Family and Group Dynamics in a Pastoralist Society

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I, Juan Du, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

How people survive and behave in different environment are some questions that Human Behavior Ecology seeks to answer.   The choices that humans make in such conditions can either be considering parental and economical investments, or the pursuit of self or group interest.   Using a Tibetan Pastoralist Society as a case study, this thesis explores how Tibetans adapt their behaviour to different contexts, from an evolutionary ecological, anthropological and demographic perspective.

I start the thesis with a brief history and demographical presentation of how these Tibetan herders behave within and outside domestic life.   The main analysis part starts from which gender get more parental care, by looking at duration of breastfeeding and the interbirth intervals.   I find female-biased parental investment.   Possible reasons are the high female workloads and the improved social status of women derived from the high economical contribution made by them.   The next analysis focusing on how wealth flows, the fertility and the length of the trial time affects the stability of marriages.   Then I examine the effects of kin on child well-being.   Within domestic life, concepts like 'Grandmother Hypothesis' and 'Mother Hypothesis' are well-documented.   While this research makes a contrary finding that it is the older male family members who are invested more in child caring than the females.

The next analysis considers questions beyond domestic life by examining herders' social networks.   I investigate the motivations behind Tibetans who choose to herd in groups, and others who prefer to herd alone.   Economic gift games are used to explore the cooperation strategy within villages, whether pastoralist prefer to share limited resources with their genetic relatives over others.   The analysis concluded that stated social norms are slow to change, while actual individual behaviours appear to evolve faster, responding to recent social and political changes in the region.

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Acknowledgements

Time flies.   I still vividly remember four years ago when I landed at Heathrow airport -   I was so excited and looking forward to my new journey in London.   It was my first time in a foreign country; I was excited, nervous and curious about everything.   And now, four years later, I am completely used to the rain and the grey skies – hallmarks of the British weather, and I love all things British - the humor, culture and tea.   I would like to thank many people who accompanied me during my PhD journey.

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Chapter 1: Literature background and history of the study area

1.1 Overview of the thesis.

Each individual has limited resources thus faces dilemmas when allocating resources.   How to trade-off between quantity and quality of offspring; How much effort to put into one gender as oppose to the other for maximum fitness; What are the costs and benefits of living alone or with a partner; Which elder to look after the grandchildren; Which individual to invest resources in.   These are important questions in life history and we all face these dilemmas when making decisions to adjust our behaviours based on ecological conditions.

This research is based on a few small villages in a Tibetan society, where yak herding is the main source of subsistence.   Pastoralist societies across the world share a similar lifestyle in that they migrate from time to time based on the availability of water and grassland, groups disintegrate and reintegrate to adjust to the unpredictable environment.   But there is no universal organization of pastoralist herding groups. For example, in East Africa, Kenyan herding groups are called '*ntipat* ', which are mainly formed by brothers and their families (Fratkin, 1986).   In Norway, herding groups called '*Siida*' consists of families which have a long-term relationship or based on the geographical closeness (Thomas et al., 2015).   On the border between Sudan and Ethiopia, the herding groups are flexible, often formed by friends in the same age group (Glowacki et al., 2016).   In Mongolia, there are different forms of herding groups including the '*Khot ail*' which mainly derives from kin groups and the '*Nukhurlul*' which is based on the community activities that people help each other in labour-intensive works (Upton, 2008).   In Tibet, herding group is called '*Ru skor*'; traditionally it is formed by herders who share the same ancestor and living close to each other (Pirie, 2005b).   Moreover, Tibetan herding society has experienced a series of political changes that not only affect their way of subsistence but also their labour division, gender-preference, marriage stability, parental investment, and social networks; all these topics will be discussed in this thesis.

Through fieldwork in this area, I am aiming at overviewing the evolutionary ecological explanations underlying their behavioural pattern.   The thesis begins with an introduction of the related literature and the background information of the study area, including the history of Amdo Tibet, how Buddhism was transmitted into this area and the Tibetan monastic system. Chapter 2 is the introduction of the ethnographical settings of the society (chapter 2).   The main research questions that will be addressed in the thesis include: i) the probable reasons underlying the phenomenon of high divorce rate and the different marital systems (chapter 3); ii) to what degree that parents are biased their investment towards infants and how these behaviours correlate with the local ecology (chapter 4); iii) who are the allocarers and how grandfathers played a role in child caring under the system where workloads are not equally divided (Chapter 5).   iv) The analysis section ends with the study of the social network of the society assessed by using economic games (Chapter 6).

1.2 Literature review

1.2.1   Marriage

In the history of natural selection, the debate surrounding mating system has always been a contentious question (Orians, 1969; Gurven et al., 2012).   Darwin (1871) introduced the concept of sexual selection: some characteristics are not evolved for adaptation to the environment, rather, the development of some popular characteristics evolved under sexual selection, in which the selection pressure mostly comes from species fighting against the same sex to gain mating opportunity (Darwin, 1871). There are two groups of competition under the sexual selection theory, one is Intrasexual selection where same-sex individuals are fighting for matting with opposite sex; the other is intersexual selection where competitions arising between sex in seeking for satisfied mates (Hughes, 2015). In most of the researches in the animal kingdom, the Intrasexual selection is mainly about male-male competition, while intersexual selection focusing more on female mate choice. Sexual selection is important in mate choice and different ecology associated with different sexual selection strategies (Emlen & Oring, 1977). Sexual selection theory is mainly about the choosing sex finding an opposite-sex mates to maximize their fitness. This can be achieved by getting direct benefits, for example, females get resources during the courtship, at the stage of reproduction and after having offspring from males; sexual selectors are

also looking for satisfied mates to get indirect benefits, for example, looking for good gene to benefit the next generation.

What kind of traits is being selected under sexual selection and why? In human society, characters related to wealthy territory (land scale), high social status (leadership) and good appearance (taller and stronger) (Mueller & Mazur, 2001) are selected in mate selection and marriage (Marlowe & Wetsman, 2001). In the society of this study, popular characteristic includes working ability, especially for females, in any age group, and the characteristics that determine a women's reputation and marriage stability.   Details are discussed in Chapter 3.

Marital status varies in different ecology, there are two main forms of marriage, monogamy and polygamy.   For polygamy, it can be further divided into two different categories: polygyny, where a male is married to two or more female, and polyandry, where one female is married to two or more men. Polygamy can be further divided into two categories, they are sororal polygyny and fraternal polyandry, based on the relationship between the co-wives or the co-husbands. Polygamy can also be divide into sororate polygyny and levirate polyandry.   In both cases, social anthropologists have interpreted polygamous marriage as a strategy to provide social and economic support in the event that a woman or man dies or becomes barren (Radcliffe-Brown & Forde, 1950), whilst evolutionary anthropologists consider this as part of a strategy for maximizing reproductive success in a given ecological context.

A cross-cultural analysis of different marital status conducted by Zeitzen (2008) showed detailed information about polygamy in different religious and cultural foundations such as Christian polygyny in Cameroon; Muslim polygyny in Malaysia; and Hindu Polyandry in India.   From a behavioural ecological perspective, polygyny or polyandry could be determined by the resource base, with high productivity of resources controlled by males enabling males to marry more than one female, and low productivity necessitating monogamy or even more than one male marrying each female (Marlowe, 2000).

Even when Polygyny is not practiced in marriage, mating may still be 'polygynous' or 'polyandrous'.   In ancient china, Greece and Rome men have

only one wife but could have as many sexual partners or concubines as they please (Ebrey, 1986; Nast, 2004; Westermarck, 1921; Scheidel, 2010).   This is further complicated by trade-offs between mating opportunities and parental investment, and social inequality caused by unequal resource distribution (Kaplan & Lancaster, 2003).

However, monogamy is still the predominant form of marriage in Asia and Europe, because conflicts relating to polygamist marriages are intense. Polygynous women often have a lower fertility rates compare to monogamous women (Henrich, Boyd & Richerson, 2012), perhaps due to lower frequency of sexual intercourse with co-husband, as shown in populations in the U.S. and India (Nag, 1972; Potter & Millman, 1986).   However, Bean & Mineau (1986) assert that the order of wife and duration of exposure to the risk of conception in Utah also results in female lower fertility.   Ezeh and other researchers found that polygyny fertility rates is low on individual level but it enables the overall fertility rates in the society higher than monogamous society, because polygynous societies in the end made every women get married even if they are monopolized by their wealthy and high social status husband in Ghana and Uganda (Agadjanian, 2000; Ezeh, 1997; Pollet & Nettle, 2008), although the presumption of group selection theory is not widely accepted by other evolutionary biologist (Hamilton, 1963) evolutionary anthropologist (Lawson et al., 2015) and psychologist (Price, 2012).

The benefit for spouses staying in a monogamous family would maximize the economic and reproductive success in a long run (Kaplan & Lancaster, 2003; Kaplan et al., 2009). Fortunato and Archetti (2009) argue that monogamy is an evolutionarily stable strategy (ESS) if females were willing to mate monogamously in return for males investing all their wealth in just one female (to whom they were married to, irrespective of their mating strategy).

In Japan (Applbaum, 1995), India (Desai & Andrist, 2010; Kaur, 2004; Gupta, 1976) and China (Riley, 1994; Xiaohe & Whyte, 1990), there are many 'arranged marriages' in which the decision of marriage is made either by female's family or male's family on the basis of social standing.   No matter whether it was the individual's own choice or from their family, in general, the choices are from either

the female side or from the male side.   But when one sex is in shortage, they will have more bargaining power and thus have more say in matting and marriage. I will discuss how sex ratio affects the marriage in Chapter 3.

1.2.1.1 Female choice

According to the female choice model, it is the women who make the decision about who they are going to marry to and whether to join a polygamous marriage or not (Searcy & Yasukawa, 1989; Mulder, 1990).   Resource is important for women and their parents in making the decision about who to marry to, and how much to pay in the marriage, especially when there are siblings who will compete with each other to get resources from parents, or when the resources in the society is not equally distributed, I will introduce below, some of the hypotheses built upon the female choice model.

i)   Polygyny threshold model

Polygyny threshold model, also known as resource-defence model when first defined by Orians (1969), is one of the female-choice hypotheses. Orian carried out extensive research about mate choice in red-winged blackbirds and found that mate choice is mostly determined by the quality of the territory and the ability to actively defend outside threats.   Human females are confronted with many similar issues in the polygynous marriage, for example, co-wives have to share their resources and paternal investment with each other; the common resource is distributed to many offspring and might be redistributed to the future generation. Parents transmit the form of resources to their offspring, and this transmission is most striking in the case of material wealth (Mulder, 2009), when children get married, parents will transfer family wealth in the form of bridewealth or dowry. Co-wives are often faced resource competition as a result of a high population density within the common territory, they fight for common resources from their co-husband not only for themselves but most importantly for their offspring. Confronted with resource limitation, why do females still choose to go down this road? This could arguably be the fact that reproductive success in polygynous marriage is higher compared to marrying to an unmated male in a poor territory. However, polygyny will stop when, 'for n+1 woman, it is better to marry to an unmated poor man rather than a wealthy mated men but sharing resources with other women, and at this point, the threshold reached' (Marlowe, 2000; Moorad

et al., 2011; Orians, 1969; Schmitt & Rohde, 2013).

ii)   Co-wife cooperation model:

Polygynous marriage could contribute to a man's wealth through the labour of his wives (Westermarck, 1921).   It is unavoidable for co-wives to compete with each other from time to time over the limited resources and parental investment from their husband.   There is also unavoidable physical and psychological jealousy exist among co-wives in some societies (Irons, 1983; Burbank, 1994) but the cooperation between co-wives is not impossible (Lamphere, 1974).   The reasons for women sometimes encourage her husband to take another wife is either to prevent her husband from engaging in adultery, or because of her own infertility.   Co-wives sharing the whole family workload can make life easier and they can have more spare time.   Indeed, polygyny is fairly common especially in non-egalitarian horticulturalist societies and pastoralists societies (Gurven et al., 2010 ; White & Burton, 1986), because men compete to obtain more wives as labours.

iii)   Sexy son model:

Whether wealth is related to reproductive success has been studied by many researchers for a very long time; social rank is one possible criteria for wealth. Lee Ellis in a review paper (Ellis, 1995) argues that although there are some exceptions about the positive relationship between social rank and reproductive success, i.e. females do not want to mate with high-status man because they are more aggressive, it is still the norm that the majority of the higher rank men have higher reproductive success.   One main reason could be that higher rank men can have more resources which not only provide the female enough food but also enable their offspring pass the weak infancy with a healthier and stronger body and in the end with better reproductive opportunities compare to the lower status male, in addition, higher rank can be passed down to the next generation which is also an incentive for potential female mates.   This correlation can be especially significant in societies with harsh environment and resources that are not equally distributed.

Apart from the social status of men, research also showed that men with higher social economic status have higher reproductive success, especially in the polygyny societies, but this effect is not significant for women (Nettle & Pollet, 2008).　Darwin's sexual selection view was elaborated by Huxley who indicated that sexual dimorphism varies a lot in different contexts (Huxley, 1938).　The body size, the ability to deposit fat, and sexual dimorphism all matter in females' mating choice; In Northern Namibia, rural and urban men have different reproductive strategies (Kirchengast & Winkler, 1995).　Females chose to mate with the most popular males, even if her offspring are at risk of deferred maturity and high new-born mortality (Mclaren, 1967).　If the female's offspring inherit his father's attractive genes and became a 'best-quality' man, then he can mate with more females in the next generation and in the end his mother would have more descendants.　For a woman, although she would suffer from lower reproductive success in a polygynous marriage, she might get more 'good gene' grandchildren in the second generation.　This strategy is also known as 'sexy' son hypothesis termed by Patrick in 1979 (Weatherhead & Robertson, 1979), and 'Marginal male effect' by Bartholomew (1970).　But the 'sexy son' priority is context dependent; the preferred gender is related to how expensive it is to rear and how much potential resource the offspring will return. I will further discuss gender preferences and the reasons for preferences in Chapter 3.

1.2.1.2 Male mate Choice:

This theory assumed that it is the men who make the decision about who they are going to choose to get married, whether it is acceptable to let his brothers or friends join his marriage and share one wife, or whether it is affordable to add another woman to a polygynous marriage.

i)　　　Male coercion model:

Chisholm and others reject the female choice model and assert that female are coerced by their current or future husband for different reasons in polygynous marriages (Chisholm & Burbank, 1991; Mulder, 1990; Hartung, 1982).　In a horticulturalist society, men use violent abuse towards their wives to control resources and pursue extra-pair mating and to reduce paternal investment (Stieglitz, Kaplan, Gurven, Winking, & Tayo, 2011).　'Child marriage' or 'early marriage' can be an example of coerced marriage, in which girls are more likely

to enter into.   In Tibetan society, there is 'trial marriage', which I will discuss in Chapter 4. It is also a form of informal marriage in which females are in a passive position. The childhood of girls can be cut short when they are still very young due to the poverty of family or political interests.   This phenomenon still exists in sub-Saharan and Africa societies (Greene, 2014; Umemoto, 2001).   Male coercion can be a big reason which leads to the collapse of polyandrous marriages.   I met a woman when I was in the field, who said that she left her husband and stayed in her natal house one year after her marriage, because when she married to her husband, after a while, her husband and her parents-in-law coerced her to also marry his brother, who is a handicap and bad-tempered man, so she refused and ran away to her natal home.   But how widespread this is awaiting quantitative assessment.   Other ethnographic studies described that polyandrous marriages mainly practised under male coercion or against female's will, generate tensions among co-husbands or between female and male, which would doom the marriage to failure.   Women are also likely to be divorced if she is barren or not good at doing houseworks, and this will be discussed in chapter 4.   Apart from polyandrous marriage, the collapsing of polygamous marriage from male coercion can be attributed to the following two factors.

ii)   Age-related polygyny:

Obtaining and keeping a mate is not an easy job. Age can be a factor which determines the duration of the polygynous marriage.   By investigating indigo Buntings, age can affect the success of polygyny in territories of different density, and old males can practice polygyny because he controlled the territory earlier (Carey & Jr, 1975).   Polygyny is often associated with age asymmetry in the marriage relationship, such that older men marry young girls, and younger men are obliged to remain celibate for extended periods, or alternatively marry widows of older men.   Polygyny may in such cases be interpreted as part of the age-gender stratification, where older men control human resources and thus control the productive and reproductive resources (Zeitzen, 2008).   On the contrary, old men are less welcomed in the mating market and cannot invest many resources to children compared to the younger men (Edlund & Lagerlöf, 2012).   But this conclusion is not universal as if when there are other allocarers available, then young man does not need to do most child care, this will be discussed in Chapter

5.

iii)   Polyandry threshold:

In a Polyandrous marriage, the older brothers are generally married first and the younger one added into his brothers' marriage.   In other words, the women may be older than the second or even the third husband.   In this case, the younger brother can be coerced by his parents or his brother to enter into a polyandrous marriage for the sake of family profit.   Another example by Symons (1995) adds on to the previous point that men prefer younger wives 'according to cues of age, hormonal status, parity, fecundity and health'.   This preference may lead younger brothers to leave a polyandrous marriage and to find his own wife who might be younger than his previous wife and himself (Haddix, 2001).   In accordance with the fraternal polyandrous marriage, younger sisters in the sororal polygynous marriage would be more likely to leave her co-husband who is much older than she is and start her own life.

Similar to polygynous threshold model, a polyandrous threshold also exist, in which case, men can perform well when they are sharing one wife (Davies, Krebs, & West, 2012).   Polyandrous marriage is mostly practised in the regional isolated area, for example, Hindu in India and Tibetan herders in Tibet, because in this area it is hard to exploit the unfriendly environment and it is a constant struggle for survival.   The economic circumstance makes it difficult for many men to maintain a family through the fruits of their own labour, and thus force them to adopt a way of life that ensure the exploitation of several substance sources.   The benefit of polyandrous marriage is to help the poor man who cannot afford to marry and pay brideprice to mix into his brother's marriage, maximize the number of adult labour, reducing the number of heirs and thus keeping the estate undivided.   But threshold will be reached 'when the cost of staying in the marriage is bigger than the benefit, for the n+1 man to marry monogamously is better than stay polyandrous.

1.2.2   Sex ratio

Population sex ratio can be biased by abortion or differential investment to the less preferred sex (Hesketh & Xing, 2006).   In many Asian societies, including China (Banister, 2004) and India (M. Das Gupta, 1987), there is a female-biased

mortality at birth, but women have longer life expectancy compared to men in general (Michel Garenne, 1994; Neumayer & Plümper, 2007).   This is because men are more likely to take part in risky activities; for example, more men enroll in war (White & Burton, 1986), men care less about their health condition (Sen, 1992), and make more contribution to the family economy by herding, fishing and hunting (Lee, 1979).   Among the Dogon in Mali, polygyny may not be advantageous for women, but men appear to control resources and a high sex ratio also gives them an advantage, giving women little option but to stay married (Strassmann, 2000).   When sex ratio is biased, there will be more competition in the predominant sex.   This could be one explanation why women are more likely to stay single and do more work than men.   Further discussion about the biased-sex preference (chapter 3) and how 'bargain' power affects male and female behaviours (chapter 4 and 5) will be discussed in later chapters.

1.2.3   Parenting and alloparenting

1.2.3.1 Biased parental care

Fisher proposed that parents should invest an equal amount of net resources to their daughters as well as sons in order to maximize their fitness (Fisher, 1930). However, sex-biased parental investment is common in the real-life settings. Differential parental investment is possibly determined by the costs of raising males and females and by resources competition.   Biased investment sometimes stems from the parent's own physical and economical conditions. When one sex is expensive to rear, parents would invest in more of the opposite sex, which increases their own fitness (Veller et al., 2016; Trivers, 1972).   Biased parental investment often manifests itself in forms of biased sex ratio.   Strongly biased sex ratio in humans is usually considered as the result of infanticide or parental neglect.   Research relating to the biased sex-preference will be discussed in Chapter 3.

1.2.3.2 Grandparental care

Unlike other great apes, humans have a slower life history characterized by late age of maturity, shorter interbirth intervals, longer lifespan, and higher fertility (Charnov & Berrigan, 1993).   The different ontogeny of humans is probably due to our large and expensive brain growth (Aiello & Wheeler, 1995).   Slow growing offspring requires more parental investment and the help of other relatives; some

suggest that humans are highly dependent on others during the first several years of growth and humans are cooperative breeders (Charnov & Berrigan, 1993; Hrdy, 2000).   Allomothers are people other than mothers who offer help to look after dependent children.   The most controversial allomother is grandmother, who are, in most cases, positively related to the survival of the grandchildren while sacrificing her own reproductive opportunity.   Studies showed that the degree of grandparental care is determined by the age and education level of grandparents (Baydar & Brooks-gunn, 1998), the age of the grandparents and grandchildren (Pollet et al., 2006), as well as number of the grandchildren (Coall et al., 2009).   In most cases worldwide, grandmothers are helpful in looking after the grandchildren, while grandfathers are less important in childcare (Sear and Mace 2008).   Yet there is no universal consensus on this phenomenon; in some cases, grandparents' care is context dependent and I will further discuss grandparental care in Chapter 5.

1.2.4   Cooperation and competition

Individuals are interacting with each other at all the times.   We define any types or degrees of interaction as a network.   Cooperation, as one type of network, is a social behaviour that not only existing in the animal kingdom but also in the human domain.   The reasons for cooperation varies, and the form of cooperation in societies of different scales or different cultural background is different (Lamba & Mace, 2011).   The main theories of cooperation including kin selection, reciprocity and group selection (Nowak, 2006).

1.2.4.1 Kin selection

Kin selection is fundamental to understand living things.   In 1964, Hamilton proposed kin selection (Hamilton, 1964), and formalized the concept of why living things are helping close kin, by showing that cooperation is favoured by the natural selection when rb > c. R in the equation means coefficient of relatedness, b means benefits to the recipients, and c means the cost for the actor measured in terms of reproductive success.   Cooperation only evolves when the benefits of cooperative behaviour and the relatedness between genetic relatives outweigh the costs of doing so.   Individuals are more likely to help people whom they share common ancestry with, because helpers can gain benefits by enhancing their own inclusive fitness in direct or indirect ways. Kaplan (Hillard Kaplan, 1994)

suggesting that wealth transfer should go down from parents to offspring that maximum their own fitness, rather than exploit resources from offspring.

1.2.4.2 Reciprocity

Kin selection may account for many cooperative acts, but cooperation does not always happen between relatives. In different societies, the degree and the form of cooperation varies. In hunter-gatherer societies, for example, male hunters go out and hunt big animals with other male hunters in the same group and share a big fraction of meat with others afterwards (Hill & Hurtado, 2009; Hawkes et al., 1991). Gatherers prepare food to share with other members, and the helpers are from either within the family or outside of the household, from adults or adolescents (Kaplan & Gurven, 2001). In farming areas, helpers with good fitness and rich local knowledge are crucial in the time of harvesting; other than helps from their kin, farmers also seek intelligent local people to cooperate with (Macfarlan & Lyle, 2015). In the pastoralist society, where high mobility and environmental uncertainty trigger the necessity of intense cooperation, the form of cooperation shifted from internal group to external groups to get as much help as possible (Yeh et al., 2013).

One character which distinguishes human beings from other animals is that humans are cooperate beyond kin, but cooperation is very difficult to evolve beyond kin-selection as there are free riders who can get benefits without paying any costs (Fehr & Fischbacher, 2003). There are common resources which will be overused by the group members and results in exploitation of the common resources (Hardin, 1968). In 1971, Trivers (1971) suggested that reciprocal altruism being the mechanism stabilizing cooperation.

Reciprocity includes direct reciprocity and indirect reciprocity. Direct reciprocity means actors temporarily reduces its fitness to increase other's fitness but expecting that the recipients will pay the benefits back afterwards (Boyd & Richerson, 1989). In this case, the interaction is not random and no punishment is involved, other than tit-for-tat noncooperation. Indirect reciprocity means that there is no direct interaction between the actors and recipients, but the benefits will have transferred between other individuals indirectly. Indirect reciprocity can be maintained through direct observation or gossip, and is mostly common in the

small society where reputation will be remembered within the group and punishment will carry out if recipients do not pay back benefits (Nowak & Sigmund, 1998; Panchanathan & Boyd, 2004).   Reputation will affect individual's fitness in one way or the other (Macfarlan & Lyle, 2015), it may enhance social status (Cronk, 1991b), increase the chance of mating opportunity (Thompson et al., 2015) and survivorship of the offspring (Kaplan et al., 2000).   Evolutionary psychologists argue that cooperation can be maintained in a small society, where everybody knows one another's information because reputation can be easily remembered and gossip can be quickly spread.   In addition, studies have shown that any subconscious cue of being watched will influence the cooperation behaviour or prosocial behaviour as well (Macfarlan & Lyle, 2015; Bateson, Nettle, & Roberts, 2006; Milinski et al., 2002; Haley & Fessler, 2005).

1.2.4.3 Cultural group selection

Human beings are taking collective actions.   But the reasons why individuals might reduce their own fitness and cooperate with other members in the same group to benefit the group as a whole is still a controversial topic (Wynne-Edwards, 1963; Panchanathan & Boyd, 2004; West, El Mouden, & Gardner, 2011).   There are conflicts between group interests and individual interests. According to Neo-Darwinism theory, selfishness should be selected on an individual level, however, according to the group selection theory, altruists will be selected on the group level (Bowles, 2009).   Some studies found no evidence that conflict enhances group level altruism (Silva & Mace, 2014; Hooper, Kaplan, & Boone, 2010).

Humans are also good at social learning, social learning may occur horizontally or vertically, but no matter in which direction, cooperation could develop from learning from each other (Hewlett et al., 2011).   Because some behaviour would bring hidden benefits, there is an innate sense of copying the behaviours from the majority of people in the same group to practice collective actions (Simon, 1990).   Some social activities include, for example, performing religious ritual (William Irons, 2001; Power, 2016), not following taboo (Sosis & Bressler, 2003), even taking side in a warfare (Bowles, 2009); All these kind of collective actions can be a signal of showing commitment and will promote intragroup cooperation (Silva & Mace, 2014).

There are other individual-level selection reasons why people may cooperate in groups. Blurton Jones invokes the 'Tolerated theft model', indicating that the cost of not cooperating is more than its direct benefits, in this case, cooperation is the most stable strategy (Blurton Jones, 1984 ; Wilson, 1998; Bird & Bird, 1997).

1.2.4.4 Costly signaling

Costly signalling and showing-off are two other theories in the field of economics and evolutionary biology to explain the mechanisms behind the schemes of cooperation (Hawkes, 1991; Zahavi, 1975).   These two theories are mostly being used to explain sexual selection; Some of the signals during courtship evolved (Miller 2000) as females are more choosy in selecting their partners (Barclay, 2010), it is usually the males who compete with other males by advertising their characters thus increase potential mating opportunities.   Costly signalling was developed by Zahavi (1975) and it has since then been studied by many evolutionary anthropologists.   Some of the research showing that signals can be extremely costly for individuals, for example, genital mutilation in Africa and foot binding in China are first referred by biologist as 'mate guarding' by men, but latter used by females as a signal of innocent and loyalty (Flinn, 1988); Some religious rituals are often companied with physical and psychological pain, but religious members have to adhere with all the costly behaviours to show commitment and loyalty which fastens the intergroup cooperation (Mackie, 1996; Sosis & Alcorta, 2003).   Others think that some social signals are beneficial to the public goods, for example, food sharing in hunter-gather groups make sure everyone will have enough suppliers at various time period (Smith & Bird, 2000). Signalers are not only showing off their good quality to attract opposite sex to get better quality mates, some older men are also practicing costly signalling activity to attract better quality daughter-in-law for their son (Smith & Bird, 2000).   By taking risky signalling activities, signalers can gain various benefits, be it higher social status, better quality mates or richer material resources.   Costly signalling is thus being used to explain public displays of generosity and cooperation.
From my research (discussed in Chapter 6), kin selection is still the foundation of the cooperation mechanism, while at the same time, individuals are more likely to take risky activities to show their generosity and enhance their social status.

1.3 Brief history of the study area

1.3.1 Who are Amdo Tibetans

Tibet sits on an elevated plateau in central Asia, metaphorically referred to as 'Roof of the World', surrounded by mountainous ranges rendering it a difficult place to access shrouded in mystery.   Tibet was unified under the Tibetan Empire (known in Chinese as the *Tubo* empire) with its heartland established in Ü-Tsang, now known as Tibet Autonomous Region under the rule of the People's Republic of China (PRC) (Hao, 2000; Janhunen, 2006; Yeh, 2003)(Figure 1.1). Extension of Tibetan populations to the northeast form two major sub-ethnic regions known as Amdo and Kham, which are now part of Qinghai, Yunnan, Sichuan and Gansu provinces (Wang, 2006).   Whilst some scholars distinguish Ü-Tsang as 'political Tibet' from 'ethnographic Tibet' of Amdo and Kham to highlight the former having been consistently ruled under Tibetan Government, others do not support this classification (Goldstein, 1990).   My field research will concentrate on the Amdo region of Tibet.
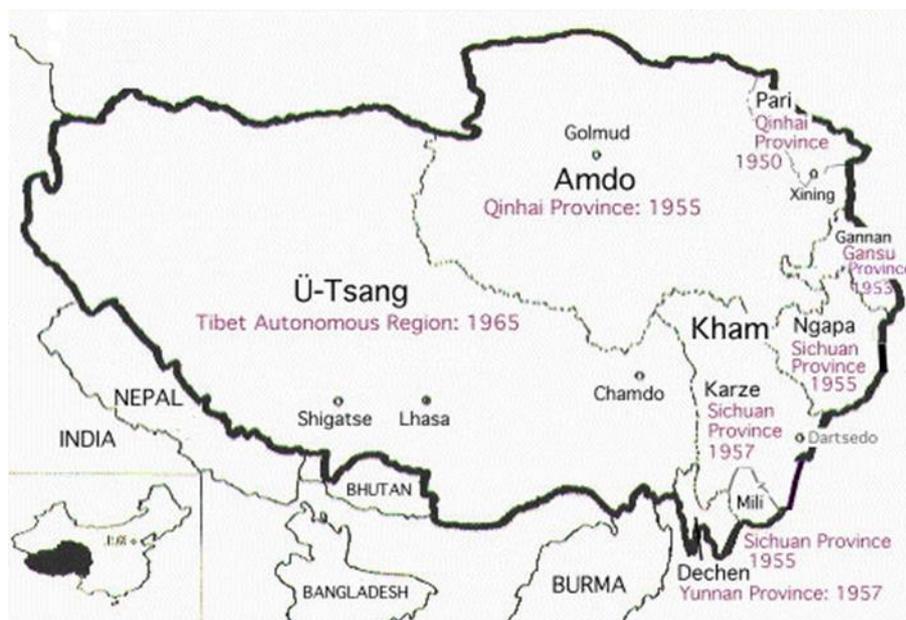
Figure1.1: Map of Tibet.   Amdo Tibet locates on the north-eastern Tibet, there are three parts of Tibetan areas: Amdo Tibet, Tibet Autonomous Region and Kham Tibet. (source: https://www.google.co.uk/search).

The majority of ethnic Amdo Tibetans live in Qinghai province with further populations located in Gansu and Sichuan provinces.   In Qinghai (Northwest part of China), there are five Tibetan autonomous prefectures; there is one

Tibetan autonomous prefecture in Gansu (Northwest part of China) and Sichuan (Southwest part of China) province respectively. The reason why it is being called Amdo has no consensus literature, one interpretation is that the four syllables are coming from the name of the holy mountains in Yushu Prefecture, Qinghai province (Gele, 2006). There is another literature showing that Amdo also called 'mdo smad', which means at the upper part of 'mdo khams', during the Tubo period, Tibet expand it's territory into eastern area, all the eastern part of Tibet area are being called 'mdo khams', and Amdo region is located at the upper or north part of the 'mdo khams' (Gruschke, 2001). Some research also shows that 'A' put in front of mdo doesn't hold any meaning, just used to emphasizing the words (Janhunen, 2006).

Tibetans living in Amdo are called Amdobas; they rely mostly on yak and sheep herding and other forms of agriculture to provide subsistence. Amdobas who practices farming in conjunction with herding is known as Rong bas, whereas nomadic herders who do not rely on farming are called Brog pa (Wu, 2013).

Tibetian society comprises of a social hierarchy with a chief at the very top governing a tribe of people. A tribe is divisible into several clans, each overseen by a local leader. A clan can then be separated based on ancestral lineage with family units forming the base of Tibetan society (Pirie, 2005a).

1.3.2 Brief history of the monks

In the Tibetan history, there are two important periods of 'Buddhist development'; one of which took place before the 10th century. Prior to that, Buddhism was not a widely practised religion, and only popular among the upper class in central Tibet, while most of the ordinary people are still believe in 'ben', the native Tibetan religion. When in the year 815, Khri-gtsug-lde-brtsan came into power, and he paid close attention to the development of Buddhism and monks' well-being. From that time on monks had very high social and political status. He also published a rule called 'seven households support one monk' requiring seven households to support one monk. Their responsibilities included looking after monks and supporting their daily expenses. Ordinary people had to show extremely high respect to the monks otherwise they would be tortured. Monks had no obligation to pay tax or serve in the army, they held high power in making

governmental decisions, and their status was much higher than that of the aristocracy (Shi, 1996).   All these policies accelerated the growth of the monk population and monastery development.   At the same time, the unequal treatment towards monks aroused anger in the ordinary people as well in the aristocracy (Xue, 2007), until the year of 838, when three ministers killed Khri-gtsug-lde-brtsan. After that, Khri-gtsug-lde-brtsan's brother named Glang dar ma, who was anti-Buddhism, took the throne.   He started to reduce the number of monks and monasteries on a large-scale; lots of monks had to flee to central Tibet and migrate to other Tibetan areas (Zhang, 2014).   Although this period is being called 'dar ma eradicate Buddhism', it is actually triggered the development and transmission of Buddhism into Sino-Tibetan areas.   The newly developed form of Buddhism was easy for ordinary Tibetans to accept because it was a mixture of 'ben' and Buddhism (Shi, 1996).

Monks prefer to go to monasteries which are close to their natal houses, especially for young monks who prefer to go to monasteries where they have elder relatives living in that monastery, so that they can receive support from them (Zou, 2006).   There is one monastery which has 362 monks in Qihama township; Cairima township has two monasteries, one with around 230 monks, the other has around 30 monks; Manrima has two monasteries, one called 'Jiaxi' monastery the other called 'Canzhihe' monastery and they have 380 and 460 monks respectively (Information from interview with the local monastery manager).   According to the Tibetan tradition, both men and women will be sent to the monastery at a younger age and will mostly stay for their lifetime.   There is a rule about the age of becoming a monk: generally it should be over 7 years old, but there are always exceptions, so one or two years older or younger is also acceptable (Zhu, 1990). Both men and women in Tibetan culture have religious freedom (Zhang, 2014), but the number of monks significantly outnumbers nuns; this is because females are more likely to abide by the social norms of the patriarchal society and act as housewives (Karma Lekshe Tsomo, 1987).   In Maqu county, there are no specific monasteries for the nuns, instead, most of the nuns go to a monastery in the neighbouring A Ba autonomous prefecture, Sichuan province, which is on the opposite side of the Yellow River.   Some researchers conducted research on Amdo Tibetan both in the ancient time (Yu, 1950) and at the present (Zou & Hou, 2012), and they argued that the monastery

system manipulate the sex ratio of the society to be female-biased.   I will further talk about the sex ratio and how it affects behaviour in chapters 4 and 5.

There are several reasons behind choosing to be a monk in a monastery.   One very important part is because the religious belief; having monks at home will raise the family's social status (Ma & Xi, 1943).   There are also economic considerations, especially with a local history of many natural disasters which could lead to starvation and death, so being a monk and staying in the monastery not only released the family's economic burden but also ensured a better life quality for monks themselves (Zou, 2006).   This system also relieved the population stress in the society, by putting lots of male monks in the monastery and reducing the population size for the current and next generation (Zou & Hou, 2012；Yu, 1950). There are also other reasons to choose to be a monk, for example, one family in the field site has three children, two girls and one son. Their second daughter was very sick and about to die, so the parents went to the monastery and made a wish that if their daughter could survive, they would send their only son to the monastery.   In the end, their daughter recovered, and then they sent the son to the monastery as they promised.   Another family said that having three sons is expensive, and they can not able to afford to support all of them, so they are planning to send at least one to the monastery.   In Tibetan history there are several rules or social norms regarding to the number of monks, for example, according to the ancient Tibetan archive, during the period of the Republic of China 'at least one son has to be a monk in the family', 'if there is only one son in the family, he has to be sent to the monastery and the eldest daughter can be the future heir'; ' in Tibetan culture, each family should only allow one son to stay at home and send the rest of the sons to the monastery' (Gong, 1948; Yu, 1950).

After the 'three households support one monk' policy in the Tŭbō empire, it later changed to 'seven households support one monk' (Zhang, 2014), as it is now in modern times.   There are mainly four ways to support the monks' daily expenses (Shi, 1996).   The most important one is from family support, especially for monks who are young and not able to participate many religious ceremonies in order to earn money (Zou, 2006).   The family will bring food and cloth to the monks from time to time, or give them pocket money.   There is also public

donation: monks can get benefit by practising religious ceremonies for private households or for the public during the big religious festivals (Zhu, 1990). Monks can also receive a salary from the government (Gu, 1998).   Nowadays, the number of monks is lower, partly because the child policy restricted the number of births, and parents do not really want their sons being sent to the monastery.   In addition, parents have to make a choice when their sons are seven of whether to send them to primary school to get a compulsory education or receive an education in the monastery.   Our research shows that now, very few of parents will send their sons to the monastery in the current generation of children.

1.3.3   Major political changes 1950-2000:

In recent history, pastoralists in Tibetan areas, including Amdo, were nomadic and kept searching for better grazing land, and those groups with strong leadership and effective fighting forces gained better land (Levine, 2015).   In the twentieth century, pastoralists on the Tibetan plateau and nearby areas underwent a series of political changes.   Policies which related to the livestock and grassland in the twentieth century included phases of recent history that I will call: Collectives, Communes, Household Responsibility System, Privatization, and Settlement action.   Policies related to the cultural life in this time period also included the child policy and the introduction of a formal education system. I will briefly introduce the major policies which were implemented in this area from earlier 1950s until 2000.

Communist regime: after the establishment of the People's Republic of China in the early 1950's, livestock was redistributed among households with the purpose of reducing wealth inequality between rich and poor(Goldstein & Beall, 1991). This policy marks the beginning of a programme of major interventions in the pastoralist system(Wu & Richard, 1999; Levine, 2015).   Between 1958 and 1960 there was serious starvation in the area, as there was all over China at that time, associated with the aftermath of Mao's 'Great Leap Forward'.

Collective: Collective was established in 1964; at that time pastoralists from different classes were forced to herd together in groups, and a 'points' system

was introduced.   How many points each person got at the end of the year depended on the difficulty and workload he/she accomplished.   The allocation of resources to each household in each community was a share of the collective's production calculated from two parts: forty percent depended on the total points, and sixty percent depended on the original wealth of each household(Zhaoli et al., 2005; Wu & Richard, 1999; Miller, 2000; Zhaoli et al., 2005).

Commune: Commune was introduced in 1968.   At that time, all animals belonged to the commune, and pastoralists shared their production each year. The share received was based on two parts, forty percent of the number of family members, and sixty percent of the total points(Gruschke, 2012; Huber, 2012; Levine & Angeles, 1995; Miller, 1999; Pirie, 2005b).   China was undergoing the cultural revolution during this period.

Household responsibility: In 1981, livestock were divided among every family, but the land was open access.   This was said to have caused overgrazing and grassland degradation as is often associated with using common pool resources (Goldstein & Beall, 1991; Hardin, 1968).

Privatization: The privatisation policy was first introduced in the mid-1980s in Qinghai Province, and quickly spread to the neighbouring province of Gansu where the field site in Maqu is located (Miller, 2000).   In the early 1990s, privatisation was implemented to confront the problems of grassland degradation and communal access, and the government began to settle the nomads.   First in the winter pastures, and later in summer pastures too, rangeland was divided between each household based on how many people were in each household, and each family was allocated a rangeland for 50 years of use, with little or no instructions given on land inheritance policy (Yamaguchi, 2011; Williams, 1996; Wu & Richard, 1999).

Sedentarisation: In 2000, the 'Great Development of the West' campaign was launched in the western regions of China, which was aimed at improving the

infrastructure and the living standard of people in this area. One of the very important ways of achieving the development was thought to be sedentarisation. The Government tried to settle the herders in two ways. The first was to settle herders in their winter grassland, and the second was to move herders into newly-built towns. The first method moved the herders from a highly mobile into a semi-settled lifestyle, and the latter strategy tried to change the source of herder's income from livestock to a more market-oriented economy (Gruschke, 2008; Gyal, 2015; Levine, 2015; Ptackova, 2011, 2012, 2015; Yeh, 2005). In Maqu, herders started to move into settled houses from 2003 onwards (Levine, 2015).

Education: In 2000, the 'Great Western Development policy' was strengthened by giving priority to the construction of schools, especially for the basic education system in minority groups in the western regions. In Maqu, the government started to build boarding schools in the late 90s; there are altogether 14 schools in the county. By the year of 2000, the enrolment rate had risen significantly compared to very low rates of secondary education before (Lopsang Gelek, 2006).

Child policy: In 1979, the 'one child policy' was first implemented in the Han area, and was extended to ethnic minority groups in the late 1980s (Attané, 2002). There were differences between the Han and other ethnic groups; these were not only differences in timing in different parts of China but also based on the rural or urban nature of an area (Guo Zhigang, 2003; Attané, 2002). According to the provincial family planning regulations in 1990, urban Tibetans were allowed to have 2 to 3 children, but no restriction was imposed on the rural Tibetans at that time. Urban Chinese Tibetans were allowed to have 2 whereas rural Chinese Tibetan later restricted to have 3(Attané & Courbage, 2000; Melvyn C ., Goldstein, 1991). In Ambo, women were allowed three children and required to undergo tubal ligation after the third birth. Our own demographic data show that in Maqu people were allowed to have a maximum of three children after late 1980s to the present day. And this restriction has some impact on the biased sex-preference as will be discussed in chapter 4.

1.3.4 History of the study villages
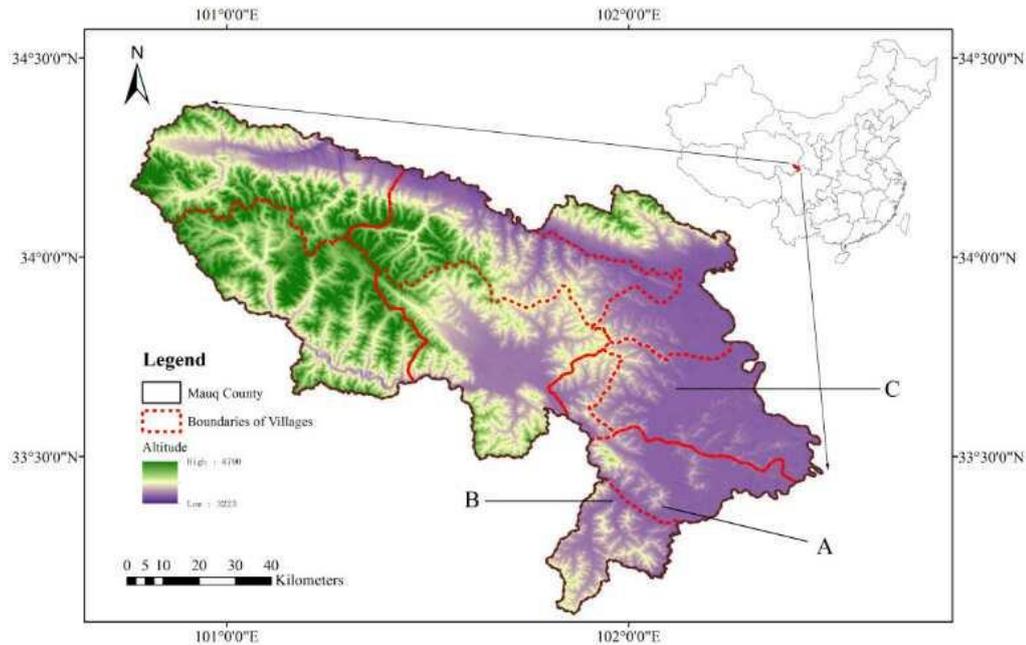
Figure 1.2: Map of Maqu county and villages where we collected demographic and herding data. The red line is the border of each villages. A is 'Qihama township', B is 'cairima township', C is 'Manrima township'.

In 2014, I conducted pilot research in Maiguer village, Cairima Township. According to the local records, Maiguer village was in Aba, Sichuan province before 1887 (there is still a Maiguer village in Sichuan province now), all the herders in this group moved to Gansu province in 1889 after a grassland conflict between two tribes in Aba. Maiguer was further divided into 8 Rukors after the migration (Rukor means 'households of friends') by their group leader named Dou geri before 1957. During the collective era, this 8 Rukor kept this division but changed their name into 'Shengchan dui' means 'production group' (Knowledge from local unpublished documents). 8 Rukors still exist in this area when I visited them in 2014. The distance between each Rukor is not very far, takes around half an hour to drive from one to the other in winter grassland. I then conducted my research in four other villages in 2014 and 2015; these four villages are Doulong village (Manrima township), Jilehe (Qihama township), Tawa (Qihama township). The history of Qihama is not well documented. I got the history of Qihama through interviewing some aged local leaders. Qihama, in

Tibetan means 'people live near the river'.   In Qihama township, there are 5 villages, 4 of them are living in the current place before 1949, only one village ('tawa') was formed more recently.   'tawa' in Tibetan means 'people lives close to monastery' because the origins of this village are from people who are initially settled around the monastery.   It has been said that the origins of Qihama township are from a family called 'Haxichuman', who fled from Sichuan province and found that Qihama is quite a nice place to live; he settled down and had three sons.   They lived together for a while; then a monk told them that living together was leading to animal death and that is anti-Buddhism and nature, so they should separate from each other and each occupies one valley.   Later on, there are four valleys that were occupied by each son, three sons and father from one family herding in different valleys in summer and only come back in winter. This strategy ensures the herding system runs well, and this land division lasts until today.   At the beginning, each big family stands for a big Rukor, for example in Jilehe, there are 3 Rukors, but in the 1980s it changed to 6 Ruchors.   In 2000, there is a big fight between two Ruckors and one herder from one Rukor killed the other from the other Rukor, so in order to avoid future revenge, the local leader dissolved this Rukor and distributed households from this Rukor into 5 other Rukors, so there are now 5 Rukors in total in Qihama.   When they mentioned about any Rukor, they will just name the biggest families at that Rukor. Under each Rukor there are more subdivisions, based on different herding groups.

Chapter 2: Ethnographical setting of the study area

Understanding the demography and the subsistence system is crucial to understand the evolution of the human behaviour.   In this chapter, I will illustrate the local demography, followed by the main methodology of this study.   The second section of the chapter will describe the formation of a new herding system in this area with an analysis of factors leading to the observed shift in herding behaviours.

2.1 Ethnography of the study sites
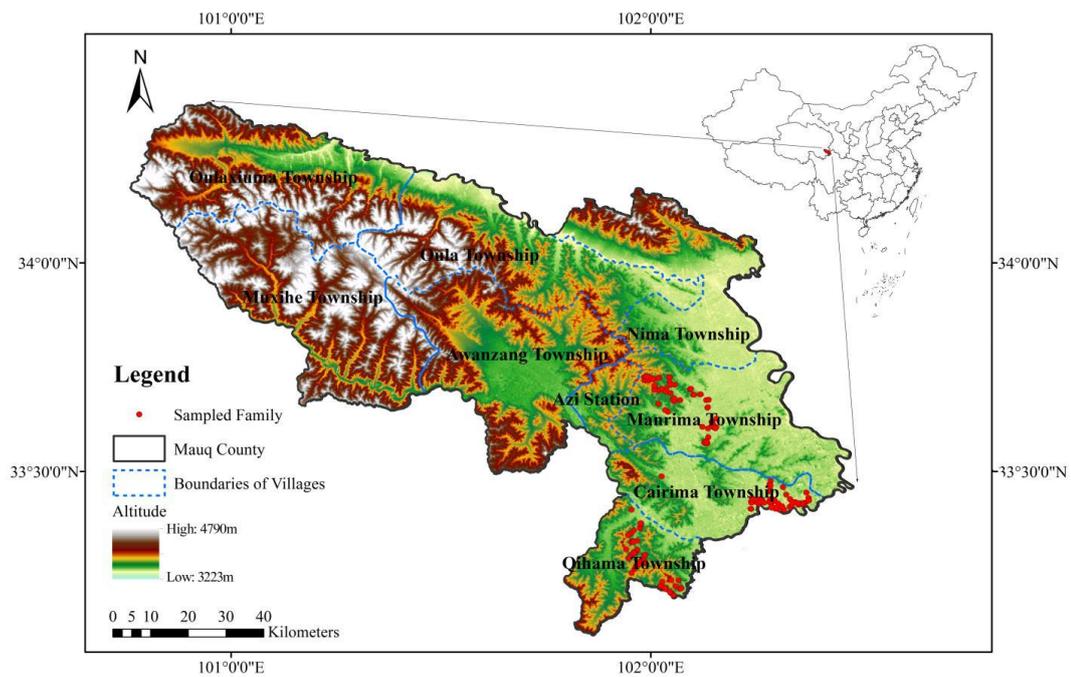
Figure 2.1: Map of Maqu county and villages where I collected demographic and herding data. The Blue line is the border of each village. The red dots are the sampled families where I collected data.

Table 2.1: Description of the field site structure and the number of 'dui' and 'households' which I got the data from.

Name of township/Xiang'	Name of 'dui'	Number of 'dui'	Number of households
Manrima	Doulong	6	108
Cairima	Cairima	12	99
Cairima	Maiguer	8	280
Qihama	Jilehe	5	131
Qihama	Tawa	8	150

Before the household responsibility policy, the basic composition of county was township ('xiang' in Chinese), and the township was subdivided into administrative villages.   Villages consisted of the production team ('dui'/'shengchandui' in Chinese), and those production teams became 'brigades' ('dadui' or 'dui' in Chinese), which is the smallest unit of the district (Yamaguchi, 2011; Murphy, Tao, & Lu, 2011).   This research is based on the information from each household, and households which I have interviewed was indicated in red dots in Figure 2.1.

I conducted my research in Maqu County, an administrative district in the southwest region of Gannan Tibetan autonomous prefecture in Gansu province. Maqu is a part of Amdo Tibet and lies at the intersection of Qinghai, Gansu and Sichuan provinces.   Maqu spans an area of about '10190 Square Kilometers and is home to 54900 people' according to a census in 2011.   The average altitude of Maqu reaches '3500~3800 meters above sea level with an average temperature of 1.2 ℃ across the year and annual average rainfall of 611.9mm' (information from Maqu records).   Most of the native people are 'Brog pa', herders making their living from selling yaks and sheep.   Maqu, named after the Yellow River that runs through the County, is made up of one town and seven 'Xiang'.   Nima town (meaning sun in Tibetan), is the political, cultural and economic centre of Maqu with several surrounding villages.   So 'Xiang' is equal to 'rural townships' (Clarke, 1998).

Within Maqu county, my research focuses on three townships (see Table 2.1) with the pilot research taking place in Maiguer group in Cairima village.   Maiguer group is made up of 280 households with an average of 5.6 persons per family according to the general records of the county in 2001.   Around 30 households migrated into Maiguer group as part of the Ecological Resettlement program when the whole family is either working or schooling in the town centre.   250 households are half-settled and herding on the plateau.   They are settled in wintertime and migrate between summer and autumn pastures.

A harsh environment on the Tibetan Plateau means Tibetan people preferably works in livestock production over traditional agriculture.   The Tibetan grazing land has supported pastoralism for thousands of years with nomads moving at high frequency between seasons.   The frequency at which nomads move between grasslands is thought to be one of the most important factors that affect the pastoralist life (Næss, 2013).   Since herders' primary source of subsistence and income are livestock and its by-products, it is therefore understandable for nomads to focus their work on maximizing the number of livestocks they own. However, livestock is vulnerable to unpredictable and uncontrollable factors, such as extreme weather and environmental conditions, therefore being successful in a pastoralist society could be largely up to chance (Yeh, 2004; Yeh et al., 2013). When herders solely focus on their own profit without regard for common resources, a scenario called the 'tragedy of commons' occurs (Hardin, 1968).   A series of policies were therefore implemented in Tibet to prevent such scenarios by giving herders incentives to improve the management of the rangeland.   The policies include settlement programs that encourage school education and ones raise the salary for migrant labourers (Clarke, 1998).   All these policies have altered the nomads' daily life.

2.2 Methods

Methods in this section, including demographic data, gift-giving game and labour ranking, are being used in every analysis chapter (Chapter 3, chapter 4, chapter 5 and chapter 6). Most of the data I have used in the thesis is from the research I conducted in the year 2014-2015.   Amdo Tibet is an interesting place to do research from behaviour ecology perspective because it is going through a series of ecological changes that affect their way of subsistence and reproduction in

different degree. It has rich nature resources to explore but also ecologically fragile, it is a remote area where most of the herders are trying to keep traditional Tibetan way of living while at the same time modernization from Han culture from social media is unpreventable. I did my master research as a social anthropologist in this area and I do notice that adult male and female have shocking difference in social and family status, especially in terms of workload; son doesn't get much more attention from this society as we thought it should be, given that it is a patrilineal society; some people willing to herding with others some doesn't and it seems that there is no big pressure to cooperate or not. These questions are interesting and I'm willing to do research on it from a quantitate way as a biological anthropology researcher.

The English version of the questionnaire used can be found in the Appendix. I also collected data from economic games and status ranking.   Gift-giving game results were presented in chapter 4, chapter 5 and chapter 6.   For the ranking data, I conducted labour ranking and wealth ranking separately.   Labour ranking results were presented in chapter 3 and chapter 5, the wealth ranking results were used in chapter 6.   I will describe the demographic data first, followed by the Gift-giving game and the labour ranking, the procedure of wealth ranking will be introduced later in chapter 6.

2.2.1   Demographic data

I interviewed local herders in their winter house or summer tent at their convenience. Because they are moving around from time to time, especially in summer time (from August to October) herders all move to their summer grassland which is far away from the main road and out of traffic, it is hard to get in contact with interviewees, so I sometimes made an appointment by phone. Besides, women take over most labour on the pasture, I need to wait for spare time when they take breaks from the housework.   Additionally, young men like to hang around instead of staying at home, hence the marriage history data I get from the male part is age-biased, as elder men answered the questionnaire about their marriage history. I will further discuss this issue in chapter 5 along with the observation that older men are doing most of the child care because they are the only available allomother.   I was assisted by three assistants, one is a local student who lives in the village and is on her school holiday, one is a master

student from Lanzhou University, and the last one is a local labour.   All of my assistants can speak the local language, which made our research much easier and smoothly.

The questionnaire consisted of three parts, the first part is the census of the whole family, including everyone living in the same household.   If a person is absent from the family, I will ask where he/she is, so that I can get dispersal information, for example, who gets a job outside or who is a monk in the monastery.   I also asked each individual the information of their parents, their birth year, age and Chinese Zodiac (sometimes it is difficult for them to remember the birth year or their age, so Chinese Zodiac will help me to estimate the birth year of the previous generation).   The second part of the survey is about the herding system, the number of livestock, and the number of births and deaths of animals in the past year.   I asked detailed information on how their herding system works, the herding situation in the past and at present, how they evaluate the quality of the grassland change and what do they think the problem is.   I also asked about the internal rules of the herding group, how people abide by these rules and what is the penalty if someone breaks the rules.   The third part of the survey is about the marriage and birth history of each individual, including details about each marriage and the payment of the brideprice, their birth history and sibling information. I also asked women who had children under age 5 recently, about how she fed her children, who did the childcare and other information. When collecting data on reproductive activities, I separate male and female to different spaces to avoid disturbance and get direct opinions from the male and female side, because females relied on their husband a lot, if asking questions to females while their husband around, they will concur with her husband's answer. It is also much easier for females to answer some private questions i.e. marriage and birth history and contraceptive use, without any male nearby.

2.2.2   Gift-giving game

The gift-giving game is one of the economic games where participants make decisions about giving gifts to others instead of keeping it to themselves. This is a simple and intuitive economic game that can be used to investigate the social networks of a society and have already been used by many other researchers. For example, Thomas et al. played gift-giving game among reindeer herders in

Norway by giving gasoline, and he found that reindeer herders prefer to give gifts to others who are in the same herding group (Thomas et al., 2015), Lamba played gift-giving games among small societies in Indian by giving salt, her research shows that having elder sisters nearby will influence the decision of taking salts (Lamba & Mace, 2011). Chaudhary et al. played gift-giving game in BaYaka hunter-gathers by giving honey-sticks, they found that popular male gift-receivers are more likely to have several wives and thus results in higher reproductive success(Chaudhary et al., 2015).

All participants are given 15 yuan, in five-yuan denominations (15 yuan equals to approximately 2 pounds, in which they can buy 4-5 bottles of soft drinks).   With 15 yuan at their dispersal, they can give it up to three people they like.   The restriction is: i) they cannot give it to anyone within the household, ii) they cannot give it to anyone outside the village, iii) they cannot leave it to themselves.

Every time when they say the name of the gift receiver, the interviewer will further ask how much they want to give it to.   In addition, gift giver self-reports the reasons of giving gifts to each nominee which interviewers recorded on the questionnaire.   The reasons for giving gifts are open-questions.   Because there are so many people who have the same name within one village, apart from the name of the receiver, I will further ask some questions to avoid mismatch, questions like who is the head of the household of the receiver, which herding group he/she is in will be asked to double check the identity of the alter (gift receiver).

Communication is not allowed during the gift-giving game, and one interviewer explains the rules of the game clearly to the participants before the game, making sure that during the process of nomination there are no bystanders observing.   I write the names down and dispatch the money to the gift receivers at the end of the experiment.

Answers given to the reasons for giving gifts are quite simple and straightforward. There are in total 14 groups of reasons being reported by the participants, I coded the 14 groups of reasons and categorized into three factors: one based on kin (Father/Mother, Son/Daughter, Brother/Sister, grandchildren, sibling's

children), the other based on reputation (poor), and reciprocity (Friends, herders who are helpful), the last category is 'others', which include some reasons that are in small number and difficult to categorized into any category.   For example, 'I don't know why I give gifts to', 'I give him/her because he/she is cute', 'hard to tell' and so on.

There are limitations of this method, for example, gift-players are not allowed to give gifts to anyone within the same household, that made the results biased as parents who are still living with their offspring are not allowed to give gifts to their children; the form of the gift, cash in this case, will probably affect gift decision; the experiment is anonymous, but I do notice that gift-giver like to tell receiver afterwards, and this might have some signaling effects of giving.

2.2.3   Labour ranking

I use labour ranking data to access the female work effort. At the end of the field work, I made name cards for every woman in one village.   On every name card, there is the photo of the interviewee, their name, as well as their partner's name and address on it.   It is necessary to put pictures and other information on the name card because there are too many people share the same name and they use different names in different situations.   Name cards with a picture make labour ranking easier and more straightforward for raters. Other information on the name card is helping me to do further analysis, raters are all illiterate so it will not influent their ratting. The 'Labour ranking experiment' was conducted with three women who have good knowledge of everyone in the village (age mean = 48).   I then ask them to put the name card into three different boxes according to a woman's working ability, these mainly include their ability to do domestic and herding-related works. Three boxes representing 'good-at-working', 'average standard', 'bad-at-working' respectively. After discussion with each other, three women will make an agreement and put the name card into each box.   In the end, there are three piles of ranking results based on the women's house working ability.

Although raters can discuss during rating to avoid the social desirability bias, there is a limitation of this method, because raters will bring her subjective opinions into the rating.

2.3 Demographics

2.3.1   Population structure

The population in the study site (including monks) in the year 2015 is 4601 (N = 2266 male and 2335 female).   The sex ratio is 97.04, female and male are not significantly different according to the one sample proportion test (Chi-square = 1.01, P = 0.32, 95% CI = [0.48,0.51]).   One striking characteristic of the population pyramid is that there is a contrast between age group 20-24 to age group under 20, the population size in the age group under 24 (in the early 1990s) sharply reduced, I interpret this phenomenon as the results of family planning policy, because although the family planning policy was implemented in most Han area in the 1980s and there are some literature suggesting that 3-child policy was practiced in Tibetan area in the late 1980s, the population pyramid here is showing that it is only until after earlier 1990s, the child policy was widely practiced (see references in chapter 1 section 2 about the child policy).

population pyramid 2015
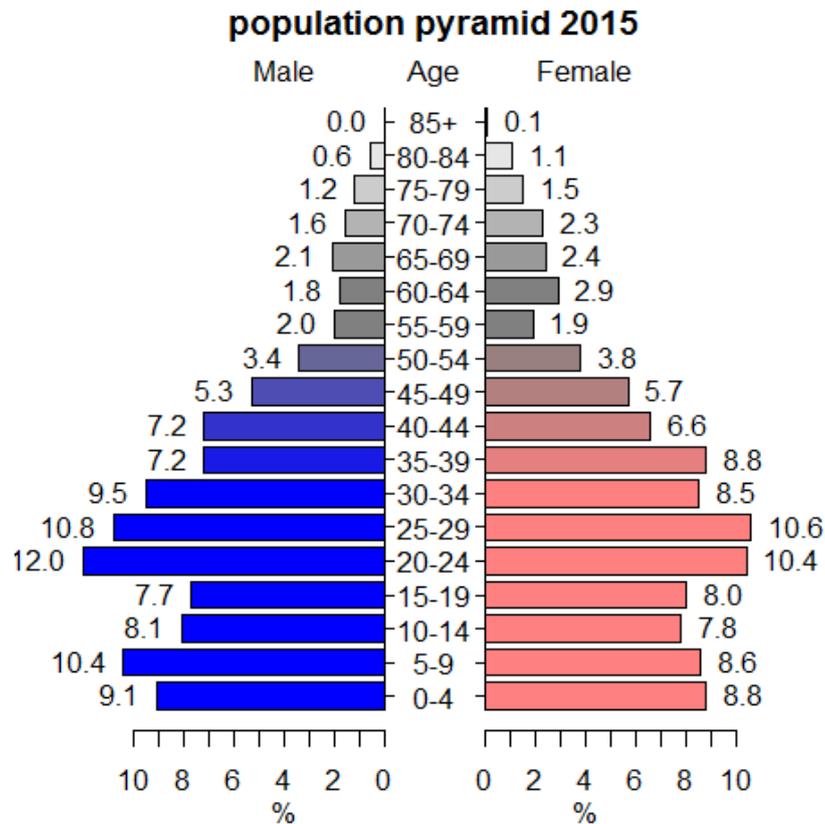
Figure 2.2: Population pyramid for 4601 living people in the 5 research villages (including monks and nuns that currently live in monasteries but are registered to village households).   The graph was split by sex, age was divided in 5 years age group.   The blue bars at the left side show the distribution of % males in each age group, the pink bars at the right side is the distribution of % females in each age group.   Grey bar at each side is the post-reproductive male and female.

Another very important factor which affects the population is violent pasture conflicts.   The conflict in this region is mainly over the borders of grassland. Between 1985 and 1991, there were forty-seven-armed rangeland conflicts recorded between counties within Gansu and on the border of Gansu and Qinghai, leading to more than twenty deaths and eighty serious injuries.   The most serious one happened in 1999, between Maqu county (my field area) and Henan county in Qinghai province, with over 2000 fighters on both sides.   This conflict lasted two years with many deaths and injuries (Yeh, 2003).   This severe war could have contributed to the reduced number of people in 15-20s that we can see from the age-sex pyramid, by reducing the birth rate at that time of the conflict, although the main reason for the reduced number of population in 15-20s

age group is from government child policy I discussed earlier.

2.3.2 Marriage

i) Number of spouses（Marital status in the history）

In Tibetan history, the marital status used to be more flexible, and there were many polygynous or polyandrous marriages (See references in chapter 1). 984 males' and 1177 females' partner information was collected. Because I don't know the marriage or postal marital residential pattern for individuals who were died or never show up during the field work, I define individuals who ever had offspring together as 'partners'. For those who died, I obtained his/her information through interviewing their children. I asked their children to recall the death year and death age of their parents, thus to get information about their parents' birth cohort (N=609 in cohort '<1960'; N=780 in cohort '1960-1979'; N= 772 in cohort '> 1980'). I also asked about whether siblings have the same genetic father/mother, indicating who is half-sibling and who share the same parents. Table 2.2 below represents the number of partners in each cohort by sex. The overall difference between male and female in terms of partner number is slightly different (Chi-square = 9.00, P = 0.06) because the majority mode of the marriage is still monogamy and thus each individual only has one partner. when I exclude 'one partner', the number of partner is statistically different from male to female (Chi-square = 8.62, P = 0.03), with females reporting have significantly more partners than male, but this does not fit with the research I did in Chapter 4 where male herders are more likely to remarry while female can afford to stay single. One possible reason is that 'partner' in this context is based on having children together, the male will misreport their number of partners because of paternity uncertainty. From the table 2.2 we can also see that in the pre-revolutionary period (pre-1960), women, as well as men, were having more partners, which can indicate that in the history polygyny and polyandry, or serial monogamy was practised more often than after 1980. The piechart plots in Figure 2.3 and Figure 2.4 shows the number of partners among those who have completed their fertility and were born before 1960.

Table 2.2: Number of reproductive partners by sex and cohort.   The cohort is the birth cohort, the partnership is defined as having children together.

Gender	Cohort	1 partner	2partner	3+partner
Male	<1960	228	45	10
	1960-1979	278	58	16
	>1980	318	27	4
Female	<1960	232	48	46
	1960-1979	355	66	7
	>1980	386	33	4
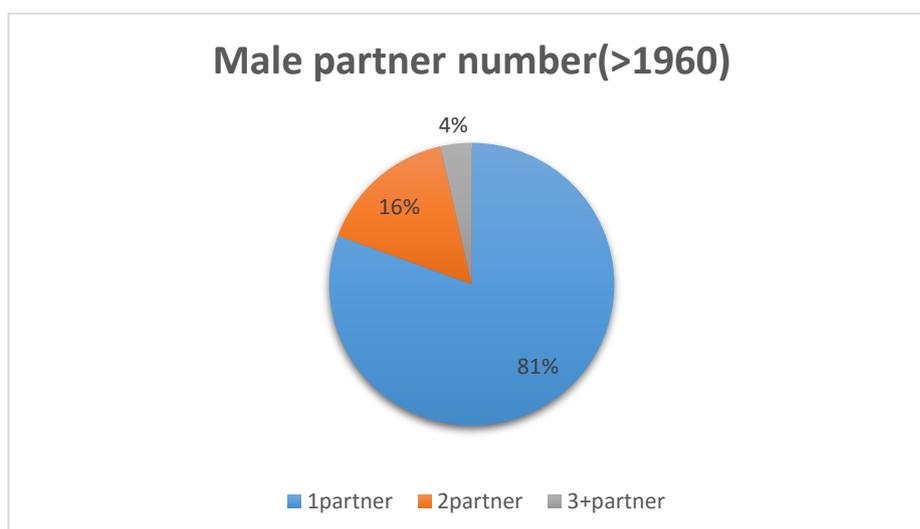
Figure 2.3: Distribution of lifetime male partner numbers reported by individuals born before 1960, the number of partners is from male self-report (direct interview) and sibling report (indirect interview).   81% of male claimed that they have only one partner, 19% of men have more than 1 partner, a mean number of partner per man is 1.24, range from 1-4, SD=0.53.

Female partner number (<1960)

14%
15%
71%

■ 1partner ■ 2partner ■ 3+partner
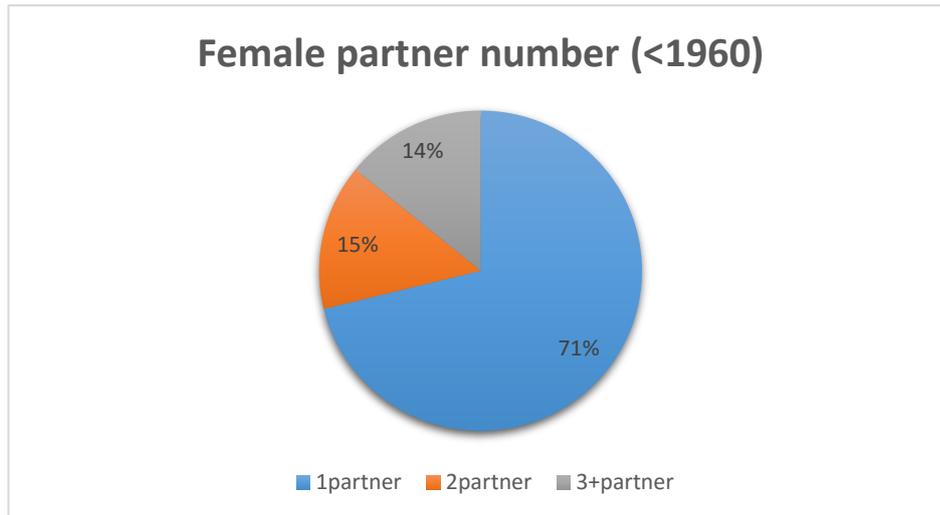
Figure 2.4: Distribution of female lifetime partner numbers for individuals who were born before 1960, the number of partners is from female self-report and sibling report (for the previous generation). 71% of females report that they only had children with one partner, 29% report more than one reproductive partner (N=94). Mean number of partners is 1.53 per women, ranges from 1-5, SD= 1.01.

ii) Current marital status

Marital Status

■ male
■ female

unmarried, married once, more than once, widow/widower, stay divorced, polygyny, polyandry
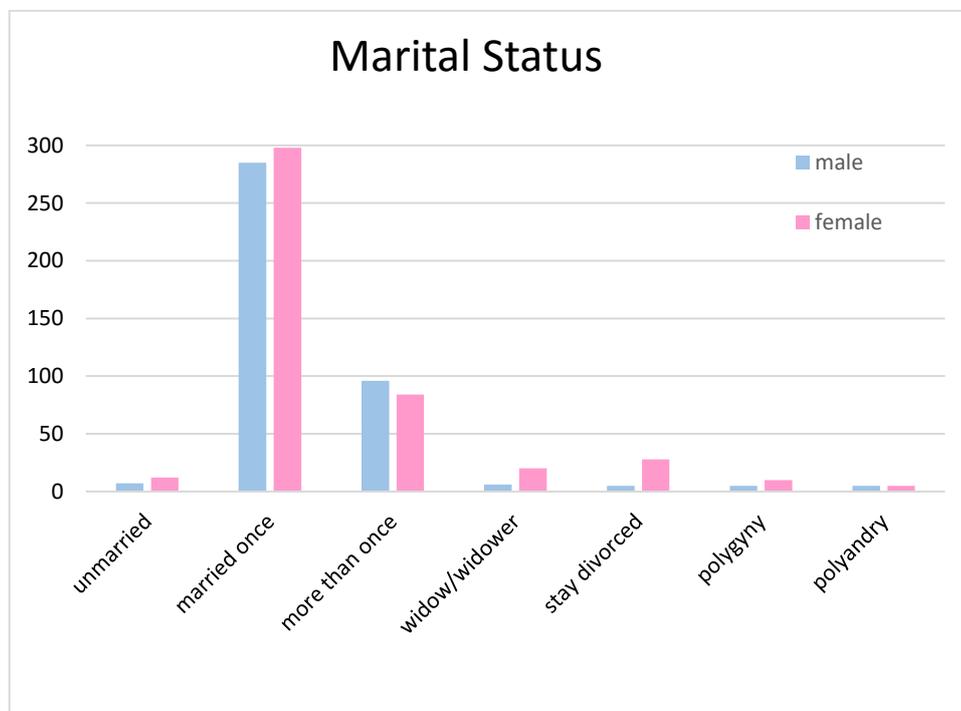
Figure 2.5: Barplot for the marital status in the village in 2015, the graph was split by sex. 864 individuals' marital status was included and divided into 7 categories,

864 individuals' marital status were included in the data (N=408 male, N=456 female).   We can see from figure 2.5 that most of the marriage is monogamous, but at the same time, there are also other forms of marriage.   The divorce rate is high and many men and women are married more than once; there are also single mothers or single fathers who never married during their lifetime or never remarried after divorce.   There are 5 polygynous marriages and 5 polyandrous marriages.   Among the 5 polygynous marriages, 3 are sororal polygyny, where sisters are married to the same husband; one of them is a woman and her daughter from the previous marriage married to the same man.   The 5 polyandrous marriages are all fraternal polyandry where brothers share one wife.

iii)   Post-marital residence
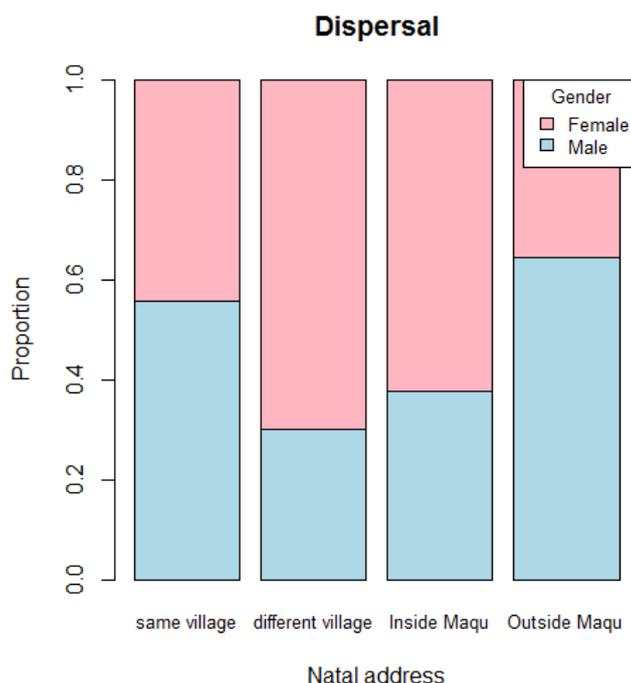
Figure 2.6: Dispersal information of males and females. Four different categories of
          home address are included in the data site.   The difference in the natal
          address as a function of sex is significant, χ² (3, N =1320) = 60.703, p < 0.001

I asked each individual about the address of their natal house and divided the address into 4 categories.   If their natal house is the same as their current house then they are in the 'same village' (male= 356 female=284), and in each

township, there are several villages or 'sheng chan dui'; each village/'sheng chan dui' within the same township are geographically close to each other and governed by the same village leader.   Maqu has 7 townships, and in this data, there are 42 males and 98 females who are living in the same township as their natal house but in different villages/'sheng chan dui'.   There are some individuals (male=175, female= 289) who were born in other townships a bit further away from their current house.   There are also a small number of individuals from outside of Maqu county, and there are significantly more males than females from outside of the county.   The difference in the address of the natal house as a function of sex is significant, with females being more likely to have dispersed between villages, χ^2(3, N =1320) = 60.703, p < 0.001).

iv)   Age of first marriage
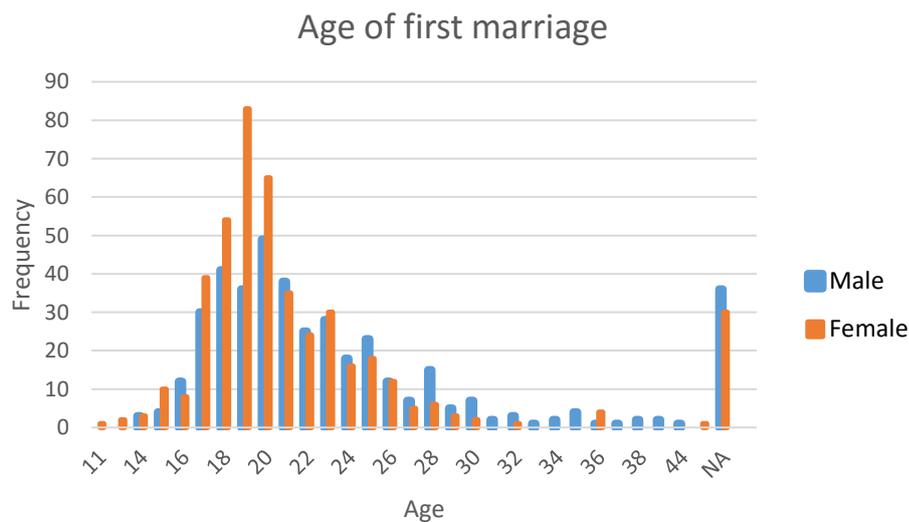
Figure 2.7: Age of first marriage.   The x-axis is the age of first marriage, Y-axis is the number of people in each age group.   The blue bar indicates male marital status (N=408) and orange bar indicates female marital status (N=452).

Mean age for men's age of first marriage is 23.83±4.824, for women is 20.63±3.13, there is a significant difference between male and female (T-test, t value=8.141, P value<0.001, 2-tailed). The majority of the married males are married between age 20 to 27, for females most of them married between age 17 to 22. For females they are all married very young, only one outlier female who get married when she is over 40 years old, she is in a sororal polygyny marriage with her younger sister now.

50

From the interview she told me that her sister and her husband get married first but living with her parents, she is always very busy with the housework until one day she found that it is already too late to find a husband, but all of her family including her sister and brother-in-law (now her husband) are very happy to add her to her sister's marriage because workload is not very heavy when two sisters stay together.

2.3.3 Fertility

i)   Number of children

Using the same dataset that to look at the partner number, I looked at 984 males and 1177 females' total number of children in each age cohort.   Offspring number varies more in the cohort before the family planning policy, which was implemented in the late 1980s restricting the number of children to less than three (Table 2.3).   There is no statistical difference between men (Mean=3.56, SD=2.34) and women (Mean=3.47, SD=2.19) on the number of offspring (t (2035) =0.96, p=0.34).

Table 2.3: Number of births in each cohort split by sex. The cohort is the birth year of the adult male and female. Number of children is categorized into '<=3 children', '4-9 children', '>=10 children'.

	Cohort	N children<= 3	N children <10	N children >= 10
Male	<1960	118	142	23
	1960-1979	193	155	4
	>1980	279	70	0
Female	<1960	124	174	28
	1960-1979	251	175	2
	>1980	359	64	0

ii)   Age Specific Fertility
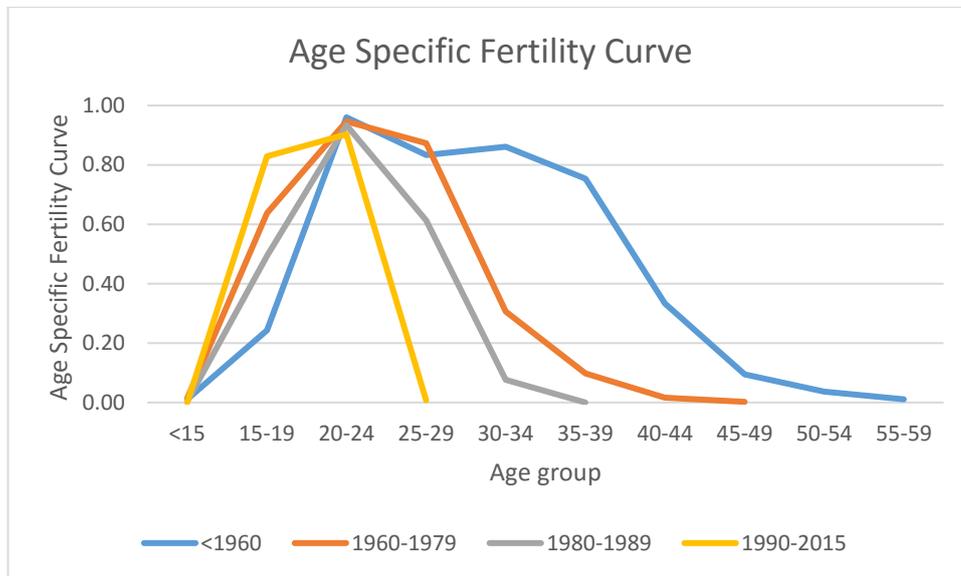
Figure 2.8: Age-specific fertility in the different age group over time. The different line indicates different time periods, x-axis is the age group, y-axis is the ratio of how many women giving birth in the age group to the total number of women at that age group.

Figure 2.8 is the age-specific fertility (ASF) for women from age 15 to 50 (calculated by the number of women who are giving birth in a specific age group, divided by the total number of women in that age group).   We can see clearly from Figure 2.8 that the peak time for women giving birth is at their late 20s before 1960 whereas most of the women are giving birth in their early 20s after 1960.   There are many reasons to explain this phenomenon; one possibility being the improvement in nutritional status and food security; It might also be because of the quality-quantity tradeoff.   Before child policy, women were able to have as many children as they want but after child policy, women are only allowed to have three.   It is possible that women considered it beneficial to have babies when they are in their early 20s when more helpers were around and the quality of offspring likely to be higher.   In addition, when there is pressure that can be perceived as mortality risk, life history theory predicts that women would give birth at a higher rate than in less dangerous situations (for example, in North Caroline, women more likely to have premature birth if there are stressful life

events, pregnancy depression and other social pressures (Dole et al., 2003)).   In Maqu, after the introduction of family planning policy, women have to be irreversibly sterilized by tubal ligation within three to six months of giving the third birth.

2.4 Herding information
2.4.1   Herding strategy

Herding is very important for the subsistence of the local people; 89% of their income is from selling livestock directly.   In early 1990, privatization was implemented in this area, and the grassland was supposed to be fenced between households.   But there are some people who chose to fence up their own pasture while others chose to herd with other families, in the latter case, the form of the herding is similar to the herding tradition that herders 'herding along with the availability of water and grass' at a more spacious land.   From the herding-related data that I have collected in this group, 89% of the households are herding communally, and the size of the herding group varies from 2-30, mean group size is 3.311 households.   Each herder was asked to rank the quality of the pasture from 1 to 7, with 1 as the lowest quality while 7 means the best quality.   There are several factors that were believed by the local herders as closely associated with the quality of the pasture: 1. Water resources; Water is important for both livestock and people, anyone who were allocated an area with water were herders with fortune.   2. Sunshine; Pasture is not always flat, and aspect will influence the condition of the grassland, especially in winter, when areas with sunshine have better quality grassland.   3. Distance to town; No one wants to herd in the far too remote areas where both going out and shipping livestock to the slaughterhouse is extremely difficult.   4. Grass quality; Diversity of grassland, growing of inedible flowers or grass) itself will influence the choice of herding formation.   5. Fungus; Caterpillar Fungus has a very high marketing value as a medicine, so grassland that has a high density of caterpillar fungus is more precious. 6. Wild animals; Wolf, fox and bear threaten sheep and calves, so the frequent appearance of wild life is not welcomed.

Table 2.4: Descriptive statistics on the herding related data. Description includes the main source of income; herding formation; herding group size; livestock number and grassland quality.

Main source of income				
Herding	Labour	Gov.work	Business	Fungus
568	22	4	11	5
Byproducts	Rent grassland	Other	No-info	
1	9	1	16	

Herding group formation			
Alone	Group	No-herding	No-info
62	576	10	1

Herding group size		
Min.	Max.	Mean
1	30	3.311

Number of livestock				
	Min	Max	Mean	No-info
Yak	0	300	62.1	60
Sheep	0	250	11.21	70
Horse	0	20	3.32	313

Grassland quality				
	Min	Max	Mean	No-info
1.Water resources	1	7	3.88	135
2. Sunshine	1	7	4.25	145
3. Distance to town	1	7	5.26	150
4. Grass quality	1	7	3.38	140
5. Fungus	1	4	1.03	302
6. Wild animals' threat	1	7	2.02	306

Biologists have conducted many studies to investigate how privatization affects the biological condition of the grassland in Maqu county. I hypothesized that the choice of herding communally or alone depends on the environmental and social factors at the time of the privatization in 1990. I then excluded any families that

were established after privatization from this analysis, because they don't have a clear idea about the grassland quality in the past.   There are three factors potentially will largely associate with the herders' choice of the herding formation. First is the satisfaction of their own grassland quality, second is the source of income, the last is the family wealth (number of animals and household member). Number of animals is directly related to the family wealth because selling animal is the biggest part of their income, number of family member relates to the family economy is because the number of family member relates to the family expenditure, possibly because the more family member each family has, the more economic pressure you got, but at the same time, having more adult members means more labours, and that will, on the contrary, relieve the family economic pressure.   I asked each head of the household to report the quality of the grassland before privatization and after, the quality was ranked from low to high.   We can see that most herders report that the grassland quality (Figure 2.9) and the water abundance (Figure 2.10) is better in the past than at the present.   It is difficult to say whether these two factors have really changed from high quality to poor quality over time or it is a biased evaluation of grassland. Although some research did show that privatization increased percentage of grass of low digestibility and grazing pressure has increased throughout time in Maqu (Cao et al., 2013), others show that individuals prefer to stated that they enjoyed the past more than the present (Lowenthal, 1975), and sometimes overgrazing is overstated (Mace, 1991).
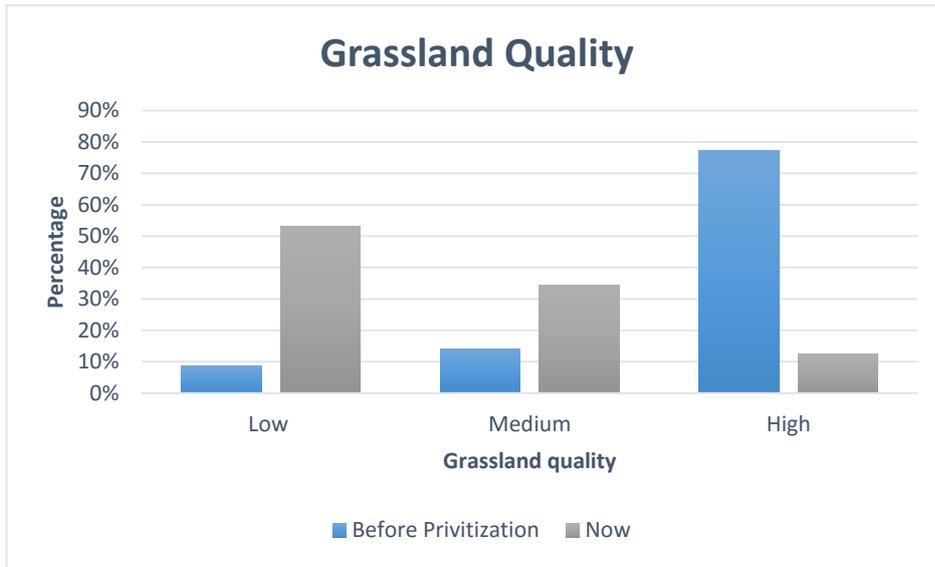
Grassland Quality

Figure 2.9: Distribution of the perception of grassland quality before privatization and now.   The x-axis is three categories of the grassland status, the Y-axis is how many people are in each category.   The blue bar indicates grassland quality before privatization, the grey bar indicates the grassland quality at the present.

Water quality
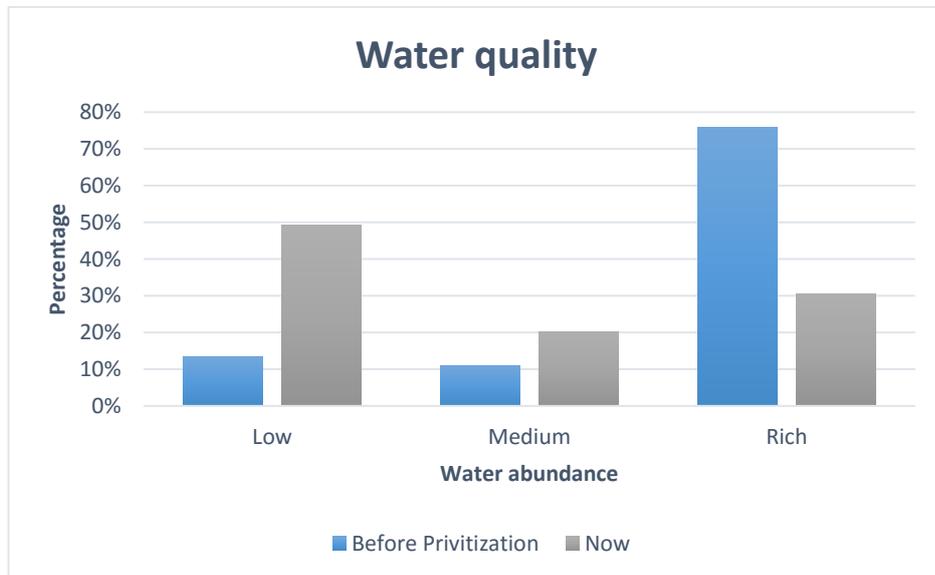
Figure 2.10: Distribution of the perception of the water abundance before privatization and now.   The x-axis is three categories of the grassland status, the Y-axis is how many people are in each category.   The blue bar indicates water situation before privatization, the grey bar indicates the water abundance at the present.

Density plot of family member
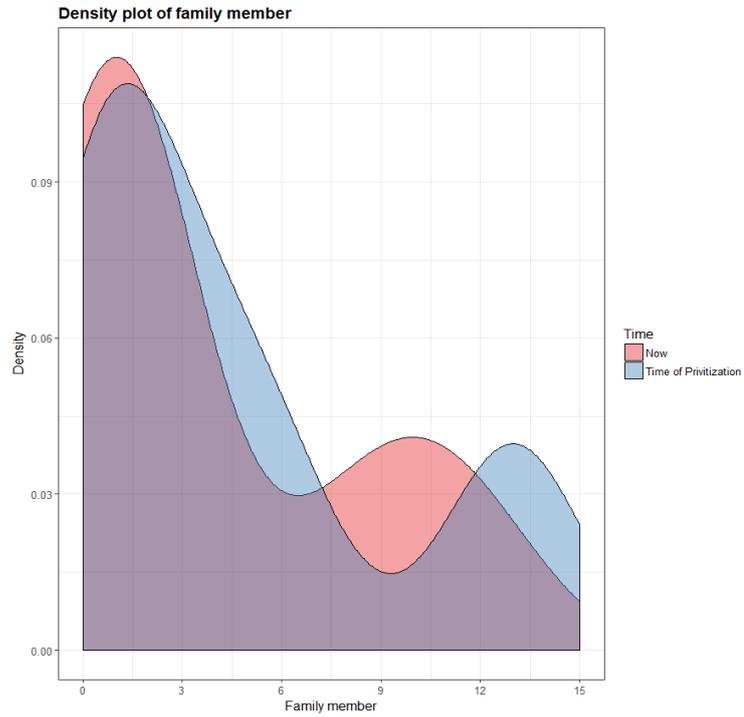
Figure 2.11: Frequency distribution of number of family members.   The x-axis is family members.   The pink area is family member density at the time of interview and blue area stands for the family member density at the time of land privatization in 1990.
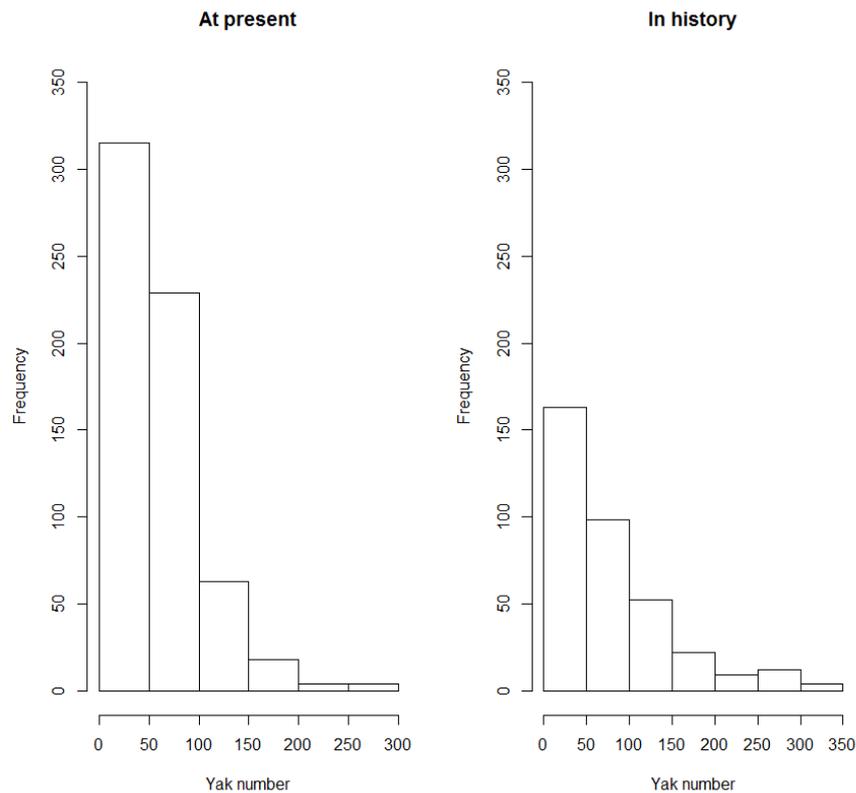
Figure 2.12: Distribution of the reported number of yaks before privatization and at present (in 2015).   X-axis is the number of yaks, Y-axis is the frequency of the yak number.

2.4.2   Why choose to herd alone or in a herding group

Herding in groups or alone affects the grassland quality.   Previous studies showed that in Maqu, herding alone degrades the environment more compared to herding communally, as measured by biomass, vegetation cover and species richness (Cao et al., 2013).   I use logistic regression to look at which factors are associated with the choice of the herding alone or communally.   Herding in groups could result in herders' better perception of and better quality of the pastures due to the inherently more flexible and efficient way of using common resources.   Herders who had more livestock would pay some fees to the herders who had less if they are in the same herding group (Wu & Richard, 1999). Large herding groups could have well established collective herding rules and enforcement mechanisms for non-compliance, resulting in a better use of the resources, which translates into a better perception of the state of the environment.   Research showed that 8-13 households are the optimal herding group size in terms of biology and social stability in Maqu (Cao, 2010).   It is

possible that there is some degree of reciprocal causation resulting in the positive relationship between herding size and the perception of the environment; Herders with large amounts of animals might perceive the environment to be in a better state because their social status allows them to access better pastures, or they might have the resource availability and the management knowledge to better prevent land degradation (e.g. through fertilization or irrigation), especially at the first several years of privatization, rich herders have enough money to install fences so that they can obtain more land than they were allocated (Williams, 1996).   As we can see from the density plot in Figure 2.11 that there is little difference from 1990 and 2015 in household size (t(250.13)=1.32, 95% CI =[-0.18,0.89], P=0.19); but the number of the yaks changed over time, as Figure 2.12 shows, in 1990 individuals had more yaks than in 2015 (t(201.94)=-5.21, 95% CI=[-60.14, -27.11], P<0.001).   We can briefly conclude that privatization has had negative effects on the herd size.

Another important factor which I suspect is closely associated with the choice of herding status is a source of income.   As far as income sources are concerned, when the main source of income is herding there might be an incentive for herders to increase the number of their livestock.   Alternatively, those whose main income does not come directly from the herding might have looked for alternative sources of income.

I conducted logistic regression analyses for those households that were both existing at the time of privatization and now (N=128), in order to examine the factors that affect the herding formation at the time of privatization.   The parameters used in the analysis are: 1) the quality of the allocated grassland at the time of privatization (grassland quality and water abundance); 2) source of income (binary income of either herding as the main source of income or there are other income);   3) wealth condition (number of yaks and number of family numbers at the time of privatization).

Table 2.5: Logistic regression to predict the choice of herding formation (herding communally or alone).   OR indicates odds ratio, 95 % CI indicates 95 % confidence intervals.   Statistical significant variables were indicated in bold. (*p<0.05, **p<0.01, ***p<0.001)

	OR	95% CI	P Value
Income (ref: have other sources)			
Herding	1.68	(0.60, 4.65)	0.32
Number of family member	**0.86**	**(0.73, 1.01)**	**0.06**
Yak number	1.04	(0.93, 1.17)	0.45
Water in history (ref: Poor)			
medium level	1.31	(0.26, 6.69)	0.75
High level	0.63	(0.17, 2.34)	0.49
Grassland quality in history(ref: poor)			
medium level	1.28	(0.32, 5.13)	0.73
High level	1.91	(0.54, 6.78)	0.32

The quality of the grassland and the richness of the water resource is not associated with the choice of herding formation.   Individuals are more likely to be herding alone if there are many family members at home, as the number of family member positively relates to the available labour at home.   However, the area of pasture per household was allocated based on the number of the family members at the time of privatization, so the more family members a family has, the more grassland a family can get from the government.   With more space at their disposal, they can either rent it out or keep more livestock.   The number of yaks has no association with the choice of herding, probably because every family is now only allowed to raise a limited number of yaks; if they have more yaks than their fields can support, then they have to rent land from somewhere else (either inside or outside the same herding group), because the rent is very high, it is not very economical to have more animals than they are allowed to.

2.5 Conclusion

Like many other pastoralist societies, Maqu herders (Amdo Tibetan pastoralists) experienced a series of transformations with regards to effectively managing the common resources and land rights.   But different from pastoralist societies in Africa and Mongolia, the demographic transitions is even more obvious in this area because government policies have not only influenced their way of life, but also the family size, which has implications for the mating and reproductive strategies that I shall discuss in later chapters.

Chapter 3 : Hard-working women and marriage partner choice

3.1 Abstract

Here we analyse how marriage partnerships are made and ended in a pastoralist society of Amdo Tibetans in China.   Women and girls are very hard working, taking responsibility for most domestic and farming and yak herding duties.   We collected demographic and socioeconomic data from 420 women and 369 men over 5 villages to assess which factors predict long partnerships.   We show that the payment of dowry and bridewealth from both sides of the family, and fertility, best predict marriage survival.   Having siblings has no effects on male marriage duration, whilst number of brothers, both elder and younger, did influence a woman's divorce risk in different directions.   Population density is low and opportunities for long courtships are limited.   Trial marriage is a test of fertility and women's working ability, which is associated with women's divorce risk.   We argue that the monastic system contributes to a low operational sex ratio, which appears to generate high female workloads, high divorce rates and many single mothers.   Divorced women are more likely to be classified as 'not hard working'. Thus working ability becomes a key factor in marriage partner choice for males, leading to a very unbalanced division of labour in favour of men.

3.2 Introduction

The incentives for women to establish long-term pair bonds or marriage is largely based on how many resources a male can provide to her and her offspring.   The division of labour, with males and females taking different and complementary roles, is an important factor favouring marriage.   To maximise the production of each household, there is no universal form of how man and woman divide their labour, as it depends on ecology.   Gurven & Hill (Michael Gurven & Hill, 2009) argue that there is always an equilibrium in terms of family investment; if one part invests less, the other part has to invest more to make a balance, and divorce will happen if the 'bargaining' fails.   There are several factors which affect the sexual

labour division, including the expertise of each partner.   In Australian foragers men emphasise bigger prey in hunts and women collect small kills or low-variant products (Bird, Codding, & Bird, 2009), while women have more family constraints, especially when they are pregnant or have dependent children around, and thus women prefer to conduct relatively sedentary and safer work (Bird, 1999).   Males may prefer to hunt bigger kills in order to share it with others and seek higher social status (Bird et al., 2009).   Marlowe argues that different ecological conditions generate either ecologically or socially imposed monogamy (Marlowe, 2000).

Males and females have different strategies in terms of mate guarding. Paternity confidence will also influence paternal investment.   Females have higher genetic confidence in their offspring while males have less certainty, thus males want to guard females to ensure their paternity certainty while females want to guard mates to acquire more resources by preventing males from forming polygynous marriages or mating outside of the marriage (Stieglitz, Gurven, Kaplan, & Winking, 2012; Flinn, 1988).

In farming and herding societies, labour is still important, but the inheritance and transfer of wealth (usually the farm or the animals) also becomes critical. Wealth transfers at marriage can be a large part of the costs of investment in offspring.   Marriage payments can be divided into different forms: bridewealth, dowry, bride-service, gift-exchange and token (Goody & Tambiah, 1973; Bossen, 1988).   In Amdo Tibetans, these different forms of marriage payment all exist, but the most widely recognised and practised are bridewealth and dowry. Polygyny and pastoralism often coevolve with bridewealth (transfers from the groom or his family to the bride's family) as a form of male-biased parental investment in enhancing their son's chances of becoming polygynous (Hartung et al., 1982).   In contrast, dowry is a payment that parents make to their daughters at the time of marriage, which is a form of female-biased property inheritance. Gaulin and Boster (Gaulin & Boster, 1990) proposed a 'female-competition model', arguing that in stratified and monogamous societies, dowry is used as a means of competition among women for desirable husbands.   It is only practised in societies with land property and mainly with monogamy.   In ancient China, dowry distinguished the higher status wife from the concubine(Laura Fortunato,

Holden, & Mace, 2006; Ebrey, 1986).   Large dowries are common in societies in India and China when hypergyny is almost impossible.   When the cost of rearing and marrying off a daughter outweighed the benefit, female infanticide emerged (Dickemann, 1979).

Siblings compete for the family property and thus one sex will delay the age of marriage and allow other siblings to marry first.   In pastoralist societies in Africa, the number of brothers will negatively affect the age of male marriage and size of dowry for his sisters (Mace, 1996).

Siblings are competing for the family resources but also collaborate with each other to protect the family property and maximise reproductive interests (Ji, Xu, & Mace, 2014; Ji et al., 2013).   Sororal polygyny and fraternal polyandry are examples that show how siblings cooperate with each other by staying in the same marriage.   Kin selection theory determines that genetically related sisters will be better off than women that have no genetic relatedness in polygynous marriages (Winking, Stieglitz, Kurten, Kaplan, & Gurven, 2013;Chisholm & Burbank, 1991), while brothers protect the family property and maximize the labour force within the family by sharing a single wife (Childs, Goldstein, & Wangdui, 2011a).   In the Himalaya area, fraternal polyandry marriage was widely practised to protect the land and family property.   In Tibet, fraternal polyandry has the advantage of protecting the family from expenses, because sharing one wife will reduce the tax fees paid and the other costs of each household (Childs, 2003).   Polygyny and polyandry are not stable, especially when there are age differences between co-husbands or co-wives, as it costs younger siblings to stay in the marriage in terms of their own reproductive success (Haddix, 2001; Haddix McKay & Gurung, 1999).   It is very often the case that the younger sibling will leave polyandrous marriages and find another partner in Tibet (Levine & Silk, 2008).

Overall, we would predict that individuals are more likely to leave a marriage when they think that it is a benefit to their fitness, but the precise reasons are diverse.   Divorce is a tradeoff between the welfare of any children from the existing marriage, against any future mating opportunities that might arise to create further offspring with a new partner.   Among all the possible reasons for

divorce, fertility is no doubt a very important one; for example in rural Gambia, divorce is usual if there are no offspring and women will formally get married only after they have had one or two children in her natal house (Sear, Mace, & McGregor, 2003).

Parental investment is also key. Disinvestment can be triggered by a tense marriage relationship (Michael Gurven, 2006).   Many divorces happen because of paternity uncertainty (Anderson, Kaplan, & Lancaster, 2007; Anderson, Kaplan, & Lancaster, 1999).   Sometimes infant mortality will result in females seeking to divorce, for example in Muslim societies in Bangladesh where child mortality is high and family abuse is common (Alam, K.Saha, Razzaque, & Ginneken, 2016) (Nag, 1972).   Who should take care of children after divorce is a problem that both parties have to worry about, which also constrains the divorce process (Weisner & Gallimore, 1977).   In an African matrilineal society, lazy men are required to desert the marriage under the maternal uncle's orders (Kishindo, 2011).   Whereas good characters, for example, those who are good at doing housework, who have better education or knowledge, wealth, or who are good looking, will be in more demand (Pedersen, 1991).

Some people stay divorced while others soon remarry.   Both males and females can sometimes increase their reproductive success by having multiple marriages (Borgerhoff Mulder, 2009; Dhondt, 2002).   The economic situation is also important because the total resources will be diluted for a man after several divorces and remarriages (Hartung, 1982).   Couples try to balance the family economics and marriage, as household production will be maximized when they are working together (Stieglitz, Gurven, Kaplan, & Hopfensitz, 2016).   There is always a tradeoff between deserting or staying in a marriage.

Sex ratio will affect which sex has more bargaining power.   The abundant sex will face more intense competition in the mating market; thus they may invest more in order to gain fitness (Pollet & Nettle, 2008).   Young men in high sex ratio societies sometimes undertake high-risk behaviours, such as homicide, crimes, gambling, and speeding driving in order to succeed in intrasexual competition (M. Wilson & Daly, 1985; McAndrew, 2009; Uggla & Mace, 2015).   Or they may compete through parental care so as to avoid the risk of divorce (Schacht &

Kramer, 2016; Angrist, 2002).

Hypotheses: Based on the previous research and the specific ecology setting in this society, I investigate that the chance of divorce is associated with the following predictors. First, the length of the trial marriage will positively related to female's chance of divorce. Second, bridewealth payment is important, as the risk of divorce is high if both bride and groom made a payment at the time of divorce. Last, sex ratio had a stand in the matting market where male has more bargaining power thus can leave and enter into a marriage more frequent than the female does.

3.3   Ethnography of a mating and marriage in Tibetan herders
3.3.1   Mating and trial marriage

In some societies, including in Tibet, trial marriage is practised.   In Ache hunter-gathers in Paraguay, women prefer to have trial marriage so that they can test the man's quality and make better decisions, whilst young male hunters, are less likely to practice trial marriage because it will generate hatred from peer male herders (Hawkes, O'Connell, & Blurton Jones, 2001; Hill & Hurtado, 1996). Some researches show that cohabiting before marriage will increase the chance of separation while others show that the risk of dissolution will be lower after cohabitation (Boyle & Kulu, 2010).

In this Tibetan society, there is also a custom of 'trial marriage', when male and female live together for a while before marriage.   Because of the ecology, 'dating' is almost impossible for young people, especially as women are always busy doing herding and housework in their natal homes.   Furthermore, the population density is low.   After several occasions of seeing each other, the man and woman will start to live together and enter into a 'trial marriage'.   Trial marriage starts with living together in the man's parents' house.   Before formal marriage, there is no proper house or tent for the new couple to stay in. Parents' opinion is very important in making a decision on whether to bring a female into the family, because of her ability to work means a lot for the prosperity of the family.   Before cohabitation begins, after briefly talking to each other on the phone, one day deep in the evening, the girl will disappear from her natal house (planned beforehand secretly), and the man will bring her to his

parents' house.   The next morning, the man's family will find this new family member.   Most often, the men's parents will bring some small gifts (tea, soft drinks, white scarf etc.) to the girl's family the next morning to show respect, but some parents will wait for several days until they are also satisfied with their potential daughter-in-law.   When a man and a woman start living together, she starts to work for her husband-to-be's family, until one day the trial process ends and the two families will move on to the next stage, where the wedding ceremony will be organized and details of marriage discussed.   Most importantly the exchange of bridewealth and dowry will proceed.   The trial time varies, but most often the wedding ceremony will take place during the first year after they are living together, there are also a few cases where, after several years of trial marriage, a woman who doesn't get pregnant is abandoned by the man's family and she will go back to her natal house and wait for the next mating opportunity. But she will have a bad reputation in the small-scale society, at risk of being considered to be barren or lazy.

One or two years of trial time might be a bit too rushed to test female fertility, but it is long enough to test women's working ability, and working ability is definitely a very important expectation of the female gender role.   Parents can also arrange a marriage for their children, and in this case, the whole process will become simpler and sometimes they will skip the trial procedure.

Before marriage, the mating system is quite relaxed in that both male and female can have multiple mates at the same time; but once they live together, mate guarding from the male side appears stronger.   Although women are the main source of labour for the family's finances, it is men who will be in charge of the family business.   This includes selling animals to the market, buying food and daily necessaries for the family - even shopping or buying female personal products are processed by men.   Women may not have detailed knowledge of the family's economic status because it is usually the husband's responsibility. Males have plenty of cash at their disposal and conduct most of the family trading activities.   Youngsters and middle-aged men can often be seen hanging around in public places, often gambling.

3.3.2 Bridewealth and dowry payments

In patrilineal societies, marriage is a time when daughters lose their relationships with their natal homes, and also a time when parents will transfer a fair share of family wealth to their daughter.   Before 1980, both bridewealth and dowry were rare, because there no private property was allowed during that period of Communism. Everyone in a household was only allocated to very few yaks. When they got married, each person would bring his/her own property away from his/her natal house to the new house (Gelek & Miao, 2002).   After 1980, also known as the commune period, bridewealth was paid before or on the day of marriage from the man's family to the woman's family or to the new couple.   The content of the bridewealth varies, but in general, the most important part of it is yaks, together with cash, tea, grain and butter. In the case of dowry, it most often consists of yaks and expensive jewellery (coral necklaces, silver belts, golden earrings etc) and sheepskin garments.   There are also some gifts from the mother to her son-in-laws' family, for example, tea, butter flour etc. Jewelry was a very important part of the dowry, and it was accumulated from when the daughter was a teenager up until the wedding day.   The bride wears all her jewellery on the wedding day, and she can pass it to her daughter in the future.   Parents accumulate dowry, in this case, jewellery, from an early time in their daughter's childhood, but daughters accumulate it themselves as well before getting married; for example, when they are doing very good housework at home, her parents will pay something back, and most of them like to use this money to buy some small items of jewellery or clothes.   One girl that I met said that her parents just added another piece of coral to her coral necklace because she worked hard and was lucky enough to collect a large amount of caterpillar fungus during the summertime.   The fungus was worth around 70000RMB in the market, and her parents spend 10000RMB on the coral as a reward for their daughter's hard work.

In Maqu, both bridewealth and dowry are practised; bridewealth is called *jerrah* (རྒྱ་རིན་) and dowry is called *Wahe jiong* (བག་རྫོངས་).   From the 1950s to 1980, both bridewealth and dowry were rare, because no private property was allowed during that period of Communism.   Everyone in a household was only allocated to very few yaks. When they got married, each person would bring his/her own property away from his/her natal house to the new house (Lobsang Gelek &

Miao, 2002).   After 1980, also known as the commune period, marriage payments resumed.   It was paid before or on the day of marriage from the man's family to the woman's family or to the new couple.   The content of the bridewealth varies, but in general, the most important part of it is yaks, together with cash, tea, grain and butter.   In the case of dowry, it most often consists of yaks and expensive jewellery (coral necklaces, silver belts, golden earrings etc) and sheepskin garments.   Both bride's parents and groom's parents will provide half of the yak hair tent for the new couple.   The bride wears all her jewellery on the wedding day, and she can pass it to her daughter in the future.   Parents accumulate dowry jewellery from early in their daughter's childhood.   Dowry is paid on the wedding day. All the yaks that make up the dowry will leave the natal house together with the bride, and in the event of divorce, the wife is entitled to take the full dowry back.   Women can recognize the yaks that they brought from their natal homes.

We focus on four factors, which may determine the chance of maintaining marriage or of divorce by analyzing: i) kin effects on divorce, including whether having children, living or dead, or of the same or different sex, increases divorce risk; ii) the size of marriage payments, and whether more payment from either side will stabilize the marriage; iii) the adult sex ratio to see whether sex ratio will affect the divorce risk; iv) trial marriage and female working ability.

3.4   Methods

3.4.1   Demographic data

Demographic data on births, deaths, and marriages of all household members was collected through an in-depth interview in 2015-2016.   In each interview, both men and women are asked separately in private spaces about their marriage history.   This included, where any ex-partner is, how much was the bridewealth, what happened after divorce, whether they had any children, and the year of birth and death of the offspring.   Seven hundred and eighty-nine individuals' marriage history data was included in the analysis (male=369, female=420).   Because divorce is relatively easy and the mating system is a bit flexible in this society, some people divorced more than once.   We only look at the first marriage in the study of marriage duration.   For the labour ranking, three senior female villagers rated all women in their village on working ability (on a

scale of 0 to 7 with 0 being 'not hard working' and 7 being 'excellent at working').
One hundred and eighty-six female subjects' ranking data was used in this
analysis (min age = 19, maximum age = 76, mean age =38.72).

3.4.2 Statistics

An event history analysis was used to determine factors associated with divorce,
including siblings and offspring (time-varying) and time-invariant covariates such
as post-marital residence, duration of the trial marriage, marriage cohort, age at
marriage, dowry and bridewealth.   Each person-year represents the possibility of
an event, starting from the time when the marriage started, ending at either the
year they got divorced or is censored at the end of the observation period (in the
year 2015 or in 2016, depending on which village they were interviewed in).   The
Polr (Proportional Odds Logistic Regression) function in package MASS was
used when the dependent variables are ordinal, such as to analyse the labour
ranking data.   All the statistical analyses were done using R(v.3.2.3).

We calculate operational sex ratio to see if intrasexual competition affects the
probability of divorce.   Operational sex ratio is used here to mean the ratio of
males to females in the society who are not monks or nuns and in the mating
market.   Those between age 15 to 50 are considered to be at their reproductive
age (Coxworth, Kim, McQueen, & Hawkes, 2015; Uggla & Mace, 2016).

3.5   Results

Most divorces happens early in marriage; the mean age for men at first divorce is
24.3 (min=15.00, max=60.00, median=22.00), for women is 24.45 (min=16.00,
max=48.00, median=23.00).   Male herders are more likely to keep divorcing until
a much older age compared to female herders.   Variance in age at divorce is
greater in men than women (Figure 4.1).

Age of first divorce

Figure 3.1: Boxplot of first divorce age for males and females.

3.5.1 Predictors of divorce

We use event history analysis to explore whether i) gender of offspring, including same-sex resource competition, ii) the distribution of the bridewealth and dowry, and iii) the length of the trial marriage are associated with the risk of divorce. There are time-variant kin effects and time-invariant variables in the model. Time-variant variables include the birth and the death of the offspring, and time-invariant variables include the existence of siblings and whether the marital residence is in the same village as the natal house. There are N=6206 person-years for females and N=6121 person-years for males; the event of divorce was N=114 for females and N= 94 for males. Among all those who divorced, 90% of females and 68% of males divorced during the first 10 years of marriage.

I first did model selection by putting different variables in different models, control models are: age of marriage, time of marriage and birthplace. The model was ranked according to its AICc, the best model has the lowest AIC number (Table 3.1).

Table 3.1. Model selection for the probability of divorce for male and female separately. Candidate models were ranked in ascending order based on the AICc.

Male divorce

Models	delta	AICc
Full model	0.00	721.7
control+bridewealth	35.29	757.0
control+offspring	50.47	772.2
control+trial	71.19	792.9
control	124.00	846.4
control+sibling	129.31	851.0

Female divorce

Models	delta	AICc
Full model	0.00	984.67
control+offspring	15.84	1000.52
control+trial	61.12	1045.79
control+bridewealth	64.85	1049.52
control+sibling	69.14	1053.82
control	69.16	1053.83

We can see from Table 3.2 that women are more likely to get divorced if her natal house is in the same village as her post-marital residence (OR = 1.91, 95% CI = [1.25,2.92], P = 0.003).   This may be because women are more likely to go back to their natal household to seek help from parents or siblings if the natal house is close by; whereas the distance between the natal house and the post-marital residence pattern has no association with the probability of divorce for males (OR = 0.76, 95% CI = [0.45,1.29], P = 0.315).   Regardless of the offspring gender difference, a baby is always a good sign for the stability of the marriage for both adult males and females.   Children's death has no association with male marriage duration, while the death of the daughter will reduce the divorce risk for females, in that women are less likely to get divorced if her daughter dies (OR = 0.30 95% CI = [0.13,0.70], P = 0.005).   Siblings of the male have no associations with marriage duration, but interestingly, the female having brothers, both elder and younger, is associated with divorce risk but in different directions: the more younger brothers the woman has, the more likely that she will divorce (OR =1.81, 95% CI = [1.13,2.88], P = 0.01), whereas, by contrast, the elder

brothers the woman has, the less likely it is that she will get divorced (OR = 0.56, 95% CI = [0.35,0.91], P = 0.019).

The trial marriage duration, as a continuous variable, is important for the continuity of the marriage (Min = 0.00, Max = 10.00, Mean = 0.68); we can see that the longer the trial time before marriage, the more likely that her marriage will survive (OR = 0.82, 95% CI = [0.69,0.98], p = 0.033) (although for the male herders' sample, there was no significant difference (OR = 0.81, 95%CI = [0.69,0.98], p = 0.208).   The proportion of marriages preceded by the trial mating system has reduced during recent years (Figure 4.2).   The time of marriage is also an important predictor of the survival of the marriage.   As we can see from Table 3.1 that the risk of divorce increases from 1990 onwards, compared to the marriages before 1990, especially for the marriages after 2000, when the odds of divorce was 2.76 times higher in the sample of women and 1.83 times higher than in the sample of men who get married before 1990.
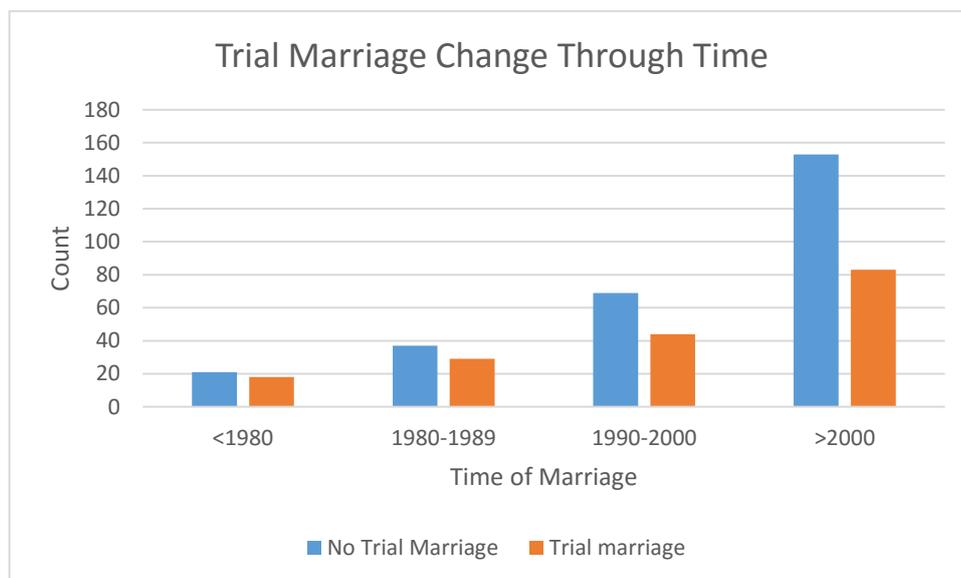
Figure 3.2: Trial marriage change through time. N=420 female marital information was used in the plot. The x-axis is the time of marriage, Y-axis is frequency. The blue bar indicates no trial marriage, the orange bar indicates that there is a trial marriage before the formal wedding.

Between 1980-1990, the commune society collapsed, and by 1990 both males and females started to inherit wealth from their parents in the form of animals or land.   The change of the wealth inheritance affects the marriage stability, as do bridewealth and dowry payments.   Figure 4.3 shows the distribution of

bridewealth and dowry, based on the number of yaks given. Dowry (Min=2.00, Max=63.00, Mean=13.22) is significantly bigger than bridewealth (Min=2.00, Max=68.00, Mean=10.22) (Fisher's exact test, p =0.002). We can see from the EHA (Table 3.2) that bridewealth and dowry both have a very strong effect individually on divorce risk, and the effect is additive (Figure 4.4), so if a couple does not have any bridewealth or dowry (no payments from neither the bride's nor the groom's families) then the marriage is in greater danger of breaking down than in any other combinations of bridewealth payments (Figure 4.4). If neither of the couples contributes to the 'common pool' of the marriage, the economic foundation of and family commitment to the marriage is probably relatively low.
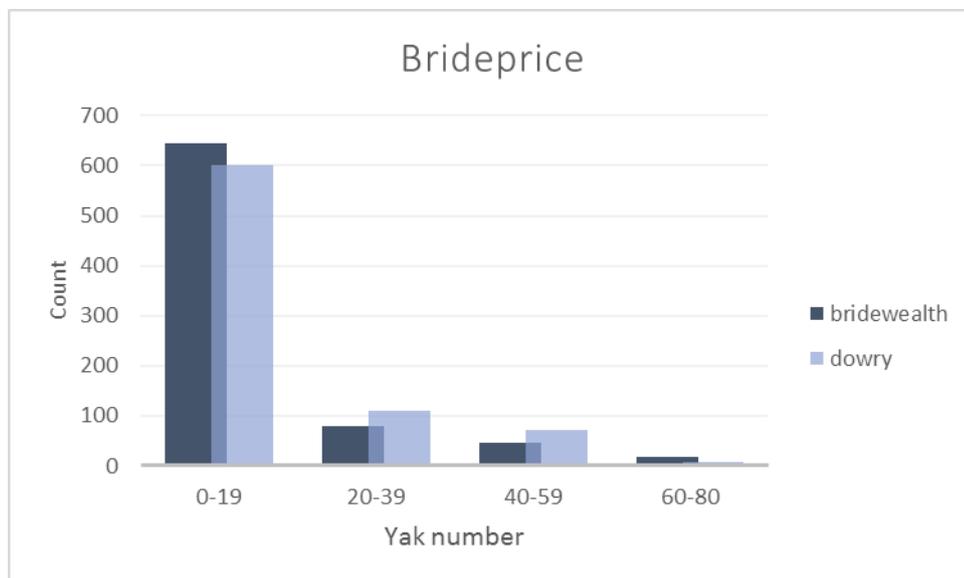
Figure 3.3: Distribution of bridewealth. The x-axis is number of yaks, the y-axis is frequency. Dark blue is brideprice, light blue is dowry.

Brideprice and divorce
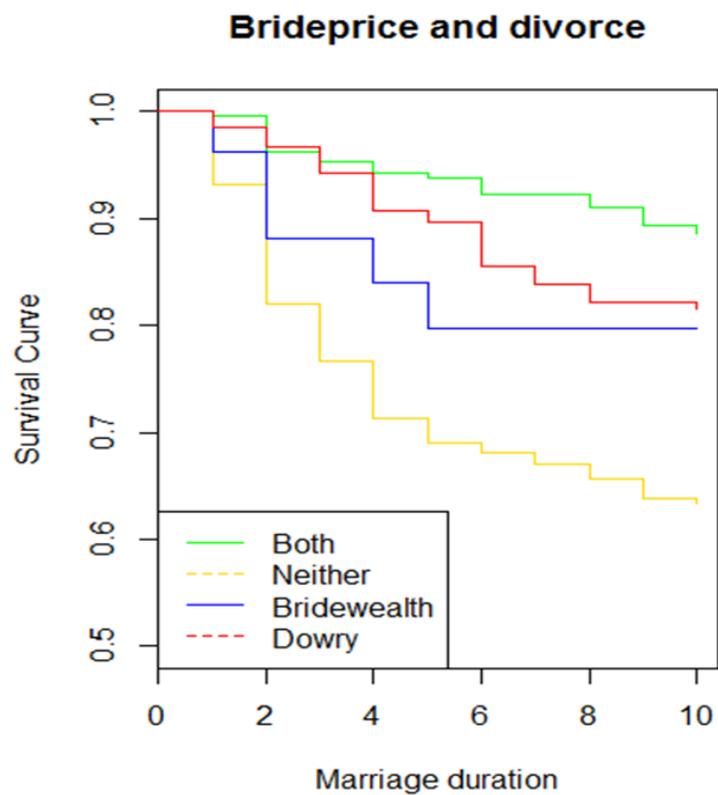
Figure 3.4: Survival curve of the marriage over the first 10 years. The green line indicates both brideprice and dowry were paid, the yellow line indicates neither brideprice nor dowry, the blue line is only brideprice, the red line is only dowry.

Female				Male		
Parameters	OR	Estimate(SE)	P value	OR	Estimate(SE)	P value
Age of marriage (ref:<20)						
20-25	1.38	0.32(0.29)	0.262	0.55	-0.60(0.29)	0.040*
>25	0.71	-0.35(0.33)	0.298	0.21	-1.55(0.36)	<0.001***
Time of marriage (ref:<1990)						
1990-2000	1.73	0.55(0.34)	0.105	1.71	0.53(0.32)	0.099.
2001-2015	**2.76**	**1.02(0.31)**	**0.001****	**1.83**	**0.61(0.30)**	**0.047***
Trial time	**0.82**	**-0.20(0.09)**	**0.033***	0.81	-0.22(0.17)	0.208
Living son	**0.51**	**-0.66(0.13)**	**<0.001****	**0.56**	**-0.58(0.15)**	**<0.001****
Living daughter	**0.61**	**-0.50(0.13)**	**<0.001****	**0.48**	**-0.74(0.18)**	**<0.001****
Dead son	0.76	-0.27(0.21)	0.203	0.7	-0.35(0.225)	0.153
Dead daughter	**0.30**	**-1.19(0.43)**	**0.005****	0.91	-0.10(0.32)	0.762
Older bro	**0.56**	**-0.58(0.25)**	**0.019***	1.12	0.11(0.12)	0.358
Older sis	0.89	-0.12(0.25)	0.633	1.01	0.01(0.11)	0.945
Younger bro	**1.81**	**0.59(0.24)**	**0.013***	0.9	-0.11(0.15)	0.476
Younger sis	1.00	0.00(0.25)	0.991	1.09	0.09(0.14)	0.539
Birth place (ref:different to post marital)	**1.91**	**0.65(0.22)**	**0.003****	0.76	-0.27(0.27)	0.315
Dowry (ref: no dowry)	**0.64**	**-0.45(0.25)**	**0.064.**	**0.21**	**-1.56(0.31)**	**<0.001****
Brideprice (ref:no brideprice)	0.34	-1.09(0.75)	0.146	**0.21**	**-1.56(0.62)**	**0.011***
Dowry * Brideprice	1.98	0.68(0.81)	0.401	3.11	1.14(0.76)	0.133
		N Observation = 6206			N observation = 6121	

Table 3.2: Event history Analysis(EHA) on the risk of divorce, with males and females analysed separately (N= 420 women with 6206 person-years, the event of divorce is 114; N= 369 men with 6121 person-years, the event of divorce is N=94). The dependent variable is whether divorced (1=divorced, 0=not divorced). Variables in the analysis include time-variant kin effects and time-invariant variables. Control variable includes cohort of time of marriage and age of marriage. OR stands for odds ratio, SE stands for a standard error. Statistically significant effects are indicated in bold.

3.5.2 Sex Ratio and divorce

The temporal and geographical difference in the Operational Sex Ratio (OSR) can be an important predictor of pair-bond stability (Clutton-Brock & Parker, 1992).   Sending at least one son from each extended family to the monastery is a tradition of the Tibetan culture.   At some points in Tibetan history, up to 1/3 of males were in the monastery during most of their life; but with the implementation of the child policy and compulsory education, the size of the monasteries reduced and the number of monks and nuns reduced accordingly (Hao, 2000).   In 2015, there were 182 living monks and 15 nuns in our study villages.   A monks' household register (*hu kou* in Chinese) is still in his natal house, and their family still treated him as a family member.   Some old monks have very high family status, and their family believes that a family monk is the head of the household, and they will consult their family monk from time to time.   There are also monks from outside of the village, but we do not have any census data from them.   The sex ratio excluding monks for the population is 89.83 (Figure 4.6), that is significantly skewed towards females (one-side proportion test (Chi-square = 12.54, P = 0.0004, 95% CI = [0.46,0.49]).

The skewed sex ratio is especially pronounced in older age groups.   Table 3.3 shows the sex ratio with and without monks in this society.   The sex ratio at birth is 99.51.   The mean age of monks in the population is 29.14 (Min.=7.00, Max.=80.00, SD=15.89).   We define the age group between 15-50 to calculate the Adult Sex Ratio.   The Adult Sex Ratio is 98.82 in the whole sample and 90.48 in the 'without monk' sample.   The latter determines the level of intrasexual competition because monks are not in the mating market.   As such it better reflects the 'operational sex ratio' of the population.   As the size of monasteries has been declining somewhat in the last few decades, it is possible that the operational sex ratio may have been even more female-biased in the past.

Table 3.3: Sex ratios of the living population with and without monks. Sex ratio at birth was calculated for the living male birth to female birth; Adult sex ratio was calculated for the adults aged 15-50; Population sex ratio was calculated from all living males to females.

Sex ratio	With monk	Without monk
Sex ratio at birth	99.51	99.51
Adult sex ratio	98.82	90.48
Population sex ratio	97.04	89.83

Between age 20 to 35 there are similar numbers of males and females in this society, but after age 35, the sex ratio is female-biased. In other words, middle-aged and older men in the society have less competition and more bargaining power. After their middle age, they are still popular, and divorce and remarry until their 60s. Males older than that are not very popular in the mating market compared to the younger men, nor are they very useful in the family economy compared to women, so they usually stay at home and look after their grandchildren when their wives and daughters-in-law are busy doing herding and house or farm work. Women are statistically more likely to stay single after the first divorce while men will quickly be remarried (Chi-squared=14.629, df=1, P<0.001).

Figure 3.5: Sex ratio of the whole population. The x-axis is different age group from 0-85+ divided by 5 years age group. Y-axis is the sex ratio of males to females.
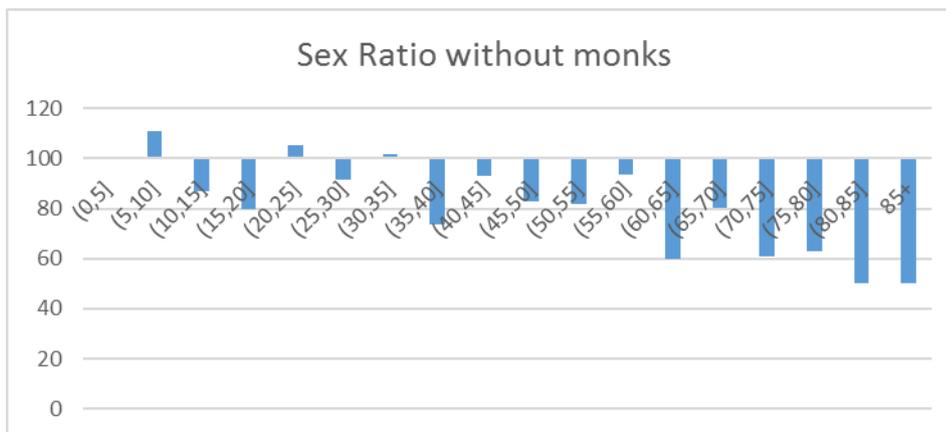
Figure 3.6: Sex ratio of the population without monks. The x-axis is different age groups from 0-85+ divided by 5 years age group. Y-axis is the sex ratio of males to females.

3.5.3   Reputation for hard work:

Table 3.4 shows factors associated with a low or high ranking for hard work among women (N=186), controlling for women's wealth, age and the total number of offspring.   Age has little effect on the ranking, although wealthy women (i.e. more yaks owned) are seen as less hard working.   The variable 'marital status of women' codes whether a woman has ever been divorced in their marriage history or not.   As we can see from the proportional odds ratio in Table

3.4, when a woman's marital status changed from married to divorced the odds of being ranked low will increase 2.48, so from the rank of 'very good at working' to 'average', or 'average' to 'very bad at working'.   We cannot distinguish cause and effect, i.e. whether it is because they are less hard working that they get divorced, or whether it is because divorced people are more likely to consider them to be bad workers.

Table 3.4: Covariates associated with labour ranking of women. OR stands for odds ratio, SE stands for a standard error, statistically significant effects are indicated in bold.

Parameters	OR	SE	t value	P value
N Yaks	0.99	0.002	-2.06	0.039
Age	0.99	0.159	-0.511	0.609
N children	0.90	0.101	-0.994	0.320
Marital status (ref: never divorced)				
Divorced	2.48	0.375	2.421	0.015**

3.6   Discussion and conclusion

When it comes to divorce, the man and woman are under different pressures.   In this pastoralist society, both men and women are less likely to get divorced if they have children.   However, the death of daughters was associated with a reduced risk of divorce, perhaps because a living daughter makes it easier for women to live without a husband, given the high contribution women can make as a potential contributor to the family economy.

One very important feature associated with divorce is the working ability of the woman, as female labour contribution to the household is key to the family's economic development.   Women who are good at working will have stable marriages and will be popular within society.   The longer the trial marriage time is, the less likely that she will get divorced.   Because of exogamy, women are more likely to reside virilocally during the trial marriage, so male partners and in-laws will have time to evaluate the fertility and working ability of the potential bride.

We also found that the divorce risk is increasing over time.   This is true in many modern societies   (Glick & Lin, 1986; Amato, 2000).   Government policy changes in the 1990s may have influenced this trend.   The child policy has limited fertility per woman to three children since the 1990s. Some women are sterilized as early as their twenties as they already have three children.   This could possibly also have increased the divorce risk, as males can still reproduce in future marriages.   After 1990, land privatization was also implemented, and women came to own their own portions of land.   Although a bride is not able to bring the land with her into the marriage as dowry, she will usually get payment from her family (around 3000-5000 RMB) per year as land rental fees.   Land rights for women may also have increased the possibilities for divorce.   Their economic value makes sisters popular among their unmarried younger brothers, which influences a woman's chances of being welcomed back to her natal home if she is not happy in her marriage.   There are many divorced women in this community who have not officially remarried, and who are raising children through their own efforts, often with the support of their natal families.   Some may be in an unofficial polygynous relationship and can get help from their mates.   However, the division of labour is so biased in favour of a low input from males that it seems that women can survive and parent relatively successfully inside or outside of the institution of marriage.

In this Tibetan society, one reason for increased divorce may be the reduced rate of trial marriage.   If the couple does not trial the marriage beforehand, they are more likely to divorce.   We cannot say whether it is the man or his family who will take the initiative to divorce a woman, or it is women who have improved economic independence which gives them more confidence to leave if they are not happy with the trail marriage partner.

Marlowe argued that in pastoralists societies, males provide more resources to the family but put less effort into direct child care compared to other subsistence societies (Marlowe, 2000).   However, we do not find much evidence here males are investing heavily in food production, which appears to be mostly seen as women's work.   In Tibetan societies, polyandrous marriage used to be common, but may not be about workloads as much as being about protecting the family wealth (usually land), as brothers sharing one common wife will effectively protect

the family property (Levine, 1987).

Marriage is by far the most important act of partner choice in most people's lives. Here we describe a case which illustrates how that partnership is more likely to survive when a) the partners first have the opportunity to assess the quality of their potential spouse before marriage (in this case in terms of both working ability and fertility), and b) have an initial investment from both the families that are party to the union.   However, investment in the union after marriage appears unequal.   This unequal division of labour may partly reflect recent changes in the history of the area; males are no longer much needed for resource defence, raiding or for active herding given the fenced pastures (discussed in Du & Mace in press).   Or it may reflect the biased operational sex ratio, generated at least in part by the monastic system.   This may be one of the reasons men have more bargaining power and can be lazy in daily life after they are married, and demand very high workloads from their wives.

Chapter 4 : Parental investment does not reflect stated cultural norms

4.1 Abstract:

In this paper, we examined both stated norms of gender preference and actual sex-biases in parental investment in a Tibetan pastoralist society.   We collected detailed demographic data to examine how biased parental investment had an effect on infant mortality, infant feeding, the length of interbirth intervals and a decision when giving gifts.   Our results indicate a mismatch between self-reported son preference and measures of actual parental investment that favour daughters.   We interpret this female-biased parental investment as a possible response to daughters generating more economic resources.   However, the stated gender preferences of both sexes reflect cultural norms that appear to have remained unchanged over a long period, which may reflect the importance of male roles in the past.   Our behavioural measures of parental investment are those most likely to be in the control of women (such as breastfeeding and interbirth interval), so this mismatch between stated and actual investment may be especially true of women.

4.2 Introduction:

Patterns of wealth inheritance and resource transfer associated with marriage are important determinants of the parental investment received by each sex, especially in societies with bridewealth or dowry payment systems (Mace 2010). Behavioural variation can be understood as an adaptation to the local ecology, but several models suggest reliance on social learning can be slow to respond to rapid environmental change (Mesoudi et al. 2009).   Cultural norms (in the sense of the shared expectations and rules that guide the behaviour of people within social groups), by definition, tend to be considered invariant within the group

(Henrich & Boyd 2001; Henrich & Broesch 2011). However, behaviour that maximises individual inclusive fitness may vary between individuals within one population, such as males and females, or older and younger generations (Micheletti 2016). Here we use detailed demographic data from five villages in Amdo, China, to examine different measures of parental investment that can reveal sex-biases in parental behaviour. We measure sex-biased parental investment through the breast and bottle feeding of infants, the length of birth intervals and investments in others in their family in economic gift games. We show how sex-biased parental investment has changed over a period of considerable upheaval, as government policy has altered who controls resources over the last fifty years (Gates 1993). We found that for most of this period, behavioural measures indicate that daughters have been favoured in Amdo Tibet, yet people report their stated preference to be in favour of sons.

Individuals are predicted to prioritise care for descendants in ways that increase their own inclusive fitness (Hamilton 1964). The costs and benefits of parental investment depend on the offsprings' potential reproductive success based on that investment, be it care (Bereczkei & Dunbar 1997), or inherited resources (Hartung 1976). While female-biased parental investment is recorded in many societies (Alexander & Richard 1974; Holden et al. 2003; Cronk 1989; He et al. 2016), son-biased parental investment appears to be more common (Williamson 1976), and is certainly the more prevalent norm in China (Murphy et al. 2011). Son-biased investment is commonly found in patrilineal societies where marriage and mating are polygynous and where males generate or control resources (Hartung 1976; Aitane 2009; Mace 1996). In societies where males generally compete for females through wealth ownership, parents of females can often demand a brideprice for their daughters. Where wealth inheritance is a more important determinant of the reproductive success of males than of females, males can become the more costly sex in terms of wealth transfers, whereas daughters can be profitable as a source of brideprice. In monogamous societies, females often compete with each other for a wealthy husband, as all a husband's resources pass to the offspring of his only wife. Female competition in monogamous societies means that a desirable husband can demand the payment of a dowry by the bride's parents (Gaulin & Boster 1990); hence females

can become the more costly sex to marry off.   Among Tibetan groups in China, both monogamy, polygyny, dowry and brideprice are all observed, with wealth transfers being an important factor affecting long-term fitness.

The 'Trivers-Willard Hypothesis' (Trivers 1972) predicts that high-quality mothers are more likely to produce or rear sons when there is higher variance in reproductive potential for sons compared to daughters; whereas when mothers are of low socioeconomic status they do better to produce and rear daughters, who show less wealth-related variance in reproductive success.   Whilst there is general agreement that this theory predicts sex ratio at birth, its application to parental investment after birth is now thought to be more context-dependent (Veller et al. 2016).   However several studies have shown that the birth order of the offspring and socioeconomic status affects son-biased parental investment in different provinces in China (Banister, 2004; Aitane 2009; Murphy et al. 2011). In the United States, by contrast, it has been shown that family status has no effect on the gender-biased investment (Keller et al. 2001).   Female-biased mortality is expected to increase in China after the implementation of the family planning policy, as restricting births to one or a few children intensifies pressure for the one child to be of the preferred sex, which is usually male (Edlund 1999).

Demographers have noted that sex-biased parental investment is also based on the potential benefits that parents are expecting to get from the offspring when in need (termed 'local resource enhancement' by Gowaty & Lennartz (1985)).   For example, daughters are thought to be favoured in Tibetan societies (Childs et al. 2011) and in other parts of China (Zhan & Montgomery 2003) because they are more likely to provide both emotional and instrumental support for their parents in their later life.   Daughters are thought to be favoured by mothers in the United States Hutterite society because they are more likely to help mothers in babysitting the younger offspring and to be useful in helping with daily household duties (Margulis et al. 1993).   Daughters can get more educational investment in Southeast Asian societies, because parents are more likely to get support from their daughters compared to their sons (Degraff & Bilsborrow 1996; Anderson et al. 2003), and daughters offer more help in looking after siblings in Hungarian gypsy populations (Dunbar 2002).   Mukogodo parents in Kenya breastfed daughters more and were more likely to take daughters to the clinic because they

had higher reproductive success and brought more economic benefits to the family (Cronk 1993).   Cronk describes that in India, ancient Germany, ancient Portugal and contemporary North America, there is also a female-biased parental investment (Cronk 1991).   In other species, daughter-biased investment is also seen among socially living vervet monkeys where mothers are more likely to feed daughters rather than sons, mothers and daughters have more frequent grooming interactions, and daughters are more likely to help mothers in aggressive conflicts (Fairbanks & McGuire 1985).

Breastfeeding duration can be one measure of maternal investment (Oddy 2001). It is an obligate maternal investment behaviour essential for child survival (Dewey 1998; Bezner Kerr et al. 2008).   The amount of nutritious support from the mother through breastfeeding can ameliorate the negative effects of poor socioeconomic status on children's health (Sparks, 2011).   Early complementary feeding can bring many side effects for child health, sometimes resulting in increased child mortality (Kalanda et al. 2006).   Breastfeeding incurs the opportunity cost of time and energy, so breastfeeding mothers are presented with the choice between providing resources for themselves and for their children (WHO 2003; Wilhelm et al. 2008).   Birth intervals can be indicative of sex-biased parental investment if mothers tend to postpone the space of the birth after a specific gender (Mattison et al. 2016; Crognier et al. 2002; Mattison et al. 2015; Veller et al. 2016; Mace & Sear 1997).

Complementary feeding can be dangerous for infants because breast milk is more nutritious and reduces the chance of disease (Martin et al. 2016); but bottle-feeding is very useful to help maintain a mother's physical condition during a time of high energy requirements (Martin et al. 2016; Kramer 2010).   However mothers not only initiate bottle-feeding to less favoured offspring, but they sometimes do so to feed big infants that require more nutritional resources (Mace & Sear 1997; Margulis et al. 1993).   Decisions about how long to breastfeed and when to initiate complementary feeding influence both the interbirth interval and the survival of children; thus, feeding strategies have a significant influence on reproductive success.   Although the decision to have another baby or the degree of investment in offspring comes from both the father and mother,

weaning is mainly in the hands of mothers (Mace & Sear 1997).   The social and economic status of a woman is an important factor which determines how much energy she is able to invest in production and reproduction (Fujita et al. 2012; Wander & Mattison 2013; Hare 1999).

Before the communist regime in the 1950s, land and livestock were not distributed equally among households in Tibet, leading to wealth inequality. Wealth inequality results in more polygamous marriage and social hierarchy (Levine 2015).   In Tibetan history, men played an important role as herders and warriors, especially when the social system was shaped by local warfare with neighbouring villages and the raiding of livestock (Huber 2012).   Traditional nomadic lifestyles were highly mobile, less buffered from natural disasters (Yeh et al. 2014) and prone to frequent conflicts at the borders of their pastures (Yeh 2003).   Male herders were key to safeguarding the family and family livestock, and supplemented the family income with raids on other groups.   Traditional Tibetan herders, like many other pastoralist societies (Mace 1996; Sieff et al. 1990), had a preference for sons (Levine 1987).

The last 70 years in China were characterised by many major political changes, shown below in Figure 4.1 (see the chapter 1 for details).   These have influenced how resources are owned and inherited across generations, which has, in turn, influenced the roles of male and female Tibetan herders.   Major changes arose first from the general changes brought by the incoming communist regime when all production was communal and planned by the government.   Later, from the 1990s on, the land was semi-privatized and herders had the right to use their own land leased from the government; herding became a more individual/domestic activity.   Both males and females gained the right to own and fence private land.   The involvement of males in both warfare and herding diminished (Zhaoli et al. 2005).   Since 2000, all children in the Amdo area were required to attend school, and their future in herding is now uncertain (Beimatsho 2008; Sun Zhenyu 2000; Gelek 2006).   All these political changes have effects on the local life and will further influence the biased-parental investment and stated a preference.

Hypotheses: Here, we investigate factors that affect real life sex-biased parental investment and stated sex preferences through the following questions: First, do mothers invest more in one or other sex by feeding them longer and longer birth intervals after they are born. Second, do changes over the last 50 years in access to resources, inheritance rules and sex roles influence sex-biased investment. Third, does sex-biased parental investment and/or stated sex preference differ across age groups or between parents of different sex, and do the stated sex preferences reflect the sex-biases observed in parental investment.

Timeline of major political changes

1950s	1960s	1980s	1990s	2000
1.Communist Regime	1.Collective Commune	1.Household Responsibility 2. Child-Policy	1.Land Privatization	1.Sedentarization 2. Compulsory education
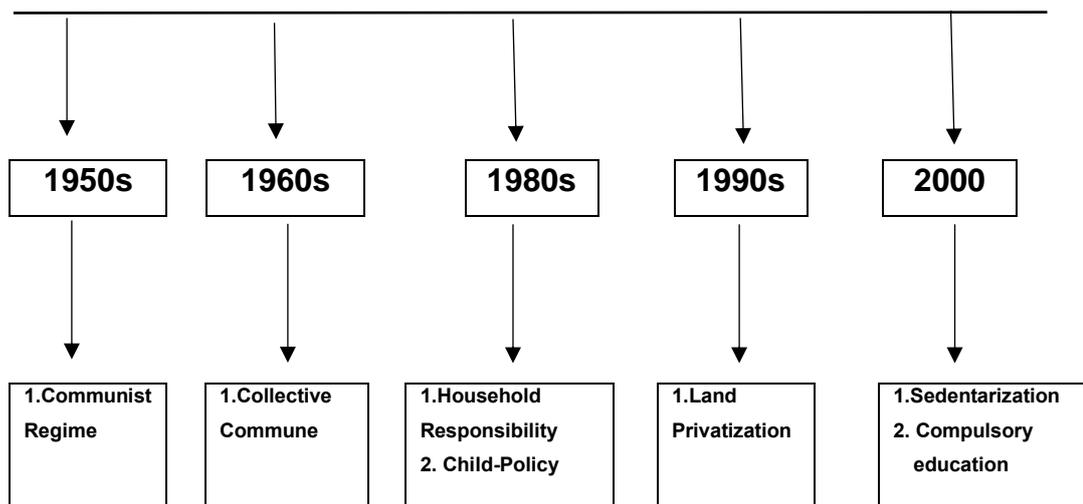
Figure 4.1: Timeline of the major political changes in the local area from the 1950s until 2015 (see Chapter 1 for details).

4.3   Study Area and Methodology

4.3.1   Study area

The field work took place between June–October 2014 and March–December 2015.   Detailed demographic data were collected in Maqu, located in the eastern part of Tibetan plateau, which stands on the south-west part of Gannan Tibetan autonomous prefecture, Gansu province, China.   People in Maqu share a common culture and speak a distinctive dialect of Tibetan (Levine 2014).   Over 90% of the population is Tibetan in our study site.   Because of limited education

resources, most of these Tibetans are herders by selling livestock as a main source of income; some of them also get government benefits as a supplementary income.   The marital system used to include polygamy (both polygyny and polyandry) but now is predominately monogamy.   In general, the local herders live at two sites over the year: one summer site, which is in more remote high altitude areas where families live in yak hair tents, and another winter site, which is more settled and easy to access from local towns and in which the houses are built of mud or bricks (traditional herders moved to many more sites each year).   The smallest herding group is called *repkor* (encampment) the composition of which is largely shaped by demographic, ecological and socio-economic or kinship factors.   The larger herding groups are called *dewa* (tribe) which are generally shaped by cultural relations with neighbouring groups and states.

4.3.2   Methodology

Demographic Data: We collected demography data from 696 households in 5 villages through questionnaires with the help of a local interpreter.   Each adult man and woman were interviewed in separate spaces to avoid influence from each other.

Stated gender preferences: We asked each adult male and female to report their gender preference for offspring at the end of the interview.   Some refused to state a preference, but among 654 males and 759 females, 697 individuals (N = 330 males and 367 females) reported their gender preference for offspring (mean age = 40.76, SD = 13.29).   Young people were less likely to report a preference, probably because they believed it an old-fashioned idea to have any gender preference.

Child mortality: We asked women who had children about their birth history, including those children who were born alive but died later.   We also asked about the birth history of their mothers, if their mothers were dead or absent when we did our interview.   1448 women's birth histories were used in the survival analysis (N = 759 direct interviews and 689 indirect interviews, where information

was gathered from their children). The limitation of this method is that the time of death was calculated on a year basis, because the interviewee became quite emotional when talked about any death children, they will just briefly provide information of the death on year basis, for ethics consideration, the details of the death children was not recorded, that made the results not very accurate.

Marital status: We presented data about the marital status to illustrate female economical independence, especially for women who stay single after a divorce or being a single mother. Seven types of marital status are included: single mother/father, monogamous marriage, married more than once, unmarried after divorce, unmarried widow/widower, polygynously married and polyandrous married. All adults were asked about their marital status (N = 654 males, N = 759 females). Monogamy is the principle form of marriage (in line with current Chinese law). Polygamous marriage is much less frequent than in recent history; there are 5 men and 10 women who described themselves as in polygynous relationships, and 5 men and 5 women who are in polyandrous relationships among those we interviewed.   We then divided marital status into two main groups: single and married based on their current marital status (Figure 4.2). Females are significantly more likely to stay single than males (although some may have been in unreported polygamous relationships given that polygamous marriage is not recognised in Chinese law) (RR=0.34, 95% CI= [0.14, 0.80], P <0.001)

Infant feeding: For the breastfeeding and bottle-feeding analyses, we interviewed women in our sample that had children after 1990 (N = 167), about the start and the end date of breast and bottle feeding.   Women who gave birth before 1990 have difficulty remembering the timing of breastfeeding or bottle-feeding, so we excluded them from this analysis to avoid misreporting. We censored children who were still having breast milk at the time we conducted the research (N = 220 male children and 191 female children included in the analysis) (Figure 4.7).   We compared children who were breastfed and bottlefed within the first 12 months since their birth.

Gift game: We also played an individual gift game with both male and female herders to determine who they would like to give a small amount of money to. By playing gift-giving game, we would like to reveal the social network and the preference difference between gift givers.   Details about how gift game was conducted were introduced in chapter 2.   The restrictions were: 1) they cannot give it to anyone within the household, 2) they cannot give it to anyone outside the village, 3) they cannot keep it themselves.   The restriction against giving to others within their own household meant that many parents could not give to their coresident children, but it will not affect giving gifts to any children who have already set up their own family outside of the natal house.

Statistics: We used cox regression survival analysis to compare the mortality rates for male and female children (Cox 1972).   1448 female birth histories were used in the analysis (which included N = 2414 male children and 2212 female children).   Those who had had children after 1990 were asked about the duration of breastfeeding and bottle-feeding (N = 167 mothers, N = 220 male children and 191 female children).   Sex differences in mortality before age 5 (Figure 4.6), the termination of breast-feeding (Figure 4.7a) and the initiating of bottle-feeding (Figure 4.7b) were predicted by cox models, controlling for family wealth and parity.   To examine the effects of inter-birth intervals on gender biased parental investment, we used cox regression to look at first three births and hence the first two interbirth intervals. 759 women's birth histories were used in the cox regression model (N = 638 male children, N = 554 female children). We used the package Mumin (Barton 2015) to compare models, including those with and without a gender cohort interaction, in both the mortality analysis and interbirth interval analysis.   The best model was selected based on the lowest Akaike's Information Criterion.
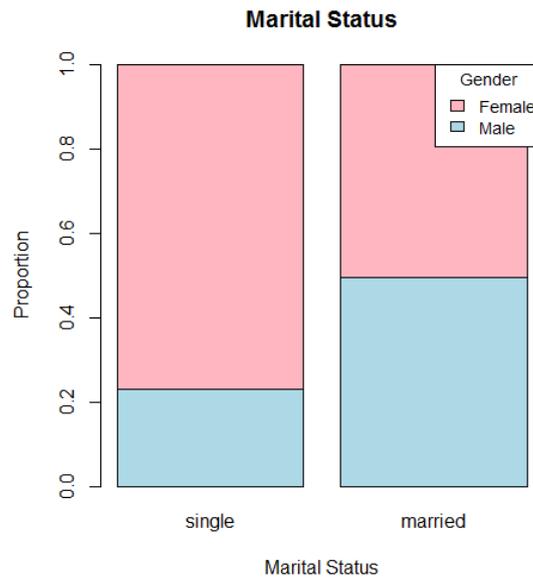
Marital Status

Figure 4.2: Bar plot of the Marital status of males and females who ever had children. The blue bar represents adult males; red bar represents adult females.

4.4 Results:

4.4.1 Self-reported gender preferences:

Self-reported data on the preferred gender of offspring indicates that both men (Figure 4.3) and women (Figure 4.4) report a preference prefer sons over daughters. Older people show a slightly weaker son preference, but otherwise, there is little variation between different age groups and across different time periods (Figure 4.5). We performed logistic regression to look at whether wealth is associated with gender preference (Table 4.1), controlling for the gender of the reporters. There is no significant difference between male and female stated gender preferences (OR = 0.90, 95% CI = 0.51-1.61, P = 0.73). The stated gender preference is statistically different from age group < 29 to age group > 50, with elderly herders more likely to say they prefer daughters than do younger herders (OR = 2.27, 95% CI = 1.29-3.98, P = 0.004). Wealthy individuals say they prefer sons more than do poor individuals, in line with predictions from the Trivers Willard hypothesis (OR = 0.99, 95% CI = 0.99-1.00, P = 0.039). Wealth and gender of the reporter show no significant interaction (OR = 1.00, 95% CI = 0.99-1.01, P = 0.73) (Table 4.1); so wealth effects seem to apply equally to male and female reporters.
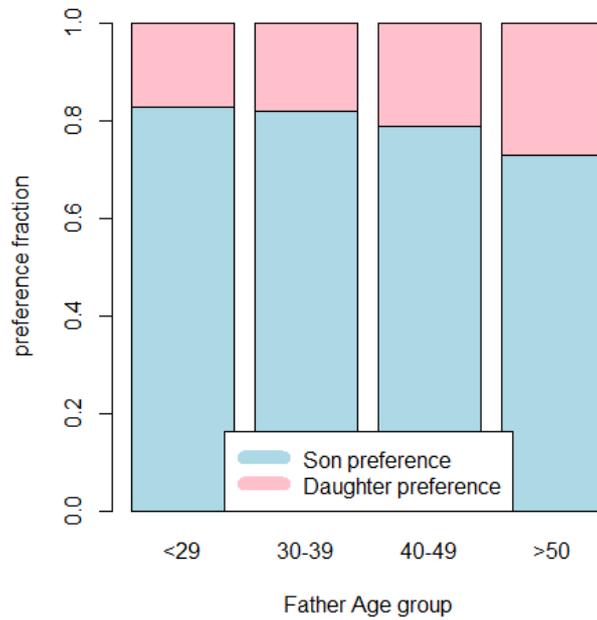
Figure 4.3: Male self-reported offspring sex preference in 4 different age groups. Pink bars indicate a preference for a daughter, the blue bars indicate a preference for a son.
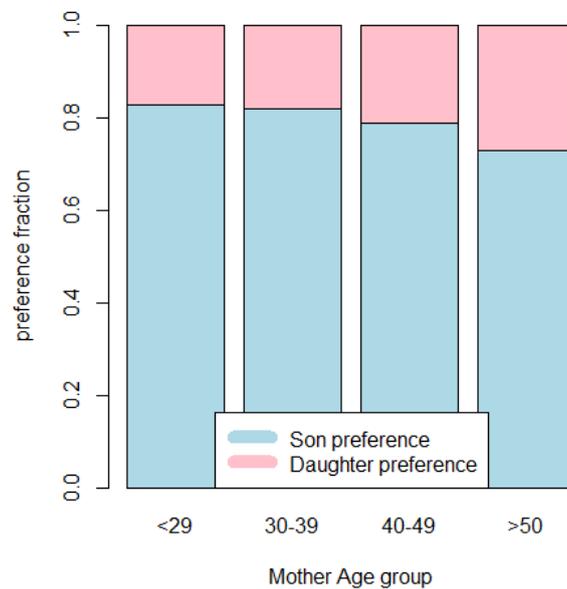
Figure 4.4: Female self-reported offspring sex preference in 4 different age groups. Pink bar indicates a preference for a daughter, the blue bar indicates a preference for a son.
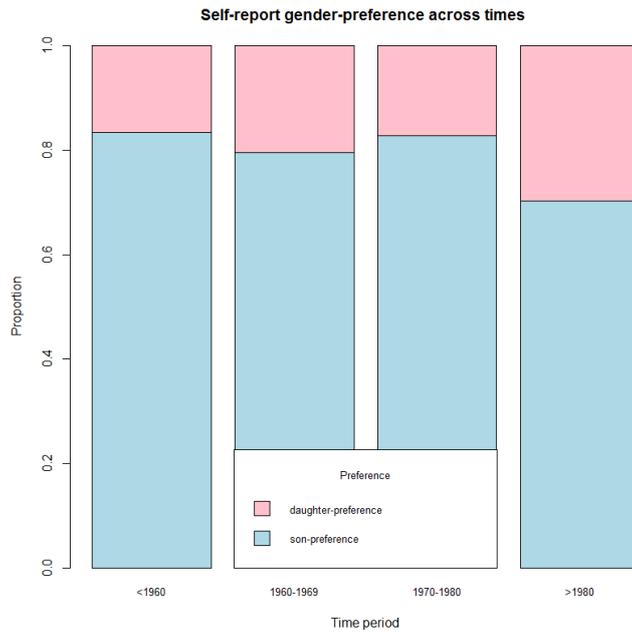
Figure 4.5: Self-report of offspring gender preference in 4 different time periods (N = 330 males and 367 females). The pink bars indicate a stated preference for a daughter; the blue bars indicate a stated preference for a son.

Table 4.1: Logistic regression of self-report preference from adult males and females on preference for daughters. OR indicates odds ratio, 95% CI means 95% confidence intervals. Statistical significance indicates in bold.

Variables	OR (95% CI)	P value
Female reporter (ref: male reporter)	0.90 (0.51,1.61)	0.730
Age group (ref: <29)		
30-39	1.27(0.72,2.21)	0.407
40-49	1.07(0.60,1.90)	0.831
>50	2.27(1.29,3.98)	0.004**
Yak	0.99(0.99,1.00)	0.039*
Yak*Female reporter	1.00(0.99, 1.01)	0.733

4.4.2 Child mortality before age 5:

We used all 1448 females' complete birth histories to look at the mortality rate of children before age 5: N = 251 male and N = 165 female children were reported dead before age 5 (Figure 4.6a). Figure 3.6b shows how the survival rate for

male and female children differs across different time periods.   We conducted a mixed-effects cox model to analyse how ecological factors affect the mortality of children under age 5 controlling for children birth order, sex order, and mother's age of giving birth (Table 4.3).   Mother's ID is controlled as a random effect in the cox mixed-effects model.   Mother's education and distance to a local clinic do not differ between villages.   Only 10 out of 1448 of the women had had an official school education.   The villages are close to each other relative to the distance to the clinic, so the distance to the local clinic is the same between villages.   The results in Table 4.3 show that, over the whole-time period, the mortality rate for male children exceeds that of female children (HR = 1.96, 95% CI = 1.32-2.91, P < 0.001).   Survival rates in different time periods are shown in Table 4.3. Mothers age at the birth, cohort and gender all influence mortality.   A model including an interaction between cohort and gender did not improve the fit of the model (Table 4.2).

Because nearly all the income of this society is from herding, we consider the number of yaks the most important measure of economic status.   There is no association between number of yaks and overall child mortality (see Table 4.3). However, the sex of children and the number of yaks interact in line with the original formulation of 'Trivers-Willard hypothesis': daughters in a poor family are relatively more likely to survive than those in a wealthy family (HR = 0.99, 95% CI = 0.99-1.00, P = 0.04).   Children who were born in the 1980–1989 cohort had significantly higher mortality from the earlier pre-1980 period (see Table 4.3).
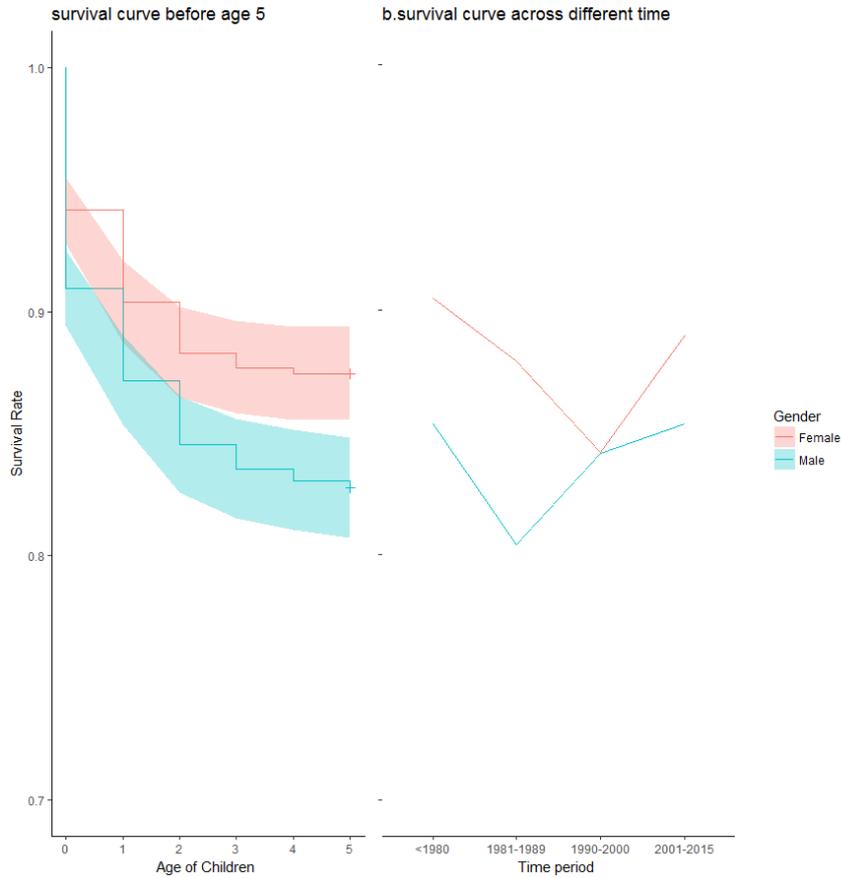
Figure 4.6: the Mortality rate of children (a) before age 5 (b) across different time periods. Sample includes N = 1448 female's birth histories (reporting N = 2456 children). Shaded bands indicate 95% confidence intervals. The blue line and shaded band represent survival of male children, red line and shaded band represents the survival of female children.

Table 4.2: Model selection for the mortality analysis before age 5. Candidate models were ranked in the ascending order based on the number of AICc.

Candidate models	Loglik	AICc	delta	weight
1. Control+cohort +yak+ yak*gender+sexorder	-2687.87	5773.105	0.000	0.862
2. Control+cohort*gender +yak+yak*gender+sexorder	-2688.184	5776.804	3.699	0.135
3. Control	-2709.113	5784.918	11.813	0.002

Table 4.3: Mixed-effects Cox model of mortality risk before age 5 (dead = 1, alive = 0). N = 2456 children (N = 1293 male, N = 1163 female) are included in the data site. Statistical significance indicates in bold, HR stands for Hazards Ratio, 95% CI indicates 95% Confidence intervals.

Variables	HR (95% CI)	P value
Fixed effects		
Son (ref: Daughter)	1.96(1.32-2.91)	<0.001***
Mother age of giving birth	0.24(0.13, 0.46)	<0.001***
Children birth year(ref<1980)		
1980-1989	1.92(1.28, 2.88)	0.002**
1990-2000	1.25(0.82, 1.89)	0.29
2001-2015	0.98(0.64, 1.48)	0.91
Yak	1.00(1.00, 1.00)	0.81
sex order (ref: 1st sex)		
2nd sex	1.01(0.78, 1.32)	0.92
3rd+ sex	1.16(0.84, 1.59)	0.37
Son*Yak	0.99(0.99, 1.00)	0.04*
Random effects	Variance(SD)	
Mother ID	0.759(0.86)	

4.4.3 Infant feeding:

The duration of breastfeeding is recognised as a measure of parental investment, especially in the first twelve months when an infant's nutrition is largely from breast-feeding and when breast-feeding is crucial for the infants' survival. 66 out of 220 male children, and 37 out of 191 female children had stopped breastfeeding before 12 months (Figure 4.7a). The mean length for breastfeeding for female children is 10.62 months and for male children is 9.36 months; Cox regression indicated this is a statistically significant sex difference (HR = 1.738, 95% CI = 1.162-2.599, P = 0.007).

Mothers initiate bottle-feeding as a way of supplementing breast milk. 97 female children and 125 male children started bottle-feeding before 12 months (Figure 4.7b). The mean time for female children to start bottle-feeding is 7.12 months, and for male children is 5.98 months. Cox regression showed a small sex difference in the duration of exclusive breastfeeding (i.e. the earlier introduction of bottle feeding) (HR = 1.212, 95% CI = 0.93-1.58, P = 0.156).
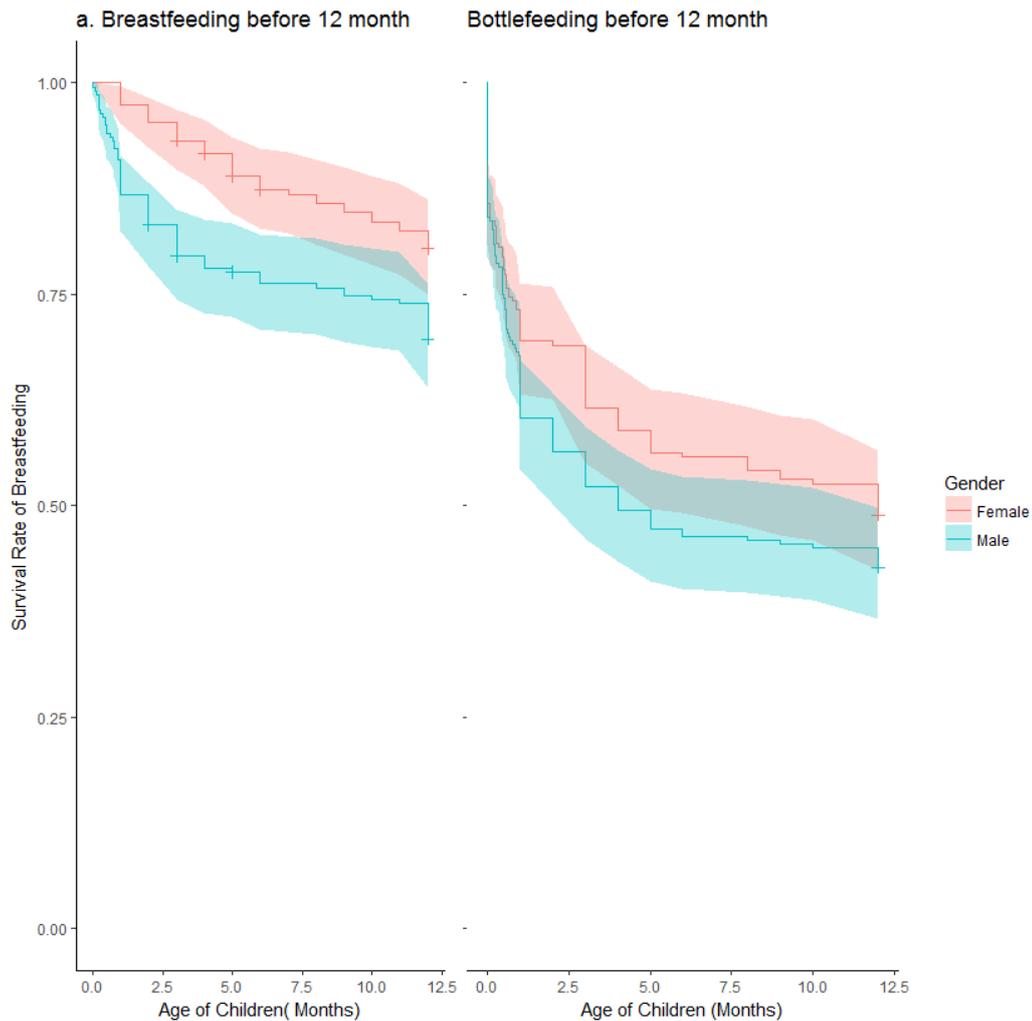
Figure 4.7: Feeding strategy. (a) Survival of breastfeeding for children who have been breast fed over 12 months (b) Onset of bottle feeding (shown as the survival rate of exclusive breastfeeding) over 12 months). The sample includes only births after 1990 (N = 167). The survival curve indicates the risk of a) stopping being breast-fed over 12 months and b) the risk of starting to be bottle-fed over 12 months, for male and female children separately. The time was recorded based on days. The shaded bands represent 95% confidence intervals. The blue bands and lines represent male offspring; the red bands and red lines represent female offspring.

4.4.4   The length of the birth interval:

The nationwide family planning policy was implemented in this area in the 1980s; from that time on, every family in this area was allowed no more than three children.   Figure 4.8a shows the birth interval after a son was longer than after a daughter before 1970, but after 1970 the intervals became longer after a daughter.   After 2000, when the compulsory primary education was introduced, every family had to send school-age children to a local boarding school, and sex-biased parental investment seems to decline, at least in terms of the interbirth intervals (Figure 4.8a).   However, a model including an interaction between cohort and gender did not improve the fit of the model (Table 4.5).   Over all the data, which covers the last 50 years, Figure 3.8b shows the length of the IBI after having a son is significantly shorter than after having a daughter (Table 4.4), but we do not find any evidence for TWH for the birth interval analysis.

Table 4.4 shows that over the whole period up to 2010, interbirth intervals after a boy was significantly shorter than after a girl (rate of birth HR = 1.25, 95% CI = [1.02-1.54], P = 0.03); the birth intervals across different time periods (cohort) and sex order (whether same sex as previous birth) are strongly associated with the length of the birth interval.   Other covariates included mother's age of giving birth and the number of livestock.   Birth intervals became shorter and shorter from the 1980s until after 2000, in which time period the compulsory education was implemented.   Sex order indicated a strong effect on the risk of finishing reproduction, in that the length of the interbirth interval is reduced if the second born is the same sex as the first one (HR = 0.48, 95% CI = 0.40-0.59, p < 0.001), suggesting a preference for having children of both sexes.
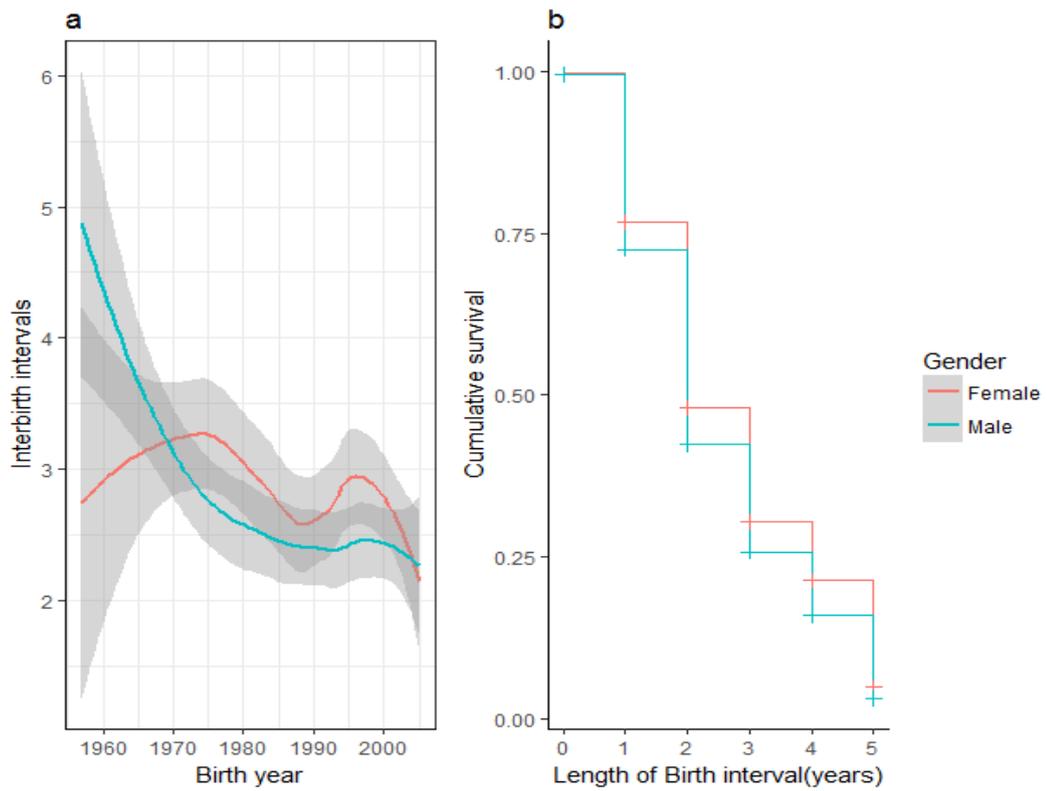
Figure 4.8: Inter birth intervals. a) Interbirth intervals in years across different time periods after births of each sex. The red line represents interbirth intervals after a female child, the blue line represents interbirth intervals after a male child. The shaded bands represent 95% confidence intervals. b) The survival function of the birth interval after having a son (blue line) and after a daughter (pink line).

Table 4.4: The effects of sex and different time period on the length of the interbirth intervals by using Cox regression.   HR stands for Hazard ratio, 95% CI indicates 95% confidence intervals.

Variables	HR (95% CI)	P value
Gender (ref: Daughter)		
Son	1.25(1.02-1.54)	0.03*
Mother age of giving birth	0.97(0.95-0.99)	<0.001***
Children birth year (ref:<1980)		
birth year 1980-1989	1.42(1.11-1.81)	0.01**
birth year 1990-2000	1.69(1.36-2.09)	<0.001***
birth year 2001-2015	2.44(1.99-3.00)	<0.001***
Yak	1.00(1.00-1.00)	0.79
Sex order (ref: 1st sex)		
2nd sex	0.48(0.40-0.59)	<0.001***
Son*Yak	1.00(1.00-1.00)	0.89

*p<0.05, **p<0.01, ***p<0.001

Table 4.5: Model selection for the interbirth intervals analysis. Candidate models were ranked in ascending order based on the AICc.

Candidate models	Loglik	AICc	Delta	weight
1. Control + cohort + yak + yak*gender+ sex order	-5829.901	11677.95	0.000	0.934
2. Control + **cohort*gender** +yak+yak*gender+ sex order	-5828.475	11683.26	5.305	0.066
3. Control	-5900.822	11805.65	127.700	0.000

4.4.5 Gift decisions:

We used a gift game to examine how gifts to direct kin (parents, sibling, offspring) depend on the sex of the giver and the receiver. In the gift game, there are 150 male givers and 157 female givers giving gifts to direct kin. Table 4. 6 shows that the sex of the giver strongly determines which parent is given a gift: same-sex offspring give significantly more gifts to same-sex parents (Chi-square = 12.14, P < 0.001). This suggests that mothers may be correct in assuming that daughters are more likely to help support them in adulthood (whereas fathers may be more likely to get help from sons). Regarding offspring, mothers are more likely to give gifts to daughters than are fathers (Chi-square = 3.11, P = 0.08). As the mean age of women who took part in the gift-giving game was 41.67, and because the restriction of the game that givers are not allowed to give gifts to the individuals living in the same household, the possibility of giving gifts to offspring was low for younger parents.

Table 4.6: The patterns of giving gifts to direct kin by adult male and female herders. Results of 2×2 Chi-square test indicate statistical difference between male and female givers preferentially giving to same-sex kin. The results are divided into gifts to parents, siblings and children.

Parents

	Male giver	Female giver	Chi square	P value
Father	33	19	12.14	<0.001
Mother	13	33		

Sibling

	Male giver	Female giver	Chi square	P value
Brother	45	38	0.93	0.34
Sister	32	37		

Children

	Male giver	Female giver	Chi square	P value
Son	15	12	3.11	0.08
Daughter	12	24		

4.5 Discussion:

Levine (1987) reported that most Tibetan societies have son-biased parental investment. From our self-report data, male and female herders report this norm as their current preference. However, we find that this stated son preference did not reflect the behavioural measures taken by mothers to invest in their children over the last 50 years.

The birth interval and mortality data both suggest that 1980–1990 reflected a period of increased mortality, followed by a steady decline in mortality. Birth rates sped up throughout this period. All our measures suggest mothers in our study area are generally investing more in daughters. Data on all births from the last 50 years suggested that daughters are generally more likely to survive than sons over their first 5 years. Feeding data shows that daughters were being breastfed for longer and sons were put onto milk substitutes earlier, indicating a female-biased parental investment in terms of nutrition decisions. The longitudinal data from children born in different age cohorts show that there is generally a longer interbirth interval after a daughter.

The marital status data suggested low levels of polygamous marriage in this pastoralist society, although polygamous mating opportunities are still present. There are significantly more female than male single parents (Figure 4.2), which we interpret as the result of increased female economic independence, due to the relatively higher economic and labour contributions to the household from females (Hare 1999; Gates 1993). Gift giving decisions also suggested stronger investments in same-sex offspring, especially by females. As children get older, reciprocity may be at play, given that daughters were more likely to give gifts to their mother, and in Tibetan society daughters are generally more helpful in looking after elderly parents (Childs et al. 2011).

Policies over the last 50 years have had an impact on sex roles and rights that we believe influenced sex-biased investment. During the early stages of the

socialist regime, livestock was owned communally, individual decision-making was limited, and dowry and brideprice were not allowed as animals were not the property of individuals. In the period of collectives and communes (see Figure 4.1), resources were equally distributed, and the property and food each family received were largely dependent on the number of labourers in the household, so having a big family ensured more income (Chen 2004). When wealth inequality was low, men did not have the same potential for polygyny. The new roles and high workloads women adopted within the family diminished males' contribution to the domestic economy. After 1990, the privatisation policy marked a major changing point in sex-biases in wealth. Shares of the grassland were allocated to each household according to the number of people in their family and most plots were fenced. The land was given to families for 50 years of use, although no system of inheritance was made clear. Women were allowed to have their own portion of land to use. When they married, women could take their own property with them in the form of dowry. But because land is not moveable, women tended to rent their land back to their parents or siblings at their natal house, or she could use the land herself, especially when her husband's land is not enough for their livestock. The restrictions on land use and the equal opportunity of land inheritance affected the sex-biased dispersal pattern at marriage, with women dispersing less. Currently, few individuals migrate into the county (8% male, 4% female are from outside of the county) and there is little difference between the number of males and females born in the village (discussed in Chapter 2). Fencing practices, adopted in the 1990s, largely reduced the need for men to herd animals actively, which reduced male workloads; female workloads increased, however, as the distance to water often increased, and the necessity of growing barley to feed animals also increased because pasture space after the introduction of fencing has shrunk and some animals were in danger of malnutrition (Yan et al. 2011). The shift towards higher female workloads was likely to underlie the increase in daughter-biased investment as daughters became more helpful at enhancing wealth and more likely to bring benefits to their mothers (Gowaty & Lennartz 1985; Margulis et al. 1993; Pirie 2005; Zhaoli et al. 2005; Gates 1993). Since the introduction of the nine-year compulsory education system, all children were sent to boarding schools after 2000, for the sake of 'Pastures to Grassland' (Yeh 2005). As these children are likely to abandon herding in the future after education (Bessho

2015), there are no longer likely to be predictable differences between the sexes in terms of potential on the job market.

Self-reporting is the general method of measuring sex preference used by demographers (Murphy et al. 2011), which we also used here, and compare it with biodemographic data on mortality, parental investment and feeding.   The majority of the respondents reported that they preferred sons over daughters, so the self-report results on gender preference do not match the detailed data on sex-biased parental investment, at least with respect to maternal investment. However, one area where self-report matched investment was with respect to the interaction between wealth (in yaks) and son preference.   Both mortality data and the stated preferences of males and females showed that wealthy families with many yaks stated a stronger preference for males and showed higher survival of males relative to females than poorer families (in other words females were relatively more likely to survive and be preferred in poorer families).

The mismatch between daughter biased maternal investment and stated son preference suggests individuals continue to report behaviour as fitting longstanding social norms, which in this case is to prefer sons.   Norms, generally defined as shared cultural preferences guiding the behaviour of group members, may be slower to change than the costs and benefits that have more immediate influences on actual behaviour.   In this case, male norms and behaviour may not show this mismatch, as males are not involved in infant feeding decisions and in the gift game they favoured male recipients, so it may only be females who stated norms that are not reflected in their behaviour. Females may incur reputational costs if they were to change their stated norms from deep-rooted cultural beliefs, or they may simply internalise those norms and give standard responses when asked.   It should be noted that China has put out much propaganda against having any gender preference since the implementation of its one-child policy in the1980s, so that may also explain why a large proportion of the sample did not want to state any preference. However, this is not the only case where stated gender preferences for males do not reflect behaviour.   Cronk (1993), who showed that the Kenyan Mukogodo favoured daughters in their parental investment decisions, also comments on the fact that

their stated preference was for sons.   There are many examples in other domains showing that there is an inconsistency in individual's actual behavior and their intention when reputation is at stake (for example, some lab-based experiments showing that individuals show widely acknowledged 'good characters' when they think that there were possible mating opportunities (Barclay 2010), and when the participants thought that there were potential eyes watching their behavior (Haley & Fessler 2005; Bateson, Nettle, & Roberts 2006)).   Another example where most individuals' documented behaviour does not follow their reported preference is cases where stated fertility preference systematically exceeds actual family size (Cypriot et al. 2010).

The evolutionary processes leading to the emergence of cultural norms may generate some conflicts of interest between individuals and their family or the wider group.   For example, Micheletti *et al.*(2016) have shown, through models that maximise inclusive fitness, that it is possible that there are different interests in males and females and in the older generation and the younger generation, leading to possible parent-offspring and parent-parent conflict in favoured behaviours.   They show how the older generation is predicted to favour warlike behaviour in young men, to protect the extended family, whereas younger generation males or females could benefit from less warfare and more individualistic interests.   Micheletti *et al.*'s model (2016) predicts this is because young men and women are less related to the extended family group than are their elders; and young men also pay the majority of the costs of warfare. However, a mechanism of cultural transmission in which children adopt their parent's norms may mean the societal norms reflect the preferences of the older generation and do not vary much in the population with age and sex.   It is possible that cultural evolutionary processes generate stated norms (or ideals) favour the group, or favour the more powerful members of the group, but these do not necessarily reflect variations in individual behaviour, especially that of less dominant members of the group such as women. When answering a question on sex preference, both men and women may be reiterating long accepted cultural norms.   But in day-to-day parental care, mothers appear to be responding to more immediate changes in individual costs and benefits that would benefit their own inclusive fitness.

Chapter 5: Grandfather is more important to child survival than grandmother

5.1 Abstract

A growing body of research has highlighted the importance of kin to women's reproductive success, leading some to suggest that we are communal breeders. This chapter will focus on caregivers, especially grandparents and how it affects grandchild survival.   As described earlier, local herders live in herding groups, but different herding groups are far away from each other, and there is a strong correlation between genetic relatedness and herding groups (see chapter 6). Households within each herding group are geographically and genetically close to each other, and alloparenting is more likely to come from close relatives. Females do more child care in most of the societies, but when women are engaged in the local economy with high workloads, it appears to be a major constraint on childcare.   Additionally, pastoralist mobility and low population density imply that grandmothers are not available for childcare.   We argue that social and ecological factors should be taken into account when understanding patterns of child survival and alloparenting.

5.2 Introduction

Previous research indicates that there are differences between chimpanzees and humans in terms of life history - unlike other Primates, humans have a later age at first birth, shorter inter-birth intervals and a mid-life menopause.   Humans have a relatively lengthy period of fifteen years, following weaning, when the young continue to grow and develop (Kramer, 2005; Hawkes et al., 2003; Mace, 2000).   They are the longest living and slowest growing of all primates.   This would entail greater physical and psychological dependence on a parent or their relatives for the daily energy resources and care that they would need.   Like most primates, Gurven et al(2012) argue that humans are highly cooperative

and; but the degree of social interaction varies in societies with different subsistence; In agricultural societies contacts between households are more frequent because they follow a more sedentary lifestyle, while in the hunter-gather or pastoralist societies the degree of interaction between households are less frequent due to mobility (Aureli et al., 2008).   Proximity affects the availability of investment from older to younger generations and vice versa (Bengtson & Roberts, 1991).   Theses investment include physical and psychological help from mothers to daughters, which are determined by the post-marital residence pattern (Schacht & Borgerhoff Mulder, 2015); Close distance ensures how much care grandparents can offer to grandchildren (Cronk, 2007), and how much resources older parents can get from their offspring in return (Childs, Goldstein, & Wangdui, 2011b).

Humans are highly cooperative, and communal breeding is one of many important aspects of human cooperative behaviours; This phenomenon is likely to have coevolved in relation to the slow human life history.   Children are highly reliant on others for subsistence, according to Hrdy (2000), who suggested that humans are cooperative breeders.   There are many other hypotheses on allomothers, especially relatives who substitute the role of mothers in different degree on communal breeding (Sear & Mace, 2008).   The 'helpers-at-the-nest hypothesis' (Paul, 1988) proposes that daughters are able to provide some help to their parents by looking after other siblings.   The 'mother hypothesis' (George, 1957; Pavard et al., 2008) argues that grandmothers look after their daughter's offspring in order to increase their own fertility.   The 'grandmother hypothesis' suggests that women stop their own reproduction in order to invest and care for her grandchildren.

Blurton Jones and Marlowe (2002) suggested that human ontogeny requires mothers to partake in an intensive effort to provide provisions for their offspring. Mothers are the most reliable and crucial caregiver compared to others because they are the direct nutrition supplier and psychological more close to their offspring (Kaplan, 1994).

Just as with their mother, a child's coefficient of relatedness with full siblings and genetic fathers is the same.   Although the fathers' attention and energy are often

spent on mating, they also provide direct investment to their offspring through the provision of food and protection.   With father's presence, children show a greater chance of survival and better achievement (Leonetti, Nath, Hemam, & Neill, 2004).   This could also be seen in a hunter-gatherer society where the responsibility of hunting often falls to men and women usually rely on their husbands for food which allows more energy to go towards childrearing and reproduction (Hawkes, 2003).   In terms of protection, hunter-gatherer men are often seen near their children and would babysit toddlers while their mothers are out foraging. Marlowe (1999) found that *Hadza* men also provides protection during the 12 hours of darkness.   Men in an Indian matrilineal group are trying to increase the quantity of the offspring by pushing their wife to decrease the interbirth intervals thus getting the most use of his wife's embodied capital and increasing the number of offspring (Leonetti, Nath, & Hemam, 2007).   Fathers often prefer to matting instead of child caring, and some of their investment in child caring may raise their social status and gain mating opportunity termed as 'costly signalling' (Gurven & Hill, 2009).

Apart from genetic parents, there are also 'non-producing' helpers.   These helpers include maternal grandparents, paternal grandparents, siblings, and other relatives who share the burden of child-rearing with parents or with each other.   The degrees of childcare from grandparents are different; In Coall & Hertwig review paper, they argued that genetic relatedness, reproductive value and resources investment should all be taken into consideration in terms of grandparental effects (Coall & Hertwig, 2010).   Euler et al. (1996) ranked grandparental care from high to low as the following: maternal grandmother, maternal grandfather, paternal grandmother, and paternal grandfather, based on the degree of relatedness, which is influenced by paternity certainty.

Grandmothers, especially maternal grandmothers, are usually revered by other family members for their special role in raising offsprings (Galbarczyk & Jasienska, 2013).   Direct childcare from grandmothers can decrease the demand for maternal care and significantly reduce the mother's workload and energy expenditure (Meehan, Quinlan, & Malcom, 2013).   Also, it can be shown that with the existence of a grandmother, women at reproductive ages perform less labour work than post-reproductive women (Hawkes et al., 1997).   In

Australian desert Martu, older women are more likely to stay with their maternal kin and provide help either in labouring or child caring than other adult men (Scelza & Bliege Bird, 2008).   Grandmother's status can be even higher in a mobile patrilineal society where they make the decision of start and the frequency of complementary feeding (Bezner Kerr et al., 2008).   But not all of the women beyond the age of reproduction are helpful allomothers.   Some research shows that paternal grandmothers have an opposite influence on infant mortality and daughter-in-law's fertility. (Voland & Beise, 2002; Sheppard & Sear, 2016).   The 'mother hypothesis' also argues that the evolution of menopause is to increase maternal investment, thus it is the daughter who supposed to gain direct benefits, not grandchildren (Peccei, 2001; Fox, Johow, & Knapp, 2011).

Apart from Grandmothers, Sear et al. (2002) showed that having older sisters could have a positive effect on the mortality of younger children.   Similarly, indirect childcare by older juveniles, who chose to delay their own reproduction, could be another source of help in the care of their younger siblings.   But sibship is not always helpful; having siblings can cause competition over wealth and parental resources (Lawson & Mace, 2009), and biased parental care can result in mortality in child's early life (Brittain, 1992; Mace, 2000).   Brideprice payments also influence the number of siblings (Cronk, 1991a; Fortunato et al., 2006; Goody & Tambiah, 1973; Mace, 1996).

On the other hand, there are still debates whether the cooperative breeding behaviour is as important as initially thought.   Minturn and Lambert (1964, cited in Bove, Valeggia, & Ellison, 2002) argue that women's and helper's roles are mutually exclusive and that most direct childcare is still derived from the infant's mother.   Likewise, girl helpers in Argentina did not exhibit any measurable effect on the frequency or duration of nursing (Bove et al., 2002).   Furthermore, contrary to the preceding arguments put forward by Marlowe, grandfathers and fathers can spend more effort in attracting best quality females than nepotistic investment in children or grandchildren (Strassmann & Garrard, 2011; Hawkes, Rogers, & Charnov, 1995).   This is notwithstanding the fact that paternity certainty is lower than maternity confidence in species with internal fertilisation, meaning males would be more likely to desert (Trivers, 1997).   Data from the contemporary United Kingdom have also shown that paternal grandparents'

presence increases the number of grandchildren, especially for paternal grandfathers who have frequent interactions with grandchildren (Tanskanen, Jokela, Danielsbacka, & Rotkirch, 2014).   In a matrilineal society in Malawi, the presence of maternal grandmothers and maternal aunts are seen as a threat to children, and the local child mortality rates are high (Sear, 2008).   In 2008, Sear and Mace reviewed studies before 2008 about the kin effects on the survival of the offspring and showed that kin could play negative or positive roles in child survival, but in different situations, the measurements are different, the strength of the child care is different as well.   Table 5.1 lists selected recent literature about different roles of allocarers (except parents).   I categorized the effects of the alloparenting from different relatives into positive and negative.

Hypothesis: Based on the previous theoretical and empirical considerations about alloparenting, we investigate how local ecology shaped the grandparental investment. My hypothesis is that female made more contribution to the local economy and grandmothers are very useful in the labour market, in this situation, grandfathers, especially paternal grandfathers are doing more child caring than grandmothers.

Table 5.1: Literature of allomothers in positive and negative mediating effects

Child careers	Mediating Effects	Mediating variables	Population	Selected Literatures
Grandmother	Positive	1. MGM positively affect infant length 2. MGM reduce child mortality 3. X-chromosome determined PGM prefer granddaughters; 4. Human longevity and life history compared to apes 5. Matrilineal societies GM invest more resources to daughter's children; 6. Post-marital residence pattern made MGM have access to help grandchildren 7. PGM will help in childcare determined by proximity; 8. MGM invest more (matrilateral effects) 9. Genetic relatedness is not as important as geographical closeness in terms of grandparental care; 10. MGM emotionally closer to grandchildren 11. Biological grandparents are more likely to invest to grandchildren 12. MGM increase grandchildren's nutritional status 13. Grandparents influence the time of haveing another child and the family size 14. Maternal grandparents reduce chance of grandchildren taking risky activities and emotional problems	1. Guatemala 2. Review paper 3. Review paper 4. Review paper 5. Southwest china 6. Ethiopia 7. Indonesia 8. Europe 9. Netherland 10. Southeastern Florida 11. 11european countries 12. Gambia 13. Swiss 14. England & Wales	1. (Sheppard & Sear, 2016); 2. (Strassmann & Garrard, 2011); 3. (Fox et al., 2011); 4. (Hawkes et al., 1998); 5. (He et al., 2016); 6. (Gibson & Mace, 2005); 7. (Snopkowski&Sear, 2013) 8. (Danielsbacka, 2011); 9. (Liddle & Nettle, 2006); 10. (Michalski&Shackelford, 2005); 11. (Coall et al., 2014); 12. (Sear et al., 2000) 13. (Coall et al., 2009) 14. (Tanskanen&Danielsbacka, 2012)

	Negative	1. Resource competition with daughters-in-law, PGM negatively relates to infants height; 2. paternity uncertainty; PGM not help 3. if only PGM alive, grandchildren are more likely to die 4. high mobility of GM from both sides reduce child care; 5. MGM increase mortality in resource-limited society where matrilineal kin compete for resources; 6. X-chromosome decrease PGM 's survivorship to grandson; 7. GM Reduce breastfeeding;	1. Guatemala 2. Review paper 3. Krummhorn(Germany) 4. Hadza(Tanzania) 5. Malawi 6. Review paper 7. U. K	1. (Sheppard & Sear, 2016); 2. (Strassmann & Garrard, 2011); 3. (Voland & Beise, 2002); 4. (Blurton Jones et al., 2005); 5. (Rebecca Sear, 2008); 6. (Fox et al., 2011); 7. (Emmott & Mace, 2015);
Grandfather	Positive	1. Infant length; 2. MGF reduce child mortality 3. Frequent contact with PGF have higher chance of having another child	1. Guatemala 2. Review paper 3. U. K	1. (Sheppard & Sear, 2016); 2. (Strassmann & Garrard, 2011); 3. (Tanskanen et al., 2014)
	Negative	1. PGF has the least paternal certainty; 2. Living with GF increase child mortality 3. Gf reduce infant height; 4. resources competition in the strict patrilocal farming societies;	1. Germany 2. Northeast China 3. Guatemala 4. Germany	1. (Euler, et al., 1996); 2. (dong et al., 2016); 3. (Sheppard & Sear, 2016); 4. (Ariane Kemkes-Grottenthaler, 2005)

Siblings	Positive	1. Elder sisters as extra caregiver for her brother; 2. Brothers protect family estate in polyandrous marriage; 3. Brothers help each other in the polyandrous marriage 4. Sibling as caretaker 5. older sibling provide food for the younger sibling; 6. older siblings help younger sibling to mature age, increase sibling's reproductive success 7. sisters help brothers to get a wife through bridewealth, livestock positively relates to the reproductive success; 8. full sibling support for disabled sibling	1. Northern Tanzania 2. Mathematic model 3. Humla district(Nepal) 4. Review paper 5. South America 6. Aymara communities 7. Mukogodo 8. Tsimane	1.(Hawkes et al., 1997); 2.(Archetti, 2013; 3. Haddix, 2001); 4. (Weisner & Gallimore, 1977); 5. (Hill & Hurtado, 2009); 6. (Crognieret et al., 2002); 7.(Cronk, 1991c); 8. (Gurven et al., 2012
	Negative:	1. High mortality in twins; 2. less parental care for later-born; 3. same-sex competition for resources; 4. wealth competition between sibling (inheritance, and family wealth) 5. sibship configuration and size dilute financial and education resources 6. first, born child has negative effects on the later born 7. siblings compete for gp care	1. Africa 2. U.K 3. Kipsigis(southwestern Kenya) 4. NLS-Y data 5. U.S and Europe 6. Southern America 7. SHARE survey data	1. (Becher et al., 2004); 2. (Lawson&Mace, 2009); 3. (Mulder, 1998); 4. (Keister, 2003); 5. (Steelman et al., 2002); 6. (Hames& Draper, 2004) 7. (Aassve et al., 2012)

Other relatives	Positive	1. Paternal aunt co-residence reduce child mortality; 2. paternal uncle as a protector in a wealthy family, uncle can provide food; 3. In levirate marriage, uncle is also the stepfather; 4. Paternal uncles and cousins help to raise the bride-price; 5. Maternal aunts provide a lot of care to her niece and nephews (emotional/physical resources)	1. Northeast China 2. Kipsigis 3. Northern Tanzania 4. Datoga, Juhaina, Arabs, Sangu, Yomut 5. Pittsburgh	1. (dong et al., 2016); 2. (Mulder, 2007); 3. (F Marlowe, 1999); 4. (Borgerhoff Mulder et al., 2010); 5. (Pashos & McBurney, 2008)
	Negative	1. Co-resident uncles increase child mortality; 2. maternal aunts increase child risk;	1. Northeast China, Taiwan 2. Malawi	1. (dong et al., 2016); 2. (Sear, 2008)

*MGM indicates maternal grandmother, MGF indicates maternal grandfather, PGM indicates paternal grandmother, PGF indicates paternal grandfather

5.3   Methods:

In this chapter, I will analyse the effects of grandparents on the survival of their grandchildren, and how it is related to the social structure and ecology in a society where labour division is biased and women undertake more labour work.

5.3.1   Demography data

The demographic data used in this chapter were collected in the year 2014 and 2015. Mostly from interviews with male and female herders in the households using questionnaires; There is also some descriptive information recorded from the participant observation. The limitation of the demographic data is that I do not know whether grandparents were co-reside with grandchildren or not, we think that given pastoralist is highly mobile, so that being alive but not necessarily living together will still affect the odds of infants mortality.

5.3.2   Games

Data from two types of the experiments were used in the analysis: gift-giving the game and labour ranking based on reputation for hard work.   From the gift-giving results, I examine whether there is grandparents' preference to give gifts to grandchildren.   Labour ranking experiments were designed to look at whether grandmothers are still being considered as useful labour in the society, given that 'grandmother-age' women are competitive in terms of doing housework in comparison to younger female herders.

5.3.2.1 Gift-giving game

We give every participant 15 yuan and ask them to nominate anyone in the village that they like to give gifts to. Details of the gift-giving game protocol are introduced in chapter 2.

5.3.2.2 Labour ranking

When I was collecting the demography data, I took pictures of both interviewees after each interview and made a name card for the labour ranking experiment. The age distribution of the women who have the name card is shown in Figure 5.3.   The age distribution is slightly biased because older women are reluctant to have pictures of them taken, so I do not have as many old women's photos as I had for young women.   At the end of the field work, I made name cards for

women in one village.   On every name card, there is the photo of the interviewee, their name, as well as their partner's name and address.   It is necessary to put pictures and other information on the name card because many people share the same name and may use different names in different situations. The 'Labour ranking experiment' was conducted with three women who have good knowledge of everyone in the village (age mean=48).   I ask them to put name cards into three different boxes according to a woman's working ability, representing 'good-at-working', 'average standard', 'bad-at-working' respectively. After discussion with each other, the three women will make an agreement and put the name card into each box.   In the end, there are three piles of ranking results based on the women's house working ability.

5.3.3   Statistical analysis

I use a model selection approach in the Package MuMin (Barton, 2015) by putting a different combination of the grandparents from the maternal and paternal line into different models, the best-fitted models were selected based on the Akaike's Information Criterion.

Cox proportional hazard regression in the survival analysis was used to investigate how the hazard of death for children before age 5 depends on the existence or the absence of the grandparents from the maternal and paternal side.   We censor children who were beyond age 5.   For the grandparents' hypothesis, we coded 1 if grandparents were alive during the first 5 years of grandchildren, 0 if grandparents were dead.   Children who have missing information about their grandparents were excluded from the analysis.

5.4   Results:
5.4.1   Demography data

423 living mother's birth histories were used in the analysis (N=681 male children, N=629 female children).   Only 1 child's father was dead, so the effects of mother and father on children mortality were excluded from the analysis. Among 681 male children, 560 were alive while 121 died before age 5; Among 629 female children, 538 were living and 91 died before age 5.   Table 5.2 shows the demography data of children and grandparents' living status.

Table 5.2: Description of how many children in each living status of the grandparents, split into Paternal Grandparents and Maternal Grandparents.

	Maternal Grandparents			
	MGM		MGF	
	living	dead	living	dead
Children living	986	112	919	179
Children dead	192	20	180	32
	Paternal Grandparents			
	PGM		PGF	
	living	dead	living	dead
Children living	964	134	839	259
Children dead	193	19	156	56

Proximity, especially that of post-marital residence, is another important factor which determines the availability of caring (Gibson & Mace, 2005; Kiros & Kertzer, 2000). Generally speaking, there are four kinds of post-marital residence pattern: patrilocal (females disperse), matrilocal(males disperse) (Kiros & Kertzer, 2000), neolocal (both disperse) and duolocal/natalocal(no disperse) (Mattison et al., 2014).   Proximity is even more important in highly mobile, pastoralist society where the population density is low and villages are far away from each other. The traditional Tibetan marriage system is patrilocal, with daughters residing with or close to her husband's family after marriage (Childs et al., 2011b).   The residential pattern in this society is not strictly patrilocal. From our demography data - 622 males and 698 females gave details of their natal house and table 3 shows the difference between a natal house and the post-marital place - we can see from the table 3 that very few of the male herders (4%) and female herders

(4%) are from outside of the county, which means that neither male nor female herders are likely to disperse after marriage; Male and female herders are more likely to stay close to their natal house when married.   Seeking help from the natal house is one explanation of low dispersal; Most importantly, the inheritance system in this society, since the 1980s, means both male herders and female herders have an equal opportunity to inherit wealth from parents, be it land or livestock (Levine, 2015).

Apart from moving outside of the county, males are more likely to stay in the same township than females after getting married (chi-square=11.665, df=1, P<0.001), which means paternal grandparents have closer proximity to the grandchildren.

Table 5.3: the difference between a natal house and the post-marital residence for male and female herders.

	Same township	Different township, same county	Other county
Male	398(64%)	175(28%)	49（8%））
Female	382(55%)	289(41%)	27(3%)

5.4.2   Gift game

A gift giving game was conducted at the end of each interview to investigate the difference between paternal grandparents and maternal grandparents' decision on giving gifts to grandchildren.   The reasons for giving gifts vary, but If we only look at the gifts from grandparents to grandchildren, we can see in table 4 that paternal grandparents are more likely to give gifts to grandchildren than maternal grandparents, but because the number is very small we cannot see any statistical significance.

Table 5.4: Description of the gifts distribution among different kin. Gifts from grandparents to grandchildren were indicated in bold.

Receiver	Male giver	Female giver	Total	(%)
Parents	46	52	98	(25%)
Sibling	66	64	130	(33%)
Children	18	25	43	(11%)
Cousin	11	5	16	(4%)
Paternal grandchildren	6	7	13	(3%)
Maternal grandchildren	3	4	7	(2%)
other relatives	37	48	85	(22%)
Total	187	205	392	(100%)

5.4.3 Labour ranking
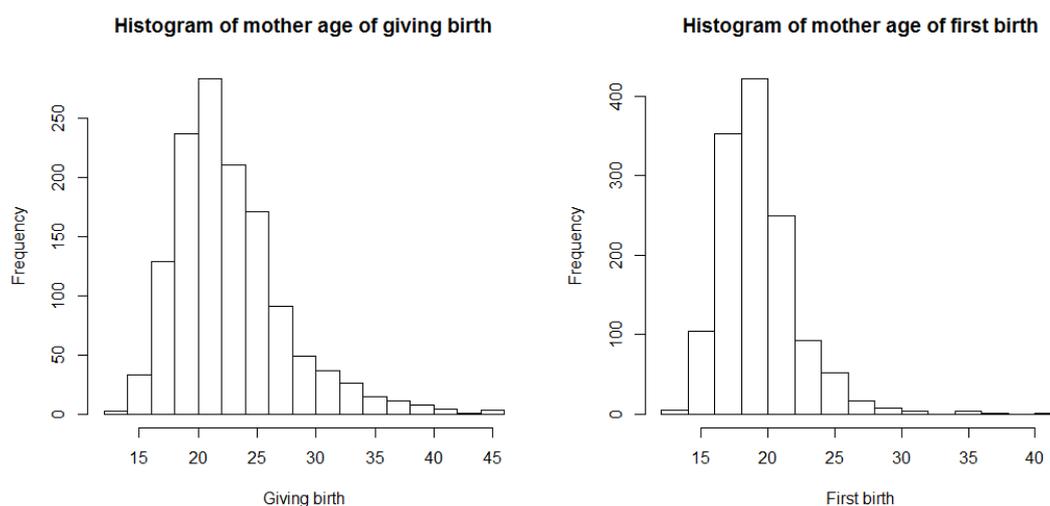
Figure 5.1: Histogram of mothers age of giving birth and mother's age at first birth.

Figure 1 shows the age when mothers are having children.   The mean age of a mother giving birth is 23.21(min=13.00, max=46.00, sd=4.76); the mean age for

the first birth is 19.78 (min=13, max=41, sd=2.88).   Women in the society give birth when they are very young, so when they became the grandmothers they are still at their 40s and are considered as useful labour in the family.   We looked at the age when adult males and females became grandparents for the first time (Figure 5.2), the mean age at which females became a grandmother is 46.89 (min= 32.00, max=74.00, sd=7.74), the mean age at which males became grandfathers is 50.21 (min=32.00, max=79.00, sd=9.19).
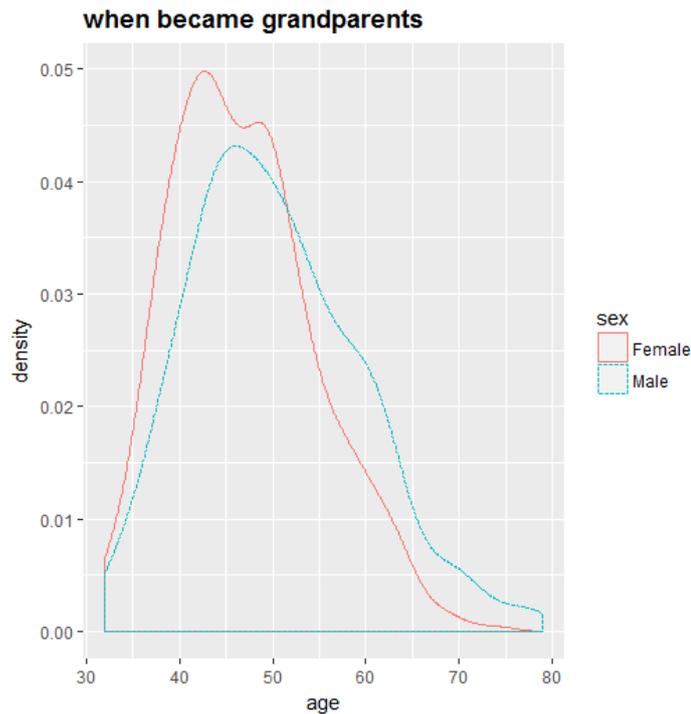
Figure 5.2: Age of having the first grandchild for grandmother and grandfather. Red line indicates age density of grandmother, the blue line indicates age density of grandfather.
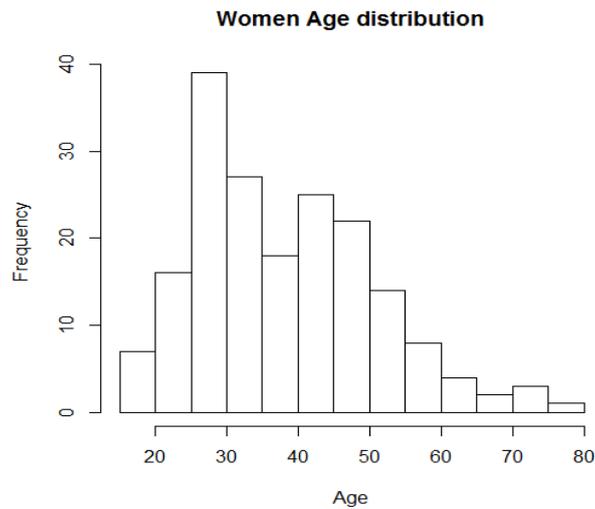
Figure 5.3: Histogram of women's age distribution. This histogram shows age of women who are in the labour ranking experiments

Figure 5.3 shows the age of women who will be ranked by others according to their working ability.   Labour ranking varies with age groups.   We can see from Figure 5.4 that the majority of the women fall in the first two ranking categories, very few of them are considered as 'bad workers' and fall into rank '3'. Interestingly, there is very little difference between different age groups in the 'good-at-work' category (rank '1'), and for women who are in age group>50, most of whom have become grandmothers already, are more likely to be ranked as 'good-at-working' (chi-square=3.774, df=1,P=0.05) (table5).
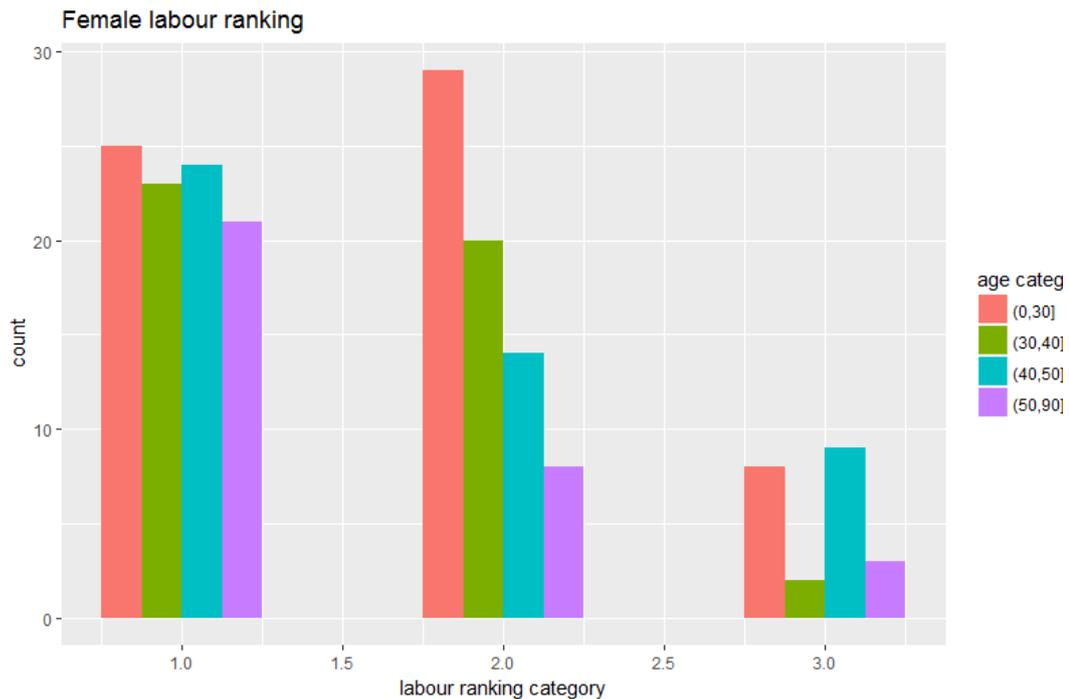
Figure 5.4: women's working ability ranks by age category (colour bars).   A rank of '1' means the 'good-at-working' women, a rank of '3' means the ' bad-at-working' women, rank '2' means women who are at the medium standard of working ability.

Table 5.5: description of 4 different age groups in three different labour rankings.   For women in different age group and the statistical difference between the distribution of women in different ranking categories.

	Very good	not very good	Chi-square	P value
<30	25	37	3.480	0.06
30-39	23	22	0.029	0.86
40-49	24	23	0.029	0.87
>50	21	11	3.774	0.05

The sexual division of labour is very clear in the pastoralist households.   I made a timetable of the housework distribution of female herders and briefly described the male working schedule based on the observation while I conducted my research in the local area.   The family which I recorded the housework allocation is of the middle-lower level of wealth.   This family has 5 members, a couple and three children who are at boarding school.   The adult female herder and the male herder are the only labourers in the family.   The family owns 50 yaks, 25

out of 50 yaks are milk yaks. In general, it takes about 6-10mins for one person to milk one yak, so in this family, three hours are needed to milk all the yaks. Women have to milk yaks three times a day every day, especially in summer.

Table 5.6: A typical Timetable of the female herders in summer periods.

Time	Work
3:00 am – 6:00 am	Milking: Women have to milk all the milk yaks and sent them to eat grass as early as possible because grass with dew in the early morning is considered with high nutrition
6:00 am – 9:00 am	Making dairy by-products: Boiling milk collected in the morning and from last night, in order to make cheese and butter
9:00 am – 11:00 am	Other works: Preparing breakfast, doing other family chores (sweep the floor，wipe oven etc.)
11:00 am – 14:00 pm	Milking: Bring iron drums of about 25 kgs to do the second round of milking, sometimes her husband will help her to chase the milk yaks close to tent so that women can save some time
14:00 pm – 17:00 pm	Making dairy by-products: Processing the milk collected from the second round of milking.
18:00 pm – 21:00 pm	Milking: Fasten all the yaks next to the tent and milking all the milk yaks for the third times of the day
21:00 pm – 22:00 pm	Other works: Making/ having dinner and off to sleep

The time schedule of adult male herders' daily activities is quite flexible; apart from family religious ceremonies that men have to do every morning, most of the time they are free. When there is more than one man in the family, it is usually the older man who is in charge of the religious ceremony for his prestigious status; sometimes male herders help female herders or relatives living in the same herding group look after the yaks, chase yaks back home at night, etc. However, the labour required for herding is becoming minimal because with the fences built between each household grassland plots, the livestock is now less likely to get lost or face any threat from other wild animals.   In addition, sometimes male herders would help each other look after a group of yaks when

necessary, and herding can take several male herders doing it in turn, as there is no difference between herding livestock in a number of 10 and in a number of 100.   A very important part of the collaboration is to find the lost animals, which was also important in the past; There are cases when herders lost their animals and other male herders in the same herding group helped search for it, but it does not happen very frequently.   Also, because of the fences, the main labour effort goes to milking and making dairy products rather than keeping animals alive, safe and in the right place, and all the high-risk labour conducted by men in the past is becoming less necessary.   The labour-division between women and men is becoming more significant.

On the contrary, women work on a tight schedule; Their routines are repetitive and they rarely get any help from female neighbours, because there are seldom leisure time available. Apart from all these major tasks (shown in table 5) that females have to do every day (especially milking yaks three times per day), there is other works that women do three or four times a week, for example, they have to collect yak droppings (ཅེ་བ), which is dried and used as fuel; they have to dry the cheese (ཕྱུར་བ); make butter (མར)and save them in the pocket made by yak's full-grain leather (the leather is soaked in salt water and is very soft and thin); they have to fetch water for their family and livestock because there is no running water available; they also have to do laundry by hand from time to time for the whole family and sometimes for the livestock, etc.   Extremely high workloads leave females, including mothers as well as grandmothers, hardly have any time to look after the offspring.

5.4.4   Model fitting:

Table 7 listed all the candidate models, with the four grandparent combinations in each candidate models.   In the control model, we take account of child gender, mother's marital status, mother's cohort, mother's age of giving birth, birth order and family wealth.   The best-fitted model selected is shown in Table 8.   Four models fit the analysis better than other candidate models, with PGF, paternal grandparents, control and PGM with the weighted probability of 24%, 18%, 15% and 11%, respectively.   Interestingly, we can see that paternal grandparents were selected in the best model instead of maternal grandparents. We then average the models that explain 95% of the AIC weight, and the final cox

regression model was shown in table 9.   The strongest predictor of child mortality was mother's age of giving birth, children birth order.   For grandparent effects, only paternal grandfathers statistically affect the grandchildren's survival probability.

Table 5.7: 95% confidence set of candidate models for Cox regression on the child mortality before age 5.   The candidate models are presented in the table in order of AICc, from zero to largest.   The table includes a number of parameters (K), Log-likelihood of each candidate models (LL), differences between AIC of each model with the minimum of the model set ($\triangle$AICc), the weight of each candidate models(Weight).   Control model includes children gender + mother's marital status + mother's age of giving birth + mother birth cohort + birth order + family wealth + family wealth*gender.

Candidate Models	K	LL	$\triangle$AICc	Weight
Control+PGF	11	-1488.086	0.00	0.25
Control+Paternal Grandparents	12	-1487.367	0.60	0.18
Control	10	-1489.572	0.94	0.15
Control+PGM	11	-1488.867	1.56	0.11
Control+Grandfathers	12	-1488.082	2.03	0.09
Control+MGM	11	-1489.397	2.62	0.07
Control+MGF	11	-1489.572	2.97	0.06
Control+Grandmothers	12	-1488.715	3.30	0.05
Full Model	14	-1487.235	4.42	0.03
Control+Maternal Grandparents	12	-1489.395	4.66	0.02

* MGM: Maternal grandmother; MGF: Maternal grandfather;

PGM: Paternal grandmother; PGF: Paternal grandfather.

Table 5.8: Parameter values: summary of the best 95% models predicting the probability of child mortality before age 5. Models are listed in the table in the descending order of importance. The table includes a number of parameters (K), Log-likelihood of each candidate models (LL), differences between AIC of each model with the minimum of the model set ($\triangle$AICc), the weight of each candidate models (Weight). Control model includes children gender + mother's marital status + mother's age of giving birth + mother birth cohort + birth order + family wealth + family wealth*gender.

Candidate Models	K	LL	$\triangle$AICc	Weight
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Control	10	-1489.572	0.94	0.15
Control+PGM	11	-1488.867	1.56	0.11
Control+Grandfathers	12	-1488.082	2.03	0.09
Control+MGM	11	-1489.397	2.62	0.07
Control+MGF	11	-1489.572	2.97	0.06
Control+Grandmothers	12	-1488.715	3.3	0.05

*PGF: paternal grandfather, PGM: paternal grandmother

MGM: maternal grandmother, MGF: maternal grandfather

Table 5.9: Cox regression on child mortality before age 5 after averaging the 4 best-fitted candidate models in table 2. HR indicates hazard ratio; 95% CI indicates 95% confident intervals. Significant results were indicated in bold.

Paremeters	HR	95% CI	P value
Gender (ref: male)			
Female	0.74	(0.46,1.17)	0.20
Mother married (ref: single)			
Married	0.91	(0.64, 1.31)	0.62
Mother birth cohort (ref: <1960)			
1961-1980	1.18	(0.61,2.28)	0.63
>1980	0.90	(0.45,1.80)	0.77
Mother age of giving birth	1.34	(0.87,2.07)	0.18
Squared mother age of giving birth	0.02	(0.00, 1.71)	0.09
Birth order (ref: 1st)			
2nd born	1.57	(1.06,2.33)	0.02
3rd born	1.76	(1.13,2.72)	0.01
N Yak(log scale)	1.00	(0.99,1.00)	0.40
PGM Living	1.33	(0.82,2.15)	0.25
PGF Living	0.75	(0.54, 1.03)	0.07
MGM Living	0.88	(0.55, 1.42)	0.61
MGF Living	0.99	(0.66, 1.49)	0.98
Daughter*Yak	1.00	(1.00,1.00)	0.68

*PGM：paternal grandmother; PGF: paternal grandfather
MGM: maternal grandmother, MGF: maternal grandfather

From table 9 we can see that mother's age of giving birth negatively correlated with child mortality, the older the mother's age of giving birth, the less likely that her children will die (HR = 0.02, 95% CI = [0.00-1.71], P = 0.09). Birth order predicts the hazard of child mortality, with the later the child born the more likely that he/she will die, the 2nd born (HR = 1.57, 95% CI = [1.06,2.33], P = 0.02) and the 3rd born (HR=1.76, 95% CI=[1.13,2.72], P=0.01) are all more likely to die than the first born. Most importantly, the existence of paternal grandfather will reduce the hazard of child death (HR = 0.75, 95% CI = [0.54, 1.03], P = 0.07). The predictor is not very strong, I want to highlight here that 'grandmother

hypothesis' is not universally applicable, the role of grandparent-caring varies in different ecology.   Figure 5 shows how the presence of the paternal grandfather affects the mortality rate of male grandchildren and female grandchildren separately. Paternal grandfather's presence will correlate with the probability of grandchildren death.
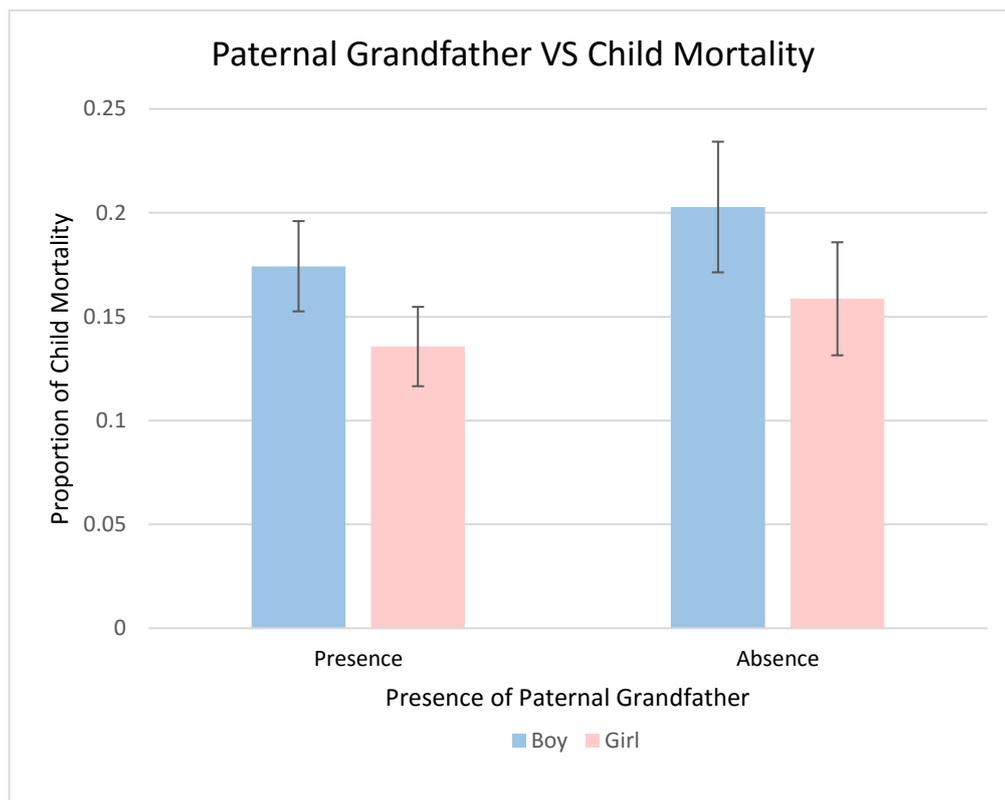
Figure 5.5: Presence status of paternal grandfather affects child mortality.   X-axis indicates whether paternal grandfather is living or dead before children age 5. The y-axis indicates the probability of death of the children.   The blue bar indicates mortality probability of boys, the pink bar indicates the mortality probability of girls.

5.5   Discussion

The Grandmother hypothesis for the evolution of menopause proposed that post-reproductive women who look after the grandchildren would gain inclusive fitness.   There are a lot of research which highlight the positive influence of grandmothers, especially maternal grandmothers on grandchildren's survival (see table 5.1 for details), because they are most likely to share genes with the grandchildren, they are predicted to be more likely to invest resources on the grandchildren (Euler et al., 1996).   There are fewer studies focusing on the (grand)father effects (Table 5.1).   But in many societies, adult males and

females have a similar lifespan, why is there not a 'male menopause', if grandfathers, at least maternal grandfathers can have some influence on grandchildren?   There are some theories addressing the male life history from evolutionary perspective, apart from the degree of genetic confidence, the main theory about the difference in biased grandparents hypothesis is that because man will spend more resources on mating rather than parenting (Gurven, 2006; Gurven & Hill, 2009; Kristen Hawkes, 1991).   This might be true in the polygamous society, where men can have several wives thereby increasing his reproductive success (Josephson, 2002).   However, in polyandrous and monogamous society, when the wife reaches menopause, men are also no longer able to reproduce (Vinicius, Mace, & Migliano, 2014), then what is the evolutionary sense for grandfathers to live long after they have stopped reproducing.   Most researches indicating that grandmothers gain fitness by looking after grandchildren.   Lahdenperä (Lahdenperä, Russell, & Lummaa, 2007) reviewed researches on (grand)fathers (mostly in farming areas) and found that in historical Finns, although there are no universal effects from grandfathers on grandchildren, grandfathers don't gain any fitness through grandfathering, unlike grandmothers.

In pastoralists societies, there is a close relationship between labour availability and herding success (Næss, 2012).   Family labour is extremely important to raise pastoral production, and the sexual division of labour is thought to have evolved to maximise family productivity (Scelza & Bliege Bird, 2008). Cooperation between males and females in the household is crucial in resource stressed societies, while cooperative provision may be less important in resource-abundant areas (Bird, 1999).   In hunter-gather societies, it is mostly males that hunt big game, share it with family members and with others living in the same camp, and females do more gathering work with the help of the junior children (Gurven & Hill, 2009).   Although there are some women who also hunt, most of the time it is male hunters who get large prey, not the female hunters. One incentive for males to hunt is to 'showing off' and gain mating opportunities (Hawkes et al., 1995; Marlowe, 1999); at the same time male hunters also have physical advantages(tall, strong), skill, knowledge and bravery for hunting (Lewis et al., 2014; Walker et al., 2002); the other reason is that women are needed at home for childcare, especially before weaning (Michael Gurven & Hill, 2009).

Sexual division of labour also affects fertility in the contemporary Finn society where an increased workload decreases female fertility, not male fertility (Miettinen, Lainiala, & Rotkirch, 2015).   Proximity between children and allomothers is very important for offspring wellbeing, and this effect can go indirectly from mothers to free daughters in doing labour activities, or it works directly from grandparents to grandchildren in alloparenting.

In pastoralist societies, there are a lot of conflicts between borders of the pastures in the history, and the lifestyle is highly mobile, this requires labour division between the two genders.   Male herders go out and safeguard the family and herd livestock, while female herders stay at home and do herding-related housework (Yeh, 2003).   However, limited moving space after privatisation has diluted the importance of male herders' role in the family as guards and warriors, while female herders perform the same amount of work as before; thus women became the major contributor to domestic production (Tashi & Foggin, 2012; Manderscheid, 2002).   This may explain why caring has been diverted from grandmothers to grandfathers.   Pirie described in details the unequal working allocation in Maqu, saying that the appearance of industry minimised male responsibility and that the male aggressive character makes them more hands-off in family production (Pirie, 2005b). This research suggests that because of the high pressure and workload of female labour in the family (regardless of age), childcare becomes less important compared to the other economic contributions women make, leaving grandfathers as the main available source of alloparenting in the family.

5.6   Conclusion

Considering the high workload of women, economic contributions from a woman might be more important for a household than parental care she could provide. The reason could be that women possess particular skills in farming work, or that the mismatch of males' role under new policies left males with little to do (see chapter 3 regarding the sex preference).   Alternatively, males are somehow winning a conflict of which sex does the hard work.

Sex ratio can influence the bargaining power of each sex in a mating market.

According to on the 'principles of the least interest' theory, 'when the number of one sex group is less than the other, it is always the fewer group of people who have priority and has bargain power' (Pedersen, 1991).   High sex ratio(Male-biased) could push men to compete in many aspects to get the best quality partner, which could be wealth.   But apart from resources and higher education, parenting is becoming a new character that wins in the mating markets for male intrasexual competition (Kokko & Jennions, 2008).   When men offer limited resources to the family, a male who participates in childcare may be favoured by females, thus male can gain benefits by being allocarers, as observed in Aka pygmies (Hewlett, 1988).

In this case, sex ratio is low(female-biased), this could be due to the highly male-biased mortality (discussed in chapter 4) and the Tibetan tradition of sending at least one son to the monastery leading to a scarcity of males in the mating market.   Therefore, it is possible that male herders have more bargaining power in the family, at least when they were young, and consequently invest less in domestic production, leaving heavy workload to the women. Our data show that sex ratio is female-biased especially after the 1960s, when almost everyone became grandparents, if male is in short, isn't that means they have harder bargain power and shouldn't do the child care.   One possible reason is that looking after grandchildren is not out of grandfathers' wish, since they are not very competitive in the matting market with younger males, nor able to help out females in housework, alloparenting seems a better strategy to help earn their keep in the household.

Parental and grandparental care varies under different ecologies, and it is striking that sometimes in this society it is being neglected altogether, with children tethered for their own protection whilst their mother's work in the fields. Although our research has found the greater influence on child survival from the grandfather than the grandmother, we did not conduct a formal survey on the time budget data, frequencies of interaction and the degree of the parental care should be explained in more details, which opens the option for the future research.

Chapter 6: Herders show off generosity while still preferring to cooperate with kin

6.1 Abstract

Human beings are living in an environment that the changes happen at a very fast speed so that sometimes the inclusive fitness is not always maximized at one go, human behaviours are in a process of adapting the best strategy so that to maximize the fitness. Cooperation behaviour is evolved to have beneficial effects at the individual as well as the group level. There are several factors determining the incentives of cooperation, it could base on the genetic relatedness, the possibility of interaction in the future, the signal of good quality and sometimes a bit of both of these factors. This chapter will investigate the cooperation behaviour in a 'natural field' experiment where pastoralists chose who they want to herd with. I played gift games on this pastoralist society to look at who they want to give gifts to and the reasons for giving gifts. I find that kin selection is still the most important factor which determined whether they want to invest to, but the reported reasons for giving gifts are not consistent. I conclude that sharing with kin will be encouraged within the small-scale society, in this case, is the herding group, while individuals care about reputation so that being generous to the less wealthy herders will still be illuminated from self-report information.

6.2 Introduction

Individuals are interacting with each other at all the times. We define any types or degrees of interaction which can be modelled as a network. Cooperation, as one type of network, is a social behaviour that evolved to maximize fitness for animals and humans. The reasons for cooperation varies, and the form of cooperation in different scales of society or different cultural background is

different, and these differences are possibly driven by the demographical factors or by the social norms (Lamba & Mace, 2011; Henrich et al., 2005). One of the most well-known theories of cooperation is kin selection; individuals prefer to help others who share the same ancestry, and by helping relatives they can increase their own inclusive fitness. kin selection is fundamental to human evolution that, no matter in communal breeding (Mace, 2013), food sharing (Hillard Kaplan & Gurven, 2001) or marital decision and residential decision after marriage (Wu et al., 2015;He, Wu, Ji, Tao, & Mace, 2016), kin selection is the key determinants which affects fitness. Apart from Kin selection theory, reciprocity and indirect reciprocity is also the widely acknowledged theories regarding the cooperation (see chapter 1 for the literature reviews).

Cooperation not only occurs between kin, not genetically related individuals cooperate with each other at all the time as well. Reciprocity is often being used to explain the dynamics of cooperation beyond kin, but individuals still get reciprocity between relatives, so reciprocity and kin selection are not mutually exclusive explanations. Individuals help each other based on the exchange of benefits and by doing so both can raise their reputation and social status, and in the end, increase their own fitness, this is also termed as 'indirect reciprocity' or reputation-based partner choice, which isn't quite the same as reciprocity, that cooperators are collaborated in expecting to get back some rewards. There are a lot of research conducted based on this topic, some of them using real-life setting to play the economic games (see Chapter 2 for details) (Wu, Ji, He, Du, & Mace, 2015;Lamba & Mace, 2011;Henrich et al., 2005;Henrich et al., 2010; Thomas et al., 2015). There are also lots of the researches in laboratory-based experiments conducted by the university students (Henrich et al., 2001; Henrich et al., 2005).

In different societies, the demand for cooperation and the degree of it is different. For example, in hunter-gatherer groups, cooperation is widely practiced in the form of sharing meat between members of the same camp (Gurven & Hill, 2009), but there are also hunter-gathers who hide some portion of their hunt and are reluctant to contribute to the common pool, there are also less sharing in the small groups than in bigger groups, because bigger groups have harsher punishment (Marlowe, 2005; Henrich et al., 2001). In horticultural groups,

cooperation is very different even in a small-scale society and the difference is based on ecology or demography (Lamba & Mace, 2011) In the farming area, cooperation is a bit different from others, as farmers prefer to cooperate with knowledgeable individuals to seek help (Macfarlan & Lyle, 2015).   In rural Columbia, cooperation relied on the wealth difference within the community (Cardenas, 2003).   Cooperation is extremely important in the resources limited areas for example in the pastoralists society, but there are very few studies investigating their cooperative behaviour from an evolutionary perspective, especially among Tibetan groups which are experiencing a series of political and ecological changes recently, and their ecological environment is changing in different aspects as I have introduced in Chapter 1 (Yeh et al., 2013).

Doing research in this area has an advantage of looking at the incentives for cooperation without interaction from outside because pastoralists form herding groups out of their own interests, it could be the constrain of ecology, or some of them favour the strategy that joint labours in the group work more efficient than alone.   It is also possible that people got social pressure to collaborate, that the common value or the social norm will trigger cooperation (Ostrom, 2000).   No matter which is the potential mechanisms under their selection, putting up fences between herding groups is a sign of refusing to cooperate with herders outside one's own herding group.   On the other hand, regardless of the government assignment and uneven grassland quality, breaking down the fences and herding together with kin as well as non-kin is obviously a signal of cooperation.   But what are the norms shaping cooperation within herding groups, and what are the most important criteria for staying in or leaving a herding group in this society is still under study.

Hypotheses: In order to test how individual behave in a real-world setting, I used demographic data and economic games data with both adult male and female herders.   The three hypotheses that I'm interested to look at are i) the decision of herding communally or solitarily is based on genetic relatedness.   ii) based on the close relatedness in the same herding group, gift givers are more likely to give gifts to their kin. iii) the reasons for giving gifts should be consisted with the actual behaviour.

6.3 Methods

6.3.1 Questionnaire

I interviewed male herders and female herders in each household separately in four different villages.   For female herders, I asked detailed information about marriage history (time and bride wealth in each marriage if there is any) and birth history (including children who were born alive but died later).   For each adult individual, I asked about marriage history and birth history and asked the head of the household (mostly man) the basic information of the whole family, and their herding history.   By asking details about the family herding system, I have an idea of the total number of animals and the area of their pasture.   By giving an ID number to each interviewee and their parents, I can link all the people in the village together through parents' ID and calculate genealogical relatedness between each pair of herders.   The questionnaire was implemented by the male interviewer and female interviewer at the same time but in different spaces, to avoid distraction from two respondents and make sure the interviews were anonymous.

6.3.2 Gift game

A common tool for revealing existing social relationships and partner choice is to play economic games (Milinski et al., 2002; Ostrom, 2000; Cardenas, 2003; Wu et al., 2015). In this area of Tibet, some people put fences up between each household, sometimes even between relatives, as a way of refusing to cooperate with other herders.   But at the same time, some choose to herd together, regardless of government policy and conflicts between households. They are playing natural economic games by themselves in their daily lives.   In order to look at who is willing to cooperate and the partner choice of cooperation, at the end of each questionnaire participants played an individual gift game. Details of how the gift-giving game was conducted were introduced in chapter 2 (see Chapter 2).

6.3.3 Wealth ranking procedure

I did wealth ranking experiments in one out of the four villages in the area. Wealth ranking was conducted by three male herders in one village.   The three participants were all head of the village and knew everyone in the village very well.   I prepared name cards with a picture of the head of the household in the

village, I put three boxes labelled 'rich', 'medium' and 'poor' in front of three participants, asking the three village leaders to divide the name card into three piles.   After the first round of division, I let them divide the three piles into six piles based on the same rule, until in the end, I know the poorest and the richest herders in the village.   During the ranking process, three of the participants can communicate and exchange ideas so that they will have an agreement with their decision.

6.4   Results
6.4.1   Self-stated reasons for giving gifts
i)   Total number giving gifts

Table 6.1: Number of participants who played the gift-giving game, and the division of the gifts based on the gender of the givers and receivers.

	Male receiver	Female receiver
Male giver	338(62%)	147(38%)
Female giver	208(38%)	253(62%)
Total	546	400

485 male givers and 461 female givers took part in the individual gift game. There were 546 gifts given to males and 400 gifts given to females.   Males were more likely to give gifts to other males: For male givers, 70% of their gifts were given to other males; only 30% were given to females.   For female givers, 45% of the gifts were given to male recipients and 55% gifts were given to other females; female givers gave roughly equal proportions of gifts to females and males.

ii)   Difference between male givers and female givers

Table 6.2: Number of gifts given by male and female givers in each reason category and their statistical differences. Statistical significant variables are indicated in bold.

Receiver	Male giver	Female giver	Chi-square	P Value
Father	33(7%)	19(4%)	3.27	0.070
Mother	13(3%)	33(7%)	10.24	0.001
Brother	36(7%)	35(8%)	0.01	0.92
Sister	30(6%)	29(6%)	0.00	0.95
Son	9(2%)	9(2%)	0.01	0.91
Daughter	9(2%)	16(3%)	2.40	0.12
Bro's children	1(0%)	3(1%)	na	na
Sis's children	10(2%)	2(0%)	5.00	0.03
Son's children	6(1%)	7(2%)	0.14	0.71
Daughter's children	3(1%)	4(1%)	na	na
Friends	83(17%)	68(12%)	0.98	0.32
Poor	103(21%)	104(23%)	0.24	0.62
Helpers	112(23%)	84(18%)	3.41	0.06
Others	37(8%)	48(10%)	2.24	0.13
Total	485	461		

Among all the 15 reasons of giving gifts, male givers were more likely to give gifts to their fathers compared to female givers (Chi-squared=3.27, df=1, P= 0.07), although the results are not significant;   female givers were significantly more likely to give gifts to their mothers compared to male givers (Chi-square= 10.24, df=1, p = 0.001); male givers gave significantly more gifts to their sister's children compared to female givers (x-square=5.00, df=1, p=0.03); male givers were more likely to give gifts to people who helped them in the past compared to female givers (Chi-square=3.41, df=1, p=0.06) although the difference is not very strong. On the whole, there is no relationship between male givers and female givers on the reasons of giving gifts if looking at the reasons for giving gifts (Chi-squared = 16.067, df = 13, p-value = 0.2455).

iii)   Percentage of reasons for giving gifts

Table 6.3: Percentage of each reason for giving gifts from male and female givers, listed
        in descending order. The most popular reasons are indicated in bold, which
        sums up to more than 50% of reasons for giving gifts

	Receiver	Total Number	Percentage
	Helpers	112	23%
	Poor	103	21%
	Friends	83	17%
	Siblings	66	14%
Male giver	Parents	46	9%
	others	37	8%
	Children	18	4%
	Cousin	11	2%
	Grandchildren	9	2%
	Poor	104	23%
	Helpers	84	18%
	Friends	68	15%
	Siblings	64	14%
Female Giver	Parents	52	11%
	others	48	10%
	Children	25	5%
	Grandchildren	11	2%
	Cousin	5	1%

As there were not many differences between male and female receivers, I further
looked at the percentages of each reason for giving gifts in male givers and
female givers.   From Table 6.3, we could see that for male givers, the three most
frequent reasons were: 'Friends,' 'poor,' and, 'Helper'.   These three reasons in
total account for 61% of the reasons of gift-giving.   For female givers, the most
popular reasons for giving gifts are the same as the male givers: 'Friends,' 'Poor,'
and, 'Helper'.   These three reasons make up 56% of the reason for giving gifts.
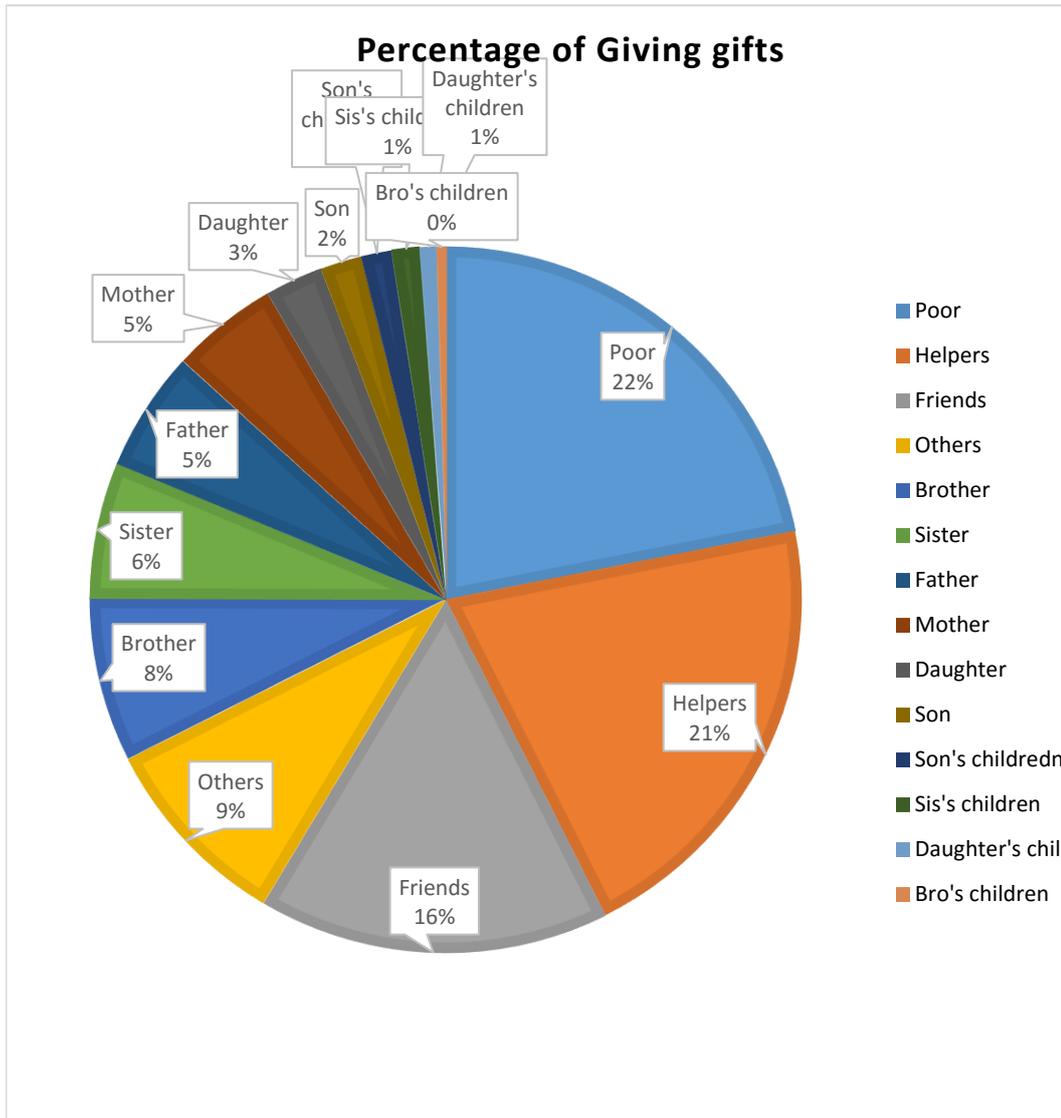
Figure 6.1: Distribution of the reasons of giving gifts from male givers and female givers in total. legend on the right side is listed in descending order, the most popular reasons of giving gifts are 'Poor', 'Helper', 'Friends'.

If I combine the reasons of giving gifts between male givers and female givers together, we can see from Figure 6.1 that 'Poor', 'Helper', 'Friends' are the most popular self-reported reasons of giving gifts, which takes up to 59% of all the 14 reasons of giving gifts.

Relatedness is important according to Hamilton's rule when hold benefits and costs constant, individuals who are sharing similar genes will be more closely related to each other (Wright, 1922) and thus more likely to collaborate (Hamilton, 1964).   Apart from close kin, in which category r = 0.5 (parents, full-siblings and offspring), there is also kin whose relatedness is less than 0.5

(grandparents, grandchildren, cousin etc), there are also relatives who are categorized as 'fictive kin' and 'affinal kin'. The analysis presented in this chapter will focus on the close kin(r=0.5), and distant kin (0<r<0.5). Reasons for giving gifts are presented in Table 6.3 in descending order. As we can see from Table 6.3 that both male givers and female givers are more likely to give gifts to their close kin. This is in consistent with kin selection theory. And in this pastoralist society, relatedness is the most important reason for sharing resources for male givers and female givers.

iv)   Kin or other reasons

Table 6.4 : Reasons of giving gifts for kin and other reasons from male givers and female givers separately. Popularity is listed in descending order.

	Receiver	Total Number	Percentage
Male Giver	Close kin(r=.5)	130	27%
	Helpers	112	23%
	Poor	103	21%
	Friends	83	17%
	Others	37	8%
	Distant kin(r<.5)	20	4%
Female Giver	Close kin (r=.5)	141	31%
	Poor	104	23%
	Helpers	84	18%
	Friends	68	15%
	Others	48	10%
	Distant kin (r<.5)	16	3%

Under the kin categories, I also looked at which relatives they prefer to give gifts to and whether there are differences between male givers and female givers. Table 6.4 shows that male givers gave gifts to closely related male relatives while female givers preferred to give gifts to closely related female relatives; male givers gave 53% gifts to male relatives, including brothers get 31% and father get 22%; female givers gave 48% of their gifts to the female relatives which include sisters get 27% endowment and mothers 21%. Mother give 8% of the gifts to daughters while male givers only gave 2% to daughters. Male givers and female givers did not differ in giving gifts to son, as there were 10% and 8% of the gifts given to sons.

v)   Which kin can get more gifts

Table 6.5 : Under kin category, which relatives is more popular for male givers and female givers. Reasons for popularity listed in descending order.

Male Giver	Reason	Number	Percentage
	Brother	46	31%
	Father	33	22%
	Sister	20	13%
	Son	15	10%
	Mother	13	9%
	Brother's child	9	6%
	Grandson	6	4%
	Daughter	3	2%
	Granddaughter	3	2%
	Sister's child	2	1%
Female Giver	Reason	Number	Percentage
	Sister	42	27%
	Mother	33	21%
	Brother	22	14%
	Father	19	12%
	Daughter	13	8%
	Son	12	8%
	Granddaughter	8	5%
	Brother's child	3	2%
	Grandson	3	2%
	Sis's child	2	1%

From this self-report data, there were no differences between male givers and female givers in their reasons for giving gifts.   Putting kin into categories of 'close kin' and 'distant kin', kin selection was the most likely explanation for giving gifts.   Dividing kin into specific categories, for male and female givers, instead of giving gifts to the genetically related relatives, the largest proportion of gifts were given to the poor, friends, and herders who helped them before.   Male givers were more like to give gifts to their brother and father; female givers were more likely to give gifts to their sister and mother.

6.4.2   Wealth ranking

When asking gift givers why they gave to the poor, they reported: 'because 'poor herders' have very few yaks, they are in a short of cash, I want to give him/her

some help'.   In the pastoralists' society, the majority of income is from selling livestock, so the number of the livestock can be a reliable way to measure family wealth.   The quality of the livestock does not make a difference to the herder's income because they will only wait for the animals until they grow big enough (based on the teeth of the animal), especially after summer, when animals could gain some weight, and they will sell them to butcher.   Wealth plays an important role in marriage and herding (Cronk, 1991b), but how to define wealth from a local perspective is not always clear.   Generally speaking, livestock number, pasture space and family size are the basic criteria for herders in terms of material wealth (Fortes, 1978).   Enough pasture space ensures enough resources for the animal to eat, herders can also rent the pasture out and they can earn money by doing this.   Renting grassland is a very easy way to earn money, and it will make the family accumulate wealth quickly, but at the same time, renting pasture out is a bad strategy for environmental conditions (Cao et al., 2013).   Having a big family before privatisation is a good thing because it means that by the time of land division, the family can get more space.   In addition, the bigger the family size is, the more power the family has, this can be seen in the Tibetan history that only family in power (for example, empire family and clan leader's family) is big, having a big family also avoid the problems of shorting labour.

i)   Does wealth mean size of yaks?

In the local area, herders mainly raise yaks, because sheep are very fragile and take time and energy to look after, it is not very economical to have sheep compared to yak.   Every family has at least one motorbike; very few herders ride horses to move around but they use them for herding sometimes.   In addition, fences limited the space for yaks to move around so herders do not need to ride horses to look after livestock all day long.   Considering that horses are inconvenient and consume a lot of grass, it is becoming a 'luxury' animal to raise in the local area.   Only rich herders can afford to own horses. Some elderly herders insisted on keeping one or two horses at home to follow the ancient Tibetan tradition; they told me that, 'horses made me feel comfortable.   Tibetan herders without horses are not real herders'.   Another herder said, 'I guess it's going to be very awkward if my son rides a horse to go to play basketball while his other friends are all riding motorbikes'.

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Since the only income is from selling livestock (yaks and sheep) and by-products, I first use a number of yaks (4 sheep equals one yak according to the local calculation) in each household (owned by the head of household) to test whether the number of yaks determined the wealth ranking results.

ii)   Are there any other factors relating to wealth?

The scale of land relates to the number of livestock each family is allowed to raise. Especially after the privatization policy, herders need to pay a penalty within their herding group or spend money to rent grassland from other places if overcrowded livestock; according to Tibetan culture, bigger families have more available labourers: more labourers equals higher social status and power.   So apart from the number of livestock, whether land space and family size have some effects on the definition of wealth from the local context.

iii)   Yak number determines wealth rank

Table 6.6: ordinal logistic regression of the wealth rank. Three variables are included in the ordinal regression to test the relationship between the wealth rank and candidate variables, statistical significant variables are indicated in bold.

Variables	OR (95% CI)	P value
Family member	1.24(0.95, 1.62)	0.11
Land space (per Family member)	0.99(0.998, 1.00)	0.06
Yak number	0.98(0.97, 0.99)	<0.001

Probability of number of animals in each wealth category
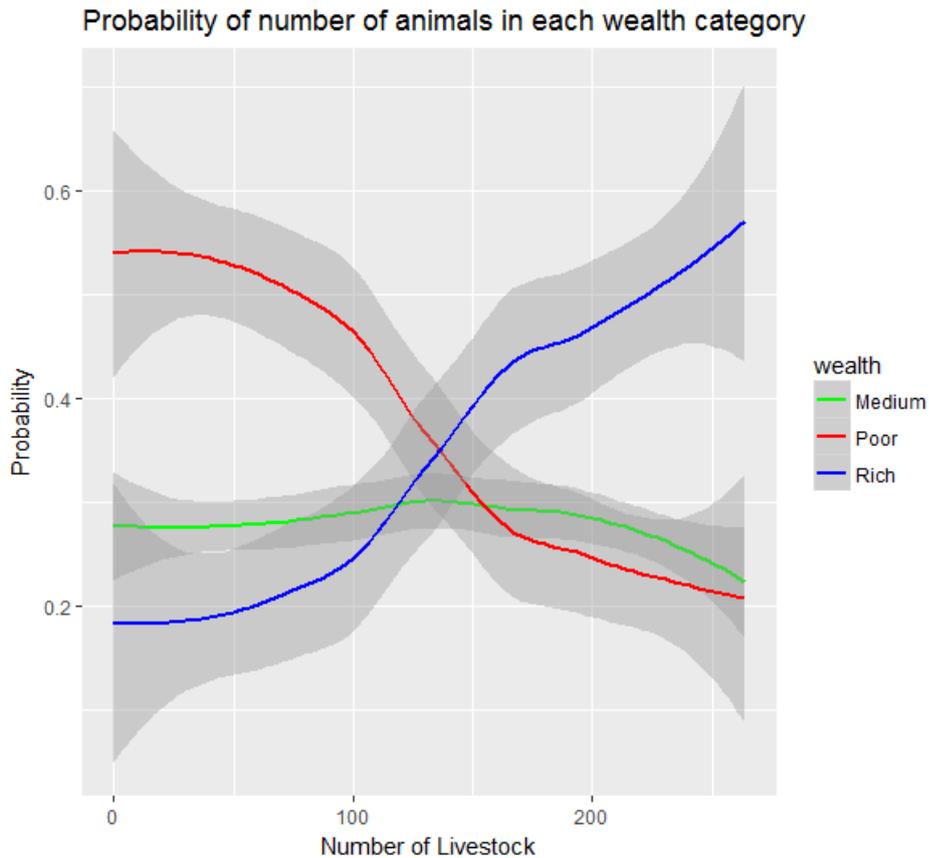
Figure 6.2: Probability of wealth ranking based on the number of livestock. The red line means the probability of poor, blue line means rich and green line stands for medium categories.

There are altogether 208 wealth ranking results, 132 valid data (132 individuals have both information of their family size and land space).   I used ordinal regression to test three different factors which determined the wealth ranking results.   These three factors are: family size (number of family members living together), number of yaks, and land space (225acre * number of adult individuals at the time of division, 125acre * number of children by the time of division according to local government policy).   The participants divided wealth ranking into three categories (Rich, Medium, Poor), 46 individuals belonged to the rich category, 37 belonged to medium, and 49 belonged were poor.   Table 6.6 shows that the number of the yaks significantly determined the wealth rank results (OR=0.98, 95% CI= [0.97, 0.99], P value<0.001).   Figure 6.2 shows the probability of different wealth rank based on different herd sizes, controlling for family size and pasture space; the more yak each family has, the more likely it is that they will be ranked as 'rich'.

Family size was not related to wealth rank.   One possible explanation is that the 'Chinese one child policy' and '9 years compulsory education policy' made family size became much smaller: there is not a big difference from one family to the other.   Land space is also not statistically associated with wealth rank.   This is because even if some families have limited space, they will spend money to rent grassland from somewhere else.   Compared to other factors, the number of yaks is the most reliable way to distinguish wealth and poor.

iv)   Whether gender associated with giving gifts

Cairima village

Doulong village

Jilehe village

Tawa village
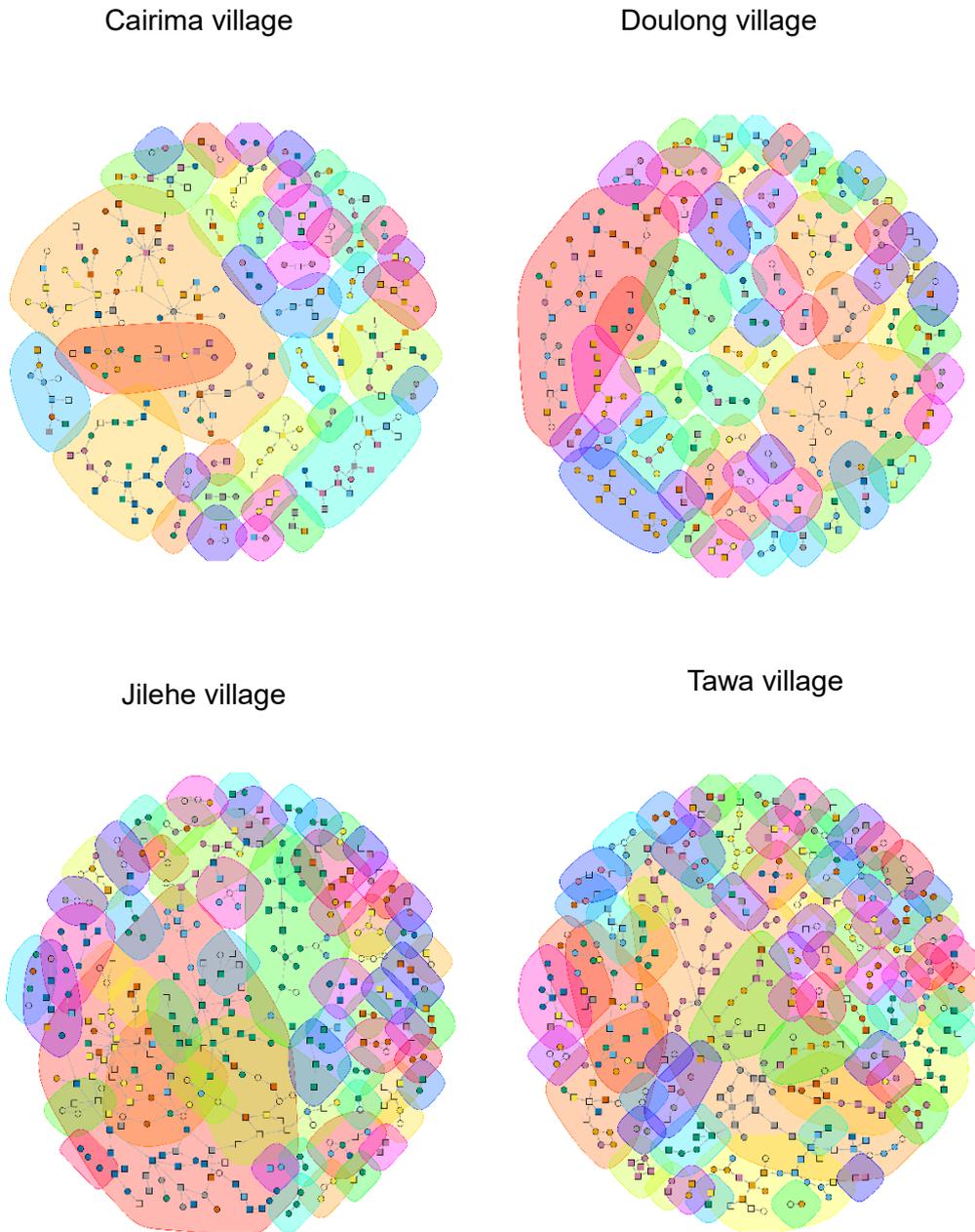
Figure 6.3: Networks of observation from giving gifts for four villages. In the plots, squares represent males and circles are females. The plot was coloured by herding group membership. The big clouds of colour around a bunch of people are statistically detected communities.

From Figure 6.3 we can see that there is not an obvious association between giving gifts and gender of the ego and alter, males and females are equally like to

give and receive gifts from each other.

6.4.3   Reasons for giving gifts

As well as the self-stated data about the reasons for giving gifts, I looked at their preference of giving gifts through demographic data, apart from giving gifts to the kin, they also like to give gifts to someone they believed are respectable or adorable, they also like to give gifts to someone who is poor or financially in need.   I predict that age difference and wealth difference will affect the reasons for giving gifts in one way or the other.   I use 'ego' and 'alter' to indicate the gift game player and receiver respectively. Age and wealth difference between ego and alter are shown below.

i)   Descriptive statistics
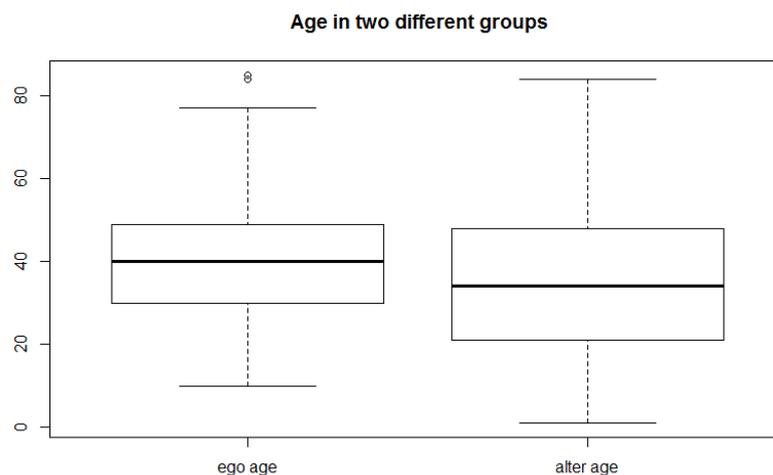
Figure 6.4: Box plot of ego age and alter age.

Looking at the age of the ego and alter first, the mean age for ego is 41.67, mean age for alter is 35.26.   The age difference between ego and alter is statistically different (t = 7.2, df = 1364.6, p-value < 0.05).

Whether there is age difference between individuals in the same herding group and different herding group is the next question I am interested to look at.   If the age difference is negative, it means ego are older than alter.   There are 414 male givers and 360 female givers, 479 male receivers, and 295 female receivers

for whom I have complete age information.

Same herding group **Different herding group**
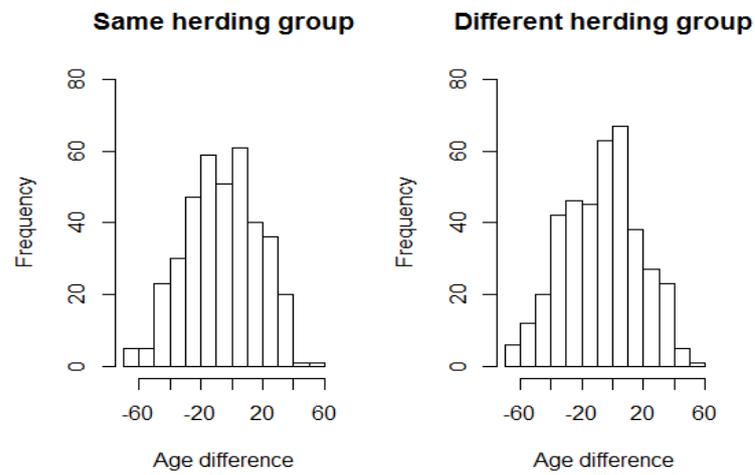
Figure 6.5: Age difference for ego and alter split by whether ego or alter in the same herding group or in the different herding group.

There is not much age difference between egos and alters who are in the same herding group and who are not (Figure 6.5; t = 0.6, df = 771.99, p-value = 0.5458).
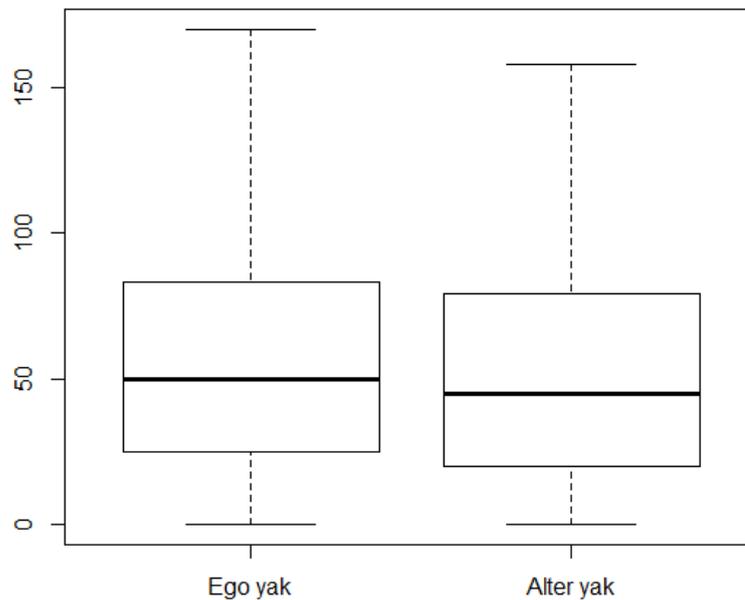
Figure 6.6: Boxplot of number of yaks owned by egos and alters who took part in the gift-giving game. For ego's number of yak: min=0, max=300, mean=63.09; for alter's number of yak: min=o, max=300, mean=57.06. Outliers were deleted from the boxplot.

There is a wealth difference between ego and alter, but the effect size is really small (Figure 6.6; t = 2.5, df = 1543.6, P = 0.01), I divided the ego and alter groups into three wealth categories based on the number of yaks, the poorest group has <= 10 yaks, the wealthiest group has >= 100 yaks, and the rest of the individuals belongs to the middle group.

For the poorest group of herders (based on the number of livestock) (n=55, female=23, male=32) 25% of the gifts from the male giver and 20% of the gifts from the female givers are reported that they are giving gifts to the poor receiver, so 45% of their reasons of giving gifts is to the poor, although according to the number of livestock, the alter's yak is more than the ego.   For the rich groups (n=35, female=13, male=22), 18% of the gifts from male givers and 31% of the gifts from female givers were given to the poor, 49% of the reasons for giving gifts in the rich group is because the alters are 'poor'.   There is no statistical

difference between rich and poor on giving gifts to the poor (Chi-squared = 5.9413, df = 10, P = 0.8202), so giving gifts for the reported reason of poor is not different from rich herders and poor herders.   Poor herders, defined by the number of livestock, gave gifts to alters who owned more livestock but still claimed that 'Alters are 'poorer''.

6.4.4   Generalized linear mixed effects model

For 4 villages, after deleting missing variables, there were 766 gifts given by 535 adult herders to 531 recipients.   There are 239,360 possible dyads.   To model which factors affect the gift-giving decision, I constructed generalized estimating equation models (GEE) to explain whether or not a gift was given by using GEE package clustering on ego ID because ego is a non-independent observation in dyadic analyses.   This analysis has been used by other researches to explain the possibilities of giving gifts in dyadic data when there are repeated observations in the model (Pan, 2004; Smith et al., 2016; Thomas, Nass, Bårdsen, & Mace, 2015).   The binary response variable is whether there is a gift in each dyad.   I chose to use GEE model because I am only interested in the population average effects of relatedness, herding group membership and wealth.   Apart from gifts I actually did observe, I am also interested to which factor predict the possibilities of giving gifts.

i)   Descriptive statistics

Table 6.7: This table including all the possible dyads in the area, divided by whether ego
and alter in the same herding group and whether they are genetically related.

SameHerdingGroup	Kin	Giving gifts	
		No	Yes
Yes	Yes	2010(12%)	146(1%)
	No	13903(85%)	233(1%)
No	Yes	1956(1%)	104
	No	220725	283

Table 6.8: Relatedness between each dyad divided by whether ego and alter in different
herding group or in the same herding group.

	Relatedness					
	0	0.0625	0.09375	0.125	0.25	0.5
Different herding group	288	1	0	7	17	79
Same herding group	233	3	2	7	42	92

Table 6.8 shows the distribution of relatedness in the same herding group and in
different herding groups among individuals where there is a gift in the dyad.
People in the same herding group have higher relatedness than in the different
herding groups (t=18.4, df=1021, p<0.001).

ii)   Generalized estimating equation models

Table 6.9: 7 Candidate generalized estimating equation models. Predictors in each candidate models include kin (coded as a continuous variable), whether Ego or Alter in the same herding group (coded as a binary variable), kin and herding group interaction, yak number for ego and alter separately (coded as continuous variables).   The best fitting model is based on calculating the quasi-likelihood information criterion, and the lowest QIC is the final model. As we can see from the candidate model listed in the table, the best fitting model is the first model which explains the 96% of the model confidence.

Models	QIC	Weight
1. kin*SameGroup+Yak	8495.5	0.963
2. kin*sameGroup	8502.1	0.037
3. kin+samegroup+Yak	8796.9	0.000
4. kin+samegroup	8800.6	0.000
5. kin	9229.6	0.000
6. Same group	9298.3	0.000
7. Yak	10327.3	0.000

Table 6.10: Best fitting generalized estimating equation results. We can see from the table that kin, same herding group and their interaction significantly affects the binary response of giving gifts or not in each dyad.

Variables	Log OR	95% CI	SE	P Value
Intercept	6.513	(-6.690, -6.336)	0.090	<0.001
kin	9.963	(9.385, 10.541)	0.295	<0.001
SameHerdingGroup	2.627	(2.436, 2.818)	0.097	<0.001
Ego yak	0.001	(-0.001, 0.002)	0.001	0.458
Alter Yak	0.003	(-0.005, -0.001)	0.001	0.007
kin*SameHerdingGroup	6.790	(-7.546, -6.034)	0.386	<0.001
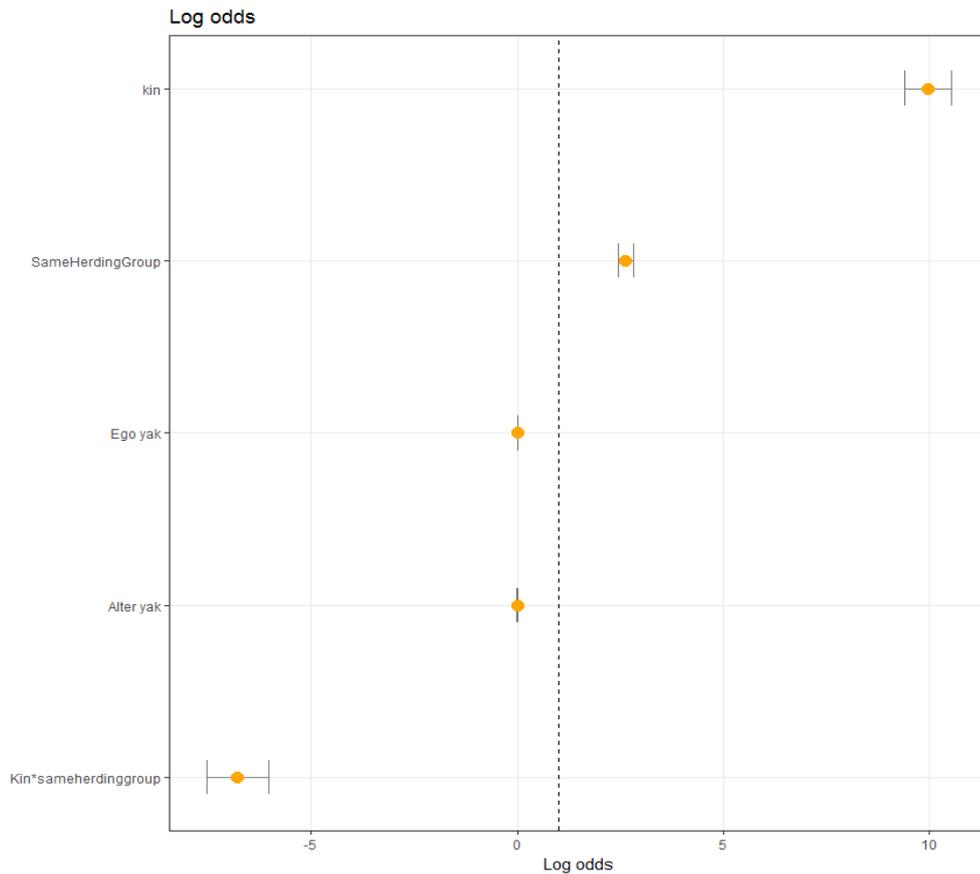
Figure 6.7: Log odds for the predict variables. Odds ratio are calculated by the generalized estimating equation.   Response variables are whether received a gift or not, dots mean odds of co-occurrence of given gifts when individuals in a dyad belong to the following categories: the genetic relatedness, whether they are in the same herding group, whether there is animal difference, and the interaction between the same herding group and whether they are related. Error bar indicates 95% confident intervals.

The results from the generalized estimating equation model showed that genealogical relatedness and herding group membership have the strongest effects on the decision of giving gifts.   Individuals were more likely to give gifts when they lived in the same herding group (OR = 2.627, 95% CI = [2.436, 2.818], P<0.001) and when they were more closely related (OR = 9.963, 95% CI = [9.385, 10.541], P<0.001).   The interaction between living in the same herding group and genetically related also strongly affect gift-giving decision (log odds=-6.790, 95%CI = [-7.546, -6.034]).   Wealth did not predict the decision to give gifts: ego's yak number (log odds=0.001, 95% CI = [-0.001, 0.002]), or alter's yak

number (log odds=-0.003, 95% CI=[-0.005, -0.001]).   This is different from the self-reported reasons for giving gifts, as in the self-reported data, egos reported that they gave to alters who were poor.

6.5   Discussion:

Self-report data are widely used by demographers, psychologists and other social anthropologists.   It is a direct and basic way to understand the overall situation of the society, from the self-report data we can get a first and immediate impression of interviewees' thoughts.   While sometimes people saying one thing while doing another. In this research, for example, I asked participants the reasons for giving gifts.   If I put all the kin into one category, the most popular reason is because ego and alter are relatives, but apart from kin selection, the three most popular gift-giving reasons were: ① receivers are poor; ② they are friends (have good friendship, close to each other); ③ the gift receiver helped the gift giver before.   However, wealth was not a predictor of gifts.   There was not much difference in wealth between ego and alter; instead, kin selection was a strong predictor: individuals gave gifts to relatives.   In addition, living in the same herding group was also a strong predictor of cooperation.   In this society, living close by means being in the same herding group.   Herding groups are mostly formed by kin, so there is a strong correlation between kin and same herding group.

Reasons from evolutionary theory and self-report for herders who are willing to cooperate varies.   In general, shortage of labour is a constraint for the pastoralist production (Næss, 2012).   Pastoralists are constantly seeking help from other herders, this is also one main reason why herders want to herd together.   Kin will help each other all the time, but the reason why not genetically related individuals are also helping depends on the ecological and social situations.   In the Tibetan Pastoralists society, there is always a possibility of unpredictable nature disasters, and husbandry of livestock is, even more, labour intensive under harsh environment conditions (Kuznar, 2001).   Throughout history, there have been wars happening on the borders of each clan regarding grassland boundaries in the Tibetan plateau; having more herders living close by can raise the possibility of survival (James & Ekvall, 1963；Yeh, 2003).   Another

reason which determined cooperation for pastoralist is reputation, individuals who have good reputations will attract more collaborators (Hooper et al., 2010). My analysis shows that when we ask herders the reasons for giving gifts, they report that they give people gifts because they are poor or they helped them before thus to show their generosity. Reputation is important in the small society where it will be easily remembered or easily transmitted through gossip. One way of raising reputation is to show generosity towards others, as generosity is regarded as a good characteristic (Barclay, 2010). Generosity will evolve although it will show obvious costs at the beginning, but it will build up trust and gain reputation from the third party, and in the long run, it will benefit individuals and strengthen group cooperation (Wedekind & Braithwaite, 2002). Generosity is also common in societies experience food insecurity and where health condition is very poor. Generous individuals who are willing to frequently share most of the resources with others are also able to receive more care and food in return when they are sick or in the unsecure period compared to greedy people who don't share much with others (Gurven, Allen-Arave, Hill, & Hurtado, 2000). But being generous and sharing with others is not necessarily sharing willingly, the generous behaviour is more likely from the others who have right to demand of them.

Cooperation does not necessarily require individuals to invest as many resources in the common pool as possible; sometimes, investing a small amount of resources and adjust investment according to others' behaviour can stabilize reciprocity (Roberts & Sherratt, 1998). In another word, occasional cheating can sometimes increase cooperation. But cheating might not be applicable to small-scale societies, for example among pastoralists where repeated interactions are unavoidable. Cheating even just once is a high-risk strategy because your reputation will be ruined and no one will cooperate with you in subsequent interactions.

One important advantage of showing generosity or having a good reputation or higher social status is to gain mating opportunities. Lab-based psychological experiments have showed that men are more likely to show generosity compared to women, because women are keen on looking for 'high quality' men to reduce their costs in parental investment, and generosity as a way of showing good characteristic ensured mating opportunity and increased the reproductive

success especially for males (Barclay, 2010).   We can see this in the self-reported reasons for giving gifts, although majority of male and female participants said that they prefer to give gifts to the poor, male herders are statistically more likely to say so compared to female herders, I interpret it as 'generosity' is a very important character for male herders as a way of signaling quality rather than there is a norm of helping the needy, whereas females' reputation is more related to hard working and marital status (discussed in chapter 4).

People show generosity mostly in public, and the size of the audience will affect the degree of generosity (Barclay, 2010).   In the gift-giving game as I conducted in this pastoralist society, the whole process was anonymous, therefore why people still want to show generosity is an interesting 'puzzle'.   Some evolutionary psychologists found that people pretend to be generous if they think there is an audience watching their behaviour in the lab-based 'eyes experiment' (Haley & Fessler, 2005; Bateson, Nettle, & Roberts, 2006a).   Even if the 'eyes' around are not real, and either the sex of the eyes or the sex of the participants will not affect the behaviour (Nettle et al., 2013).   In the review paper by Price (Price, 2012), he furthered argued that when participants know that their behaviours will be recorded and scrutinized by others in the economic game, even though they have been informed that the process is anonymous, they still behave differently from their 'natural behaviour'.   'Fake' signalers are showing their generosity to gain reputation and thus receive different kinds of benefits as I discussed above.

6.6   Conclusion

Sociality arises when there are more benefits than the costs of living in a group. Social networks are formed between different dyads living in the group, and social networks evolve when individuals are able to balance their costs and benefits so that they can maximize their fitness.   Cooperation is crucial, showing generosity is an important strategy in cooperation because it will increase social status at the same time, in the end, generosity signalers will get more help if in need.   That is why the herders in the community like to show their generosity from self-stated reasons of giving gifts. Reputation is important in different societies, and it is even more crucial in high-risk environment, as in this

pastoralists society, where herding group are far away from each other, and mostly kins are clustered in the same herding group, keeping a stable relationship with kin and group members in the same herding group will secure the livelihood.   Although I analyzed the data from self-report and real-life data, I argue that what people behave are different from what they report.   People tend to show they are generous as much as possible in a more direct way in public so that everyone else in the group will know their prosocial behaviour and in the end get higher social status.   On the contrary, when it comes to the costs and benefits, in this case will give some free cash to close relatives or to non-related individuals, then gift givers will still prefer to give it to genetically related relatives (although they won't say it directly), as kinsman are the most closely related individuals that worth investing resources to.

Chapter 7: Conclusion

Ecology and subsistence can influence social organisation and behaviour, both in our evolutionary history, recent history and in the present. Behavioural ecologists make hypotheses about how behavioural variation can be understood as an adaptation to local ecology (in animal species or humans), testing their models with data from natural populations. This thesis furthers the previous study of how behaviours are adjusted in different ecological context by focusing on a highly mobile population where unexpected natural disasters happen all the time.

This Tibetan herding society is experiencing a series of political changes that not only affect their subsistence but also their division of labour, gender-preference, marriage stability, parental investment and social networks which were discussed in the thesis.

7.1 Overview of findings:

Based on the review of behavioural ecology and the related history and demography of this area, which was discussed in Chapter 1 and Chapter 2, the question that I examined were: a) how political and ecological changes affects the gender preference and parental investment from the mother. b) what are the important predictors of divorce. c) who are the actual allomothers when women are busy all the time. d) when it turns to giving gifts, what is their preference and why.

Chapter 3 is about how gender preference was changed in the history and after some political policies. As I discussed in Chapter 3，breastfeeding believed to have unreplaceable nutritional value to the infants but it costs mothers' energy and future reproductive opportunity, in addition, postpone the intervals of one birth means that mothers are not in a rush to have another baby, which in turn probably predicts that the previous birth is the one that women are expected. In Tibetan and Chinese history, especially in the patrilineal societies, there is a tradition of son preference in accordance with the irreplaceable male social and political status. While I found that son preference is not as strong as people thought. Although from self-stated preference, son preference is the norm that everyone sticks to daughters get more parental care from the actual investment.

This is possibly derived from the recent political changes that made women became more valuable in terms of economic contribution to the family and society, and this biased gender preference will further influence the female status in the family and marital status which was further discussed in Chapter 4. The limitation of this chapter is that the time of death and birth was calculated on year basis, it is possible that there are more differences in the mortality rates for male and female children in years or even days differences. Future investigation for any demographic data collection and assessment should be in more details, for example, the data of birth and death, duration of birth intervals.

In chapter 4, I showed the reasons of divorce for both adult males and females, and why there are so many 'single mothers' living by themselves. In the Tibetan society, both these forms of the marriage or mating system existed in the recent past. At the present, there is less polygamous marriage, but extra-pair mating appears to be still common, with both men and women remained in the same household while having children with other men or women outside of the marriage. I found that offspring living status, wealth transfer within marriage and the length of 'trial marriage' all have some effects on the marriage continuity. When both bride and groom (or their family) invest resources (brideprice) into the newly built family, that will strengthen the family tie. The longer the trial marriage time is, the less likely that the couple will get divorced, and for women who get divorced, they also consider by others as 'lazy/bad workers'.   I also argued that under the Tibetan tradition of sending males to the monastery, reduced the number of men in the mating market is reduced, that will give men more bargaining power to be lazy, being popular in the mating market and many other fields. The limitation of this work is that the definition of the marital status and divorce is not very clear, should single mothers count as in informal polygynous marriage and whether the end of the trial marriage is divorce. Since I only looked at the female work load in this chapter, I neglect the possibility that male labour ability and their workload ranking is also an interesting topic that worth to explore. Future work could, however, attempt to rank male work ability as well, at the same time, to rank male ability in terms of doing domestic work, business and childcare, these could also be potential research topics that worth to compare with male and female.

The core question in the previous two quantitate chapters is about the changing of the female social status. From female infants get more parental care to the reason of why fertile women can afford to get divorced and stay single. These changes are based on the condition that the whole production and reproduction system was a bit female biased, that they have harsher intragroup competition and higher economical value in the family and society. But what about the post-reproductive female, is the biased female social status affected their way of life, this question is the main topic that I discussed in Chapter 5. From the behavioural ecology theory, how post-reproductive women increase their inclusive fitness by looking after their grandchildren. But considering the high female working load and the disadvantage for adult male to compete with the young males in the mating market, it is grandfathers who are actually doing the child care, otherwise, children will just be fastened up when women are in the field. I thus argued that grandmother hypothesis is not universally practical, and grandfathers are not useless in childcare; grandfathers have to look after grandchildren when they are the only available 'allomother' within the household.   However, there are some limitations in this analysis, for example, living status might not be very reliable in determining mortality rates, future research should also address the residential status of, or the distance between grandparents and grandchildren.

Chapter 6 is about the experimental research that I conducted among adult male and female herders to investigate the social relationship through playing economic games. I found that kin are preferred to stay in the same herding group, and the interaction between kin and the same herding group have the strongest positive effects on giving gifts, wealth is not a big determinant of giving gifts, because the number of yaks from neither ego nor alter had effects on giving or receiving gifts. On the contrary, from the self-report data about why they are giving gifts, I found that 'being poor' is a very popular reason for giving gifts; I thus interpreted that reputation and social status still had a play in their daily subsistence, especially when the size of the community is small and reputation spreads faster and penalty is more intense compared to the big scale societies. In addition, although the whole process is anonymous, in some situations the gift-giver will tell the gift-receiver afterwards, that made the giving-process a bit biased. A very important limitation also goes with the sample bias, as the restriction of the game made more gift-givers, especially younger generation, not

able to give gifts to their offspring, we do not really know what is the results if they could do so, in the future research, I should have two rounds of gift-game, one doesn't have any restriction on the gift-receiver, the other has, and it would be interesting to see the difference between two of them.

7.2   A new way of interpreting results/reading self-report data

Playing economic game is a widely used method by behavioral ecologist and economics in order to explain the social networks and relationships, but some researches argued that it is not as simple as directly transform the experimental data to reflect the real-world life (Price, 2012), as there is sometimes striking difference between experimental and daily behaviour (Henrich et al., 2005). For example, Levite and List (Levitt & List, 2007) put forward 5 factors that they believed will influence the decision-making in the laboratory experiments and the real world human behaviour. Interpreting human behaviour is far more complicated than just doing the calculation from the laboratory experiments. These five factors include 1) the ethic or moral influence. Participants have a pressure of making 'the right and ethically good decisions'. 2) anonymous. Participants behave differently when they realized that the behaviour was monitored by others. 3) experiments and daily behaviour are context-dependent. Behaviours in the real-life setting are much more complicated than in a carefully designed experiments. 4) the sample size used in the experiments is not representative of the whole population. Especially when many laboratory-based experiments often recruit university students as the participants.   5) the stake of the game influence the behaviour, mismeasurement of the stake in different setting incurs different behaviour (Levitt & List, 2008).

Self-report is a well-used methodology to get qualitative data and help researchers and readers to understand the field site better. It is being used in many subjects, for example in reporting the gender preference (Cronk, 1993), the reasons for giving gifts (Thomas et al., 2015), why individuals are following specific behaviour etc. Most of the research in social anthropology and human behaviour ecology, as well as psychology and economics,   are using this method to get a better idea of the whole system, through a direct interview or lab-based experiment. Some researchers mentioned about the inconsistency of the self-report data and daily behaviour, but so far from my knowledge, I did not find

any related kinds of literature that had made a quantitative comparison between self-report data and the actual behaviour in the pastoralist society. My research expands this topic and reflects the point that Individuals are not always reporting what they really think, because they get social pressure to behave in a way that accepted by most people, for example, most often herders stick to the social norm by reporting son preference and giving gifts to the less wealthy herders, while their actual behaviour is different. Social norms govern behaviour and in many societies, it is a strategy where individuals can improve their social status and increase fitness. But for the evolutionary anthropologists, we should not ignore the mismatch that was probably happening underneath the self-statement, and emphasis more on the local ethnographical context.

7.3   Furthering the research and conclusion remarks

Changes in ecology and subsistence, including changes in land tenure and relationships with markets, can influence many aspects of the social organisation, both in our evolutionary history up to the present. Human behaviours can also feedback into environmental conditions, causing further human-environment interactions. In the recent history, Amdo Tibetans are experiencing lots of changes that affect their way of living in different aspects, the traditional pastoralist system does not exist and the whole society is at the stage where they got a cultural shock from Han-Chinese. They are trying to better adapt to the social and ecological environment, at the same time willing to keep their own cultural and social norms. Investigating how changes in a subsistence system influence social behaviour using approaches from human behavioural ecology is relatively new in China (with most studies of social systems only taking a descriptive and qualitative approach). That opens the door for the future research where Tibetans are starting to settle down, do more farming, opening a business, getting more education, migrating to the outside of the plateau and so on. My future research will focus on a comparative research on different Tibetan groups and investigate how ecological and social environment shapes the behaviours of people who are sharing the same culture. I will use the human behavioural ecology framework to examine how the variable ecology that Tibetan pastoralists and agro-pastoralists experience shaped their life histories, their cooperative networks and social organisation, subsistence and workloads, reproduction and parenting. The wristband will be used in some areas to investigate the difference

between male and female workload, time-budget data will also be collected about the previous 24 hours of work for both men and women. The demographical research will be conducted in the monastery to better investigate how sex ratio affects marriage and parental care.

References

A.R.Radcliffe-Brown, & Forde, D. (1950). *African Systems of Kinship and Marriage*. London: Oxford University APress.

Aassve, A., Meroni, E., & Pronzato, C. (2012). Grandparenting and childbearing in the extended family. *European Journal of Population / Revue Européenne de Démographie*, *28*(4), 499–518. https://doi.org/10.1007/s10680-012-9273-2

Agadjanian, V. & E. C. A. (2000). Polygyny , gender relations , and reproduction in Ghana. *Journal of Comparative Family Studies*, *31*(4), 427–441.

Aiello, L. C., & Wheeler, P. (1995). The expensive-tissue hypothesis. *Current Anthropology*, *36*(2), 199–221.

Aitane, I. (2009). The determinants of discrimination against daughters in China: Evidence from a provincial-level analysis. *Routledqe Population Studies*, *63*(3), 41–14. https://doi.org/10.1080/00324720802535023

Alam, N., K.Saha, S., Razzaque, A., & Ginneken, J. K. Van. (2016). The Effect of Divorce on Infant Mortaity In A Remote Area of Bangladesh. *Journal of Biosocial Science*, *33*(2001), 271–278. https://doi.org/10.1017/S0021932001002711

Alexander, Richard, D. (1974). The Evolution of Social Behavior. *Annual Review of Ecology and Systematics*, *5*(171), 325–383. https://doi.org/10.1111/j.1365-294X.2011.05232.x

Amato, P. R. (2000). The Consequences of Divorce for Adults and Children. *Journal of Marriage and the Family*, *62*(November), 1269–1287.

Anderson, K. G., Kaplan, H., & Lancaster, J. (1999). Paternal care by genetic fathers and stepfathers I: Reports from Albuquerque men. *Evolution and Human Behavior*, *20*(6), 405–431. https://doi.org/10.1016/S1090-5138(99)00022-7

Anderson, K. G., Kaplan, H., & Lancaster, J. B. (2007). Confidence of paternity, divorce, and investment in children by Albuquerque men. *Evolution and Human Behavior*, *28*(1), 1–10. https://doi.org/10.1016/j.evolhumbehav.2006.06.004

Anderson, K. H., King, E. M., & Wang, Y. (2003). Market Returns, Transfers and Demand for Schooling in Malaysia, 1976-89. *Journal of Development Studies*, *39*(3), 1–28. https://doi.org/10.1080/00220380412331322801

Angrist, J. (2002). How Do Sex Ratio Affect Marriage And Labor Markets? Evidence From America's Second Generation. *The Quarterly Journal of Economics*, *117*, 997–1038.

Applbaum, K. D. (1995). Marriage with the Proper Stranger: Arranged Marriage in Metropolitan Japan. *Ethnology*, *34*(1), 37–51.

Archetti, M. (2013). Evolution of polygamous marriage by maximization of inclusive fitness. *Journal of Theoretical Biology*, *319*, 134–43. https://doi.org/10.1016/j.jtbi.2012.11.017

Ariane Kemkes-Grottenthaler. (2005). Of Grandmothers , Grandfathers and Wicked Step-Grandparents.Differential Impact of Paternal Grandparents on Grandoffspring Survival. *Historical Social Research/Historische Sozialforschung*, *30*(3), 219–239.

Attané, I. (2002). China's Family Planning Policy: An Overview of Its Past and Future. *Studies in Family Planning*, *33*(1), 103–113.

Attané, I., & Courbage, Y. (2000). Transitional stages and identity boundaries: The Case of Ethnic Minorities in China. *Population and Environment*, *21*(3), 257–280. https://doi.org/10.1007/BF02436131

Aureli, F., Schaffner, C. M., Boesch, C., Bearder, S. K., Call, J., Chapman, C. a., … Van Schaik, C. P. (2008). Fission-Fusion Dynamics: New Research Frameworks. *Current Anthropology*, *49*(4), 627–654. https://doi.org/10.1086/586708

Banister, J. (2004). Shortage of girls in China. *Journal of Population Research*, *21*(1), 19–45.

Barclay, P. (2010). Altruism as a courtship display: some effects of third-party generosity on audience perceptions. *British Journal of Psychology (London, England : 1953)*, *101*(Pt 1), 123–135. https://doi.org/10.1348/000712609X435733

Barry S. Hewlett. (1988). Sexual selection and paternal investment among Aka pygmies. In L. Betzig, M. B. Mulder, & Paul Turke (Eds.), *Human Reproductive Behavior: A Darwinian Perspective* (pp. 263–274). New York: Cambridge University Press.

Bartholomew, G. A. (1970). A Model for the Evolution of Pinniped Polygyny. *Evolution*, *24*(3), 546–559.

Barton, K. (2015). Multi-Model Inference.

Bateson, M., Nettle, D., & Roberts, G. (2006a). Cues of being watched enhance cooperation in a real-world setting. *Biology Letters*, *2*, 412–414. https://doi.org/10.1098/rsbl.2006.0509

Bateson, M., Nettle, D., & Roberts, G. (2006b). Cues of Being Watched Enhance Cooperation in a Real-World Setting. *Biology Letters*, *2*(3), 412–414. https://doi.org/10.1098/rsbl.2006.0509

Baydar, N., & Brooks-gunn, J. (1998). Profiles of Grandmothers Who Help Care for Their Grandchildren in the United States. *Family Relations*, *47*(4), 385–393.

Bean, L. L., & Mineau, G. P. (1986). The Polygyny-Fertility Hypothesis:A Re-evaluation. *Population Studies: A Journal of Demography*, *40*(1), 67–81. https://doi.org/10.1080/0032472031000141846

Becher, H., Müller, O., Jahn, A., Gbangou, A., Kynast-Wolf, G., & Kouyaté, B. (2004). Risk factors of infant and child mortality in rural Burkina Faso. *Bulletin of the World*, *243*(2), 265–273. https://doi.org/10.1590/S0042-96862004000400008

Beimatsho. (2008). Population, Pasture Pressure, and School Education: Case Studies from Nag chu, TAR, PRC. *International Association of Tibetan Studies*, (4).

Bengtson, V. L., & Roberts, R. E. L. (1991). Intergenerational Solidarity in Aging Families : An Example of Formal Theory Construction. *Journal of Marriage and Family*, *53*(4), 856–870.

Bereczkei, T., & Dunbar, R. I. M. (1997). Female-biased reproductive strategies in a Hungarian Gypsy population. *Proceedings of the Royal Society B: Biological Sciences*, *264*(1378), 17–22. https://doi.org/10.1098/rspb.1997.0003

Bessho, Y. (2015). Migration for ecological preservation? Tibetan herders' decision making process in the eco-migration policy of Golok Tibetan autonomous prefecture (Qinghai province, PRC). *Nomadic Peoples*, *19*(2), 189–208. https://doi.org/10.3197/np.2015.190203

Bezner Kerr, R., Dakishoni, L., Shumba, L., Msachi, R., & Chirwa, M. (2008). "We Grandmothers Know Plenty": Breastfeeding, complementary feeding and the multifaceted role of grandmothers in Malawi. *Social Science and Medicine*, *66*(5), 1095–1105. https://doi.org/10.1016/j.socscimed.2007.11.019

Bird, R. (1999). Cooperation and conflict: The behavioral ecology of the sexual division of labor. *Evolutionary Anthropology*, *8*(2), 65–75. https://doi.org/10.1002/(SICI)1520-6505(1999)8:2<65::AID-EVAN5>3.0.CO;2-3

Bird, R. (1999). Cooperation and Conflict: The Behavioural Ecology of the Sexual Division of Labor. *Journal of Evolutionary Anthropology: Issues, News, and Reviews*, *8*(2), 65–75. https://doi.org/10.1002/(SICI)1520-6505(1999)8

Bird, R. L. B., & Bird, D. W. (1997). Delayed Reciprocity and Tolerated Theft: The Behavioral Ecology of Food-Sharing Strategies. *Current Anthropology*, *38*(1), 49. https://doi.org/10.1086/204581

Bliege Bird, R., Codding, B. F., & Bird, D. W. (2009). What explains differences in men's and women's production?: Determinants of gendered foraging inequalities among Martu. *Human Nature*, *20*(2), 105–129. https://doi.org/10.1007/s12110-009-9061-9

Blurton Jones, N. G. (1984). A selfish origin for human food sharing: Tolerated theft. *Ethology and Sociobiology*, *5*(1), 1–3. https://doi.org/10.1016/0162-3095(84)90030-X

Blurton Jones, N. G., K.Hawkes, & O'Connell, J. (2005). Hadza Grandmothers as Helpers: Residence Data. In E. Voland, A. Chasiotis, & & W. Schiefenhoevel (Eds.), *Grandmotherhood: The evolutionary Significance of the Second Half of Female Life* (pp. 160–177). New Brunswick: Rutgers University Press.

Borgerhoff Mulder, M. (2009). Serial Monogamy as Polygyny or Polyandry? *Human Nature*, *20*(2), 130–150. https://doi.org/10.1007/s12110-009-9060-x

Borgerhoff Mulder, M., Fazzio, I., Irons, W., McElreath, R. L., Bowles, S., Bell, A., … Hazzah, L. (2010). Pastoralism and Wealth Inequality. *Current Anthropology*, *51*(1), 35–48. https://doi.org/10.1086/648561

Bossen, L. (1988). Toward a Theory of Marriage : The Economic Anthropology of Marriage Transactions. *Ethnology*, *27*(2), 127–144.

Bove, R. B., Valeggia, C. R., & Ellison, P. T. (2002). Girl helpers and time allocation of nursing women among the Toba of Argentina. *Human Nature*, *13*(4), 457–472.

https://doi.org/10.1007/s12110-002-1003-8

Bowles, S. (2009). Did Warfare Among Ancestral Hunter-Gatherers Affect the Evolution of Human Social Behaviors? *Science*, *324*(5932), 1293–1298. https://doi.org/10.1089/ast.2011.0760

Boyd, R., & Richerson, P. J. (1989). The evolution of indirect reciprocity. *Social Networks*, *11*(3), 213–236. https://doi.org/10.1016/0378-8733(89)90003-8

Boyle, P., & Kulu, H. (2010). Premarital cohabitation and divorce: Support for the "Trial Marriage" Theory? *Demographic Research*, *23*, 879–904. https://doi.org/10.4054/DemRes.2010.23.31

Brittain, A. W. (1992). Birth Spacing and Child Mortality in a Caribbean Population. *Human Biology*, *64*(2), 223–241.

Burbank, V. K. . (1994). Women, Aggression, and Cooperation. In *Fighting Women: Anger and Aggression in Aboriginal Australia*. Berkeley: University of California Press.

Cao, J. (2010). *Research on Grassland Management on Qinghai Tibetan Plateau*. Lanzhou University Press.

Cao, J., Yeh, E. T., Holden, N. M., Yang, Y., & Du, G. (2013). The effects of enclosures and land-use contracts on rangeland degradation on the Qinghai-Tibetan plateau. *Journal of Arid Environments*, *97*(October), 3–8. https://doi.org/10.1016/j.jaridenv.2013.05.002

Cardenas, J. C. (2003). Real wealth and experimental cooperation: Experiments in the field lab. *Journal of Development Economics*, *70*(2), 263–289. https://doi.org/10.1016/S0304-3878(02)00098-6

Carey, M., & Jr, V. N. (1975). Polygyny in Indigo Buntings: A Hypothesis Tested. *Science*, *190*(4221), 1296–1297.

Charnov, E. L., & Berrigan, D. (1993). Why do female primates have such long lifespans and so few babies? or Life in the slow lane. *Evolutionary Anthropology*, *1*(6), 191–194. https://doi.org/10.1002/evan.1360010604

Chaudhary, N., Salali, G. D., Thompson, J., Dyble, M., Page, A., Smith, D., … Migliano, A. B. (2015). Polygyny without wealth: popularity in gift games predicts polygyny in BaYaka Pygmies. *Royal Society Open Science*, *2*(5), 150054–150054. https://doi.org/10.1098/rsos.150054

Chen, F. (2004). The division of labor between generations of women in rural China. *Social Science Research*, *33*(4), 557–580. https://doi.org/10.1016/j.ssresearch.2003.09.005

Childs, G. (2003). Polyandry and population growth in a historical Tibetan society. *The History of the Family*, *8*(3), 423–444. https://doi.org/10.1016/S1081-602X(03)00045-9

Childs, G., Goldstein, M. C., & Wangdui, P. (2011a). Externally-Resident Daughters, Social Capital, and Support for the Elderly in Rural Tibet. *Journal of Cross-Cultural Gerontology*, *26*(1), 1–22. https://doi.org/10.1007/s10823-010-9135-5

Childs, G., Goldstein, M. C., & Wangdui, P. (2011b). Externally-Resident Daughters, Social Capital, and Support for the Elderly in Rural Tibet. *Journal of Cross-Cultural Gerontology*, *26*(1), 1–22. https://doi.org/10.1007/s10823-010-9135-5

Chisholm, J. S., & Burbank, V. K. (1991). Monogamy and polygyny in Southeast Arnhem land: Male coercion and female choice. *Ethology and Sociobiology*, *12*(4), 291–313. https://doi.org/10.1016/0162-3095(91)90022-I

Coall, D. A., & Hertwig, R. (2010). Grandparental investment : Past , present , and future. *Behavioral and Brain Sciences*, *33*(0), 1–59. https://doi.org/10.1017/S0140525X09991105

Coall, D. A., Hilbrand, S., & Hertwig, R. (2014). Predictors of grandparental investment decisions in contemporary Europe: Biological relatedness and beyond. *PLoS ONE*, *9*(1). https://doi.org/10.1371/journal.pone.0084082

Coall, D. A., Meier, M., Hertwig, R., Wänke, M., & Höpflinger, F. (2009). Grandparental investment: The influence of reproductive timing and family size. *American Journal of Human Biology*, *21*(4), 455–463. https://doi.org/10.1002/ajhb.20894

Cox.D.R. (1972). Regression Models and Life-Tables. *Journal of the Royal Statistical Society. Series B(Methodological)*, *34*(2), 187–220.

Coxworth, J. E., Kim, P. S., McQueen, J. S., & Hawkes, K. (2015). Grandmothering life histories and human pair bonding. *Proceedings of the National Academy of Sciences*, *112*, 11806–11811. https://doi.org/10.1073/pnas.1599993112

Crognier, E., Villena, M., & Vargas, E. (2002). Helping patterns and reproductive success in Aymara communities. *American Journal of Human Biology*, *14*(3), 372–379. https://doi.org/10.1002/ajhb.10047

Cronk, L. (1989). Low Socioeconomic Status and Female-Biased Parental Investment: The Mukogodo Example. *American Anthropologist*, *91*(2), 414–429.

Cronk, L. (1991a). Preferential Parental Investment in Daughters Over Sons. *Human Nature*, *2*(4), 387–417.

Cronk, L. (1991b). Wealth, Status, and Reproductive Success among the Mukogodo of Kenya. *American Anthropologist*, *93*(2), 345–360. https://doi.org/10.1525/aa.1991.93.2.02a00040

Cronk, L. (1991c). Wealth, Status, and Reproductive Success among the Mukogodo of Kenya. *American Anthropologist*, *93*(2), 345–360. https://doi.org/10.1525/aa.1991.93.2.02a00040

Cronk, L. (1993). Parental favoritism toward daughters. *American Scientist*, *81*(3), 272–279.

Cronk, L. (2007). Boy or girl: gender preferences from a Darwinian point of view. *Reproductive Biomedicine Online*, *15 Suppl 2*(3), 23–32. https://doi.org/10.1016/S1472-6483(10)60546-9

Cypriot, G., Republic, T., Nations, U., Union, E., States, M., Commission, E., & Republic, T. (2010). OECD Family Database. *Social Policy*, 1–5.

Danielsbacka, M. E. Al. (2011). Grandparental Child Care in Europe : Evidence for Preferential Investment in. *Evolutionary Psychology*, *9*(1), 3–24.

Darwin, C. (1871). *The Descent of Man and Selection in Relation to Sex* (1889th ed.). New York: D.Appleton and Company.

Davies, N. B., Krebs, J. R., & West, S. A. (2012). Mating System. In *An Introduction to Behavioural*

Ecology (Fourth, p. 275). Oxford: Willey-Blackwell.

Degraff, D. S., & Bilsborrow, R. E. (1996). Southern Demographic Association Children 鈇s Education in the Phillipines : Does High Fertility Matter ? *Population Research and Policy Review*, *15*(3), 219–247.

Desai, S., & Andrist, L. (2010). Gender scripts and age at marriage in India. *Demography*, *47*(3), 667–687. https://doi.org/10.1353/dem.0.0118

Dewey, K. G. (1998). Cross-cultural patterns of growth and nutritional status of breast-fed infants. *Am J Clin Nutr*, *67*(1), 10–17. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9440369

Dhondt, A. A. (2002). Changing mates. *Trends in Ecology and Evolution*, *17*(2), 55–56. https://doi.org/10.1016/S0169-5347(01)02407-7

Dickemann, M. (1979). The ecology of mating systems in hypergynous dowry societies. *Social Science Information*, *18*, 163–195. https://doi.org/10.1177/053901847901800201

Dole, N., Savitz, D. ., Hertz-Picciotto, I., Siega-Riz, A. ., McMahon, M. ., & Buekens, P. (2003). Maternal Stress and Preterm Birth. *American Journal of Epidemiology*, *157*(1), 14–24. https://doi.org/10.1093/aje/kwf176

dong, H., Manfredini, M., Kurosu, S., Yang, W., & Lee, J. Z. (2016). Kin and Birth Order Effects on Male Child Mortality: Three East Asian Populations, 1716–1945. *Evolution and Human Behavior*, *38*(2), 1–9. https://doi.org/10.1016/j.evolhumbehav.2016.10.001

Dunbar, R. I. M. (2002). Helping-at-the-Nest and Sex-Biased Parental Investment in a Hungarian Gypsy Population. *Current Anthropology*, *43*, 804–809. https://doi.org/10.1086/344374

Ebrey, P. (1986). Concubines in Sung China. *Journal of Family History*, *11*(1), 1–24. https://doi.org/10.1177/036319908601100101

Edlund, L. (1999). Son Preference, Sex Ratios, and Marriage Patterns. *Journal of Political Economy Journal of Political Economy This*, *107*(18), 1275–1278. https://doi.org/10.1086/250097

Edlund, L., & Lagerlöf, N.---Petter. (2012). *Polygyny and Its Discontents: Parental Age and Human Capital Accumulation*.

Ellis, L. (1995). Dominance and Reproductive Success Among Nonhuman Animals: A Cross-Species Comparison. *Ethology and Sociobiology*, *16*(4), 257–333.

Emlen, S. T., & Oring, L. W. (1977). Ecology , Sexual Selection , and the Evolution of Mating Syst ; ens. *Science*, *197*(4300), 215–223. https://doi.org/10.1126/science.327542

Emmott, E. H., & Mace, R. (2015). Practical Support from Fathers and Grandmothers Is Associated with Lower Levels of Breastfeeding in the UK Millennium Cohort Study. *Plos One*, *10*, e0133547. https://doi.org/10.1371/journal.pone.0133547

Euler, H., Euler, H., Weitzel, B., & Weitzel, B. (1996). Discriminative grandparental solicitude as reproductive strategy. *Human Nature*, *7*(1), 39–59. https://doi.org/10.1007/BF02733489

Ezeh, a C. (1997). Polygyny and reproductive behavior in sub-Saharan Africa: a contextual analysis. *Demography*, *34*(3), 355–368. https://doi.org/10.2307/3038289

Fairbanks, L. A., & McGuire, M. T. (1985). Relationships of vervet mothers with sons and daughters from one through three years of age. *Animal Behaviour*, *33*(1), 40–50. https://doi.org/10.1016/S0003-3472(85)80118-4

Fehr, E., & Fischbacher, U. (2003). The nature of human altruism. *Nature*, *425*(6960), 785–791. https://doi.org/10.1038/nature02043

Fisher, R. A. (1930). *The Genetical Theory of Natural Selection*. Oxford: Clarendon press. https://doi.org/10.1038/158453a0

Flinn, M. V. (1988). Mate guarding in a Caribbean village. *Ethology and Sociobiology*, *9*(1), 1–28. https://doi.org/10.1016/0162-3095(88)90002-7

Fortes, M. (1978). Parenthood, Marriage and Fertility in West Africa. In G.Hawthorn (Ed.), *Population and Development: High and Low Fertility in Poorer Countries* (pp. 121–149). London: Frank Cass.

Fortunato, L., & Archetti, M. (2009). Evolution of monogamous marriage by maximization of inclusive fitness. *Journal of Evolutionary Biology*, *23*(2010), 149–156. https://doi.org/10.1111/j.1420-9101.2009.01884.x

Fortunato, L., Holden, C., & Mace, R. (2006). From bridewealth to dowry? *Human Nature*, *17*(4), 355–376. https://doi.org/10.1007/s12110-006-1000-4

Fox, M., Johow, J., & Knapp, L. A. (2011). The Selfish Grandma Gene : The Roles of the X-Chromosome and Paternity Uncertainty in the Evolution of Grandmothering Behavior and Longevity. *International Journal of Evolutionary Biology*, *2011*, 9–16. https://doi.org/10.4061/2011/165919

Fratkin, E. (1986). Stability and Resilience in East African Pastoralism : The Rendille and the Ariaal of Northern Kenya. *Human Ecology*, *14*(3), 269–286.

Fujita, M., Roth, E., Lo, Y. J., Hurst, C., Vollner, J., & Kendell, A. (2012). In poor families, mothers' milk is richer for daughters than sons: A test of Trivers-Willard hypothesis in agropastoral settlements in Northern Kenya. *American Journal of Physical Anthropology*, *149*(1), 52–59. https://doi.org/10.1002/ajpa.22092

Galbarczyk, a, & Jasienska, G. (2013). Timing of natural menopause covaries with timing of birth of a first daughter: evidence for a mother-daughter evolutionary contract? *Homo- Journal of Comparative Human Biology*, *64*(3), 228–32. https://doi.org/10.1016/j.jchb.2013.03.004

Gates, H. (1993). Cultural Support for Birth Limitation among Urban Capital-owning Women. In D. Davis & S. Harrell (Eds.), *Chinese Families in the Post-Mao Era* (pp. 151–274). University of California Press.

Gaulin, S. J. C., & Boster, J. S. (1990). Dowry as Female Competition. *American Anthropologist*, *92*(4), 994–1005. https://doi.org/10.1525/aa.1990.92.4.02a00080

Gele. (2006). *Ancient Tibetan History and Cultural*. Beijing: Shang wu yin shu guan.

Gelek, L. (2006). Anthropological field survey on basic education development in the Tibetan nomadic community of Maqu , Gansu , Anthropological Field Survey on Basic Education Development in the Tibetan Nomadic Community of Maqu , Gansu , China. *Asian Ethnicity*, *7*(April 2014), 37–41. https://doi.org/10.1080/14631360500505777

Gelek, L., & Miao, H. (2002). Marital Payments : The Case of Tibetan Nomads. *Chinese Sociology & Anthropology*, *34*(4), 84–95.

George C. Williams. (1957). Pleiotropy , Natural Selection , and the Evolution of Senescence. *Society for the Study of Evolution*, *11*(4), 398–411.

Gibson, M. A., & Mace, R. (2005). Helpful grandmothers in rural Ethiopia : A study of the effect of kin on child survival and growth. *Evolution and Human Behavior*, *26*, 469–482. https://doi.org/10.1016/j.evolhumbehav.2005.03.004

Glick, P. C., & Lin, S. (1986). Recent changes in divorce and remarriage. *Journal of Marriage and Family*, *48*(4), 737–747.

Glowacki, L., Isakov, A., Wrangham, R. W., Mcdermott, R., & Fowler, J. H. (2016). Formation of raiding parties for intergroup violence is mediated by social network structure. https://doi.org/10.1073/pnas.1610961113

Goldstein, M. C. (1990). Change,Conflict and Continuity among a Comminity of Nomadic Pastoralists: A Case Study from Western Tibet, 1950-1990. In R. Barnett & S. Akiner (Eds.), *Resistance and Reform in Tibet* (pp. 76–111). Bloomington: Indianna University Press.

Goldstein, M. C., & Beall, C. M. (1991). Change and Continuity in Nomadic Pastoralism on the Western Tibetan plateau. *Nomadic Peoples*, (28), 105–122.

Gong, J. (1948). Xunhua ting zhi-Di liu juan. In *Xunhua ting zhi*. Chengwen chu ban she.

Goody, J., & Tambiah, S. J. (1973). *Bridewealth and Dowry*. Cambridge: The Cambridge University Press.

Gowaty, P. A., & Lennartz, M. R. (1985). Sex Ratios of Nestling and Fledgling Red-Cockaded Woodpeckers (Picoides borealis) Favor Males. *American Society of Naturalists*, *126*(3), 347–353.

Greene, M. (2014). *Ending Child Marriage in a Generation*.

Gruschke, A. (2001). *The cuktural monuments of Tibet's outer provinces:Amdo volume 1. The Qinghai part of Amdo*. Bangkok: White Lotus Publishers.

Gruschke, A. (2008). International Association of Tibetan Studies, (4).

Gruschke, A. (2012). Tibetan Pastoralists in Transition . Political Change and State Interventions in Nomad. In H. Kreutzmann (Ed.), *Pstoral practices in High Asia* (1st ed., pp. 273–289). Dordrecht: Springer. https://doi.org/10.1007/978-94-007-3846-1

Gu, Q. (1998). Monastery economic situation before Democratic reform in Sichuan. *China Tibetology*, *2*, 85–87.

Guo Zhigang. (2003). Cong Zheng Ce Sheng Yu Kan Zhong Guo Sheng Yu Zheng Ce de Duo Yang Xing. *Population Research*, *27*(5).

Gupta, G. R. (1976). Love , Arranged Marriage , and the Indian Social Structure. *Journal of Comparative Family Studies*, *7*(1), 75–85.

Gupta, M. Das. (1987). Selective Discrimination against Female Children in Rural Punjab , India. *Population and Development Review*, *13*(1), 77–100.

Gurven, M. (2006). Hunting as subsistence and mating effort?A re-evaluation of "Man the Hunter", the sexual division of labor and the evolution of the nuclear family. *The IUSSP Seminar on Male Life History in Giessen*, 29.

Gurven, M., Allen-Arave, W., Hill, K., & Hurtado, M. (2000). "It's a Wonderful Life":signaling generosity among the Ache of Paraguay. *Evolution and Human Behavior*, *21*(4), 263–282. https://doi.org/10.1016/S1090-5138(00)00032-5

Gurven, M., & Hill, K. (2009). Why Do Men Hunt? *Current Anthropology*, *50*(1), 51–74. https://doi.org/10.1086/595620

Gurven, M., Mulder, M. B., Hooper, P. L., Kaplan, H., Quinlan, R., Sear, R., … Bell, A. (2010). Domestication alone does not lead to inequality : intergenerational wealth transmission among horticulturalists. *Current Anthropology*, *51*(1). https://doi.org/10.1086/648587

Gurven, M., Stieglitz, J., Hooper, P. L., Gomes, C., & Kaplan, H. (2012). From the womb to the tomb: the role of transfers in shaping the evolved human life history. *Experimental Gerontology*, *47*(10), 807–13. https://doi.org/10.1016/j.exger.2012.05.006

Gyal, H. (2015). The politics of standardising and subordinating subjects: the nomadic settlement project in Tibetan areas of Amdo. *Nomadic Peoples*, *19*(2), 241–260. https://doi.org/10.3197/np.2015.190206

Haddix, K. A. (2001). Leaving your wife and your brothers: when polyandrous marriages fall apart. *Evolution and Human Behavior*, *22*(1), 47–60. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11182574

Haddix McKay, K., & Gurung, J. B. (1999). "Excess Women": Non-Marriage and Reproduction in Two Ethnic Tibetan Communities of Humla, Nepal. *Himalayan Research Bulletin*, *XIX*(1), 56–62.

Haley, K. J., & Fessler, D. M. T. (2005). Nobody's watching? Subtle cues affect generosity an anonymous economic game. *Evolution and Human Behavior*, *26*(3), 245–256. https://doi.org/10.1016/j.evolhumbehav.2005.01.002

Hames, R., & Draper, P. (2004). Women's work, child care, and helpers-at-the-nest in a hunter-gatherer society. *Human Nature*, *15*(4), 319–341. https://doi.org/10.1007/s12110-004-1012-x

Hamilton, W. D. (1963). The Evolution of Altruistic Behavior. *The American Naturalist*, *97*(896), 354–356.

Hamilton, W. D. D. (1964). The genetical evolution of social behaviour. I. *Journal of Theoretical Biology*, *7*(1), 1–16. https://doi.org/10.1016/0022-5193(64)90038-4

Hao, Y. (2000). Tibetan Population in China: Myths and Facts Re-examined. *Asian Ethnicity*, *1*(1), 11–36. https://doi.org/10.1080/146313600115054

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*(3859), 1243–8. https://doi.org/10.1126/science.162.3859.1243

Hare, D. (1999). Women's economic status in rural China: Household contributions to male-female disparities in the wage-labor market. *World Development*, *27*(6), 1011–1029. https://doi.org/10.1016/S0305-750X(99)00034-0

Hartung, J. (1976). On Natural Selection and the Inheritance of Wealth. *Current Anthropology*, *17*, 607. https://doi.org/10.1086/201799

Hartung, J. (1982). polygyny and inheritance of wealth. *Current Anthropology*, *23*(1), 1–12.

Hartung, J. (1982). Polygyny and inheritance of wealth. *Current Anthropology*, *23*(1), pp.1-12.

Hartung, J., Dickemann, M., Melotti, U., Pospisil, L., Scott, E. C., Smith, J. M., & Wilder, W. D. (1982). Polygyny and Inheritance of Wealth. *Current Anthropology*, *23*(1), 1–12. https://doi.org/10.1086/202775

Hawkes, K. (1991). Showing Off: Tests of an Hypothesis About Men's Foraging Goals. *Ethnology and Sociobiology*, *54*(1991), 29–54.

Hawkes, K. (2003). Grandmothers and the evolution of human longevity. *American Journal of Human Biology*, *15*(3), 380–400. https://doi.org/10.1002/ajhb.10156

Hawkes, K., O'Connell, J. F., & Blurton Jones, N. G. (2001). Hunting and Nuclear Families. *Current Anthropology*, *42*(5), 681–709. https://doi.org/10.1086/322559

Hawkes, K., O'Connell, J. F., & Blurton Jones, N. G. (2003). Human Life Histories: Primate Trade-Offs, Grandmothering Socioecology, and the Fossil Record. In *Primate Life Histories and Socioecology* (pp. 204–227).

Hawkes, K., O'Connell, J. F., Jones, N. G. B., Alvarez, H., & Charnov, E. L. (1998). Grandmothering, menopause, and the evolution of human life histories. *Proceedings of the National Academy of Sciences*, *95*(3), 1336–1339. https://doi.org/10.1073/pnas.95.3.1336

Hawkes, K., O 'connell, J. F., & Blurton Jones, N. G. (1997). Hadza Women's Time Allocation, Offspring Provisioning, and the Evolution of Long Life Spans. *Current Anthropology*, *38*(4), 551–577. https://doi.org/10.1086/204646

Hawkes, K., Rogers, A., & Charnov, E. (1995). The male's dilemma: increased offspring production is more paternity to steal. *Evolutionary Ecology*, *7653*, 662–677. Retrieved from http://link.springer.com/article/10.1007/BF01237661

He, Q. Q., Wu, J. J., Ji, T., Tao, Y., & Mace, R. (2016). Not leaving home: Grandmothers and male dispersal in a duolocal human society. *Behavioral Ecology*, *27*(5), 1343–1352. https://doi.org/10.1093/beheco/arw053

Henrich, J., & Boyd, R. (2001). Why People Punish Defectors Weak Conformist Transmission can Stabilize Costly Enforcement of Norms in Cooperative Dilemmas. *Journal of Theoretical Biology*, *208*(1), 79–89. https://doi.org/10.1006/jtbi.2000.2202

Henrich, J., Boyd, R., Bowles, S., Camerer, C. F., Fehr, E., Gintis, H., … Tracer, D. (2005). "Economic man" in cross-cultural perspective: behavioral experiments in 15 small-scale societies. *Behavioral and Brain Sciences*, *28*(6), 795-815–55. https://doi.org/10.1017/S0140525X05000142

Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., & McElreath, R. (2001). In search of Homo economicus: Behavioral experiments in 15 small scale societies. *American Economic Review*, *91*(2), 73–78. https://doi.org/10.1257/aer.91.2.73

Henrich, J., Boyd, R., & Richerson, P. J. (2012). The puzzle of monogamous marriage. *Philosophical Transactions of the Royal Society B*, *2012*(367), 657–669. https://doi.org/10.1098/rstb.2011.0290

Henrich, J., & Broesch, J. (2011). On the nature of cultural transmission networks: evidence from Fijian villages for adaptive learning biases. *Philosophical Transactions of the Royal Society B-Biological Sciences: Biological Sciences*, *366*(1567), 1139–1148. https://doi.org/366/1567/1139 [pii]\r10.1098/rstb.2010.0323

Henrich, J., Ensminger, J., Mcelreath, R., Barr, A., Barrett, C., Bolyanatz, A., … Gwako, E. (2010). Markets, Religion, Community Size, and the Evolution of Fairness and Punishment. *Science*, *327*, 1480–1484. https://doi.org/10.1126/science.1182238

Hesketh, T., & Xing, Z. W. (2006). Abnormal sex ratios in human populations: Causes and consequences. *Proceedings of the National Academy of Sciences*, *103*(36), 13271–13275. https://doi.org/10.1073/pnas.0602203103

Hewlett, B. S., Fouts, H. N., Boyette, A. H., & Hewlett, B. L. (2011). Social learning among Congo Basin hunter-gatherers. *Philosophical Transactions of the Royal Society B-Biological Sciences: Biological Sciences*, *366*(1567), 1168–1178. https://doi.org/366/1567/1168 [pii]\r10.1098/rstb.2010.0373

Hill, K., & Hurtado, A. (1996). *Ache Life History: the ecology and demography of a foraging people*. New York: Aldine Transaction.

Hill, K., & Hurtado, A. M. (2009). Cooperative breeding in South American hunter-gatherers. *Proceedings of the Royal Society B*, *276*(1674), 3863–70. https://doi.org/10.1098/rspb.2009.1061

Holden, C. J., Sear, R., & Mace, R. (2003). Matriliny as daughter-biased investment. *Evolution and Human Behavior*, *24*(2), 99–112. https://doi.org/10.1016/S1090-5138(02)00122-8

Hooper, P. L., Kaplan, H. S., & Boone, J. L. (2010). A theory of leadership in human cooperative groups. *Journal of Theoretical Biology*, *265*(4), 633–646. https://doi.org/10.1016/j.jtbi.2010.05.034

Hrdy, S. B. (2000). *Mother Nature: Maternal instincts and the shaping of the species*. London: Vintage.

Huber, T. (2012). The Changing Role of Hunting and Wildlife in Pastoral Communities of Northern Tibet. In Hermaann Kreutzmann (Ed.), *Pastoral practices in High Asia* (pp. 195–215). Springer Netherlands. https://doi.org/10.1007/978-94-007-3846-1

Hughes, A. L. (2015). Sexual Selection and Mate Choice: Insights from Neutralist Perspectives. *Evolutionary Biology*, *42*(3), 366–378. https://doi.org/10.1007/s11692-015-9315-x

Huxley, J. S. (1938). Darwin's Theory of Sexual Selection and the Data Subsumed by it , in the light of recent research. *The American Naturalist*, *72*(742), 416–433.

Irons, W. (1983). Human Female Reproductive Strategies. In *Social Behavior of Female Vertebtrates* (pp. 169–213). New York: Academic Press.

Irons, W. (2001). Religion as a Hard-to-Fake Sign of Commitment. In R. M. Nesse (Ed.), *Evolution and the Capacity for Commitment* (pp. 292–309). Russell Sage Foundation. https://doi.org/10.1007/springerreference_76056

James, F., & Ekvall, B. (1963). Peace and War Among the Tibetan Nomads. *American Anthropologist*, *66*(5), 1119–1148.

Janhunen, J. (2006). On the Shirongolic Names of Amdo. *Studia Etymologica Cracoviensia*, *11*, 95–102.

Ji, T., Wu, J.-J., He, Q.-Q., Xu, J. J., Mace, R., & Tao, Y. (2013). Reproductive competition between females in the matrilineal Mosuo of southwestern China. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *368*(1631), 20130081–20130081. https://doi.org/10.1098/rstb.2013.0081

Ji, T., Xu, J. J., & Mace, R. (2014). Intergenerational and Sibling Conflict Under Patrilocality: A Model of Reproductive Skew Applied to Human Kinship. *Human Nature*, *25*(1), 66–79. https://doi.org/10.1007/s12110-013-9188-6

Jones, N. B., & Marlowe, F. W. (2002). Selection for delayed maturity. *Human Nature*, *13*(2), 199–238. https://doi.org/10.1007/s12110-002-1008-3

K.Hawkes, J.F.O'connell, & Jones, N. G. B. (1991). Hunting income patterns among the Hadza: big game, common goods, foraging goals and the evolution of the human diet. *Philos Trans R Soc Lond B Biol Sci*, *334*(1270), 243–251. https://doi.org/10.1098/rstb.2010.0098

Kabzung, G. (2015). Housing projects in the nomadic areas of China's eastern Tibetan plateau: representation, market logic, and governmentality. *Nomadic Peoples*, *19*(2), 261–280. https://doi.org/10.3197/np.2015.190207

Kalanda, B. F., Verhoeff, F. H., & Brabin, B. J. (2006). Breast and complementary feeding practices in relation to morbidity and growth in Malawian infants. *European Journal of Clinical Nutrition*, *60*(3), 401–407. https://doi.org/10.1038/sj.ejcn.1602330

Kaplan, H. (1994). Evolutionary and Wealth Flows Theories of Fertility: Empirical Tests and New

Models. *Population and Development Review*, *20*(4), 753–791.

Kaplan, H., & Gurven, M. (2001). The natural history of human food sharing and cooperation: a review and a new multi-individual approach to the negotiation of norms. *Moral Sentiments and Material Interests: The Foundations of Cooperation in Economic Life*, 75–113. https://doi.org/10.1007/s10997-007-9032-7

Kaplan, H., Hill, K. I. M., Lancaster, J., & Hurtado, A. M. (2000). A Theory of Human Life History Evolution : Diet , Intelligence , and Longevity. *Evolutionary Anthropology*, *9*(4), 156–185.

Kaplan, H., & Lancaster, J. (2003). An evolutionary and ecological analysis of human fertility, mating patterns, and parental investment. In K.W.Wachter & R.A.Bulatao (Eds.), *Offspring: Human fertility behavior in biodemographic perspective* (pp. 170–223). Washington: National Academy.

Kaplan, H. S., Hooper, P. L., & Gurven, M. (2009). The evolutionary and ecological roots of human social organization. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *364*(1533), 3289–99. https://doi.org/10.1098/rstb.2009.0115

Karma Lekshe Tsomo. (1987). Library of Tibetan Works and Archives Tibetan Nuns and Nunneries. *The Tibet Journal*, *12*(4), 87–99.

Kaur, R. (2004). Across-Region Marriages: Poverty, Female Migration and the Sex-ratio. *Economic and Political Weekly*, *39*(25), 2595–2603.

Keister, L. A. (2003). Sharing the Wealth : the Effect of Siblings on Adults ' Wealth Ownership. *Demography*, *40*(3), 521–542.

Keller, M. C., Nesse, R. M., & Hofferth, S. (2001). The Trivers – Willard hypothesis of parental investment No effect in the contemporary United States. *Evolution and Human Behavior*, *22*(2001), 343–360.

Kirchengast, S., & Winkler, E. (1995). Differential Reproductive Success and Body Dimensions in Kavango Males from Urban and Rural Areas in Northern Namibia. *Human Biology*, *67*(2), 291–309.

Kiros, G.-E., & Kertzer, D. I. (2000). The impact of postmarital residence of fertility , early childhood mortality , and child health in Southern Ethiopia. *Journal of Comparative Family Studies*, *31*(4), 503–518.

Kishindo, P. (2011). The marital immigrant. Land, and agricultue: A malawian case study. *African Sociological Review*, *14*(2), 89–97. https://doi.org/10.4314/asr.v14i2.70238

Kokko, H., & Jennions, M. D. (2008). Parental investment, sexual selection and sex ratios. *Journal of Evolutionary Biology*, *21*(4), 919–948. https://doi.org/10.1111/j.1420-9101.2008.01540.x

Kramer, K. L. (2005). Children's help and the pace of reproduction: cooperative breeding in humans. *Evolutionary Anthropology: Issues, News, and Reviews*, *14*, 224–237. https://doi.org/10.1002/evan.20082

Kramer, K. L. (2010). Cooperative Breeding and its Significance to the Demographic Success of

Humans. *Annual Review of Anthropology*, *39*(1), 417–436.
https://doi.org/10.1146/annurev.anthro.012809.105054

Kuznar, L. (2001). Risk Sensitivity and Value among Andean Pastoralists: Measures, Models, and Empirical Tests1. *Current Anthropolog*, *42*(3), 432–440. https://doi.org/10.1086/320483

Lahdenperä, M., Russell,   a F., & Lummaa, V. (2007). Selection for long lifespan in men: benefits of grandfathering? *Proceedings of The Royal Society B*, *274*(1624), 2437–2444.
https://doi.org/10.1098/rspb.2007.0688

Lamba, S., & Mace, R. (2011). Demography and ecology drive variation in cooperation across human populations. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(35), 14426–14430. https://doi.org/10.1073/pnas.1105186108

Lamphere, L. (1974). Strategies, Cooperation, and Conflict Among Women in Domestic Groups. In M. Z. Rosaldo & L. Lamphere (Eds.), *Women, Culture, and Society* (pp. 89–97). California: Stanford University Press.

Lawson, D., James, S., Ngadaya, E., Ngowi, B., Mfinanga, S. G. M., & Borgerhoff Borgerhoff, M. (2015). No evidence that polygynous marriage is a harmful cultural practice in northern Tanzania. *Proceedings of the National Academy of Sciences of the United States of America*, 1–6. https://doi.org/10.1073/pnas.1507151112

Lawson, D. W., & Mace, R. (2009). Trade-offs in modern parenting: a longitudinal study of sibling competition for parental care. *Evolution and Human Behavior*, *30*(3), 170–183.
https://doi.org/10.1016/j.evolhumbehav.2008.12.001

Lee, G. R. (1979). Marital Structure and Economic Systems. *Journal of Marriage and Family*, *41*(4), 701–713.

Leonetti, D. L., Nath, D. C., & Hemam, N. S. (2007). In-law Conflict: Women's Reproductive Lives and the Roles of Their Mothers and Husbands among the Matrilineal Khasi. *Current Anthropology*, *48*(6), 861–890. https://doi.org/10.1086/520976

Leonetti, D. L., Nath, D. C., Hemam, N. S., & Neill, D. B. (2004). Do Women Really Need Marital Partners for Support of Their Reproductive Success? the Case of the Matrilineal Khasi of N. E. India. *Research in Economic Anthropology*, *23*, 151–174. https://doi.org/10.1016/S0190-1281(04)23006-2

Levine, N. E. (1987). Differential Child Care in Three Tibetan Communities: Beyond Son Preference. *Population and Development Review*, *13*(2), 281–304.
https://doi.org/10.2307/1973194

Levine, N. E. (2014). Reconstructing Tradition: Persistence and Change in Golog Social Structure.

Levine, N. E. (2015). Transforming inequality: Eastern Tibetan pastoralists from 1955 to the present. *Nomadic Peoples*, *19*(2), 164–188. https://doi.org/10.3197/np.2015.190202

Levine, N. E., & Angeles, L. (1995). From Nomads to Ranchers: Managing Pasture Among Ethnic Tibetans in Sichuan. In G. E. Clarke (Ed.), *Predeedings of the 7th seminar of the International*

Association for Tibetan Studies，Garz 1995 (pp. 70–76).

Levine, N. E., & Silk, J. B. (2008). Why Polyandry Fails. *Current Anthropology*, *38*(3), 375–398.

Lewis, H. M., Vinicius, L., Strods, J., Mace, R., & Migliano, A. B. (2014). High mobility explains
demand sharing and enforced cooperation in egalitarian hunter-gatherers. *Nature
Communications*, *5*, 1–8. https://doi.org/10.1038/ncomms6789

Liddle, B., & Nettle, D. (2006). Higher-order theory of mind and social competence in school age
children. *Journal of Cultural and Evolutionary Anthropology*, *4*(January 2014), 231–246.
https://doi.org/10.1556/JCEP.4.2006.3

Lowenthal, D. (1975). Past time, present place: Landscape and memory. *Geograohical Review*,
65(1), 1–36. https://doi.org/10.1038/126199a0

Ma, R., & Xi, L. (1943). Gan qing tu rang diao cha ji. *Bian Zhen Gong Lun*, *2*(11,12), 12–13.

Mace, R. (1991). Overgrazing overstated. *Nature*, *349*, 280–281.
https://doi.org/10.1038/349280d0

Mace, R. (1996). Biased parental investment and reproductive success in Gabbra pastoralists.
Behavioral Ecology and Sociobiology, *38*(2), 75–81.
https://doi.org/10.1007/s002650050219

Mace, R. (2000). Evolutionary ecology of human life history. *Animal Behaviour*, *59*(1), 1–10.
https://doi.org/10.1006/anbe.1999.1287

Mace, R. (2010). Ch 15. Social behaviour in humans. In T. Székely, A. J. Moore, & J. Komdeur
(Eds.), *Social Behaviour: Genes, Ecology and Evolution C.U.P.* (Vol. 177, pp. 395–409).
https://doi.org/10.1086/658149

Mace, R. (2013). Cooperation and conflict between women in the family. *Evolutionary
Anthropology*, *22*(5), 251–8. https://doi.org/10.1002/evan.21374

Mace, R., & Sear, R. (1997). Birth interval and the sex of children in a traditional African
population: an evolutionary analysis. *Journal of Biosocial Science*, *29*(4), 499–507.
https://doi.org/10.1017/S0021932097004999

Macfarlan, S. J., & Lyle, H. F. (2015). Multiple reputation domains and cooperative behaviour in
two Latin American communities. *Philosophical Transactions of the Royal Society B:
Biological Sciences*, *370*(20150009), 1–12. https://doi.org/10.1098/rstb.2015.0009

Mackie, G. (1996). Ending Footbinding and Infibulation : A Convention Account. *American
Sociological Review*, *61*(6), 999–1017.

Manderscheid, A. (2002). Decline and re-emergence of nomadism : Tibetan pastoralists revive a
nomadic way of life and production. *Geo Journal*, *53*(2), 173–182.

Margulis, S. W., Altmann, J., & Ober, C. (1993). Sex-biased lactational duration in a human
population and its reproductive costs. *Behavioral Ecology and Sociobiology*, *32*(1), 41–45.
https://doi.org/10.1007/BF00172221

Marlowe, F. (1999). Showoffs or Providers? The Parenting Effort of Hadza Men. *Evolution and Human Behavior*, *20*(6), 391–404. https://doi.org/10.1016/S1090-5138(99)00021-5

Marlowe, F. (2000). Paternal investment and the human mating system. *Behavioural Processes*, *51*(1–3), 45–61.

Marlowe, F. (2005). Dicators and Ultimatums in an Egalitarian Society of Hunter-Gatherers: The Hadza of Tanzani. In *Foundations of Human Sociality: Economic Experiments and Ethnographic Evidence from Fifteen Small-Scale Societies* (pp. 1–31). https://doi.org/10.1093/0199262055.001.0001

Marlowe, F., & Wetsman, A. (2001). Preferred waist-to-hip ratio and ecology. *Personality and Individual Differences*, *30*, 481–489. https://doi.org/10.1016/S0191-8869(00)00039-8

Martin, M. A., Garcia, G., Kaplan, H. S., & Gurven, M. D. (2016). Conflict or congruence? Maternal and infant-centric factors associated with shorter exclusive breastfeeding durations among the Tsimane. *Social Science & Medicine*, *170*, 9–17. https://doi.org/10.1016/j.socscimed.2016.10.003

Mattison, S. M., Beheim, B., Chak, B., & Buston, P. (2016). Offspring sex preferences among patrilineal and matrilineal Mosuo in Southwest China revealed by differences in parity progression Subject Areas :

Mattison, S. M., Scelza, B., & Blumenfield, T. (2014). Paternal investment and the positive effects of fathers among the matrilineal mosuo of Southwest China. *American Anthropologist*, *116*(3), 591–610. https://doi.org/10.1111/aman.12125

Mattison, S., Wander, K., & Hinde, K. (2015). Breastfeeding over two years is associated with longer birth intervals, but not measures of growth or health, among children in Kilimanjaro, TZ. *American Journal of Human Biology*, *27*(6), 807–815. https://doi.org/10.1002/ajhb.22729

McAndrew, F. T. (2009). The interacting roles of testosterone and challenges to status in human male aggression. *Aggression and Violent Behavior*, *14*(5), 330–335. https://doi.org/10.1016/j.avb.2009.04.006

Mclaren, I. A. (1967). Seals and Group Selection. *Ecology*, *48*(1), 104–110.

Meehan, C. L., Quinlan, R., & Malcom, C. D. (2013). Cooperative breeding and maternal energy expenditure among Aka foragers. *American Journal of Human Biology*, *25*(1), 42–57. https://doi.org/10.1002/ajhb.22336

Melvyn C . Goldstein, C. M. . B. (1991). China 鈥s Birth Control Policy in the Tibet Autonomous Region : Myths and Realities. *Asian Survey*, *31*(3), 285–303.

Mesoudi, A., Chang, L., Murray, K., & Lu, H. J. (2015). Higher frequency of social learning in China than in the West shows cultural variation in the dynamics of cultural evolution. *Proceedings of the Royal Society B*, *282*(20142209), 1–7. https://doi.org/10.1098/rspb.2014.2209

Michalski, R. L., & Shackelford, T. K. (2005). Grandparental investment as a function of relational uncertainty and emotional closeness with parents. *Human Nature*, *16*(3), 293–305. https://doi.org/10.1007/s12110-005-1012-5

Michel Garenne. (1994). Sex Differences in Measle Mortality: A World Review. *International Journal of Epidemiology*, *23*(3), 632–642.

Micheletti, A, R. G. . G. A. (2016). Intrafamily and intragenomic confilcts in human warfare. *Proceedings of Royal Society B*, *in press*.

Miettinen, A., Lainiala, L., & Rotkirch, A. (2015). Women's housework decreases fertility: Evidence from a longitudinal study among Finnish couples. *Acta Sociologica*, *58*(2), 139–154. https://doi.org/10.1177/0001699315572028

Milinski, M., Semmann, D., & Krambeck, H.-J. (2002). Reputation helps solve the "tragedy of the commons." *Nature*, *415*(6870), 424–426. https://doi.org/10.1038/415424a

Miller, D. J. (1999). Nomads of the Tibetan Plateau Rangelands in Western China — Part Three : Pastoral Development and Future Challenges. *Rangelands*, *21*(2), 17–20.

Miller, D. J. (2000). Tough Times for Tibetan Nomads in Western China: Snowstorms, Settling down, Fences and the Demise of Traditional Nomadic Pastoralism. *Nomadic Peoples*, *4*(1), 83–109. https://doi.org/10.3167/082279400782310674

Minturn, L., & Lambert, W. . (1964). *Mother of Six Cultures: Antecedents of child rearing*. New York: John Wiley & Sons.

Moorad, J. A., Promislow, D. E. L., Smith, K. R., & Wade, M. J. (2011). Mating system change reduces the strength of sexual selection in an American frontier population of the 19th century. *Evolution and Human Behavior*, *32*(2), 147–155. https://doi.org/10.1016/j.evolhumbehav.2010.10.004

Mueller, U., & Mazur, A. (2001). Evidence of unconstrained directional selection for male tallness. *Behavioral Ecology and Sociobiology*, *2001*(50), 302–311. https://doi.org/10.1007/s002650100370

Mulder, M. B. (1990). Kipsigis women's preferences for wealthy men: evidence for female choice in mammals? *Behavioral Ecology and Sociobiology*, *27*(4), 255–264. Retrieved from http://link.springer.com/10.1007/BF00164897

Mulder, M. B. (1998). Brothers and Sisters: How Sibling Interactions Affect Optimal Parental Allocations. *Human Nature*, *9*(2), 119–162. https://doi.org/10.1007/s12110-998-1001-6

Mulder, M. B. (2007). Hamilton 鈇s rule and kin competition : the Kipsigis case. *Evolution and Human Behavior*, *28*(October 2007), 299–312. https://doi.org/10.1016/j.evolhumbehav.2007.05.009

Mulder, M. B. (2009). Serial Monogamy as Polygyny or Polyandry? Marriage in the Tanzanian Pimbwe. *Human Nature*, *20*(2), 130–150. https://doi.org/10.1007/s12110-009-9060-x

Murphy, R., Tao, R., & Lu, X. (2011). Son preference in rural China: Patrilineal families and socioeconomic change. *Population and Development Review*, *37*(4), 665–690. https://doi.org/10.1111/j.1728-4457.2011.00452.x

Næss, M. W. (2012). Cooperative Pastoral Production: Reconceptualizing the Relationship between Pastoral Labor and Production. *American Anthropologist*, *114*(2), 309–321. https://doi.org/10.1111/j.1548-1433.2012.01427.x

Nag, M. (1972). Sex, Culture, and Human Fertility: India and the United States. *Current Anthropology*, *13*(2), 231. https://doi.org/10.1086/201272

Nast, H. J. (2004). British Colonial Abolition of Slavery and Concubinage. In *Concubines and Power: Five Hundred Years in a Nigerian Palace* (New Editio, pp. 139–166). University of Minnesota Press. Retrieved from http://www.jstor.org/stable/10.5749/j.cttttqrv

Nettle, D., Harper, Z., Kidson, A., Stone, R., Penton-Voak, I. S., & Bateson, M. (2013). The watching eyes effect in the Dictator Game: It's not how much you give, it's being seen to give something. *Evolution and Human Behavior*, *34*(2), 35–40. https://doi.org/10.1016/j.evolhumbehav.2012.08.004

Nettle, D., & Pollet, T. V. (2008). Natural selection on male wealth in humans. *The American Naturalist*, *172*(5), 658–66. https://doi.org/10.1086/591690

Neumayer, E., & Plümper, T. (2007). The gendered nature of natural disasters: The impact of catastrophic events on the gender gap in life Expectancy, 1981-2002. *Annals of the Association of American Geographers*, *97*(3), 551–566. https://doi.org/10.1111/j.1467-8306.2007.00563.x

Nowak, M. A. (2006). Five Rules for the Evolution of Cooperation. *Science*, *314*(5805), 1560–1563. https://doi.org/10.1126/science.1133755

Nowak, M. A., & Sigmund, K. (1998). The Dynamics of Indirect Reciprocity. *Journal of Theoretical Biology*, *194*(4), 561–574. https://doi.org/10.1006/jtbi.1998.0775

Oddy, W. (2001). Breastfeeding protects against illness and infection in infants and children: a review of the evidence. *Breastfeeding Review*, *9*(2), 11–18. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=106929140&site=ehost-live

Orians, G. H. (1969). On the evolution of mating systems in birds and mammals. *The American Naturalist*, *103*, 589–603.

Orians, G. H. (1969). On the Evolution of Mating Systems in Birds and Mammals. *The American Naturalist*, *103*(934), 589–603.

Ostrom, E. (2000). Collective Action and the Evolution of Social Norms. *Journal of Economic Perspectives*, *14*(3), 137–158.

Pan, W. (2004). Akaike's Information Criterion in Generalized Estimating Equations. *Biometrics*, *57*(March), 120–125. https://doi.org/10.1111/j.0006-341X.2001.00120.x

Panchanathan, K., & Boyd, R. (2004). Indirect reciprocity can stabilize cooperation without the second-order free rider problem. *Nature*, *432*(7016), 499–502. https://doi.org/10.1038/nature02978

Pashos, A., & McBurney, D. H. (2008). Kin relationships and the caregiving biases of grandparents, aunts, and uncles : A two-generational questionnaire study. *Human Nature*, *19*(3), 311–330. https://doi.org/10.1007/s12110-008-9046-0

Paul W.Turke. (1988). Helpers-at-the-Nest:Childcare Networks on Ifaluk. In L.Betzig, M.Borgerhoff Mulder, & Paul Turke (Eds.), *Human Reproductive Behavior: A Darwinian Perspective* (pp. 173–188). Cambridge: Cambridge University Press.

Pavard, S., Metcalf, C. J. E., & Heyer, E. (2008). Senescence of reproduction may explain adaptive menopause in humans: A test of the "mother" hypothesis. *American Journal of Physical Anthropology*, *136*(2), 194–203. https://doi.org/10.1002/ajpa.20794

Peccei, J. S. (2001). A critique of the grandmother hypothesis: old and new. *American Journal of Human Biology*, *13*(February), 434–452.

Pedersen, F. a. (1991). Secular trends in human sex ratios: Their influence on individual and family behavior. *Human Nature*, *2*(3), 271–91. https://doi.org/10.1007/BF02692189

Pirie, F. (2005a). Segmentation Within the State : the Reconfiguration of Tibetan Tribes in China 鈥S Reform Period. *Nomadic Peoples*, *9*(1&2), 83–102. https://doi.org/10.3167/082279405781826074

Pirie, F. (2005b). Segmentation Within the State: The Reconfiguration of Tibetan Tribes In China's Reform Period. *Nomadic Peoples*, *9*(1), 83–102. https://doi.org/10.3167/082279405781826074

Pollet, T. V, & Nettle, D. (2008). Market forces affect patterns of polygyny in Uganda. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(7), 2114–2117.

Potter, R. G., & Millman, S. R. (1986). Fecundability and the Frequency of Marital Intercourse: New Models Incorporating the Ageing of Gametes. *Population Studies*, *40*(1), 159–170. https://doi.org/10.1080/0032472031000141906

Power, E. A. (2016). Discerning devotion: Testing the signaling theory of religion. *Evolution and Human Behavior*, *38*(1), 82–91. https://doi.org/10.1016/j.evolhumbehav.2016.07.003

Price, M. E. (2012). Group Selection Theories are Now More Sophisticated , but are They More Predictive ? *Evolutionary Psychology*, *10*(1), 45–49.

Ptackova, J. (2011). Sedentarisation of Tibetan nomads in China: Implementation of the Nomadic settlement project in the Tibetan Amdo area; Qinghai and Sichuan Provinces. *Pastoralism: Research, Policy and Practice*, *1*(1), 4. https://doi.org/10.1186/2041-7136-1-4

Ptackova, J. (2012). Implementation of Resettlement Programmes Amongst Pastoralist Communities in Eastern Tibet. In H. Kreutzmann (Ed.), *Pastoral practices in High Asia* (pp.

217–234). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-007-3846-1

Ptackova, J. (2015). Hor - a sedentarisation success for Tibetan pastoralists in Qinghai? *Nomadic Peoples*, *19*(2), 221–240. https://doi.org/10.3197/np.2015.190205

Riley, N. E. (1994). Interwoven Lives: Parents, Marriage, and Guanxi in China. *Journal of Marriage and Family*, *56*(4), 791–803. https://doi.org/10.2307/353592

Roberts, G., & Sherratt, T. N. (1998). Development of cooperative relationships through increasing investment. *Nature*, *394*(6689), 175–179. https://doi.org/10.1038/28160

Scelza, B., & Bliege Bird, R. (2008). Group structure and female cooperative networks in Australia's western desert. *Human Nature*, *19*(3), 231–248. https://doi.org/10.1007/s12110-008-9041-5

Schacht, R., & Borgerhoff Mulder, M. (2015). Sex ratio effects on reproductive strategies in humans. *Royal Society Open Science*, *2*, 140402. https://doi.org/10.1098/rsos.140402

Schacht, R., & Kramer, K. L. (2016). Patterns of Family Formation in Response to Sex Ratio Variation. *Plos One*, *11*(8), 1–14. https://doi.org/10.1371/journal.pone.0160320

Scheidel, W. (2010). Monogamy and Polygyny. In B. Rawson (Ed.), *A Companion to Families in the Greek and Roman Eorlds* (pp. 108–115). Oxford: Wiley-Blackwell.

Schmitt, D. P., & Rohde, P. a. (2013). The Human Polygyny Index and its Ecological Correlates: Testing Sexual Selection and Life History Theory at the Cross-National Level. *Social Science Quarterly*, *94*(4), 1159–1184. https://doi.org/10.1111/ssqu.12030

Sear, R. (2008). Kin and Child Survival in Rural Malawi. *Human Nature*, *19*(3), 277–293. https://doi.org/10.1007/s12110-008-9042-4

Sear, R., & Mace, R. (2008). Who keeps children alive? A review of the effects of kin on child survival. *Evolution and Human Behavior*.

Sear, R., Mace, R., & McGregor, I. a. (2000). Maternal grandmothers improve nutritional status and survival of children in rural Gambia. *Proceedings of Royal Society B*, *267*(1453), 1641–1647. https://doi.org/10.1098/rspb.2000.1190

Sear, R., Mace, R., & McGregor, I. A. (2003). The effects of kin on female fertility in rural Gambia. *Evolution and Human Behavior*, *24*(1), 25–42. https://doi.org/10.1016/S1090-5138(02)00105-8

Sear, R., Steele, F., McGregor, I. A., & Mace, R. (2002). The Effects of Kin on Child Mortality in Rural Gambia. *Demography*, *39*(1), 43–63. https://doi.org/10.1353/dem.2002.0010

Searcy, W. A., & Yasukawa, K. (1989). Alternative Models of Territorial Polygyny in Birds. *The American Naturalist*, *134*(3), 323–343.

Sen, A. K. (1992). Missing women. *British Medical Journal*, *304*(6827), 587–8. https://doi.org/10.1136/bmj.304.6827.587

Sheppard, P., & Sear, R. (2016). Do grandparents compete with or support their grandchildren? In Guatemala, paternal grandmothers may compete, and maternal grandmothers may

cooperate. *Royal Society Open Science*, *3*(160069), 1–10.
https://doi.org/10.1098/rsos.160069

Shi, S. (1996). The influence from Dar Ma evadicate Buddhism on the Transimision of Buddhism
in the Tibetan societies. *China Tibetology*, *2*, 34–43.

Sieff, D. F., Betzig, L., Cronk, L., Fix, A. G., Flinn, M., Gibson, K., … Sieff, D. F. (1990). Explaining
Biased Sex Ratios in Human Populations. *Current Anthropology*, *31*(1), 33–34.

Silva, A. S., & Mace, R. (2014). Cooperation and conflict: field experiments in Northern Ireland.
Proc. R. Soc. B, *281*(1792), 20141435.

Simon, H. A. (1990). A mechanism for social selection and successful altruism. *Science*,
250(December), 1665–1668. https://doi.org/10.1126/science.2270480

Smith, D., Dyble, M., Thompson, J., Major, K., Page, A. E., Chaudhary, N., … Mace, R. (2016). Camp
stability predicts patterns of hunter-gatherer cooperation. *Royal Society Open Science*, *3*,
160131. https://doi.org/10.1098/rsos.160131

Smith, E. A., & Bird, R. L. B. (2000). Turtle hunting and tombstone opening. *Evolution and Human
Behavior*, *21*(4), 245–261. https://doi.org/10.1016/S1090-5138(00)00031-3

Snopkowski, K., & Sear, R. (2013). Kin influences on fertility in Thailand: Effects and mechanisms.
Evolution and Human Behavior, *34*(2), 130–138.
https://doi.org/10.1016/j.evolhumbehav.2012.11.004

Sosis, R., & Alcorta, C. (2003). Signaling, Solidarity, and the Sacred: The Evolution of Religious
Behavior. *Evolutionary Anthropology*, *12*(6), 264–274. https://doi.org/10.1002/evan.10120

Sosis, R., & Bressler, E. R. (2003). Signaling Theory of Religion. *CrossCultural Research*, *37*(2), 211–
239. https://doi.org/10.1177/1069397103251426

Sparks, C. S. (2011). Parental investment and socioeconomic status influences on children's
height in Honduras: An analysis of national data. *American Journal of Human Biology*,
23(May 2010), 80–88. https://doi.org/10.1002/ajhb.21104

Steelman, L. C., Powell, B., Werum, R., & Carter, S. (2002). Reconsidering the effects of sibling
configuration:Recent Advances and Challenges. *Annual Review of Sociology*, *28*(1), 243–
269. https://doi.org/10.1146/annurev.soc.28.111301.093304

Steven C.Josephson. (2002). Does Polygyny Reduce Fertility ? *American Journal of Human
Biology*, *14*(2), 222–232.

Stieglitz, J., Gurven, M., Kaplan, H., & Hopfensitz, A. (2016). Why household inefficiency? An
experimental approach to assess spousal resource distribution preferences in a subsistence
population undergoing socioeconomic change. *Evolution and Human Behavior*, *38*(1), 71–
81. https://doi.org/10.1016/j.evolhumbehav.2016.07.002

Stieglitz, J., Gurven, M., Kaplan, H., & Winking, J. (2012). Infidelity, jealousy, and wife abuse
among Tsimane forager-farmers: Testing evolutionary hypotheses of marital conflict.
Evolution and Human Behavior, *33*(5), 438–448.

https://doi.org/10.1016/j.evolhumbehav.2011.12.006

Stieglitz, J., Kaplan, H., Gurven, M., Winking, J., & Tayo, B. V. (2011). Spousal violence and paternal disinvestment among Tsimane' forager-horticulturalists. *American Journal of Human Biology*, *23*(4), 445–457. https://doi.org/10.1002/ajhb.21149

Strassmann, B. I. (2000). Polygyny, family structure and child mortality: a prospective study among the Dogon of Mali. In L. Cronk, N. A. Chagnon, & W. Irons (Eds.), *Adaptation and human behavior* (1st ed., pp. 49–67). Aldine de Gruyter.

Strassmann, B. I., & Garrard, W. M. (2011). Alternatives to the grandmother hypothesis: a meta-analysis of the association between grandparental and grandchild survival in patrilineal populations. *Human Nature*, *22*(1–2), 201–22. https://doi.org/10.1007/s12110-011-9114-8

Sun Zhenyu. (2000). A study of education problems in Tibetan pastoral areas. *Journal of Central University for Nationalities(Philosophy and Social Science)*, *27*(6), 83–90.

Symons, D. (1995). Beauty is in the Adaptation of the Beholder: the Evolutionary Psychology of Human Female Sexual Attractiveness. In *Sexual Nature, Sexual Culture* (pp. 80–121).

T.H.Clutton-Brock, & G.A.Parker. (1992). Potential Reproductive Rates and the Operation of Sexual Selection. *The Quarterly Review of Biology*, *67*(4), 437–456.

Tanskanen, A. O., & Danielsbacka, M. (2012). Beneficial effects of grandparental involvement vary by lineage in the UK. *Personality and Individual Differences*, *53*(8), 985–988. https://doi.org/10.1016/j.paid.2012.07.019

Tanskanen, A. O., Jokela, M., Danielsbacka, M., & Rotkirch, A. (2014). Grandparental Effects on Fertility Vary by Lineage in the United Kingdom. *Human Nature*, *25*(2), 269–284. https://doi.org/10.1007/s12110-014-9200-9

Tashi, G., & Foggin, M. (2012). Resettlement as Development and Progress? Eight Years On: Review of Emerging Social and Development Impacts of an "Ecological Resettlement" Project in Tibet Autonomous Region, China. *Nomadic Peoples*, *16*(1), 134–151. https://doi.org/10.3167/np.2012.160110

Thomas, M. G., Nass, M. W., Bårdsen, B.-J., & Mace, R. (2015). Saami reindeer herders cooperate with social group members and genetic kin. *Behavioral Ecology*, *26*(6), 1495–1501. https://doi.org/10.1093/beheco/arv106

Thomas V.Pollet, Nettle, D., & Nellssen, M. (2006). Contact frequencies between grandparents and grandchildren in a modern society: Estimates of the impact of paternity uncertainty. *Journal of Cultural and Evolutionary Psychology*, *4*(3–4), 203–213. https://doi.org/10.1556/JCEP.4.2006.3

Thompson, J., Dyble, M., Page, A., Smith, D., Chaudhary, N., Salali, G. D., … Migliano, A. B. (2015). Polygyny without wealth : popularity in gift games predicts polygyny in BaYaka Pygmies Subject Category : *Royal Society Open Science*.

Trivers, B. Y. R. L. (1971). The Evolution of Reciprocal Altruism. *The Quarterly Review of Biology*,

46(1), 35–57.

Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man* (Aldine, pp. 136–179). Chicago.

Uggla, C., & Mace, R. (2015). Effects of local extrinsic mortality rate, crime and sex ratio on preventable death in Northern Ireland. *Evolution, Medicine, and Public Health*, 266–277. https://doi.org/10.1093/emph/eov020

Uggla, C., & Mace, R. (2016). Local ecology influences reproductive timing in Northern Ireland independently of individual wealth. *Behavioral Ecology*, *27*(1), 158–165. https://doi.org/10.1093/beheco/arv133

Umemoto, S. H. (2001). *Early Marriage: Child Spouses*. *United Nations Children's Fund Innocenti Research Center* (Vol. 7).

Upton, C. (2008). socialist Mongolia Social Capital , Collective Action and Group Formation : Developmental Trajectories in Post-socialist Mongolia. *Human Ecology*, *36*(2), 175–188. https://doi.org/10.1007/sl0745-007-9158-x

V.C.Wynne-Edwards. (1963). Animal Dispersion in Relation to Social Behaviour. *OIKOS*, *14*(I), 113–120. Retrieved from http://www.jstor.org/stable/3564964

Veller, C., Haig, D., & Nowak, M. A. (2016). The Trivers–Willard hypothesis: sex ratio or investment? *Proceedings of the Royal Society B: Biological Sciences*, *283*(20160126), 1–9. https://doi.org/10.1098/rspb.2016.0126

Vinicius, L., Mace, R., & Migliano, A. (2014). Variation in male reproductive longevity across traditional societies. *PLoS ONE*, *9*(11). https://doi.org/10.1371/journal.pone.0112236

Voland, E., & Beise, J. (2002). Opposite effects of maternal and paternal grandmothers on infant survival in historical Krummhörn. *Behavioral Ecology and Sociobiology*, *52*, 435–443. https://doi.org/10.1007/s00265-002-0539-2

Walker, R., Hill, K., Kaplan, H. S., & McMillan, G. (2002). Age-dependency in hunting ability among the Ache of eastern Paraguay. *Journal of Human Evolution*, *42*(6), 639–657. https://doi.org/10.1006/jhev.2001.0541

Wander, K., & Mattison, S. M. (2013). The evolutionary ecology of early weaning in Kilimanjaro, Tanzania. *Proceedings of the Royal Society of London B: Biological Sciences*, *280*(1768), 20131359. https://doi.org/10.1098/rspb.2013.1359

Wang, J.-G. (2006). The first Amdo-Tibetan history in the 18th century:the contemporary interpretation of "Ming Shi Xi Fan Zhu Wei Zhuan." *China Tibetology*, *4*, 22–33.

Weatherhead, P. J., & Robertson, R. J. (1979). Offspring Quality and the Polygyny Threshold : " The Sexy Son Hypothesis ." *The American Naturalist*, *113*(2), 201–208.

Wedekind, C., & Braithwaite, V. A. (2002). The long-term benefits of human generosity in indirect reciprocity. *Current Biology*, *12*(12), 1012–1015. https://doi.org/10.1016/S0960-9822(02)00890-4

Weisner, T. S., & Gallimore, R. (1977). My Brother 鈇s Keeper : Child and Sibling Caretaking. *Current Anthropolog*, *18*(2), 169–190.

West, S. A., El Mouden, C., & Gardner, A. (2011). Sixteen common misconceptions about the evolution of cooperation in humans. *Evolution and Human Behavior*, *32*(4), 231–262. https://doi.org/10.1016/j.evolhumbehav.2010.08.001

Westermarck, E. (1921). Monogamy and Polygyny. In *The History of Huamn Marriage* (Fifth, pp. 85–89). London: Macmillan and Co.

White, D. R., & Burton, M. L. (1986). Causes of Polygyny : Ecology, Economy, Kinship, and Warfare. *American Anthropologist*, *90*, 871–887.

Whitehead, H., & Richerson, P. J. (2009). The evolution of conformist social learning can cause population collapse in realistically variable environments. *Evolution and Human Behavior*, *30*(4), 261–273. https://doi.org/10.1016/j.evolhumbehav.2009.02.003

WHO. (2003). Global Strategy for Infant and Young Child Feeding. *World Health Organizationorld*, 1–30. https://doi.org/ISBN 92 4 156221 8

Wilhelm, S. L., Rodehorst, T. K., Stepans, M. B. F., Hertzog, M., & Berens, C. (2008). Influence of intention and self-efficacy levels on duration of breastfeeding for midwest rural mothers. *Applied Nursing Research*, *21*(3), 123–130. https://doi.org/10.1016/j.apnr.2006.10.005

Williams, D. E. E. M. (1996). Grassland Enclosures: Catalyst of Land Degradation in Inner Mongolia. *Human Organization*, *55*(3), 307–313.

Williamson, N. E. (1976). *Sons or Daughters A Cross-Cultural Survey of Parental Preferences* (1st ed.). London: Sage Publication.

Wilson, D. S. (1998). Hunting, Sharing, and Multilevel Selection. *Current Anthropology*, *39*(1), 73–97. https://doi.org/10.1086/204699

Wilson, M., & Daly, M. (1985). Competitiveness, risk-taking, and violence: The young male syndrome. *Ethology and Sociobiology*, *6*(1959), 59–73. https://doi.org/10.1016/0162-3095(85)90041-X

Winking, J., Stieglitz, J., Kurten, J., Kaplan, H., & Gurven, M. (2013). Polygyny among the Tsimane of Bolivia: an improved method for testing the polygyny-fertility hypothesis. *Proceedings of Royal Society B*, *280*(1756), 20123078. https://doi.org/10.1098/rspb.2012.3078

Wright, S. (1922). Coefficients of Inbreeding and Relationship. *The American Naturalist*, *56*(645), 330–338.

Wu, J.-J., Ji, T., He, Q.-Q., Du, J., & Mace, R. (2015). Cooperation is related to dispersal patterns in Sino-Tibetan populations. *Nature Communications*, *6*(8693), 8693. https://doi.org/10.1038/ncomms9693

Wu, N., & Richard, C. (1999). The privatization process of rangeland and its impacts on pastoral dynamics in the Hindu- Kush Himalaya: The Case of Western Sichuan, China. In

International Rangeland Congress, Townsville Australia (pp. 1–17).

Wu, Q. (2013). *Tradition and Modernity*. University of Helsinki.

Xiaohe, X., & Whyte, M. K. (1990). Love Matches and Arranged Marriages: A Chinese Replication. *Journal of Marriage and the Family*, *52*(3), 709. https://doi.org/10.2307/352936

Xue, S. (2007). Reasons of why Lang Darma evadicate Buddhism. *Journal of Minorities Teachers College of Qinghai Teachers University*, *18.2*, 28–31.

Yamaguchi, T. (2011). Transition of Mountain Pastoralism: An Agrodiversity Analysis of the Livestock Population and Herding Strategies in Southeast Tibet, China. *Human Ecology*, *39*(2), 141–154. https://doi.org/10.1007/s10745-010-9370-y

Yan, J., Wu, Y., & Zhang, Y. (2011). Adaptation strategies to pasture degradation: Gap between government and local nomads in the eastern Tibetan Plateau. *Journal of Geographical Sciences*, *21*(6), 1112–1122. https://doi.org/10.1007/s11442-011-0904-z

Yeh, E. T. (2003). Tibetan Range Wars: Spatial Politics and Authority on the Grasslands of Amdo. *Development and Change*, *34*(3), 499–523. https://doi.org/10.1111/1467-7660.00316

Yeh, E. T. (2005). Green Governmentality and Pastoralism in Western China: "Converting Pastures to Grasslands." *Nomadic Peoples*, *9*(2005), 9–30. https://doi.org/10.3167/082279405781826164

Yeh, E. T., Nyima, Y., Hopping, K. a., & Klein, J. a. (2013). Tibetan Pastoralists' Vulnerability to Climate Change: A Political Ecology Analysis of Snowstorm Coping Capacity. *Human Ecology*, *42*(1), 61–74. https://doi.org/10.1007/s10745-013-9625-5

Yeh, E. T., Nyima, Y., Hopping, K. A., & Klein, J. A. (2014). Tibetan Pastoralists' Vulnerability to Climate Change: A Political Ecology Analysis of Snowstorm Coping Capacity. *Human Ecology*, *42*(1). https://doi.org/10.1007/s10745-013-9625-5

Yu, X.-W. (1950). *Social research among the North-west part of Tibetan pastoralists*. Shanghai: Shang wu yin shu guan.

Zahavi, A. (1975). Mate selection-A selection for a handicap. *Journal of Theoretical Biology*, *53*(1), 205–214. https://doi.org/10.1016/0022-5193(75)90111-3

Zeitzen, M. K. (2008). *Polygamy, A Cross-Cultural Analysis*. Oxford: Berg.

Zhan, H. J., & Montgomery, R. J. V. (2003). Gender and elder care in China: the influence of filial piety and structural constraints. *Gender and Society*, *17*(2), 209–229. https://doi.org/10.1177/0891243202250734

Zhang, J. (2014). Investigating of the Numbers of the Buddhist Temples and Monks Prosecuted by King Darma in the 9th Century. *Tibetan Studies*, *1*, 49–56.

Zhaoli, Y., Ning, W., Dorji, Y., & Jia, R. (2005). A Review of Rangeland Privatisation and its Implications in the Tibetan Plateau, China. *Nomadic Peoples*, *9*(1), 31–51. https://doi.org/10.3167/082279405781826155

Zhu, Y. (1990). Gansu sheng xiang tu zhi gao-zong jiao yu si yuan. In J. Wu (Ed.), *Zhong guo xi bei*

wen xian cong shu (1st ed., pp. 214–238). Lanzhou: Lanzhou gu ji shu dian.

Zou, Z. (2006). *Monk's System in Tibetan Buddhist Temple and Ecological Environment in Tibetan Area-View of the South Gansu Tibetan Area during the Period of Republic of China*. Shanxi Normal University.

Zou, Z., & Hou, Y. (2012). Monk's System of Labrang Temple and Ecological Environment in the South Gansu Tibetan Area during the Period of Republic of China. *Northwest Population*, *33*(2), 93–102. https://doi.org/10.15884/j.cnki.issn.1007-0672.2012.02.003

Appendix

Basic Information of Household

We would like to start our questionnaire by asking you some basic questions of you and your family (living in the same house)

Location															GPS	House							
Date															Time	tent							
HH								Interviewer									Interviewee						

	Name	Sex	AGe	Ethnic group	Date Of birth	AY	Marriage Status	Marriage time	M's name	F's name	M's age	F's age	M's birth year	F's birth year	Is your mother still alive? if not, the year of death	Is your father still alive? if not the year of death	Is this your natal house? Y/N	If not, where is your natal house?	When did you come to this house?	Where are the absent members?	Relationship with HH	Education

1																						
2																						
3																						
4																						
5																						
6																						

Marital status:

1. Never married 2. First marriage 3. Married more than once. 4. Widow/widower 5. Single divorced 6. Polygynous 7. Polyandrous

Education :

1.   Illiterate   2. Self-learned (less than one term school education)   3. Can read and write basic Tibetan or Chinese 4. primary education
5. Middle school education   6.   university education

Herding   system

1. How many XX your family have now?

Yak	Male		Sheep/	Male	
	Female		Goat	Female	
	Kid			Kid	

2. How many yak XX last year?

Born	Male		Dead	Male		Sold	Male	
	Female			Female			Female	
	Kid			Kid			Kid	

3. How many sheep/goat XX last year?

Born	Male		Dead	Male		Sold	Male	
	Female			Female			Female	
	Kid			Kid			Kid	

4. Is herding your main source of income?

Y ☐   N ☐

5. If not, what are the other sources?

Working in the town ☐ Business ☐ Caterpillar fungus☐ others ☐

-Note:

6a.   How many land your household have?

The year start to practice privatiza tion policy	Family size			Current situation	Family size		
	Land				Land		
	225 mu	125 mu	other		225 mu	125 mu	other

6b. How many livestock your family have before the privatization?

 ----

7.   Rate the quality of your grassland before the privatization policy and after (From 1-7)

Factors	Water (1:lack of water. 7: sufficient water)	Steep (1:very steep hill 7: flat plateau)	Shadow or Sunshine of the hill (1: shadowed all the year round 7: lots of	Distance to different seasonal grassland (1:takes more than one day to reach 7:	Distance to the main road (1: easy walking distance. 7: impossible to	Grass (1: many weed 7: very good quality)	Others (e.g. Wolf, hard to move from one site to other)

			sunshine)	very close by, 2-3 hours)	walk)		
the first year of privatization							
Current situation							

8a. Columns below are the winter herding group data from the time of practicing privatization until last year.

Time	Name of the head of the household														
Last year															
At the beginning of the privatization policy															

8b. If group sizes changed in between, please indicate the changes.

When								
Who moves out/in								

Reasons 1：set new family 2. Living in the town 3: herding alone 4: others ）							
Note(if the reasons are others)							

9. If you have sub-groups, indicating how long you stayed and the name of each HH if different from the winter group

Seasonal grassland	Period	Name of the Head of the household
Spring		
Summer		
Autumn		

10. Did you rent out the grassland or rent extra grassland last year? Tick it if any.

	To others	From others
Period		
How much you paid/earned from the latest rent		

What is the criteria		

11a. Are there any leaders in the herding group?

Yes☐   No☐

11b. Name the Leaders in your herding community

Name															
When became the leader															
Reasons became the leader															
responsibility															

12. If you have problems in herding, list up to 5 people in the village that you most likely to consultant with

13. If your family have some private problems, list up to 5 people in the village that you most likely to ask for help.

14. List 5 youngsters (age15-25) from the village that you think have promising future.

15. Did you get any help from or to someone last year?　（one up to five people ）

	Support received from	Support given to
watching livestock		
Finding lost livestock		
Collecting barley in Autumn/ build tent		
Economic (lend/borrow money)		
Child rearing		
others		

16 Gift-giving game (3×5=15yuan) give money to 1-3 individuals in the village, you are not allowed to give money to yourself

Gift-recipient			
In which family (for double check)			
Amount			
Reason			

Marriage History of HH

1. We would like to ask you questions about your marriage.

Name of the interviewer		Age/animal year		Date of birth	
Marital status (the same code as in the basic information sheet):					
	Spouse's name	Current location if living(1:same community 2:same village 3:out of village 4:out of county)	Marriage time	Divorce time	
1					
2					
3					
Bridewealth:					

Time	Bride wealth			who paid	Who received	Dowry		who paid	Who received
1		Cattle					Cattle		

		Sheep					Sheep			
		Others					Others			
2		Cattle					Cattle			
		Sheep					Sheep			
		Others					Others			
3		Cattle					Cattle			
		Sheep					Sheep			
		Others					Others			

2. Information of your sibling (anyone either with same mother or same father).

Information of your sibling (including dead) in order of birth	Name	Age	Alive/dead	Date of death	Current location if living: (1:same community 2:same village 3:out of village 4:out of county)	Same father? (Y/N) if not, indicate name	Same mother? (Y/N) if not, indicate name
1							
2							
3							

4							
5							
6							
7							

3. Your birth history (start with first born, including dead)

Offspring	Name	Age	AY	Sex	Date of birth	Alive or dead	If dead, the year of death	Mother's name	If living, Current location: (1:same community 2:same village 3:out of village 4:out of county)
1									
2									
3									
4									
5									
6									

7									
8									
9									

4. If you only allowed to have one child, do you prefer a boy or a girl
   Boy □ Girl □ Doesn't matter □

Marriage History of Female

1. We would now ask every adult woman to answer the following questions.

Name		Age		Date of birth		Marital status (code as before)		Animal year	

Your parents' information	Father				Mother			
	Name				Name			
	Age				Age			
	Date of birth				Date of birth			
	If dead, death year				If dead, death year			

Your natal house: (1:same community 2:same village 3:out of village 4:out of county(name of the place)	

2. Your marriage history.

	1st	2nd	3rd	4th
Spouse's name				
Date(Age) of trial marriage				
Marriage date				
Period				

How many children do you have in this marriage			

3.   Your birth history (start from the first born, including dead)

Offspring	Name	Age	AY	Sex	Date of birth	Alive or dead	If dead, the year of death	Father's name	If living, Current location (1:same community 2:same village 3:out of village 4:out of county)
1									
2									
3									
4									
5									
6									
7									

4.   Information of your bridewealth.

Time	Bride wealth			who paid	Who received	Dowry			who paid	Who received
1		Cattle					Cattle			
		Sheep					Sheep			

		Others					Others			
2		Cattle					Cattle			
		Sheep					Sheep			
		Others					Others			
3		Cattle					Cattle			
		Sheep					Sheep			
		Others					Others			

5.   Information of your sibling (sibling with either same father or same mother, including dead, in the order of birth).

Information of your sibling	Name	Age	Alive/dead	Date of death	Current location(1:same community 2:same village 3:out of village 4:out of county)	Same father? (Y/N) if not, father's name	Same mother? (Y/N) If not, mother's name
1							
2							
3							

4							
5							
6							
7							
8							

6. Gift-giving game (3×5=15yuan) give money to 1-3 individuals in the village, you are not allowed to give money to yourself

Gift-recipient			
In which family (for double check)			
Amount			
Reason			

7. Other questions.

Have you used any contraception? Y/N	
If yes, which contraception you have used?	
Apart from yourself，Who helped you yesterday to feed kids	
Who helped you giving birth	
If you are only allowed to have one child, do you prefer a girl or boy?	Girl □　Boy　□ Doesn't matter□
If you have a boy and a girl already, do you prefer boy or girl for the third child	

Women have children under age 5

1. If bottle feeding, please answer questions below

offspring	1	2	3	4
Feeding type(1: Breast feeding 2: bottle feeding 3: mixed)				
What's in bottle (1: animal milk 2: milk powder 3: flour+water 4: others)				
When did you stop breast feeding				
When did you start bottle feeding				
When did you stop bottle feeding				

- Long ethnographic history interview with several aged people to understand the history:
  - Have a brief view of the whole village, how many communities, how many households, when they are going to move to another land and so on
  - How was land owned/ managed/grazed before privatization?
  - How they were using the land, do they had a division in between? What is the boundary of different communities?
  - If overgrazed, what happened on the extra livestock after the land is divided
  - Were there any leaders? Any difference between leaders in the history and now? Can you still remember who the leaders are? If dead, name their offspring

- Weight and height of every school children? It would be better to scale everyone in the village the height and weight. From this data you can see the parental investment and social network.