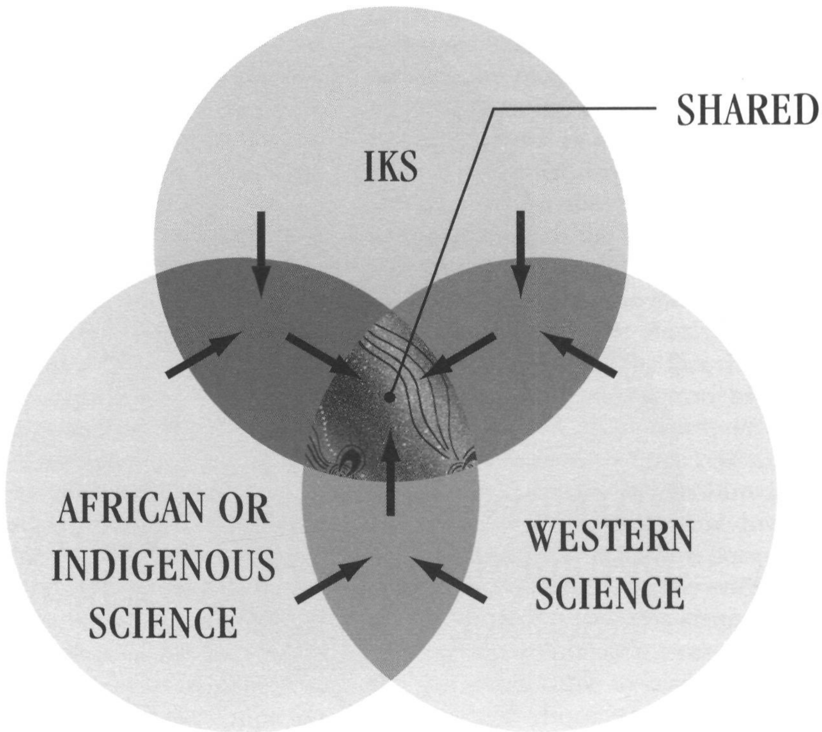


OVERLAP BETWEEN IKS,WESTERN SCIENCE & AFRICAN OR INDIGENOUS SCIENCE

Figure 3. Diagram suggesting that there is overlap between IKS African science and Western science.

communities, so teaching people about the life cycles is teaching them about the IKS and science of other communities. This knowledge is seen as part of both the domains of African science and Western science, so it exists in the region of overlap between science and IKS. In our research we have found that people make observations and may have testable hypotheses, even when they are untrained in Western science. We know of instances where the grandmother shared life cycle information with her descendents so this can be seen as part of African science. However, since some of the observations and conclusions are also indistinguishable from Western science, they belong to the area of overlap between African and Western science with IKS. The area where IKS, African science and Western science overlap is an important area where consensus exists. As a result of the process of learning from parents and grandparents, testable hypotheses can be obtained which are verifiable by observations. These observations are open to further investigation which can lead to results and interpretations that may be identical to those which could be obtained by using Western science. For example, although many people in the Limpopo Province are not aware of the life cycle of *masonja*, or the implications of this life cycle for sustainable harvesting, some of the people we interviewed are actually aware of the life cycle. Some people obtained this information from their parents or grandparents. One respondent who obtained the information about the life cycle from his parents or grandparents was asked if or why he believes the information he received. He replied that at first he was sceptical, until he verified the hypotheses by observation. This methodology corresponds with the hypothetico-deductive method of Western science where a hypothesis is tested by observation.

When I started this research I expected to find that many or most of the teachers would have learned about the life cycle of Lepidoptera at school. To my surprise I found that few of the people interviewed learned about the life cycle and metamorphosis of *masonja* at school. This is indicative of a deficiency in the school education system in South Africa where local information or examples are rarely used. It is suggested that the use of alien species, such as the Chinese silk moth, in African text books has been problematic because learners and educators may wonder what the relevance of this is to their circumstances (Toms, 2005, p. 267). In our investigations, we have found that some biology and science teachers also did not understand the life cycle.



OVERLAP BETWEEN IKS,WESTERN SCIENCE & AFRICAN OR INDIGENOUS SCIENCE

Figure 4. Diagram suggesting that the shared areas between different spheres can be added to from external systems.

Quite often learners are taught by educators who are not biology teachers and this may create further problems. We are recommending that culturally important insects such as *masonja* should be used in the teaching of life cycles, sustainable harvesting and other areas of study including mathematical examples.

The relationship between Western science and African science

In our experience, there is a great deal of overlap between Western science and African science, because most of the objects are the same (see Figure 3). However there are also some important differences. One of the important differences is that Westerners still know relatively little about African science and its achievements. One of the first achievements of African science was probably the earliest controlled use of fire at Swartkrans in South Africa more than one million years ago (Brain, 2004; Brain & Sillen, 1988), or 1,400,000 years ago in Chesowanja, near Lake Baringo in Kenya (Murfin, 1992; Van Sertima, 1983, p. 293).

One of the cornerstones of African science is the harmonious relationship between people and nature (Toit, 2005). However, this harmony (or sustainable relationship) has been disrupted in many ways, changing the relationship and replacing it with an unsustainable discordant alternative. In contrast Western science is characterised by its lack of emotions and its supposed impartiality. In Western science one searches for general or universal explanations and one obtains data by eliminating subjectivity (Wallner, 2005, p. 47). In reality, Western science is not nearly as impartial and subjective as its contributors sometimes pretend, and decisions on the legitimacy of research projects are often influenced by subjective criteria. On the other hand, African science includes people and their culture and is not at all impartial in many circumstances. In all science, culture can influence the methodology, the goals and even the results (Wallner, 2005, p. 47). In African science this relationship between culture and science is openly accepted and even celebrated. African science is devoid of ethical problems because, from the beginning, the aspect of the human being has been included in the process of gathering knowledge (Wallner, 2005, p. 51).

With reference to the research we have done on IKS in nature, which we regard as a contribution to African science, our work on edible stink-bugs (*Encosternum delegorguei*, Family Tesarotomidae) can be used as an example to show how different questions can lead to different results and different conclusions in different frames of reference. The reason we decided to work on these bugs was because they are very important in some cultures. In Venda they are referred to as *Thongolifha* and may be eaten as a meal about once a week when they are in season. People of other cultures may collect them and sell them to the Venda people, and some other groups do eat them. Some traditional healers are also known to use them for medicine. These insects are also harvested in Zimbabwe and Mozambique and exported to South Africa, earning foreign exchange for the harvesters. Knowledge of these insects can thus be regarded as a matter of great importance in IKS and African science.

The fact that no research was done on them before 2003 is an indication of the low priority attached to these insects in Western science where this large green stinkbug is just another stinkbug with no special significance. In fact, stinkbugs are regarded as being repulsive (because of their odours) in many cultures, including Western culture, so this could be a reason to avoid working on them. Some of the analysis we have now done on the nutritional and medicinal properties of this bug utilised African science methodologies and the results we have obtained are exactly the same as the results that would have been obtained in Western science research project (Teffo, 2006). However, the analysis would probably not have been done yet, since this was not a priority project in Western science. To appreciate the differences between our results and the results of a Western science project, (ironically conducted in India) we can refer to research done by Janaiah et al. (1979) on an Indian stink-bug in the same family as the edible African Stink-bug (*E. delegorguei*). When the Indian research was planned, there was no humanistic motive for the research, which was conducted to find out the chemical composition of the scent glands of adults and nymphs of the *Tessaratoma javanica*. The motives for doing the work were devoid of any emotions but perfectly acceptable in Western science. In contrast to this, similar research on edible and medically important insects can be conducted entirely because of its importance to humans. For example, the research we are doing on *E. delegorguei* is being done entirely because of the interest in the nutritional and medicinal properties of these bugs based on their cultural importance (Teffo, 2006; Toms & Thagwana, 2003). Once the results are obtained, it can be argued that they can become part of African science because they were obtained as a result of questions asked in an IKS or African science framework. The fact that some of these results are identical to the results that could have been obtained in Western science demonstrates that there is overlap between IKS, African science and Western science. One of the useful aspects of African science is that it extends the overlap between IKS and Western science (see Figures 3 and 4).

The relationship between African science and other Indigenous sciences

Recent research on the edible caterpillar *dinato* (Sotho) is starting to reveal some interesting features of African science from which principles could be derived. It is now apparent that the same insect can be important in different countries and that there can be different IKS associated with the same insect in different regions. However, the fact that the insect is known by different names in different languages and that the different communities may not be communicating with each other means that the different sets of IKS could not be compared or combined until a way of identifying the insects was found. In our study we managed to match the IKS about *dinato* with the scientific name in Western science, *Cirina forda*, family Saturniidae. This enabled us to establish that the same insect is prevalent in different parts of southern Africa, but is known by different names. The confusion is well known by linguists where *dinato* is often confused with *masonja*. It appears that people in different areas were experiencing different edible caterpillars and were discussing them without a means of positivistic determination of whether they were the same or different. Only in areas where both species were known was it evident that two different species existed, and it was this knowledge that led Jan Legwai to inform me of the existence of a different species of edible insect. This could be attributed as the first step in bringing the IKS, African science and Western science together. This research is now leading to a process of unification in African science in this area. It is also demonstrating that Western science can contribute to the unification of African science and even the unification of IKS, because Western science provides a way of identifying and comparing important insects in IKS, allowing for the IKS to be compared and potentially combined.

An African example of how Western science and IKS can interpret the same phenomenon in different ways is the case of the red locust, *Nomadacris septemfasciata*. In Western science, the red locust is a notorious plague species and an enemy of Western agriculture. It should be eliminated at all cost and the breeding grounds in Mozambique are sprayed every year to try to keep this species under control. In IKS, the same species is seen as a source of free protein and a windfall that can be harvested and stored for winter or sold for cash at the markets. Old people have told me that their mothers used to give them a handful of dried locusts for their lunch when they went to school. Damage to crops would also occur, and this was appreciated, but one could harvest protein instead of the damaged crop, so spraying at great cost would not be regarded as an option.

The validity of different solutions in different systems

From a philosophical point of view, the validity of different interpretations may depend on the eye of the beholder. However, in reality, we are dealing with food security and the sustainability of culturally important natural products. The validity of the process can be determined and measured by the success of the results. In this contribution I have suggested that there is overlap between some of the findings of IKS, African science and Western science. This can lead towards a compromise where consensus is reached in the area of overlap and education can focus on the similarities rather than the differences in different systems. This area of overlap is also the area where there is relatively little controversy, although there may be need for negotiation and discussion to bring more stakeholders on board. The reason for overlap and agreement in certain areas is not surprising. There is evidence that humankind originated in Africa, so all Western science may be based on African science. Furthermore, the problems are the same, so it is not surprising if some of the proposed solutions are the same.

The role of education in sustainable harvesting

The teaching of IKS is now a compulsory part of the South African school curriculum and it is essential to bring IK into the teaching of life sciences. Our work on sustainable harvesting is ideally suited to be used in learning outcomes such as: scientific enquiry and problem-solving skills; life sciences, technology, environment and construction and application of life sciences knowledge. Unfortunately there is little support material for teachers, and this is one of the problems being experienced in the new outcomes based education system (Sarinjev, 2003). However, there is incredible potential to use this work in the teaching of IKS, especially where project work is concerned. The fact that there is little support material means that any Indigenous learners can also take on a dual role of knowledge holders and reproducers by finding and documenting their own IKS. However, Western science and its practitioners need to make space for this, and provide sensitive collaborative support. We have identified a need for posters in the teaching of insect life cycles and sustainable harvesting. This is highly relevant to the people involved in the edible insect industry or as examples for any food security project. It is also relevant to learners who are not directly involved in this industry because our learners are taught a subject called life orientation in which they are required to learn about different cultures. We are developing material that can be used to teach learners about other cultures, the relevance of IKS in sustainable harvesting and food security. They could then look for further examples in their own culture. There is a great need for further development on the nature of IKS. We have started to investigate the IKS of edible insects in Japan and South Africa (Toms & Nonaka, 2005). One of the things I now look forward to doing is to look at similarities and differences between African IKS and IKS from Australia and New Zealand.

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