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Persistence Hunting: The Origin of Humans

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Abstract:

Hominins are smaller, slower, and weaker than most large mammals, yet they have been eating meat from large mammals since before the invention of sophisticated weaponry. It is thought that they achieved this seemingly impossible feat through persistence hunting, a practice powered by endurance running. Essentially, one or more hunters pursue a prey animal in the heat of the day, until it reaches the point of hyperthermia. This allows a hunter to safely kill the weakened animal at close range using methods such as beating, strangling, or spearing. I assessed the feasibility of persistence hunting through several energy returned on investment (EROI) calculations based on the energy used by the hunter, their success rate, the energy used by family members that they supported, and the energy returned as meat from the kudu. I calculated the EROI of hunting greater kudu (*Tragelaphus strepsiceros*) as 104:1 to 39:1, when different sized kudu were captured and eaten by the hunting party alone. When I included the energetic needs of the hunters' families into the calculations the EROI ranged from 16:1 to 6:1. The excess energy within these ranges of EROI values would have supported, and possibly even advanced, the societies that practiced persistence hunting. This could be important in explaining how hominins without advanced weaponry were able to obtain meat, sustain themselves, and could prove to be an important selective pressure that favored our modern anatomy.

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Glossary of Terms:

Basal Metabolic Rate (BMR) –the amount of energy expended by an individual that is at rest.

Bipedalism –locomotion completed on two feet. (i.e. walking)

Cranial Capacity –the volume of the braincase; used to estimate brain size.

Energy Returned on Investment (EROI) –the ratio of a sources' usable energy compared to the energy spent to obtain the energy.

Expensive Tissue Hypothesis –reduction in the size of the gut results in an excess of energy which allows for an increase in cranial capacity and cognitive abilities.

Hominins –members of the tribe Hominini within the Primate order.

Hyperthermia –increased body temperature resulting from the body's inability to shed heat.

Lean Body Mass (LBM) –the weight of the body excluding the weight of fat.

Persistence Hunting –chasing an animal to the point of exhaustion and killing it at close range.

Social Brain Hypothesis –social interactions led to increased cranial capacity and cognitive abilities in primates.

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Introduction:

Hominins began to show the characteristic trait of bipedalism around 4.4 million years ago[1]. The inclusion of meat into the hominid diet is indicated by increased brain and body size, as well as reduced tooth and gut size[2,3,4,5]. Archeological evidence of meat consumption includes cut marks on the bones of a wildebeest sized animal found in East Africa from about 2.6 million years ago [6]. At this point in history only the most rudimentary stone tools were being used, with more advanced tools, such as spears, appearing only about 400,000 years ago[7].

Hominins are small, slow, and weak compared to the mammals found on the plains of Africa. A large male lion can exceed 250 kg while a large female can weigh in at around 182 kg[8]. The average !kung bushman weighs in at about 50 kg which is between 3 and 5 times lighter than a lion[9]. The average speed of the world record 100m dash for humans, 37.7 km/h, is less than half the 98km/h run recorded for a captive cheetah[10]. Animals such as elephants are much stronger than humans, picking up 350 kg trees with their trunks[11]. Competition or a close range fight with such powerful animals in order to acquire meat would be extremely dangerous. So how would early hominins have gained access to the valuable resource of meat?

The answer may come from the less apparent advantage of humans' exceptional endurance running ability. It has been hypothesized that their superior endurance running ability made persistence hunting possible[1,12,13]. Essentially, a small group of hunters would choose an animal as prey and scare it into running[12,13]. The hunters would then take turns chasing the animal out of the shade and back into the sun, eventually causing the animal to become hyperthermic[12,13]. This would allow one of the hunters, usually the strongest, to safely kill the weakened animal at close range using methods such as beating, strangling, or spearing[12,13].

The unmatched endurance running ability of humans and their ancestors has been explained through a combination of physiological and anatomical features that are present in both modern humans and hominin fossils. Unlike other mammals, humans have escaped the one breath per locomotion cycle allowing for a greater intake of oxygen and longer periods of running[14]. Sweat glands found over the surface of the entire human body allow for sufficient cooling under hot conditions, like those of the African savannah[15]. The lower density of sweat glands coupled with fur coats prevent extensive endurance running in African mammals[16]. Bramble and Lieberman compiled a list of features that explain human endurance running including shorter feet, mouth breathing, broad shoulders, and large gluteus maximus muscles[1].

The theory has been given even further credence through recordings and observations of persistence hunting in several modern-day native cultures including: the Kalahari Bushmen[12,17], the Paiutes and Navajo[18], the aboriginals of Australia[19], and the Tarahumara indians[20]. A !kung bushwoman even recalls using the practice of persistence hunting as a child , when she stumbled upon a baby kudu and was able to capture and kill the animal[21]. More recently, the practice was used to capture two cheetahs in northeastern Kenya[22].

Despite a large amount of anatomical evidence and anthropological observations of the practice there is a dearth of energetic analyses on the hunt. It is obvious that a group of men chasing a large animal for an extended period must use a great deal of energy, especially given the uncertain results. Is it possible that such a practice could sustain a society? Could this practice allow for an advancement of tools and be a stepping stone in evolutionary time that eventually led us to where we are today?

I have set up a test of this question by testing the formal hypothesis that a typical hunt by the !kung tribesmen for 1) a small kudu (199 kg), 2) an average kudu (257 kg), and 3) a large kudu (314 kg) is a net energy loss. Specifically, I calculated the energy returned on energy investment (EROI) for persistence hunting. EROI is the ratio of energy invested into a process compared to the energy returned upon completing the process[23]. In this study the energy used by the hunters during the chase compared to the energy returned to them through the meat of their prey.

Methods:

I calculated the energy used by the hunters based on the hunts recorded by Liebenberg and data gather by Lee. Energy gained was assessed based on the energy contained in the edible carcass of a greater kudu. The probability of a successful hunt was then used to correct the EROI value. I calculated family energy requirements based on averages of Lee's data, and again corrected the EROI values. Details follow.

Energy Invested by the Hunting Party:

I calculated the average weights of hunting-age males (ages 20-59) by using the weights of !kung tribesmen presented by Lee[9]. The determination of the pace of the hunters was based on Liebenberg's recorded average hunt speeds of 6.6, 6.3, and about 10 km/hr[12]. For this study I used 8 km/hr because it is the average speed (rounded up) of the recorded hunts. I determined the energy expenditure of 1 hour of running during the hunt by inputting the weight and pace described above in McArdle's table[27]. By using the energy used established from the table, I determined the energy use per minute running. I calculated the energy expenditure of one hunter for the average hunt time of 215 minutes and then accounted for a hunting party of three men. Finally, I converted the energy from kilocalories to megajoules by multiplying by 0.0042.

Energy gained from kudu:

I determined the energy embodied within a greater kudu (*Tragelaphus strepsiceros*) using the live weights of 199 kg, the average of 257 kg, and the maximum of 315 kg to account for varying sized kudu[24]. Using the minimum dressing percentage of 54% established by Mostert, I computed the edible portion of the kudu at each weight[25]. After obtaining the edible yield of the kudu I calculated the content of protein and fat using the known values of the bushbuck (*Tragelaphus scriptus*), 50.9% protein and 12.2% fat, because it shares the same classification as the kudu down to its genus[26]. I converted the weight of both protein and fat to grams and calculated the energy content from each using 4 kcal/g of protein and 9 kcal/g of fat. Then I added the energy content from both to determine the overall energy content in the kudu and converted it to megajoules by multiplying by 0.0042. The same procedure was followed to determine the energy content using the maximum 57% dressing percentage established by Mostert[25]. Equations are shown below:

$$\text{Edible yield (kg)} = \text{Live weight (kg)} * \text{Dressing percentage}$$

$$\text{Energy from Protein (MJ)} = \text{Edible yield}/ 1000 \text{ (g/kg)} * \text{Protein percentage} * 4 \text{ kcal/g} * 0.0042$$

$$\text{Energy from Fat (MJ)} = \text{Edible yield}/ 1000 \text{ (g/kg)} * \text{Fat percentage} * 9 \text{ kcal/g} * 0.0042$$

$$\text{Total Energy (MJ)} = \text{Energy from Protein} + \text{Energy from Fat}$$

EROI of Hunters:

I calculated the energy returned on investment (EROI) for all three weights of kudu in both dressing percentage categories by using the equation[18]:

$$EROI = \frac{Energy\ Gained\ from\ kudu}{Energy\ Invested\ by\ Hunters} \times Success\ Rate$$

In order to account for the possible failure of the hunt, I multiplied the EROI of the persistence hunt by the success rates of 50% and 80% proposed by Liebenberg[12]. A 50% success rate was used because it is the observed percentage of successful hunts. An 80% success rate was used because Liebenberg explained that camera crews may have caused failed hunts that normally would not have been undertaken[12]. In addition, the African Wild Dog, another persistence hunter, can have a success rate that exceeds 80% which could lend credibility to the high success rate of this hunting style[28].

Family Contribution and Use of Meat:

In most cases, the hunters would likely have families who would also be eating the kudu meat. This meant that they had to be included in the calculations as well.

To determine lean body mass (LBM) of adult males and females I used Boer's equations[29]:

$$\text{Male LBM} = 0.407\ (W) + 0.267\ (H) - 19.2$$

$$\text{Female LBM} = 0.252\ (W) + 0.473\ (H) - 48.3$$

In order to determine the LBM of children, the extracellular fluid volume (ECV) had to be determined using the equation[30]:

$$\text{ECV} = 0.0215 \times 0.6469\ (W) \times 0.7236\ (H)$$

The LBM was determined using the equation[30]:

$$LBM = 3.8 \times ECV$$

By using the average heights (H) and weights (W) of !kung men and women in the age groups 0-4, 5-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, and 80+ I was able to get LBMs for people of various ages. From these LBMs I calculated the basal metabolic rate (BMR) for the various genders and age groups using the equation[31]:

$$BMR\ (cal/day) = 501.6 + 21.6\ (LBM)$$

I assumed that each hunter would support a wife (in the age 30-39 category), three children (one in 0-4, one in 5-9, one 1 in 10-19), as well as three elderly parents (two in the 50-59 category, and one in the 60-69 category). The three children were used because according to Lee the average number of offspring is three and they are usually three to four years apart from one another in age[9]. The BMR values from each of the supported family members for each of the hunters were added to the energy expended by the hunters and the EROI was recalculated in the same way that it was above.

Results:

The hypothesis that this form of hunting for a small, medium, and large kudu was a net energy loss was not supported. The EROI for persistence hunting was positive for all possibilities examined. Specifically, the EROI for the hunt of a small kudu varies from 66:1, when eaten by only the hunters, to 6:1, when consumed by the hunters and their families, while values for the medium kudu ranged from 85:1 to 8:1, and values for a large kudu hunt ranged from 104:1 to 10:1.

Energy gained from kudu:

The 54% dressing percentage yielded meat contents of 107 kg for the 199 kg kudu (Table 1). This edible yield resulted in a total of 54.7 kg of protein producing 916 MJ and 13.1 kg of fat supplying 494 MJ for a total of 1,410 MJ of energy (Table 1). A kudu weighing 257 kg contained a total of 139 kg of edible meat which was made up of 70.6 kg of protein and 16.9 kg of fat (Table 1). 1,821 MJ of energy, consisting of 1,183 MJ from protein and 638 MJ from fat, was available from the 139 kg of meat (Table 1). The total edible meat content of 170 kg was available from a 314 kg kudu (Table 1). Overall an energy content of 2,225 MJ, with 1,445 MJ from protein and 780 MJ from fat, was attained from killing a kudu of this size (Table 1).

Using the 57% dressing percentage the 199 kg kudu yielded 113 kg of edible meat consisting of 57.7 kg of protein and 13.8 kg of fat (Table 2). It also contained a total of 1,488 MJ of energy with 967 MJ coming from protein and 521 MJ coming from fat (Table 2). A total of 146 kg of edible meat from the 257 kg kudu yielded a total of 1,922 MJ of energy, 1,249 MJ from its 74.6 kg of protein and 673 MJ from its 17.9 kg of fat (Table 2). The 314 kg kudu provided 179 kg of edible meat (Table 2). This was made up of 91.1 kg of protein containing 1,526 MJ and 21.8 kg of fat producing 823 MJ for a total of 2,349 MJ of energy (Table 2).

Energy Invested by the Hunting Party:

The weighted average for the weights of !kung men age 20-59 that were published by Lee was 49.59 kg which I rounded up for the calculations to 50 kg[9]. McArdle's table gave a total of 400 kilocalories per hour running at the pace of 8 km/hr, the average pace of observed hunts, and the average weight of 50 kg (Table 3)[27]. The energy per minute of running ended up being 6.7 kilocalories per minute which gave a total energy expenditure by a single runner of

1433.3 kilocalories after 215 minutes of running (the average hunting time) (Table 3). The energy expended by a group of three hunters was converted to a total of 18 MJ (Table 3).

EROI of Hunters:

The EROI of a 199 kg kudu with a 54% dressing percentage ranged from 39.1:1 at a 50% success rate to 62.6:1 at an 80% success rate (Table 4). Under the same conditions, a 257 kg kudu resulted in an EROI of 50.5:1 at 50% success rate to 80.8:1 at an 80% success rate (Table 4). An EROI of 62:1 at a 50% success rate to 99.1:1 at 80% success rate was achieved upon capturing a 314 kg kudu (Table 4).

At 57% dressing percentage the EROI of a 199 kg kudu ranged from 41.3:1 for a 50% success rate to 66.1:1 for an 80% success rate (Table 4). The 257 kg kudu provided an EROI of 53.4:1 for a 50% success rate to 85.4:1 success rate for 80% success rate (Table 4). A range of EROI from 65.2:1 at 50% success rate to 104.4:1 for an 80% success rate was achieved upon capturing a 314 kg kudu with a 57% dressing percentage (Table 4).

Family Contribution and Use of Meat:

The lean body mass (LBM) of adult !kung bushmen ranged from the maximum of 44.4 kg in 40-49 year olds to 38.6 kg in individuals 80 years old or older (Table 5). !kung bushwomen's LBMs ranged from 33.9 in 20-29 year olds to 26.4 kg in individuals who were 80 years old or older (Table 5).

The extracellular fluid volume (ECV) of male !kung children ranged from 2.2 L (in boys from age 0-4 years old) to 6.5 L (in boys age 10-19 years old) (Table 6). From this the LBM of these boys was calculated and ranged from 8.5 kg (in boys age 0-4 years old) to 24.6 kg (in boys age 10-19 years old) (Table 6). The ECV of female !kung children ranged from 1.8 L (in girls age 0-4) to 6.5 L (in girls age 10-19 years old) (Table 6). The LBM of these girls ranged from 6.8 kg (in girls age 0- 4 years old) to 24.8 kg (in girls from 10-19 years old) (Table 6).

From the LBM the range of basal metabolic rate (BMR) values ranged from 2.7 MJ (in girls age 0-4) to 6.1 MJ (in men age 30-49) (Table 7).

The energy cost of having a child age 0-4 years old is 2.9 MJ/day, a child 5-9 would need about 3.4 MJ/day, and a child 10-19 would need about 4.3 MJ/day (Table 8). Supporting a wife's energetic needs in a day would require 5.1 MJ while supporting three parents (his own or his wife's) would require 5-6 MJ/day for people age 50-69 (Table 8). Adding in all of the people a single hunter would support results in a total of 32.8 MJ/day of energy, meaning that together the three hunters need to provide an additional 98.4 MJ/day energy in addition to their own survival requirements (Table 8).

The total energy invested into the hunt by both the hunters and their families was 116.4 MJ (Table 9). EROI corrected for both success rate of the hunt and the energy used by the hunters families for a 199 kg kudu at 54% dressing percentage ranged from 6:1 to 9.7:1 (Table 9). A 257 kg kudu had a corrected EROI ranging from 7.8:1 to 12.5:1 (Table 9). The corrected EROI of the 314 kg kudu was between 9.6:1 and 15.3:1 (Table 9). With a 199 kg kudu of 57% dressing percentage the corrected EROI ranged from 6.4:1 to 10.2:1 (Table 9). The 57% dressing percentage kudu of 257 kg had a corrected EROI between 8.3:1 and 13.2:1 (Table 9). The 314 kg kudu had a corrected EROI from 10.1:1 to 16.2:1 (Table 9).

Discussion:

EROI of Hunters:

The range of the EROI of the hunters alone, corrected for hunting success rate, ranged from 39.1:1 to 99.1:1 with 54% dressing percentage and from 41.3:1 to 104:4 with 57% dressing percentage. According to Hall et al. the minimum EROI necessary to sustain our society, which is significantly more technical than that of the !kung or early human ancestors, is about 3:1[32]. Using this measure it appears that the practice of persistence hunting would be able to support our society. These findings support the hypothesis that the practice of persistence hunting was a stepping stone in human evolution before the development of hunting tools.

The relevance of the EROI of only the men involved in the persistence hunt is speculative, but may be useful in understanding its potential importance to evolution. Assuming that women were involved in persistence hunting, which is supported by the !kung bushwoman's recollection of persistence hunting as a child, then the EROI would likely be closer to the values for the hunters alone because it would be possible for a family to hunt together[21]. It has been determined that human endurance running performance doesn't decline until after the age of 54, if the same training regimen is used[33]. This would be conducive to the practice of persistence hunting because an older person would still have the ability to participate in the hunts and contribute not only to the energy, but also valuable experience to their family. If you were unable to run as an elder, you would run a higher risk of dying due to starvation. Sharing would be possible, but there would be a greater strain on the hunters and a definite decrease in EROI.

In an extremely physical hunt that required raw strength, women and older people probably would not be fit enough to be involved. However, it is reasonable to think that they could take part in a persistence hunt because the hunt ends with a very weak animal which doesn't require significant strength to kill. They also may have taken part only in chasing the animal while a strong, young male would likely be the one to finish the hunt by killing the prey.

***Family Contribution and Use of Meat*:**

The EROI of the persistence hunt, corrected for success rate and including family energy needs, ranged from 6.1:1 to 15.3:1 with 54% dressing percentage and from 6.4:1 to 16.2:1 with 57% dressing percentage. This once again is above the minimum value proposed by Hall et al. meaning that the use of persistence hunting appears to be a practical way to support a society[32]. This continues to support the hypothesis of persistence hunting's role in human evolution.

The family numbers I used are an estimation based on of the family size and composition presented by Lee[5]. The average number of children for !kung tribesmen was used and the distribution was based on the average of 3-5 years between having children[9]. In Liebenberg's recorded hunts there is no information provided about the families of the hunters. The number of parents that an individual hunter would have to support was a estimation based off of the life expectancy of hunter-gatherers[34].

***Persistence Hunting and the Brain*:**

Over evolutionary time the cranial capacity of hominins has increased, and cognitive abilities likely followed suit[35]. The expensive tissue hypothesis explains that reduction in gut size potentially due to increased dietary quality could have allowed the brain increased in size[35]. Persistence hunting provides meat and nutrients that would aid in development of a larger brain.

It also provides a selective advantage for reduced gut size and changes to the shape of the pelvis, and the rest of the body, for more efficient running.

Another theory is that social interactions shaped brain development and evolution[36]. Lee documented that hunters often incorporated the help of others into their hunts to attain better results[9]. Hunters would talk to members of their community and learn what animals, tracks, feces, and environmental factors they had spotted in the surrounding area to get an idea what animals were around, and where they would likely find them[9]. By using a combination of their own and other people's observations prior to beginning the hunt the hunters would be able to cut down on the time spent searching for prey and maximize hunting efficiency.

Tracking expertise as well as extensive practical knowledge of the animals also contribute greatly to the overall success of the persistence hunt. The prey animals during the rainy season seem to be steenbok, duiker, and gemsbok while the dry season is best for running down kudu, eland, and red hartebeest[12,17]. The hunters would likely follow the best first principle selecting the easiest animals to capture: weak, pregnant, large, sick, or injured individuals as this would use the least amount of energy[37]. These invaluable skills were likely passed from generation to generate by word of mouth or through observation.

The remaining question is, with such a high EROI why isn't the !kung population significantly higher than it is? I attribute the relatively low population to a natural population control method employed by the !kung. The women will often breast feed their children until they are between the ages of 3 and 5[9]. This prevents the conception of more children by the woman and as a result holds the population relatively steady in size. I believe that the practice is done in order to manage the resources that are available to !kung populations. If the population rose significantly there may not be enough sources of food to make the practice worth doing. Further understanding of the practice as well as the EROI could be provided through a study on the population density and distribution of ungulates in the Africa.

Conclusion:

Archeological evidence has made it possible to look back in time and track the development of bipedalism and endurance running[1,38]. From these findings physiological and anatomical evidence was compiled to support the idea that a human can eliminate an ungulates physical strength and completely incapacitate them through the use of endurance running[1,14,15,16]. Anthropological data was added to confirm the practice of persistence hunting by several independent cultures in different areas of the world[12,17,18,19,20,21] . And finally energetic analysis has been used to support the feasibility of the persistence hunt. The implications of persistence hunting could be far reaching and may well have shaped all aspects of modern humans from our endurance running abilities to our cognitive abilities.

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Table 1. Energy content (MJ) of greater kudu (Tragelaphus strepsiceros) at weights 199, 257, and 314 kilograms at a 54% dressing percentage.

Live Weight (kg)	Dressing %	Meat Content (kg)	Protein (%)	Fat (%)	Protein (kg)	Fat (kg)	Protein (MJ)	Fat (MJ)	Total (MJ)
199	54	107	50.9	12.2	54.7	13.1	916	494	1410
257	54	139	50.9	12.2	70.6	16.9	1183	638	1821
314	54	170	50.9	12.2	86.3	20.7	1445	780	2225

Table 2. Energy content (MJ) of greater kudu (*Tragelaphus strepsiceros*) of various weights at a 57% dressing percentage.

Live Weight (kg)	Dressing %	Meat Content (kg)	Protein (%)	Fat (%)	Protein (kg)	Fat (kg)	Protein (MJ)	Fat (MJ)	Total (MJ)
199	57	113	50.9	12.2	57.7	13.8	967	521	1488
257	57	146	50.9	12.2	74.6	17.9	1249	673	1922
314	57	179	50.9	12.2	91.1	21.8	1526	823	2349

Table 3. Energy expended (MJ) by a group of three hunters, weighing 50 kg and running after a greater kudu (*Tragelaphus strepsiceros*) for 3 hours 35 minutes.

Average Speed (km/hr)	Hunters Weight (kg)	Energy Expended (kcal/hr)	Energy Expended (kcal/min)	Average Hunt Time (min)	Energy Expended by 1 runner (kcal)	Number of Runners	Total Energy Expended (kcal)	Total Energy Expended (MJ)
8	50	400	6.67	215	1433.3	3	4300	18

Table 4. The energy returned on investment (EROI) of a persistence hunt of a greater kudu (*Tragelaphus strepsiceros*) depending on the weight and the dressing percentage of the prey, as well as the success rate of the hunt.

Dressing	Live Weight (kg)	Energy Returned (MJ)	Energy Invested (MJ)	EROI	Success Rate	EROI (Corrected)
54%	199	1408	18	78.2	0.5	39.1
					0.8	62.6
	257	1819	18	101	0.5	50.5
					0.8	80.8
	314	2231	18	123.9	0.5	62
					0.8	99.1
57%	199	1488	18	82.7	0.5	41.3
					0.8	66.1
	257	1922	18	106.8	0.5	53.4
					0.8	85.4
	314	2349	18	130.5	0.5	65.2
					0.8	104.4

Table 5. Lean body mass (LBM) of !kung men and women based on the heights and weights presented by Lee using Boer's equation[5,24].

Age	20-29	30-39	40-49	50-59	60-69	70-79	80+
Male	43.51	44.30	44.44	43.20	42.61	40.22	38.61
Female	33.91	33.50	32.82	32.55	30.46	31.36	26.40

Table 6. The extracellular fluid volume (ECV) and lean body mass (LBM) of both genders of !kung children at various weights.

	0-4	5-9	10-19
Male ECV	2.24	3.83	6.47
Male LBM	8.5	14.6	24.6
Female ECV	1.80	3.57	6.52
Female LBM	6.8	13.6	24.8

Table 7. The basal metabolic rate (BMR) of both genders of !kung based on their ages.

	0-4	5-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Male	2.87	3.42	4.32	6.03	6.11	6.12	6.01	5.95	5.74	5.59
Female	2.72	3.33	4.34	5.17	5.13	5.07	5.04	4.85	4.94	4.49

Table 8. The energy (MJ) required by the average !kung bushman's family.

Child 1 (MJ)	Child 2 (MJ)	Child 3 (MJ)	Wife (MJ)	Parent 1 (MJ)	Parent 2 (MJ)	Parent 3 (MJ)	Total for 1 Hunter (MJ)	Total for 3 Hunters (MJ)
2.87	3.42	4.32	6.11	6.01	6.01	5.95	32.8	98.4

Table 9. The energy returned on investment of a persistence hunt of a greater kudu (*Tragelaphus strepsiceros*) corrected for the energy used by hunters' families.

Dressing	Live Weight (kg)	Energy Returned (MJ)	Energy of Hunters (MJ)	Energy of Family (MJ)	Total Invested (MJ)	EROI (Family Only)	Success Rate	EROI (Corrected Family and Success Rate)
0.54	199	1407.81	18.00	98.40	116.40	12.09	0.50	6.05
							0.80	9.68
	257	1819.22	18.00	98.40	116.40	15.63	0.50	7.81
							0.80	12.50
	314	2230.63	18.00	98.40	116.40	19.16	0.50	9.58
							0.80	15.33
0.57	199	1486.02	18.00	98.40	116.40	12.77	0.50	6.38
							0.80	10.21
	257	1920.29	18.00	98.40	116.40	16.50	0.50	8.25
							0.80	13.20
	314	2354.56	18.00	98.40	116.40	20.23	0.50	10.11
							0.80	16.18