Individual Identification of Elephants

The Relevance, Need & Importance for Reserve Management

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Abstract

Loxodonta africana (African Savannah Elephant) has faced steep declines in the last years because of numerous anthropogenic threats such as growing pressure from fragmentation and habitat loss, human-elephant conflict and most notoriously, ivory poaching. Yet, in some places like South Africa, fragmented populations have been increasing and thriving since 1992, largely as a result of reserve management. However, given their economic and environmental value, detailed demographic data is invaluable for their long-term monitoring. This is particularly important for reserve management, where elephant conservation persists at an intersection of ethical, social, and animal welfare considerations, financial and economic prospects, land availability, and ivory poaching.

Photographic capture-recapture sampling methods, in which individual animals are photographed and individually identified by their physical markings, have emerged as a powerful and reliable approach to monitor animal populations. The System of Elephant Ear Pattern Knowledge or SEEK code, established by Elephant's Alive, is one such photographic capture-recapture sampling method, in which a code is used in conjunction with photographs to identify individuals. The code helps with individual identification in numerous ways: firstly, by standardizing and describing features as specifically as possible it reduces observer bias, secondly, as the code is a description of an individual elephant, in shows the observer what to look at, thereby improving the practical discernment of elephants in the field, and thirdly, the code provides a 'label' by which individual elephants can be searched by in an elephant data base.

This report includes a case study in which nine research volunteers were involved to establish a database for elephants of the Kariega Game Reserve, using the SEEK code method for individual identification. Despite the use of the SEEK code, considerable ambiguity existed when it came to understanding of terminology, most notably between the differences of nick and a notch. Additionally, the code lacked a term that provides information on the magnitude of the identifying features observed on the ears of elephants. Both these factors are important, considering that in African Savannah elephants', accurate identification of the ears is highly crucial and is probably the most useful trait for identification. This report, thus, revises terminology used in order to reduce equivocations, and makes a suggestion that could benefit the practical utility and robustness of the code in the field through the addition of a term that provides an indication of the magnitude of the identifying features observed on elephant's ears.

1. Introduction

Loxodonta africana or the African savannah elephant is one of the three extant sub-species of elephants that are found in the wild. Throughout Africa, this species' population has been declining primarily due to poaching for ivory (Chase et al., 2016; Schlossberg et al., 2020). A 2014-2015 survey revealed that *Loxondonta africana* numbers have declined by 30% in just 7 years, an estimated loss of 144,000 individuals (Chase et al., 2016; CITES, Nov 2021). While overall *Loxodonta africana* populations have suffered in recent years, the status of individual populations varies substantially (Chase et al. 2016). This is most notable in Southern Africa and in particularly South Africa, where populations have grown steadily since 1992 (Hall-Martin, 1992, Slowtow et al., 2005; Chase et al., 2016).

1.1. Importance of Long-term Monitoring

The African savannah elephant (hereafter referred to as elephant) lives on average more than 60 years, and so it is apparent that long term studies are necessary if we are to really understand their life histories. Short term studies, even if conducted in the most comprehensive way, can only provide a snippet of information of an elephant's eco-physiological requirements, behavior, cognitive abilities and responses to stress (Fritz, 2017), which are important animal welfare considerations (Broom, 1991; Dawkins, 2004). Similarly, information on social and group dynamic changes, population fluctuations, and demographic parameters can also not be derived from short term studies (Fritz, 2017). This vulnerable species also has many anthropogenic threats to contend with during its struggle for survival such as growing pressures from fragmentation and habitat loss, the detrimental consequences of human-elephant conflict and the harvesting of ivory (Wittemyer et al., 2014; Chase et al., 2016; Schlossberg et al., 2020). Thus, in order to understand the impact of these pressures on animal welfare and elephant conservation in-depth, long-term monitoring of elephant populations is required (Fritz, 2017).

1.2. An Elephants Footprint

Elephants play a keystone role (Bond, 1994) across the diverse habitats they inhabit by creating microhabitats (Pringle, 2008), impacting plant and animal biodiversity (Kerley & Landman, 2005; 2006), influencing canopy cover (Mapaure & Campbell, 2002), affecting species distribution (Nasseri, 2009), and in seed dispersal (Blake et al., 2009). These impacts are tied to an elephant's feeding behavior. Given the large body mass and in-efficient digestive process, elephants require copious amount of food to sustain themselves (Owen-Smith, 1988; Kerley & Landman, 2006). Coupled with the absence of natural predators, which allow elephants to feed more intensely than other herbivores, and large ranges they occupy (Owen-Smith, 1988), elephants can have a severe impact on the surrounding vegetation and landscape at large (Midgley et al., 2005; Vanak et al., 2012; Morrison et al., 2016; Abraham et al., 2021). Elephants also have significant economic value in terms of their contribution to the tourism industry (Naidoo et al., 2016) and as a flagship species from a conservation perspective (Brown, 1993; Wittemyer et al., 2013). It is estimated that the economic benefits that elephants in protected areas (PA's) deliver to African countries via tourism and to local economies (Saayman & Saayman, 2006) is approximately $25 million annually (Naidoo et al., 2016). Moreover, it is worth mentioning that elephant conservation also provides positive rate of returns, with rates comparable to investments that governments in African elephant range countries make in education (Psacharopoulos & Patrinos, 2004), agriculture (Benin, 2015), electricity (Canning & Bennathan, 2000) and infrastructure (Canning & Bennathan, 2000; Naidoo et al., 2016). Thus, although governments fail to see other important aspects of conserving elephants, it still remains a wise investment from an economic standpoint (Naidoo et al., 2016). Furthermore, elephants also have a substantial contribution through their ecosystem services on carbon sequestration and carbon stocks (Chami et al., 2020). Often this is a challenge, to provide a 'true' monetary value of an animal or a piece of forest in light of its contribution to the ecosystem. Although in most financial and economic prospects, the monetary value of a resource is the foundation on which resource use and allocation, and capital budgeting decisions are made on (Chami et al., 2020), in environmental economics, the question: "whether to expend any resources at all in pursuit of environmental objectives" (Chami et al., 2020), is also of concern. From this perspective, the monetary value of each elephant to the climate crisis through its ecosystem services is $1.75 million per elephant (Chami et al., 2020). Therefore, considering their high conservation and economic value, detailed demographic data is invaluable for their long-term monitoring (Laws, 1970; Wittemyer et al., 2013), and individual identification is one approach by which such high-quality data on demographic parameters can be obtained (Turkalo et al., 2013; Wittemyer et al., 2013; Fritz, 2017).

1.3. The Role and Challenges Reserves in South Africa Play in Elephant Conservation

In South Africa, *Loxodonta africana* historically occupied large areas in the Western and Eastern Cape, KwaZulu-Natal, Mpumalanga, Gauteng, Limpopo and North-West provinces (Hall-Martin, 1992). However, in a span of 268 years (1652-1920), the population was reduced to 120 individuals and to four remnant populations (Hall-Martin, 1992). The decline observed occurred over three main phases. The main drivers responsible for this drop in numbers were increase in human growth and human settlements between 1652-1790, increase in the ivory trade between 1790-1870 and crop protection mortality between 1870-1983. Two decades later, as a result of conservation and management practices (Hall-Martin, 1992), the population substantially recovered (Harries et al., 2008). This is because within South Africa fenced wildlife reserves are extensively used in containing wildlife and have steadily increased in numbers since 1992 (Snijders, 2012; Bates et al., 2018; Blackmore & Trouwborst, 2018). Coupled with an improved ability to capture, transport, contain and manage large mammals in South Africa, and reduced incidences of poaching in Southern Africa (Chase et al., 2016; Schlossberg et al., 2020) elephant populations have grown rapidly in PA's (Slowtow et al., 2005; Pretorius et al., 2019). However, fencing-off of large areas of land obstruct historical movement routes of elephants, natural processes that limit populations such as dispersal (van Aarde et al., 2006) and change the way they use the landscape as fences restrict seasonal movements, increasing their localized impact on vegetation and inter-species competition for resources such as with the black rhinoceros (*Diceros bicornis*) (van Aarde et al., 2006; Landman et al., 2013; Pretorius et al., 2019). Moreover, small population sizes can potentially result in incomplete social structures, which have been shown to cause behavioral abnormalities such as hyper-aggression (Slowtow et al., 2000). Hence, fenced reserves, although beneficial to elephant conservation in the light of poaching, human elephant conflict and disease control (Anthony & Avery, 2008), are not only vulnerable to steep increases in elephant numbers (Mackey et al., 2006) but also gives rise to non-natural distributions, resulting in unique management problems for which elephant populations need to be managed and controlled (Harris et al., 2008; Pretorius et al., 2019).

2. Individual Identification

2.1. Is Individual Identification Always Required?

The answer that will determine if individual identification is the right approach is based on how well one needs to get to 'know' an elephant population. If the goal is to find out rough population estimates, general feeding preferences, habitats they occupy or habitat use, methods involving aerial counts, radio tracking or ground transects may be suitable enough (Moss, 1996). However, if one wants to reliably estimate population sizes, understand and describe social structure, behavior, demography, it will require the researcher to get to know the elephant population at an individual level (Moss, 1996).

2.2. Importance and Need

There is an increasing need to reliably estimate population sizes, and more so for reserves (Mackey et al., 2006), so as to (1) inform managers when a system is deviating from a desired state, (2) to measure management effectiveness and (3) to detect the effects of disturbances to a system (Nichols & Williams, 2006; Goswami et al., 2012). However, estimating population size and demographic parameters is challenging, particularly in dense habitats (Caro, 1999). Usually, typical mark-recapture methods are employed in which an individual is trapped, marked and subsequently released (de Silva et al., 2011). Such methods though can have associated consequences for an animal with the potential of causing injury (Mowat et al., 1994), disrupting an animal's activities and relationship with others (Cuthill, 1991), affecting its behavior and physiology (Hindell et al., 1996), and can even effect survivorship (Daly et al., 1992; Kelly, 2001). Moreover, for cryptic species such as felids (Karanth et al., 2006) or for large, endangered mammals that are difficult to tag such as elephants (de Silva et al., 2011; Goswami et al., 2012), non-invasive methods are preferred (Kelly, 2011; Goswami et al., 2012). Photographic capture-recapture sampling methods have emerged as a powerful and reliable approach to monitor such animal populations (Williams et al., 2002; Amstrup et al., 2005; Goswami et al., 2012). Under this approach, individual animals are photographed and individually identified by their physical markings (Alonso et al., 2015). Once they are photographically captured, they are considered 'marked' (Alonso et al., 2015). Though, identifying individuals based on their physical characteristics is a well-recognized field technique (Pennycuick, 1978; Vidya et al., 2014), these variables differ in temporal variation and conspicuousness, two factors that need to be considered to reliably identify individuals (Vidya et al., 2014). In elephants, photographic records have been used to identify and match individuals since 1972, but this largely depended on manual techniques which is not only time consuming but also highly prone to error (Kelly, 2011, Bedetti et al., 2020). Although, alternative techniques using automated software to run photographic identification of elephants is fast gaining momentum such as in the case of white sharks (Towner et al., 2013), these techniques still require time and development (Weideman et al., 2020).

The effectivity of using individual identification lies in that beyond being able to recognize individuals to make population abundance estimates (Whitehouse et al., 2001), it can provide data on processes that mediate population size such as growth through natality and immigration and loss through mortality and emigration (Wells & Scott, 1990). Furthermore, detailed understanding and investigation into aspects such as rearing young, mating and courtship, reproductive success (Delany, 1978), territoriality, social behavior, hierarchy and structure (Wittemyer et al., 2005; Murphy et al., 2020), ecophysiology and cognitive abilities (Fritz, 2017) require accurate identification. Additionally, factors influencing decision making and movement patterns (Fritz, 2017), or targeting individuals for specific conservation and management practices such as administering contraception (Garaï et al., 2018) and translocation, or in identifying the "Damage Causing Animal" in a human-elephant conflict scenario also requires individuals to be identified (Turkalo et al., 2013; Wittemyer et al., 2013; Vidya et al., 2014; Bedetti et al., 2020). Some of the most comprehensive and highest quality monitoring data on demographic processes occurring across populations of elephants comes from long-term studies on individually identified elephants (Turkalo et al., 2013; Wittemyer et al., 2013; Fritz, 2017). For example, Turkalo et al., (2013) could show that over the course of 20 years, the sex ratio of adult elephants visiting a clearing in Dzanga Bai, in the Central African Republic, was significantly skewed towards females, with a substantial increase from 56% to 70%. Although the number of elephants visiting the clearing remained roughly similar over the course of 20 years, the change in sex ratios observed was due to the effects of poaching for which males were targeted more frequently (Lee & Moss, 1986; Poole & Thomsen, 1989; Turkalo et al., 2013). Furthermore, Turkalo et al., (2013) could also show that of the ~1700 individuals visiting the clearing each year, 40% were the same migrants that visited each year; with such consistent immigration patterns not previously recorded for savannah elephants (Moss, 2001; Wittemyer et al., 2013). Similarly, Wittemyer et al., (2013) could show the impact of drought on elephant recovery. The acute drought in 2009-2010 experienced in Samburu and Buffalo Springs National Reserves in Northern Kenya, caused life expectancy declines of approximately 20 years in mature adults. In addition to this being unexpected given the drought resistance of mega-herbivores (Owen-Smith, 1988), the impact of drought intensified due to the long gestation period of elephants. Thus, although the drought occurred in one year, its impacts on population growth lasted 2-3 years (Wittemyer et al. 2013). Furthermore, Lee & Moss (2011) showed that cow mothers that experienced drought when their calves were younger than 2 years, showed shorter than average time to their subsequent conception, an adaptation likely to be due to the greater risk of losing calves to poor body condition. On the contrary however, mothers that did a lose a calf to drought delayed conception, presumably to recover body condition (Lee & Moss, 2011). Like these, there are numerous examples of long-term studies on individual elephants that have provided social, ecological, eco-physiological, emotional and cognitive context into an elephant's life (for more information see Turkalo et al., 2013; Wittemyer et al., 2013; Fritz, 2017).

2.3. Individual Elephant Coding System

2.3.1. Practical Use and Effectivity

For African Savannah Elephants, the System for Elephant Ear-Pattern Knowledge (SEEK) has been developed by the South African Non-profit organization Elephant's Alive, to help identify individuals (Bedetti et al., 2020). SEEK is a code that constitutes of six elements: the animals' sex, age-class, tusk feature, ear feature, extreme feature and special feature (Bedetti et al., 2020) (see section *Elements of the Code*); with ear-feature being the most descriptive part of this code as it is the most reliable trait in identifying individual elephants (Douglas-Hamilton, 1972; Croze, 1974; Bedetti et al., 2020). Although, a simple coding system has been in use since 1996 which depended primarily on detailed ear drawings done in the field (Bedetti et al., 2020), this system has been refined over time to reduce observer bias, as identification is dependent on the accurate determination of the markings observed by the observer and on the quality of photographs taken of the individual (Bedetti et al., 2020). As a result, only the position of five distinguishing features on the right and left ear are required for identification as opposed to more detailed shapes that were previously involved in determination. These elements are limited to tears, notches, nicks, holes and pinpricks (Bedetti et al., 2020). Thus, one of the strengths of using the code lies in that the code improves the identification by standardizing and describing features as specifically as possible. Another benefit of having a code is that it shows the observer what to look at. This is in contrary to just having a picture, as the code shows the observer or draws the observer's attention to the defining features of what makes a particular individual unique. Not only is this practically useful in the field, but it also helps in confirming identification in times of a possible resighting (Bedetti et al., 2020). Furthermore, the code is also helpful considering that physical features are temporarily variable (Vidya et al., 2014). For example, the loss of a tusk of a bull during a fight, is this bull with one tusk missing a new individual or a resighted individual? The code helps to solve this question as only if three different features can be matched, can that individual be classified as a resighted individual, or a new individual (Bedetti et al., 2020). Another benefit to having a code in contrast to the challenges of organizing and managing large quantities of photos, and trying to match these photos to the individuals, is that it helps in organizing and storing data on each individual through the development of a rather simple SEEK coding database. This can be done on Microsoft Excel for example. Once an elephant is coded, its code and detailed drawing are added to the coding library database (Bedetti et al., 2020). In this way, individuals of interest can be looked up quicker as they have a label (the code) by which they can be found, thus the code functions as a search tool. Furthermore, individuals that need to be updated either because they gained an additional tear/hole/nick/notch/pinprick or have accrued an additional mark as a result of injury, or that a feature was not observed before on the ear because for example, the ear was covered in mud, the code of that individual can easily be found in the database and updated, which is much more challenging if you only have a photo library of that individual. Lastly, if for some reason the left ear of the elephant is covered by vegetation and the elephant escapes out of sight after, it is possible to replace part of the code by question marks. These question marks can also be filtered and looked up, allowing information to be added to the missing parts of the code at a later stage and for easy comparison between two individuals with question marks in the same part of the code when confusion arises (Bedetti et al., 2020).

2.3.2. Elements of the Code

The identification code as provided by Bedetti et al., (2020) (see figure 2), with an example of an individual facing the observer, with corresponding code (see figure 1):

Figure 1: Individual: Vula, an adult male.
ID code: BAT11E9090-3030X00S001

Six feature blocks comprise the code which is used to identify each individual. The SEEK ID code has no spaces, and it contains six letters: C/B stans for bull/cow, C/J/I/S/A stands age class category, T stands for Tusk Feature, E stands for Ear Feature, X stands for Extreme Feature, and S stands for Special Feature. The first two locations provide information on the gender and age class of the individual in question. The next block is the tusk feature and provides information on tusk characteristics: whether they are present or absent and on length differences between the two tusks. The ear block comprises four locations for the right and left ear respectively. The first location stands for the position of the most prominent tear, the second for the most prominent hole, the third for the second most prominent tear and the fourth for the second most prominent hole. A tear, although in terminology it is identified separately, in the code, it constitutes a tear, notch and a nick. Whereas a hole constitutes a hole and a pinprick (see Table 1). The position of these identifying marks is determined based on their location in the imaginary clock diagram. This clock diagram can be visualized as follows: the frontal head is 12 O'clock, and the trunk is 6 O'clock. For the elephant's left ear we distinguish 1, 2, 3, 4 and 5 O'clock, and for the elephant's right ear we distinguish 7, 8, 9, 10 and 11 O'clock. As a point of reference, 3 and 9 O'clock start at the widest part of the ear, the rest are mere estimates that one will get familiar with practice. It also good to note that if an identifying feature is located at 10 and 11 O'clock, the code for the ear-feature block will constitute of 5 digits as opposed to four. The extreme feature block only comes to use "if a tear or hole extends ¼ or more in length towards the inner ear and/or is ¼ of the total ear margin width" (Bedetti et al., 2020). The last block provides information on special features. Special features provide information on any ear or body deformities that are observed. These could include permanent scars, significant tissue growths, skin issues such as warts, wavy ear, floppy ear, jagged ear, protruding veins or any marking at the back or on top fold of the ear or missing or deformed tails (Bedetti et al., 2020).

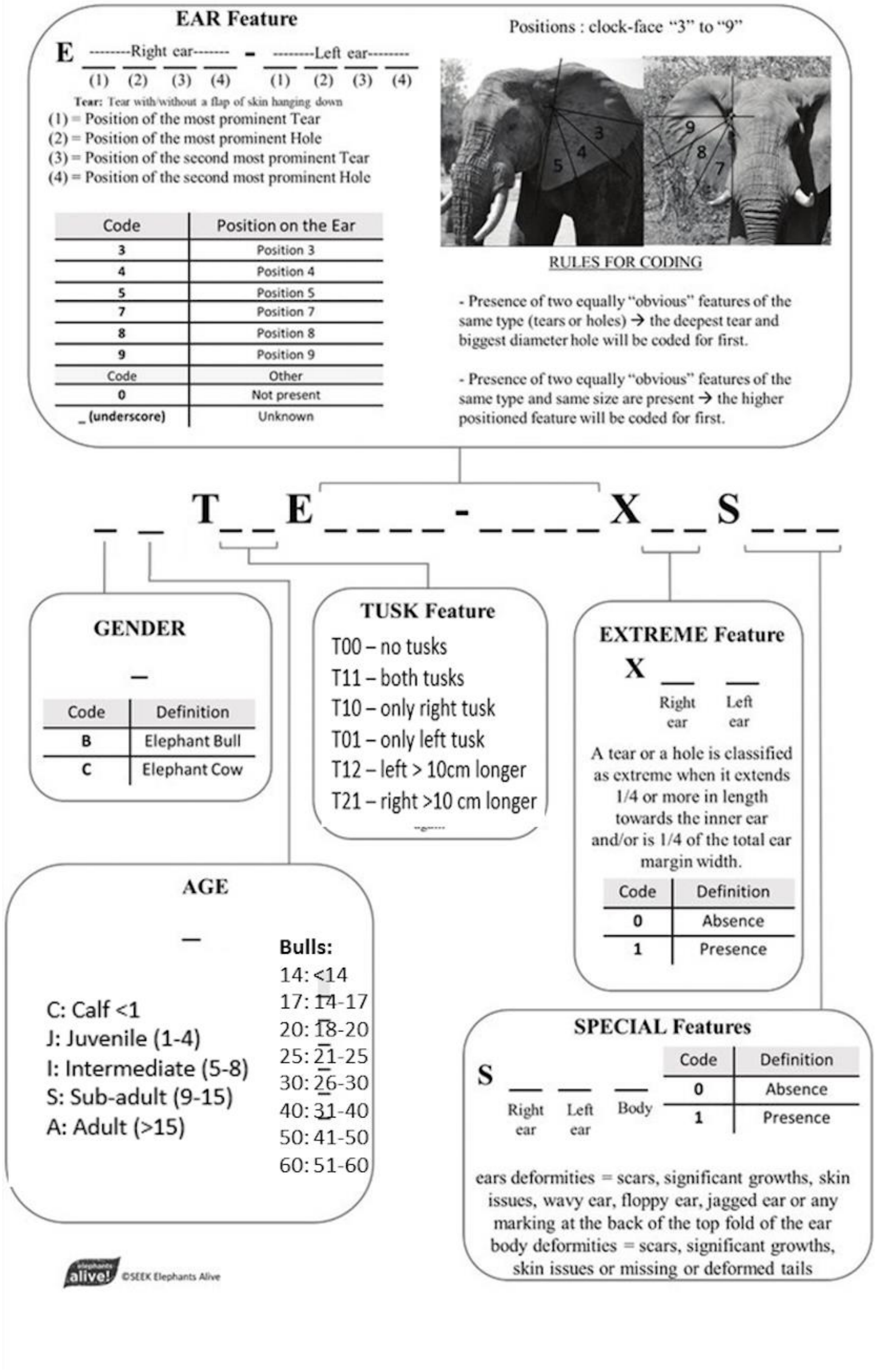


Figure 2: Detailed description of each element in the SEEK elephant identification code as adapted from Bedetti et al., 2020. Adaptations have been made to the code as there are fewer individuals at Kariega Game Reserve in contrast to the study site of Bedetti i.e., Associated Private Nature Reserves (ANPR). Furthermore, the age categories were simplified to align with Kariega's classification of its elephant population. And lastly, as we noticed variation in tusk features, additional categories were added.

Table 1: Identifying marks that constitute the ear feature block with their definitions (as described by Bedetti et al., 2020).

Ear-Feature Element	Definition
Tear	A cut in the ear where the part of the ear that has been cut has become a flap of skin that is dangling from the ear
Notch	A cut in the ear (i.e., a tear) but where the dangling part of the skin is absent
Nick	A notch that is very tiny and often not visible without binoculars.
Pinprick	A very small hole in the ear that is often not visible without binoculars. Holes that are visible without the use of binoculars are just called holes

2.3.3. Methodology: How to collect data?

Requirements:

- Pencil/Pen
- Two types of data sheets A1 (ID code sheet) and A2 (drawing sheet)
- Binoculars
- Camera for detailed photographs
- Paper clips

Elephants are approached in a quiet and respectful manner. Instead of forcing a clear sighting, wait at a safe distance at the intersection of their anticipated line of movement instead of pursuing them (Bedetti et al., 2020). Identifying individuals is best done in groups of three due to the erratic movement of elephants. Records of individuals animals sighted are collected by taking detailed photographs of the distinctive pattern of tears, holes, nicks, notches and pinpricks encountered, plus any other identifying features on the elephant's body (Bedetti et al., 2020). This implies that good and clear photographs of the frontal head (and if the situation allows with ears open wide), the tusks, the left and right ears (including behind the ears if f the natural conditions allow), the left and right side of the body and the tail are required. The sex and age are determined in the field (Bedetti et al., 2020). Whilst photographs are being taken by one person, two other individuals create detailed sketches of the identifying features observed and develop the code. Once the individual elephant has been determined, it is useful to take separator photos of other objects besides elephants before moving on to the next individual as this helps with processing and sorting photos per individual for identification later (Bedetti et al., 2020). However, it is recommended that the separator photos taken is of the data sheet that contains the identification code. Furthermore, it is crucial, once the code has been developed, that the same code is written on both data sheets so that in the unlikely event that one data sheet ends up in a different pile, they can still be corroborated together and added to the same file in the database. Lastly, when back at base, the photos need to be sorted and the identification code developed needs to be re-evaluated with the photos taken of the individual. This can best be done in groups of three so that any questions or confusions that may arise can be decided together, reducing the probability of error and observer bias that may be encountered (Bedetti et al., 2020).

3. Case Study: Application of the SEEK ID protocol to elephants in Kariega Game Reserve

3.1. Kariega Game Reserve

Kariega Game Reserve (KGR) falls within the Thicket Biome, also referred to as The Albany Thicket Biome. This biome is thought to contain the most species-rich formations of woody plants in South Africa, and is characterized by sparse to dense, spiny, evergreen shrub vegetation, with a tree component of varying proportions. KGR is a 10,000-ha reserve in the Eastern Cape of South Africa (figure 3). This reserve is home to the big five, which includes the African Savanah Elephant (*Loxodonta africana*), which is the focus of this case study. The reserve is divided into four sections: West, East, South and Haverstvale, with approximately 72 elephants located in the West and Haverstvale sections of the reserve. There are two public roads, one dividing the East from the rest of the Reserve and one between the South and the West, and Havestvale. The reserve aims to connect the West and Havestvale sections within the next 6-9 months. Until now, this has not been possible, because there is a public river between these two sections which lions are not permitted to cross without the river being fenced. However, the reserve has acquired the necessary permits and are currently conducting a public participation process in the surrounding communities, two criteria that need to be fulfilled before the internal fences can be broken down and that would allow wildlife to openly access the river.

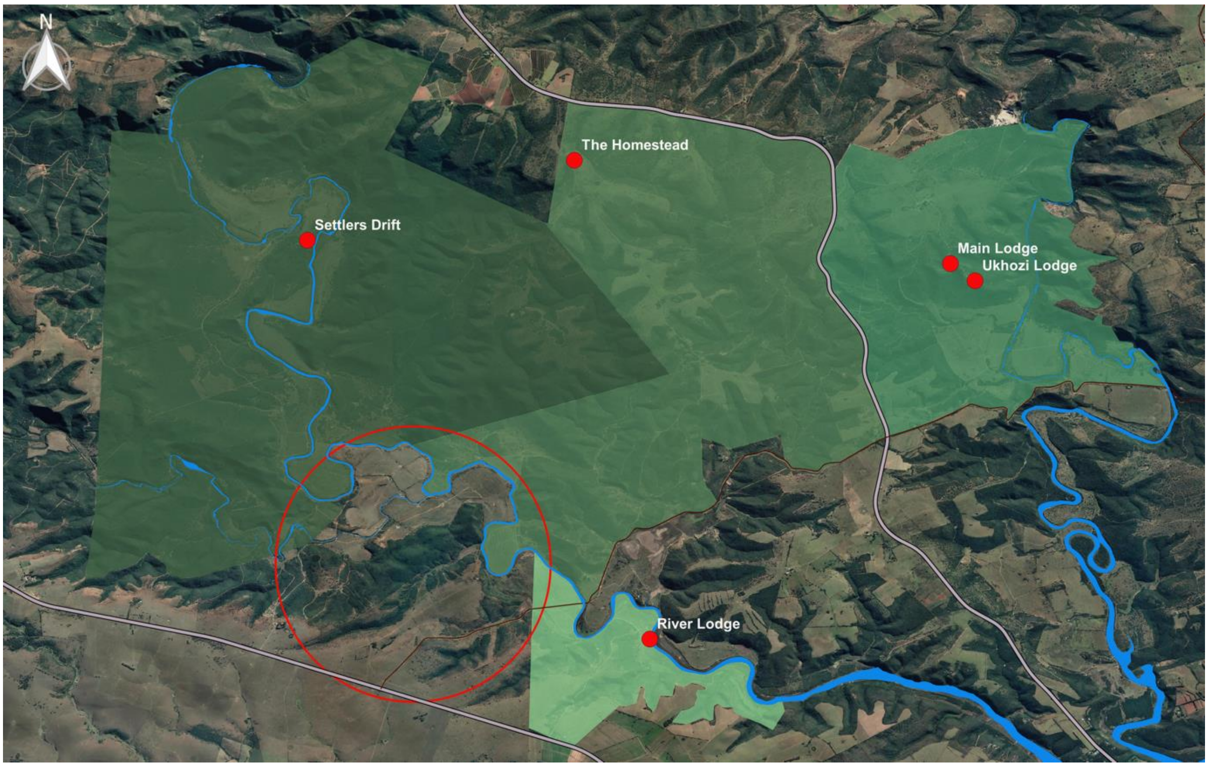


Figure 3: Overview of the Kariega Game Reserve

3.2. Context to the Project

In Southern Africa, and in particularly South Africa, the approach to wildlife conservation involves the fencing-off of large areas of land (Snijders, 2012). As elephants require a large amount of space and have significant short and long-term impacts on their environment (Guldemond & Van Aarde, 2007; Harris et al., 2008; Whyte, 2003), they pose a significant challenge from a management point of view. However, in order to make informed management decisions such as the administration of contraceptives or translocations, an in-depth understanding and knowledge of demographic data at an individual level is required (Henley, 2013; Fritz, 2017; Bedetti et al., 2020).

In order to better understand the population structure of elephant herds in Kariega, KGR management would like to develop a comprehensive population register. This register would describe key individual role players and their position, known history and associations from which ultimately an identification (ID) kit would be created by which each individual can be distinguished.

Figure 4: Kariega Game Reserve (Photo credit: Jorian)

3.3. The Problem

Currently, there are no photographic records of each individually identified elephants in Kariega Game Reserve. Yet, from a conservation point of view, the reserve needs to make critical decisions with regard to their management – such as administration of medical treatment and contraceptives, and translocations as part of maintaining genetic diversity. On the other hand, the reserve also needs to take animal welfare into consideration (Department of Environmental Affairs and Tourism: National Norms and Standards for the Management of Elephants in South Africa; Singh et al., 2020; Wiggins, 2021), for which behavioral studies assessing social and group dynamic changes in response to re-introductions, breaking down of internal fences that would allow two populations to interact, stress behavior in response to tourism or the identification of an elephant as so-called "Damage Causing Animal" is of significance. However, since elephants have a high level of cognitive ability, long-term studies on individual elephants are required to show how individual experience, knowledge, behavior and social status develops, changes and interacts with the environment (Fritz, 2017).

For identification, comprehension of terminology and the ability to practically discern identifying features in the field, were the most frequently expressed challenges by the researchers. Furthermore, the code lacked a term that provided information on the magnitude of 'damage' (notches/nicks/tears/holes; refer to Table 1 for detailed definitions) of the identifying features observed on the ears of individuals.

3.4. Methodology

Individual elephants were identified using the System for Elephant Ear Pattern Knowledge (SEEK), a code developed to aid photo-identification studies (Bedetti et al., 2020). The identification was conducted by a group of nine research volunteers from Bring the Elephant Home (BTEH), in collaboration with the Kariega Foundation. A total of 36 individuals were successfully identified over the course of three weeks, comprising of 16 males and 20 females, each with their own complementary photographic record.

3.5. Solutions

3.5.1. Building a SEEK coding database

A SEEK coding database was developed for individually identified elephants in KGR in Microsoft Excel. To start with, this database comprised the identification code, the search tool by which individual elephants could be looked up using the filter function in Microsoft Excel. The database contains a more detailed description of the identifying features that comprise the identification code and other information relevant to that individual (see the list below: Other information included in the database). Each elephant identified also has a unique hyperlink that takes the researcher to the photo-library folder of that specific elephant, which includes the identification sheets used in the field. Following on from this database, a personal profile of each elephant was also made to assist with identification in the field.

Information the database includes:

- Date of last sighting
- Name
- ID code
- Seen with/relationship to other elephants: this section provides insights into group patterns and structure as observed in the field.
- Estimated Age/Date of Birth
- Age Class
- Comment on tusks: detailed description of tusk features
- Comment on ears: detailed description of ear features
- Comment on body: detailed description of body features, including the tail
- Other comments
- Characteristic features/patterns or in other words, identifying marks
- Images: this contains a link to the photo library
- Questions: this contains any queries that someone may have on that specific individual

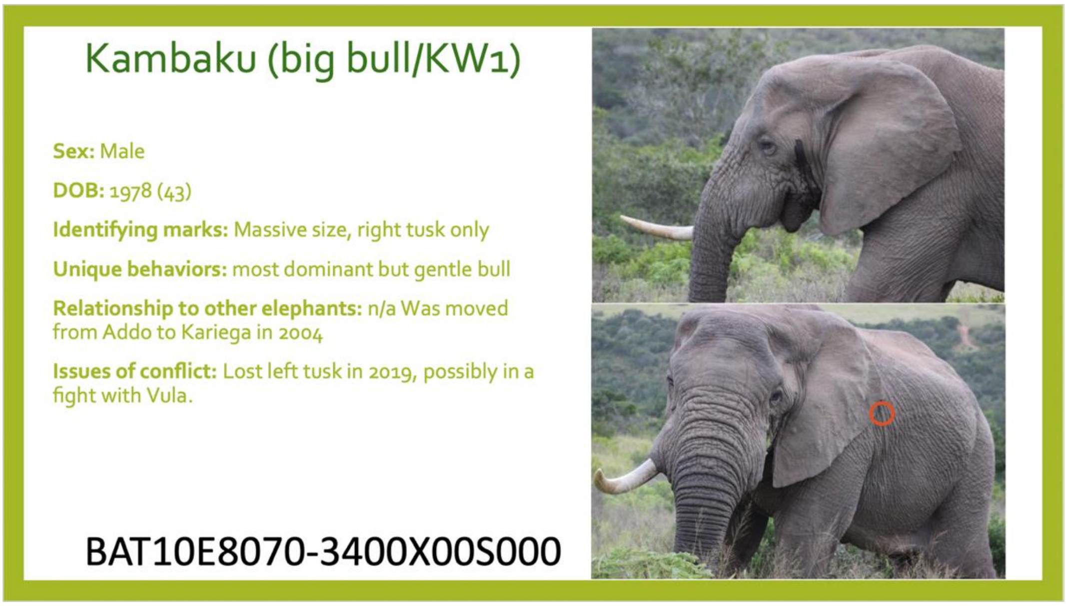
Ideally speaking, we hope that this database can include information that can assist and aid management in decision making such as which females have been administered contraception, which male has been showing enhanced stressful behavior in the presence of tourist cars, to name a few.

To view the database (which is in progress) see link: SEEK coding database

Lastly, an application is being developed to aid in identifying individual elephants. Although, the application is at a stage where it can be utilized if needed, there are a number of bugs that still require fixing. In order to view the presentation template on how this application works please see link: Elephant ID App.

Personal Profiles

Example 1: Male



Example 2: Female

3.5.2. Improvements to the SEEK code

In African elephants, accurate identification of the ears is highly crucial and is probably the most useful trait for identification (Douglas-Hamilton, 1972; Croze, 1974). It is important to mention however, that it is challenging to use the SEEK code for younger elephants as they often don't have any damage to their ears. In order to compensate for this, we recorded 'seen with' as we could then identify the younger elephants based on gender and age class. Moreover, as infants are associated with their mothers until their juvenile stage, identifying the mother would also suffice to have an 'identity' of the younger individuals. However, in most cases of older elephants, the ears of African elephants are 'damaged'. In other words, they are identified by the location and unique patterns of tears, holes, nicks and notches observed on their ears (Bedetti et al., 2020). Despite these identifying features being described in Bedetti et al., (2020), there was still considerable ambiguity when it came to understanding the terminology provided. This was particularly observed for a nick and a notch - when was a feature considered a nick and when was it considered a notch? Thus, I suggest redefining the terminology of a nick and provide examples to demonstrate the differences.

Re-defining terminology

Nick	A notch that is very tiny, cone-line and narrow in shape. It is only visible with the help of binoculars. Nicks can be visualized as snippets at the periphery of the ear. The rule of thumb is, when the shape of the identifying feature is not cone-line, narrow and shallow, it is not considered a nick.

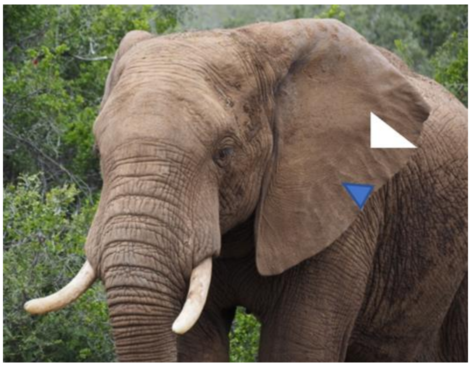
Examples:

Figure 5: Numbers 1, 4, 7 and 9 are considered nicks. They have characteristic appearance and are considered nicks due to their distinctive narrow, shallow, cone-like shape located at the periphery of the ear. The remaining features i.e., 2, 3, 5, 6, and 8 are considered notches. Number 2 is a notch because its shape is not cone-like but box-like.

Although the ability to distinguish a nick from a notch is not of extreme significance as in the code they fall under the same label of a tear, the confusion arises when an elephant's ear looks spotless (i.e., free of tears, notches and holes), but nicks are still present. The question is, if these nicks should be considered at all in the code as first and second most prominent tears if nothing else is present? The answer is yes, as they would still provide some information about an elephant's ears. However, I suggest adding an indicative term to the code for each feature unit to indicate the magnitude of the 'damage' observed, which can best be explained with the help of an example.

Two elephants A and B, with the left ear identification block showing the following two codes: 3040 and 3040, respectively. The 3 indicates that the most prominent tear is located at 3 o clock and that the second most prominent tear is located at 4 o clock. Thus, when we compare two elephants with the same identification code for the left ear, we get the following scenario:

Elephant A:



- Magnitude (size) of the first most prominent tear (white mark): 8 cm long and 6 cm wide
- Magnitude (size) of the second most prominent tear (blue mark): 4 cm long and 4 cm wide
- Hypothetical ID code for the left ear = CAT11E9080-3040X00S000

Elephant B:

- Magnitude (size) of the first most prominent tear (white mark): a nick of about 2 mm long
- Magnitude (size) of the second most prominent tear (blue mark): a nick of about 0.5 cm long
- These nicks are only visible with the help of binoculars
- ID code for the left ear = CAT11E8190-3040X00S000

What we see is that the identification code does not give any indication of the magnitude of the tear or hole observed, although the left ears (3040) of the two elephants being compared are substantially different. As the code shows the observer what to look at in the field in order to make a quick determination of an individual, it is kind of misleading that two elephants with completely different extents of 'damage' on the ears show the same code without providing further insights with regard to the extent of damage observed. In other words, the features of one elephant are more visible and apparent with the naked eye as opposed to the other. In order to resolve this conflict, I suggest adding a superscript term to the top of each ear feature unit that provides an indication of the magnitude of the identifying feature observed, thus, enhancing the code's practical utility in the field and its robustness.

Table 2: Characterization of magnitude of tears and holes.

Holes	Description	Nicks/Notches	Description
1 = small	Hardly visible even with binoculars	1 = small	Hardly visible even with binoculars
2 = medium	Easily noticeable with binoculars and to the naked eye	2 = medium	Easily noticeable with binoculars and
3 = big	Noticeable to the naked eye even from far off	3 = big	Noticeable to the naked eye even from far

Examples:

Figure 6: Indication of magnitude: what constitutes a small, medium or big hole? Left image shows a small hole; the middle image shows a large hole; and for the left image, the left feature is considered a medium hole and the right feature is considered a small hole. The right picture retrieved from: Vidya et al., 2014.

Figure 7: Indication of magnitude: what constitutes a small, medium or big tear? Top left image shows a medium tear; the top right image shows a large notch. For the bottom image, features numbered 1, 2, 4, 5, 7, and 9 are considered small, numbers 3, 6 and 8 are considered medium tears.

Examples of what the improved code would look like for the ear-feature block:

Example 1: ID code for the right ear-feature block:

Hypothetical code is underlined:

$\underline{\text{CAT11E}}9^{3}11^{3}9^{3}0\text{-}\underline{3^{2}04^{1}0\text{X00S000}}$

Example 2: ID code for the left ear-feature block:

Hypothetical code is underlined:

$\underline{\text{BAT10E}8^{2}07^{1}0}\text{-}3^{2}4^{1}\underline{\text{00X00S000}}$

3.6. The strength of individual identification: An example from the field

Early one morning, we were shown photographic evidence of a bull with a severe abdominal injury on the left of his body with internal organs exposed. The puncture was caused by a fight between two males. What was supposed to be a day of data collection i.e., identifying individual elephants, turned into an investigation: Which bull was hurt? And where was it to be found?

That morning the elephant population seemed agitated. The bulls were in musth. Their temporal glands were streaming. During this period of musth, bulls show increased aggressive behavior due to the raging hormones, causing them to fight and challenge each other for potential mates. Behavioral studies investigating different responses of younger and older bulls during musth or the influence of older bulls on younger bulls during this period, are possible only if the individuals are known.

We were unsure how deep the injury was. The reserve was in a dilemma if they should medically intervene or not. This decision came to funding: whether to save this individual bull or invest the resources into elephant conservation? A question of animal welfare vs conservation. However, what would decide this depended on the role this individual plays in this elephant population. A management question that individual identification can help answer.

Elephants have a complex social structure and behaviour (Wittemyer et al., 2005; Murphy et al., 2020), and older bulls play a key role as leaders, in passing down of ecological knowledge to younger bulls (Allen et al., 2020) and in keeping the younger bulls in check during musth by shortening their musth cycle (Poole, 1987; 1989; Slowtow et al., 2000). Keeping the younger bulls in check is particularly important during the musth season, as often it is the younger bulls that are identified as the "Damage Causing Animal" due to the raging hormones (Slowtow et al., 2000). However, due to the pandemic, the reserves are under financial constrains which lead the reserves to make trade-offs when it comes to allocation of financial resources.

Based on our prior work on identifying individuals in KW, we could draw the following conclusions: Kambaku is the oldest male, and he occupies the top position within the social structure of the elephant population on the West side of the reserve. Below him in the hierarchy, we have three adult bulls: Impi (KW3), Kanva (KW5) and Vula (KW4). These three are challengers of Kambaku (Poole, 1989). However, based on the footage we saw, this injured bull was an adult: high shoulders, depressions above the eye and relatively big tusks. But in KW, we had only identified four bulls that could have been possible candidates, with all of them mentioned above. Although, we didn't see Kanva all day, the bull in the video did not have a prominent scar on the inner right knee, which was the characteristic identifying feature of KW5, an advantage of utilizing the identification code. However, if one of these four individuals were the injured bull, our suggestion to the reserve would be to do everything possible to try and save that individual, given the considerable impact and significant roles older bulls play in elephant population dynamics and structure (Poole, 1987; 1989). However, it is important to note, that the knowledge required to answer the questions on the topics of group hierarchy, social structure, group dynamics and changes, and the influence of older bulls on younger males, can only be derived from detailed observational studies on known individuals. Thus, not only does individual identification assist reserves in management questions like the one described above, but it also lays the foundations by which detailed studies can be conducted to understand elephant populations.

To our dismay, we did not find the injured bull that day.

From additional images that were taken of the injured individual when it was found, we could conclude based on the unique patterns of identifying features, that we had not seen this bull before. We assumed that it was likely to be a migrant in KW, which could also be likely reason as to why the matriarch produced an alarm call that day. However, in order for this bull to be a migrant, the fence line between KW and Havestvale sections of the reserves would have had to be breached. When the management team checked the fence-line, a small section was broken.

This injured bull wanted to mate with the females in KW but was unluckily met by an older bull. Unfortunately, the injured bull was not found for a week. It was eventually euthanized as the wound had gotten infected to an extent such that recovery would have not been possible.

This example shows the power of individual identification, not only in the role it can play in assisting management decisions (the final outcome) but also the years of research that were made possible to study and understand the social structure, hierarchy, behavior and dynamics of known individuals on which decisions like these can be made. If the injured elephant turned out to be an older bull, from both a conservation and economic standpoint, the benefits from this saving bull would far outweigh the long-term impacts of the absence of having this bull in the population (Allen et al., 2020).

3.7. How can this population register benefit Kariega Game Reserve in other ways?

A complete record of individually identified elephants will enable KGR to better understand their elephant population, and this is crucial and invaluable in many ways. For example, a detailed record of individually identified bulls (and their behaviors) would help the reserve in describing elephant bull dynamics to ensure successful meta population management, which includes the movement of specific individuals between known populations to ensure the long-term survival and conservation of the species as the maintenance of genetic diversity in a species is important for its long-term evolutionary potential. Similarly, a record of all individually identified adult and sub-adult's elephant cows on the reserve would assist the reserve in the selection process of cows that will receive a contraception (porcine zona pellucida, PZP) application to monitor and record which individuals get young and to test if the PZP contraception is successful or not. Furthermore, individual identification would also enable the reserve to investigate questions with a high level of detail such as documenting the influence of life-history effects such as adolescence or dispersal, or the impact of social relationships. Thus, having a known record of all individually identified elephants would be crucial to KGR in assisting them with conservation management decisions.

4. Conclusion

Some of the highest quality data on elephant populations come from long-term studies on individually identified elephants. This alone, is enough to show the significance of individual identification. Given the numerous anthropogenic threats elephants face, the unique management problems that arise from confining elephants within fenced reserves, the economic and the environmental impact elephants have, data derived from individual identifications is invaluable to monitoring trends and patterns of *Loxodonta africana* numbers across spatial and temporal scales, in assisting management decisions and in gaining insight into aspects important for the welfare of elephants.

The code is an approach, but also a tool to ease the process of identification. As it comprises information on the identifying features that make an individual unique, using the code limits observe bias, one of the main factors that can make the code redundant. Re-defining the terminology of a nick and the addition of a term to indicate the magnitude of the identifying features observed will further limit observer bias and improve the robustness and the practical applicability and effectivity of the identification code. As a search tool function, the code also aids with data organization and management, crucial to long-term monitoring. Given that improvements to the code were suggested through its use during the course of just three weeks, there is room for development and in making the code more robust as a tool for elephant conservation studies. With this being said, it is strongly considered that elephant populations under study are individually identified first, given the vast number of ecological questions that can be investigated that are otherwise difficult or even impossible to examine.

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