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Inheritance and inequality among nomads of South Siberia

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At the headwaters of the Yenisei River in Tuva and northern Mongolia, nomadic pastoralists move between camps in a seasonal rotation that facilitates their animals' access to high-quality grasses and shelter. The use and informal ownership of these camps depending on season helps illustrate evolutionary and ecological principles underlying variation in property relations. Given relatively stable patterns of precipitation and returns to capital improvement, families generally benefit from reusing the same camps year after year. We show that locations with higher economic defensibility and capital investment—winter camps and camps located in mountain/river valleys—are claimed and inherited more frequently than summer camps and camps located in open steppe. Camps are inherited patrilineally and matrilineally at a ratio of 2 : 1. Despite its practical importance, camp inheritance is not associated with livestock wealth today, which is better predicted by education and wealth outside the pastoral economy. The relationship between the livestock wealth of parents and their adult children is significantly positive, but relatively low compared to other pastoralists. The degree of inequality in livestock wealth, however, is very close to that of other pastoralists. This is understandable considering the durability and defensibility of animal wealth and economies of scale common across pastoralists.

This article is part of the theme issue 'Evolutionary ecology of inequality'.

1. Introduction

What principles underlie variation in ownership of, inheritance of, and inequality in wealth? Evolutionary theories of property rights and ownership predict that the stability of ownership should depend on the benefits and costs of maintaining and transferring claims to resources over time [1–6]. According to these principles, the economic defensibility, ownership and inheritance of resources are expected to vary according to time, place and resource type. Local definitions of ownership—also termed property relations [7,8]—are culturally encoded and passed on in the form of traditions, norms and institutions. Patterns of ownership and transmission of wealth between generations are, in turn, key determinants of long-run equality or inequality [9–11].

The use of camps among pastoralists provides a unique opportunity for studying the flexible evolution of property rights and inheritance in humans [12–15]. Whether and how camps are claimed, occupied and inherited varies according to season and other aspects of ecology [16,17]. These patterns can affect the intergenerational transmission of wealth and long-run inequalities [18]. Inheritance patterns also vary according to gender [19]. While patrilineal

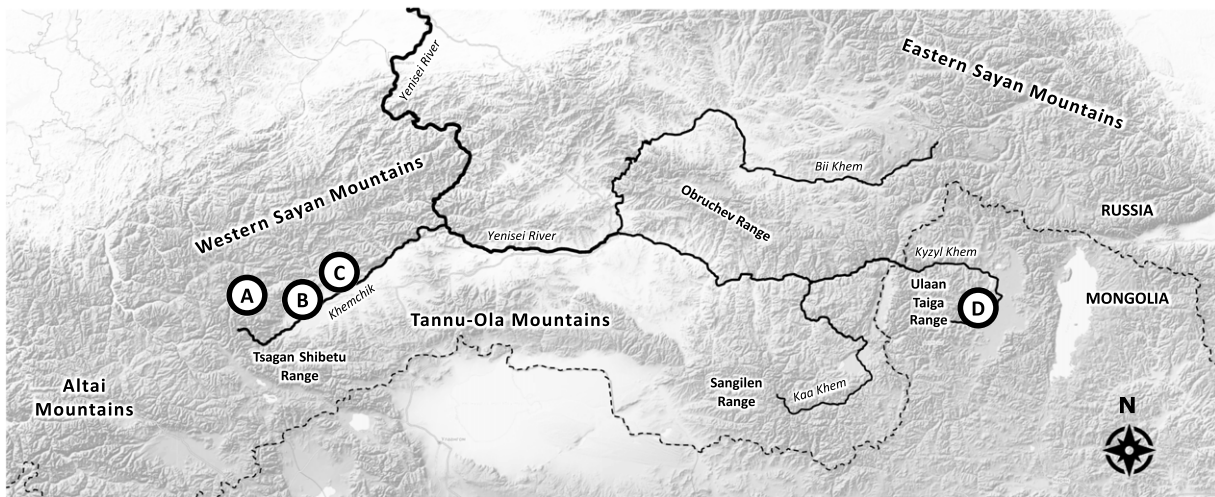


Figure 1. Location of the study sites in the upper Yenisei River basin.

inheritance is stereotypical among most pastoralists, inheritance through the female line also occurs at some frequency [20,21]. This can result from facultative adjustment to demographic constraints (e.g. unavailability of normative heirs), shared patrilineal and matrilineal residence, and/or normatively bilateral systems of inheritance [22,23].

To help shed light on the flexible evolution of property rights, inheritance and inequality, we examine patterns of camp ownership and inheritance among four nomadic communities living within the historical territory of Tannu Uriankhai (figure 1), a region that spans the present-day Republic of Tuva and adjacent areas of the Russian Federation and northern Mongolia [24]. Many studies of Inner Asian pastoralism have highlighted the importance of informal camp ownership within large, commonly or state-owned territories [17,18,25–27]. Here, we focus directly on seasonal and geographical patterns of camp ownership and inheritance in the Khemchik region of western Tuva and the Darkhad region of northern Mongolia. We analyse patterns of camp ownership and inheritance with respect to ecology, season, gender and birth order. We then characterize the intergenerational transmission of wealth, observed degree of inequality and best predictors of pastoral wealth in the sample.

The intergenerational transmission of wealth has been estimated for pastoralists in the Middle East (the Yomut Turkmen of Iran) and in Africa (the Juhaina Arabs of Chad and the Datoga and Sangu of Tanzania) [28]. This study presents comparable estimates for a sample of Inner Asian pastoralists, and provides a window onto the specific mechanics underlying wealth inequality in this unique historical and ecological context.

(a) Predictions for camp inheritance by season and terrain

Under the Qing, Soviet, and present-day Russian and Mongolian states, Tuvan and Darkhad nomads have negotiated rights to camp sites within a context of dual formal (state-level) and informal (community-level) regulatory institutions [17,24,29]. Within communities, families establish the legitimacy of informal camp ownership based on a history of prior use, inheritance from close kin, or the vouchsafe of other community members [30,31]. During the Soviet period, formal property relations were governed by the collective

farm (*kolkhoz*) system [32,33]. During and after the 1990s, the privatization of collective brigades established a new basis for formal, private household property [30,34]. Around the turn of the millennium, familial claims in Tuva were formalized to a greater extent by the registration of camp use-rights with local government offices; in most cases, these registrations documented pre-existing patterns of use, and correspond only approximately with patterns of use in any given year [18,26,30,35].

The effort families put towards maintaining informal ownership and inheritance of camp locations may be expected to vary adaptively depending on season and terrain [12]. Relative to environments with more unpredictable patterns of precipitation (high year-to-year variability), relatively stable patterns of precipitation in the mountainous regions of Tuva and northern Mongolia generally lend themselves to the regular re-use of camps by households over time [36].

The high latitude, high elevation and extreme continental climate of these areas imposes strict constraints on the suitability of camp locations by season. In western Tuva and Darkhad, the predominant pattern of transhumance (seasonal migration) cycles between open steppe or high-altitude pastures in summer, and protected mountainous areas in winter [16,30,37]. During the summer, high-quality pasture tends to be relatively abundant and extensive. Many herders camp in areas of open steppe where the distribution of grass/fodder is relatively homogeneous and geographical circumscription is relatively low [13]. Others occupy high-altitude pastures during the summer that cannot be exploited efficiently during colder months of the year.

Relative to other seasonal camps, access to a suitable winter camp is considered particularly crucial for herd success [18,38]. Because snow builds up on flatter terrain during the winter, the best winter camps tend to be located near south-facing mountain slopes where the sun and wind help to expose underlying pasture [16,39]. In addition to being in relatively short supply, winter camps are also commonly invested with a greater degree of physical capital compared to other seasonal camps [40]. The construction of insulated permanent shelters and cabins at winter sites has been typical of Tannu Uriankhai since at least the nineteenth-century, and intensified further during the Soviet period [16,17]. Hay fields for preparing winter fodder are also commonly located near winter sites, which

reinforces their capital value. In the warmer seasons, the nomads occupy mobile yurts and install open pens which are generally less capital intensive than the permanent shelters found at winter camps [16].

The relative scarcity and capital-intensive nature of winter sites together imply greater returns to claiming and bequeathing ownership of winter camps compared to other seasonal camps [18,41]. Mountain pastures are additionally expected to have high economic defensibility as a result of circumscription by steep and forested terrain. This is consistent with the observations of the Russian ethnographer Ermolaev in nineteenth century Tannu Uriankhai:

Open pasture was always regarded as common ground, but the winter pastures, particularly in years when the grass crop was poor, were for individual use: 'This is my mountain, that is yours', although observance was not necessarily very strict. ([16] p. 83)

Considerations of relative shortage, capital investment and economic defensibility lead to the following set of predictions regarding the inheritance of camps by season and terrain:

- P1: winter camps will be more frequently inherited than other seasonal camps;
- P2: summer camps will be less frequently inherited than other seasonal camps;
- P3: camps in mountainous terrain will be more frequently inherited than camps in other terrains; and
- P4: camps on the steppe will be less frequently inherited than camps in other terrains.

(b) Predictions for camp inheritance by gender and birth order

Data on the inheritance of camps allow analysis of inheritance with respect to kinship. Kinship ties are key resources for establishing community acceptance of claims to camps [30]. Like most other Turkic and Mongolian groups, Tuvan and Darkhad nomads are characterized as patrilineal and patrilocal [36,42]. Despite this patrilineal categorization, several factors lead to expectations of somewhat more balanced, bilateral patterns of inheritance. As Kazato describes in Mongolia, 'in practice, [winter camps] can be inherited by bilateral and even collateral offspring' ([40], p. 12).

There are a number of reasons to expect mixed patterns of inheritance with respect to gender in this sample. Inheritance through the female line is consistent with an observed tradition of independent and socially prominent women among Turkic and Mongolian pastoralists [43–46]. It may result from matrilineal co-residence that occurs despite normative patrilocality. As Humphrey & Sneath wrote, 'although in Inner Asia as a whole virilocal residence after marriage is the ideal norm, the Tuva data show that the norm is not always followed' ([36], p. 154). Household co-residence and inheritance are likely to respond flexibly to idiosyncratic demographic realities, such as the unavailability of normative heirs. Matrilocality may occur as a form of bride service performed by less wealthy husbands early in marriage [47]. Because multiple children may inherit and use the same camps, patrilineal and matrilineal inheritance are not always mutually exclusive within a family. In short, the use and inheritance of camps by adult daughters may not be as rare as categorically assumed. This leads to the following prediction:

- P5: informal ownership of camps will be regularly passed to adult daughters as well as sons, with greater bias towards sons.

We also evaluate patterns of camp inheritance with respect to birth order. The commonly acknowledged Mongolian norm is that the youngest son co-resides with his parents and inherits their property upon their death (i.e. ultimogeniture) [40,41,47]. Among the Kyrgyz of the Wakhan Corridor in Afghanistan, on the other hand, pastures are normatively passed to oldest sons (i.e. primogeniture) [48]. Other statements about normative camp inheritance in Tuva and Mongolia are not explicit with respect to birth order [16,41,49]. We therefore characterize the frequency of first-born, middle-born and last-born inheritance in the 13 lineages with detailed genealogical data in this sample.

(c) Predictions for transmission of wealth and inequality

In addition to the inheritance of land rights, we also examine the intergenerational transmission of and inequality in livestock wealth. The extent to which wealth persists within families across generations is quantified by the coefficient of intergenerational transmission, β [50]. This coefficient reflects the elasticity of offspring wealth with respect to parental wealth within families. Long-run inequality results from the accumulation of wealth within lineages owing to intergenerational transmission and other factors [9,10,51]. We use the Gini coefficient to quantify observed inequality in livestock wealth across households in this sample. The Gini coefficient—which ranges between 0 and 1 and measures the relative mean difference in wealth between families—is commonly used to compare wealth inequality across past and present societies [52,53].

Several factors make the pastoralist ecological niche prone to high levels of intergenerational transmission and inequality. Livestock is a classically durable, accumulable and transferable form of wealth that stores value over the long term and thus lends itself to intergenerational transmission. The exponential growth capacity of animal reproduction under favourable conditions also creates economies of scale that can allow well-capitalized herders to accumulate wealth faster than those with smaller herds [28].

Intergenerational transmission of herd wealth among pastoralists in the Middle East and Africa is consistently high, in the range of 0.54–0.96, similar to levels observed among intensive agriculturalists [28]. The Yomut Turkmen of northern Iran—who share the present sample's Turkic/Mongolian cultural origins [54]—showed a transmission coefficient of 0.56 (± 0.17 s.e.). High levels of transmission for pastoralists are also associated with high inequality in livestock wealth, with a mean Gini coefficient of 0.51 and a range of 0.35–0.69 [28]. The Yomut Turkmen showed a Gini coefficient of 0.60 (± 0.04 s.e.). The Gini estimated by Murphy [49] in Khentii province in eastern Mongolia is somewhat lower (0.46) but still within the range of pastoralists reported by Borgerhoff Mulder *et al.* [28].

There are reasons to expect that Tuvan and Darkhad herders would show patterns of intergenerational transmission and inequality similar to those observed among other pastoralists. Like in most herding societies, bequests of stock from parents and other close kin in early life provide the

Table 1. Description of the study sites.

	site A	site B	site C	site D
location	Tuva	Tuva	Tuva	Mongolia
province	Bai-Taiga	Barun-Khemchik	Barun-Khemchik	Khövsgöl
ethnolinguistic groups	Tuvan	Tuvan	Tuvan	Darkhad, Tuvan
mean elevation	1485 m	919 m	1300 m	1626 m
year of data collection	2015	2015	2013	2016
n households	13	15	10	57
n individuals	62	83	53	240

foundation for future growth. The herds of parents and children also experience similar conditions owing to co-residence, as well as inheritance of camps and pasture. Reports from Tannu Uriankhai in the nineteenth and early twentieth centuries evidence high levels of inequality, with the wealthiest herders possessing on the order of 4000–6000 head of livestock [16]. Network-dependent access to goods and services meant that inequalities persisted despite the levelling ethos of the Soviet era; inequalities have also grown in many areas of the former Soviet Union following de-collectivization and privatization, particularly in towns and cities [55].

Other factors temper expectations of high intergenerational transmission and inequality in this sample. Responses to insurrection and political purges during the early Soviet period dismantled the wealth and membership of pre-Soviet elites [17,36,56,57]. Collectivization, capital reallocation and mobilization for warfare under the socialist state in the mid-twentieth century further redistributed wealth and access to land [17,36]. There were widespread losses of stock following de-collectivization in the 1990s and generally weak markets for pastoral products in the post-Soviet period [49]. In other parts of Siberia, inequalities fell after widespread job loss and a return to traditional (pre-Soviet) levelling mechanisms [58–60]. In Inner Asia, periodic severe winter weather events (Tuvan: *chut*; Mongolian: *dzud*) can cause catastrophic loss for rich as well as poor herders, potentially upsetting the stability of household wealth over time [61]. On balance, these considerations lead to the following alternative predictions regarding intergenerational transmission:

P6a: the intergenerational transmission of wealth will be similar to that of most other pastoralists ($\beta \sim 0.7$); or

P6b: the intergenerational transmission of wealth will be less than that of most other pastoralists ($\beta \ll 0.7$).

They similarly generate the following alternative predictions regarding inequality in livestock wealth:

P7a: inequality in wealth will be similar to that observed for other pastoralists (Gini ~ 0.5); or

P7b: inequality in wealth will be less than that observed for other pastoralists (Gini $\ll 0.5$).

We test each of these predictions below. As a final step, in order to shed light on the basis of the observed inequality, we describe how livestock wealth relates to

camp inheritance, non-pastoral wealth, wages and education in this sample.

2. Material and methods

Data were collected in collaboration with households in four nomadic communities at the headwaters of the Yenisei River in 2013, 2015 and 2016 (figure 1 and table 1). Interviews were conducted with household heads recording the location of seasonal camps occupied within the last year; whether camps were inherited and from whom; the quality of grasses for animals at each camp; the number of cattle, sheep, goats, horses, yaks, *haynak* (yak-cattle hybrids) and camels owned; an inventory of material wealth (e.g. vehicles, mobile phones etc.); and the age, education and market wages of household members [62]. Interviews were conducted in Tuvan or Mongolian with the help of multilingual research assistants. Research at site D was carried out as part of the Northern Mongolia Adventure and Discovery in Science (NOMAD Science) Project.

While reindeer herding is common in some parts of this region [14,63], and some older adults at site D reported familial descent from reindeer herders living in the area in the early twentieth century, there were no reindeer herders living at the sample locations during the time of data collection. Most families maintain a dozen or more sheep and goats; a number of cattle (particularly milk cows for dairy production); and a few horses for transportation. Hooper [62] showed that wealth of better-off herders is reflected predominantly in terms of sheep and goats. Some wealthy herders also specialize in yaks, camels, or horses. The electronic supplementary material, tables S1 and S2 summarize herd composition and other key variables in the total sample and at each site.

For the analysis of camp inheritance, camps were categorized by season of occupation. Camps occupied during the winter with spillover residence during spring or autumn were counted as winter camps, while camps occupied during the summer with spillover residence during spring or autumn were counted as summer camps. Camps only occupied for a single season (autumn, winter, spring, summer) were counted for that season. The terrain characterizing the pasture at each camp was classified as ‘mountain’ (mountain slopes, valleys and taiga), ‘river’ (in or alongside a riverine floodplain), or ‘steppe’ (open, flat grassland). Models predicting the probability that a camp was inherited were estimated using the `glm()` function in R [64]. The statistical significance of contrasts between seasons and between terrains was bootstrapped using the `cluster.bs.glm()` function in the `clusterSEs` package [65]. Because each household contributes multiple camps to the dataset, contrasts included a clustering term for household identity.

For the analysis of livestock wealth transmission and inequality, the total livestock wealth of each household was calculated in units of *bodo*, a traditional measure of livestock accounting

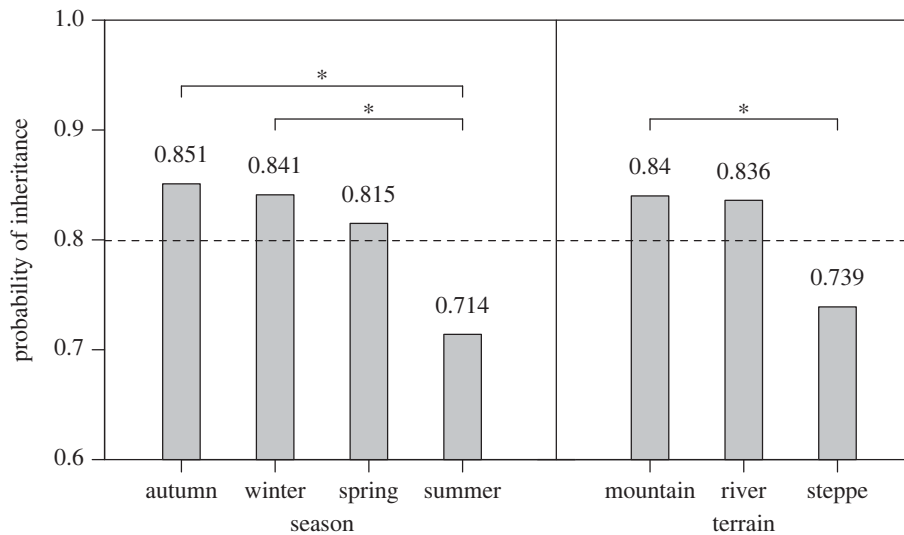


Figure 2. Camp inheritance as a function of season and terrain. Differences marked with an asterisk (*) are significant at the 95% level ($p < 0.05$). The dashed line shows the sample mean of 0.8; $n = 328$ camps.

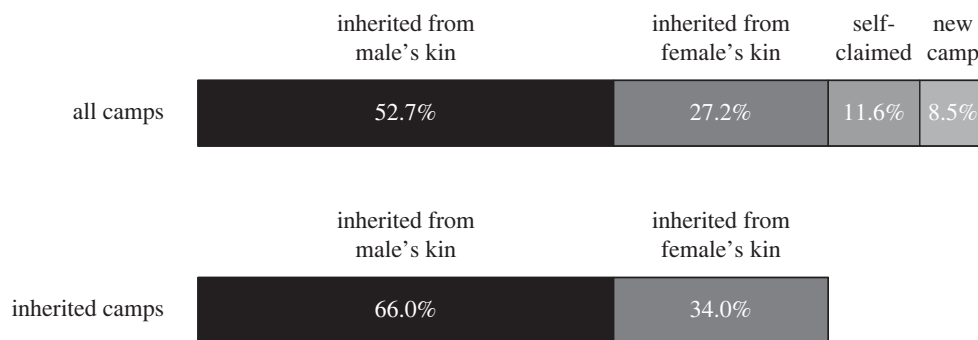


Figure 3. Sources of claims to camps; $n = 294$ camps.

employed in Inner Asia [16]. *Bodo* represents a weighted sum of number of adult animals. Pooling sheep and goats together as small stock, 1 *bodo* = 1 cow = 1 horse = 10 small stock = 1 yak = 1 *haynak* = half a camel. The sample included 22 unique parent-offspring pairs (i.e. pairs for which livestock data were available for both the parent's household and the adult offspring's household).

To estimate the coefficient of intergenerational transmission of wealth, β —also known as the intergenerational elasticity of wealth—the natural logarithm of parental wealth was regressed on the natural logarithm of offspring wealth using the `lmer()` function in R [66]. A random effect for the identity of parental household was included to account for the non-independence of multiple offspring from the same parents. Ninety-five per cent confidence intervals were calculated using the `confint()` function. The Gini coefficient for livestock wealth across households was estimated with bootstrapped 95% confidence intervals using the `Gini()` function in the `DescTools` package in R [67]. Owing to the small sample size at each site, this analysis pooled the data from all four sites.

To analyse variation in livestock wealth, education, non-livestock material wealth, wages, age (the mean age of household heads, centred on zero) and camp inheritance (the fraction of camps that were inherited) were regressed on the natural logarithm of livestock wealth using the `lm()` function. Because of collinearity between these predictor variables, we report the results of bivariate models with each individual predictor as well as a multivariate model that includes all the predictors together. Finally, the relationship between camp inheritance and reported quality of grasses was estimated using the `lm()` function. The quality of grasses at each camp—reported using a five-level Likert scale

that varied from -2 (very bad) to $+2$ (very good)—was Z-scored to have mean of 0 and a standard deviation equal to 1.

3. Results

The mean probability of a camp being inherited in this sample is 80%. The left side of figure 2 shows the probability of inheritance as a function of season. In partial support of P1, winter camps are inherited significantly more frequently (85%) than summer camps (71%). However, autumn camps are inherited just as frequently (85%) as winter camps. In support of P2, summer camps are inherited less frequently than autumn or winter camps. Spring camps are inherited at an intermediate rate (82%) close to the sample average.

The right side of figure 2 shows camp inheritance as a function of terrain. In support of P3 and P4, camps in mountainous terrain are inherited significantly more frequently (84%) than camps on the open steppe (74%). Notably, the inheritance of camps located near rivers are inherited at nearly the same rate (84%) as mountain camps. Unfortunately, co-linearity between season and terrain and small effective sample size makes the independent effects of season versus terrain difficult to identify. The frequency of each terrain type by season of occupation is summarized in the electronic supplementary material, table S3.

Figure 3 describes the sources of informal ownership of sites. Consistent with P5, the data show a pattern of mixed

Table 2. Intergenerational transmission of livestock wealth and inequality.

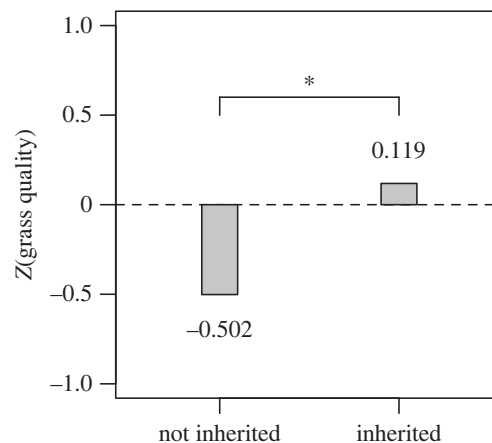
parameter	estimate	2.5%	97.5%
<i>(a) regression predicting log(offspring livestock)</i>			
intercept	2.381	1.485	3.085
log(parent livestock)	0.415	0.192	0.636
s.d.(parent random effect)	0.581	0.000	1.087
<i>n</i> = 21 parent-offspring pairs			
<i>(b) inequality in livestock wealth</i>			
Gini(livestock)	0.467	0.395	0.556
<i>n</i> = 85 households			

patrilineal and matrilineal inheritance with a 2:1 patrilineal bias. Of camps that were inherited, 66% were inherited from the male head-of-household's kin, while 34% were inherited from the female head-of-household's kin. Of the 20% of camps that were not inherited, 58% were self-claimed and used by the household in prior years, while 42% of camps were newly established in the past year.

There is substantial heterogeneity in the birth order of children that inherit camps. Some of this variation can be understood in terms of life-history stage and the availability/unavailability of inheritors within lineages. Among the 13 families with detailed genealogical data, the four oldest families (those headed by parents over the age of 62; 31% of families) show camp inheritance by youngest sons and out-migration of daughters to their husbands' families or new camps. Three relatively younger families show inheritance to oldest sons (23% of families; in two of these cases, the oldest son was the only potential adult inheritor). Two families showed inheritance to older or middle daughters (15% of families; in one case, daughters were the only available adult inheritors; in the other case, however, the youngest adult son was independent and living with his wife's family). The remaining four families (31% of families) did not yet have inheritors. It can be noted that this subsample is biased towards patriliney in comparison to the larger sample described in figure 3.

Table 2*a* reports the analysis of intergenerational transmission of wealth in livestock. The estimate for the intergenerational transmission coefficient β is 0.42. This value is relatively low, about two-thirds of the mean for other pastoralist groups (0.67). Given the small sample size ($n = 21$), however, the confidence intervals for this estimate (0.19–0.64) are wide and overlap substantially with the mean ± 1 s.e. for other pastoralists (0.31–1.38) [28]. This result—a relatively low but imprecise estimate of intergenerational transmission—does not help distinguish between P6*a* and P6*b*. In other words, it remains unclear whether transmission is (or is not) exceptionally low here compared with other pastoralists.

The Gini coefficient for inequality in livestock wealth across households in this sample is 0.47 (confidence intervals 0.40–0.56; table 2*b*). This value is very close to the value from Khentii province in Mongolia (0.46; [49]) and the overall mean for other pastoralists (0.51) [28]. Consistent with P7*a* (and inconsistent with P7*b*), this suggests that inequality in Tuvan and Darkhad livestock wealth is similar to, not lower than, inequality observed among other pastoralists.

**Figure 4.** Reported grass quality as a function of whether camps were inherited. The asterisk (*) indicates a significant difference ($p < 0.001$); $n = 247$ camps.

The inheritance of camps is associated with higher reported quality of grasses available for animals (figure 4). It is also associated with reduced expenditures on hay purchased for the winter season ($p = 0.04$). The analysis of predictors of livestock wealth (table 3), however, indicates that inheritance of camps is not a good predictor of present-day livestock wealth. There are also no observable differences in the livestock wealth of families that inherit camps patrilineally versus matrilineally ($p = 0.40$). Livestock wealth instead shows the strongest correlations with education and material wealth outside of livestock (table 3).

4. Discussion

This study finds a system of informal camp ownership and inheritance that reflects seasonally and ecologically dependent adaptations. The persistent use of and transmission of rights to camps within Tuvan and Darkhad families makes sense in light of (i) the relatively high economic defensibility of the mountainous and riverine pastures typical of the study areas, and (ii) capital investments made to improve camps, like winter cabins and shelters. Overall, while differences in inheritance are logically patterned according to season and terrain, variance across categories is still quite modest; even the least commonly inherited locations, summer camps, are inherited at a rate of 71%, only somewhat less than the sample mean of 80%.

This case study expands our understanding of the space of possibilities for systems of property rights. It provides another example of a customary system of land-use rights that persists regardless of formal deeds, boundaries or fencing [68,69]. Similar conditions are found among the semi-sedentary hunter-fishers of northern Siberia [58,70,71]. In some ways, the norms governing use rights among Inner Asian nomads are similar to the informal use-based rights (usufruct) systems typical of small-scale horticulturalists. In the horticultural case, however, with the need for frequent and lengthy periods of fallow, claims to the land and its produce tend to be relatively ephemeral [72]. Among Tuvan and Darkhad nomads, by contrast, the benefits of maintaining continuous claims to camps tip the balance towards effectively private, long-term ownership of camps. In this, an emphasis on material capital, and high wealth inequality,

Table 3. Predictors of livestock wealth.

regressions predicting log(livestock)								
parameter	(a) bivariate models				(b) multivariate model			
	estimate	2.5%	97.5%	p-value	estimate	2.5%	97.5%	p-value
intercept	—	—	—	—	0.523	−1.971	3.017	0.676
log(material wealth)	0.281	0.076	0.486	0.008	0.192	−0.047	0.432	0.113
log(education)	0.603	0.111	1.095	0.017	0.369	−0.271	1.010	0.254
log(wages)	0.094	0.011	0.177	0.028	0.041	−0.064	0.146	0.439
age	0.010	−0.005	0.026	0.195	0.005	−0.012	0.023	0.566
camps inherited	−0.056	−0.740	0.627	0.870	0.028	−0.674	0.730	0.936
<i>n</i> = 67 households								

these herders have more in common with intensive agriculturalists than horticulturalists [5,73,74].

The substantial frequency of matrilineal inheritance of camps in this sample (34% of inherited camps) is noteworthy. This study contributes to a growing literature reinforcing the obvious importance of female-biased kinship behaviour across human societies [75]. Evolutionary social science will benefit from a more careful examination of the quantitative reality of behaviour directed toward consanguineous and affinal kin, independent of normative classifications [19,76]. More generally, what conditions favour different rates of matrilineal inheritance in the context of normatively patrilineal kinship systems?

Despite a relatively low estimate of intergenerational transmission ($\beta = 0.42$), the observed extent of inequality in this sample (Gini = 0.47) is very close to that of other pastoralists. This is not surprising: pastoralism has qualities—such as the durability and defensibility of animal wealth, and economies of scale—that promote inequality even in the absence of strong intergenerational correlations [28]. One can note that this estimate, while on par with other pastoralist groups, is still substantially lower than the Gini for household wealth estimated at the national level for the Russian Federation and the USA in 2000 (Gini = 0.7 and 0.8, respectively; [52]).

Ethnographic observation of the households in this sample supports the impression of non-negligible intergenerational correlations in wealth within families. The adult children of the wealthiest herders of the older generation were observably better off in comparison with the adult children of poorer parents. The significantly positive estimate of intergenerational transmission in this sample (with the confidence intervals for β ranging between 0.19 and 0.64) validates that impression. What might explain why this estimate is relatively low compared to other pastoralists? The lack of association between camp inheritance and wealth suggests that traditional channels of inheritance may currently be less important determinants of economic success compared to educational attainment and socio-economic resources outside of pastoralism. Weak markets for pastoral goods, limited market access, losses during the Soviet and post-Soviet periods, and opportunities for generating wealth outside the pastoral economy may also have disrupted the signal of transmission between generations.

The economic landscape of rural Inner Asia continues to be dynamic and heterogeneous. While herders depend substantially on economic links to towns and settlements, opportunities for stable employment remain scarce. The adults in this sample have, at different times over the past half-century, been employed as automobile drivers, teachers, lawyers, nurses, mechanics, police, miners and construction workers. Following the breakup of the Soviet Union and the transition from a planned economy, risk-buffering and subsistence needs became predominant in rural Tuva, as in other areas of Siberia [60]. This recent history may be important in interpreting the observed patterns of intergenerational transmission and inequality.

Ethics. All methods were approved by the Institutional Review Board at Emory University (Emory IRB no. 82568) and the National Museum of Mongolia.

Data accessibility. The data and code associated with this research are available from the GitHub repository: <https://github.com/system-science/inheritance> [77].

The data are provided in the electronic supplementary material [78].

Authors' contributions. P.L.H.: conceptualization, formal analysis, investigation, methodology, project administration, resources, supervision, visualization, writing—original draft, writing—review and editing; A.Z.R.: conceptualization, data curation, formal analysis, writing—original draft, writing—review and editing; B.J.: conceptualization, investigation, methodology, project administration, resources, supervision, writing—review and editing; J.K.C.: conceptualization, investigation, methodology, project administration, resources, supervision, writing—original draft, writing—review and editing; J.P.Z.: conceptualization, investigation, methodology, resources, supervision, writing—review and editing; S.A.C.: conceptualization, investigation, methodology, project administration, resources, supervision, writing—original draft, writing—review and editing.

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References

- Brown JL. 1964 The evolution of diversity in avian territorial systems. *Wilson Bull.* **76**, 160–169.
- Dyson-Hudson R, Smith EA. 1978 Human territoriality: an ecological reassessment. *Am. Anthropol.* **80**, 21–41. (doi:10.1525/aa.1978.80.1.02a00020)
- DeScioli P, Wilson BJ. 2011 The territorial foundations of human property. *Evol. Hum. Behav.* **32**, 297–304. (doi:10.1016/j.evolhumbehav.2010.10.003)
- Bowles S, Choi J-K. 2013 Coevolution of farming and private property during the early Holocene. *Proc. Natl Acad. Sci. USA* **110**, 8830–8835. (doi:10.1073/pnas.1212149110)
- Hooper PL, Smith EA, Kohler TA, Wright HT, Kaplan HS. 2016 Ecological and social dynamics of territoriality and hierarchy formation. In *The emergence of premodern states* (eds J Sabloff, P Sabloff), pp. 105–130. Santa Fe, NM: SFI Press.
- Hartley T. 2019 The continuing evolution of ownership. *PLoS ONE* **14**, e0211871. (doi:10.1371/journal.pone.0211871)
- Goody J. 1969 Inheritance, property, and marriage in Africa and Eurasia. *Sociology* **3**, 55–76. (doi:10.1177/003803856900300104)
- Hann CM. 1998 *Property relations: renewing the anthropological tradition*. Cambridge, UK: Cambridge University Press.
- Bowles S, Gintis H. 2002 The inheritance of inequality. *J. Econ. Perspect.* **16**, 3–30. (doi:10.1257/089533002760278686)
- Borgerhoff Mulder M *et al.* 2009 Intergenerational wealth transmission and the dynamics of inequality in small-scale societies. *Science* **326**, 682–688. (doi:10.1126/science.1178336)
- Dow GK, Reed CG. 2013 The origins of inequality: insiders, outsiders, elites, and commoners. *J. Political Econ.* **121**, 609–641. (doi:10.1086/670741)
- Dyson-Hudson R, Dyson-Hudson N. 1980 Nomadic pastoralism. *Annu. Rev. Anthropol.* **9**, 15–61. (doi:10.1146/annurev.an.09.100180.000311)
- Sneath D. 2001 Notions of rights over land and the history of Mongolian pastoralism. *Inner Asia* **3**, 41–58. (doi:10.1163/146481701793647750)
- Donahoe B. 2006 Who owns the taiga? inclusive vs. exclusive senses of property among the Tozhu and Tofa of southern Siberia. *Sibirica* **5**, 87–116. (doi:10.3167/136173606780265306)
- Robinson LW. 2019 Open property and complex mosaics: variants in tenure regimes across pastoralist social-ecological systems. *Int. J. Commons* **13**, 804–826. (doi:10.18352/ijc.903)
- Vainshtein S. 1980 *Nomads of South Siberia: the pastoral economies of Tuva*. Cambridge, UK: Cambridge University Press.
- Fernández-Giménez ME. 1999 Sustaining the steppes: a geographical history of pastoral land use in Mongolia. *Geogr. Rev.* **89**, 315–342. (doi:10.1111/j.1931-0846.1999.tb00222.x)
- Joly F, Lefebvre G, Sandoz A, Hubert B. 2018 Does the ecological quality of inherited campsites cause persistent inequalities and poverty in pastoral Mongolia? *Rangeland J.* **40**, 219–230. (doi:10.1071/RJ17052)
- Borgerhoff Mulder M *et al.* 2019 Differences between sons and daughters in the intergenerational transmission of wealth. *Phil. Trans. R. Soc. B* **374**, 20180076. (doi:10.1098/rstb.2018.0076)
- Holden CJ, Mace R. 2003 Spread of cattle led to the loss of matrilineal descent in Africa: a coevolutionary analysis. *Proc. R. Soc. B* **270**, 2425–2433. (doi:10.1098/rspb.2003.2535)
- Scelza BA, Prall SP, Levine NE. 2019 The disequilibrium of double descent: changing inheritance norms among Himba pastoralists. *Phil. Trans. R. Soc. B* **374**, 20180072. (doi:10.1098/rstb.2018.0072)
- Barth FW. 1961 *Nomads of South Persia: the Basseri tribe of the Khamseh confederacy*. Boston, MA: Little, Brown and Company.
- Holden CJ, Sear R, Mace R. 2003 Matriliney as daughter-biased investment. *Evol. Hum. Behav.* **24**, 99–112. (doi:10.1016/S1090-5138(02)00122-8)
- Ewing TE. 1981 The forgotten frontier: South Siberia (Tuva) in Chinese and Russian history, 1600–1920. *Cent. Asiatic J.* **25**, 174–212.
- Finke P. 2000 From 'common property' to open access: changing pastoral land tenure in post-socialist Mongolia. In *8th Biennial Conf. of the Int. Association for the Study of Common Property, 31 May–4 June 2000, Bloomington, Indiana*. Utrecht, The Netherlands: IASC Commons.
- Upton C. 2005 Institutions in a pastoral society: processes of formation and transformation in post-socialist Mongolia. *Comp. Stud. South Asia, Africa Middle East* **25**, 584–599. (doi:10.1215/1089201X-25-3-584)
- Li WJ, Ali SH, Zhang Q. 2007 Property rights and grassland degradation: a study of the Xilingol pasture, Inner Mongolia, China. *J. Environ. Manag.* **85**, 461–470. (doi:10.1016/j.jenvman.2006.10.010)
- Borgerhoff Mulder M, Fazzio I, Irons W, McElreath RL, Bowles S, Bell A, Hertz T, Hazzah L. 2010 Pastoralism and wealth inequality: revisiting an old question. *Curr. Anthropol.* **51**, 35–48. (doi:10.1086/648561)
- Erdenebaatar B. 2003 Studies on long-distance transhumant grazing systems in Uvs and Khuvsgul aimags of Mongolia, 1999–2000. In *Transhumant grazing systems in temperate Asia* (eds JM Suttie, SG Reynolds), pp. 31–68. Rome, Italy: Food & Agriculture Organization of the United Nations.
- Arakchaa T. 2009 Household and property relations in Tuva. Masters thesis, Department of Anthropology, Boise State University, Boise, ID, USA.
- Ahearn A. 2016 The role of kinship in negotiating territorial rights: exploring claims for winter pasture ownership in Mongolia. *Inner Asia* **18**, 245–264. (doi:10.1163/22105018-12340067)
- Humphrey C. 1983 *Karl Marx collective: economy, society and religion in a Siberian collective farm*. Cambridge Studies in Social Anthropology No. 40. Cambridge, UK: Cambridge University Press.
- Wood A. 1985 Book review: Karl Marx collective: economy, society and religion in a Siberian collective farm. *Slavonic East Eur. Rev.* **63**, 313–314.
- Humphrey C. 1998 *Marx went away: but Karl stayed behind*. Ann Arbor, MI: University of Michigan Press.
- Marchina C. 2021 *Normadic pastoralism among the Mongol herders: multispecies and spatial ethnography in Mongolia and Transbaikalia*. Amsterdam, The Netherlands: Amsterdam University Press.
- Humphrey C, Sneath D. 1999 *The end of nomadism? society, state, and the environment in Inner Asia*. Durham, NC: Duke University Press.
- Clark JK. 2014 Modeling late prehistoric and early historic pastoral adaptations in northern Mongolia's Darkhad depression. PhD dissertation, University of Pittsburgh, Pittsburgh, PA, USA.
- Honeychurch W. 2015 *Inner Asia and the spatial politics of empire: archaeology, mobility, and culture contact*. New York, NY: Springer.
- Lugli F. 2021 The use of space in steppe pastoralist winter camps—an ethnoarchaeological point of view. *Tomsk State Univ. J. Hist.* **69**, 92–96. (doi:10.17223/19988613/69/13)
- Kazato M. 2006 The local value and right to winter camps under the land privatization policy in postsocialist Mongolia. In *11th Biennial Conf. of Int. Association for the Study of Common Property, 19 June 2006, Bali, Indonesia*. Utrecht, The Netherlands: IASC Commons.
- Fernández-Giménez ME. 2002 Spatial and social boundaries and the paradox of pastoral land tenure: a case study from postsocialist Mongolia. *Hum. Ecol.* **30**, 49–78. (doi:10.1023/A:1014562913014)
- Lindholm C. 1986 Kinship structure and political authority: the Middle East and Central Asia. *Comp. Stud. Soc. Hist.* **28**, 334–355. (doi:10.1017/S001041750001389X)
- Kahn P. 1984 *The secret history of the Mongols: the origin of Chingis Khan*. Boston, MA: Cheng & Tsui Company.
- Rossabi M. 2005 *Modern Mongolia: from khans to commissars to capitalists*. Berkeley, CA: University of California Press.
- De Nicola B. 2016 The economic role of Mongol women: continuity and transformation from Mongolia to Iran. In *The Mongols' Middle East: continuity and transformation in Ilkhanid Iran* (eds B De Nicola, C Melville), pp. 79–105. Amsterdam, The Netherlands: Brill.
- Broadbridge AF. 2018 *Women and the making of the Mongol Empire*. Cambridge, UK: Cambridge University Press.

47. Holmgren J. 1986 Observations on marriage and inheritances practices in early Mongol and Yüan society, with particular reference to the levirate. *J. Asian Hist.* **20**, 127–192.
48. Shahrani NM. 2002 *The Kyrgyz and Wakhi of Afghanistan: adaptations to closed frontiers and war*. Seattle, WA: University of Washington Press.
49. Murphy DJ. 2014 Booms and busts: asset dynamics, disaster, and the politics of wealth in rural Mongolia. *Econ. Anthropol.* **1**, 104–123. (<https://anthrosource.onlinelibrary.wiley.com/doi/abs/10.1002/sea2.12007>)
50. Solon G. 2002 Cross-country differences in intergenerational earnings mobility. *J. Econ. Perspect.* **16**, 59–66. (doi:10.1257/089533002760278712)
51. Rogers JD, Cioffi-Revilla C, Linford SJ. 2015 The sustainability of wealth among nomads: an agent-based approach. In *Mathematics and archaeology* (eds I Bogdanovic, J Barcelo), pp. 431–447. Boca Raton, FL: CRC Press.
52. Davies JB. 2009 Wealth and economic inequality. In *The Oxford handbook of economic inequality* (ed. W Salverda *et al.*), pp. 127–149. Oxford, UK: Oxford University Press.
53. Kohler TA, Smith ME (eds) 2018 *Ten thousand years of inequality: the archaeology of wealth differences*. Tucson, AZ: University of Arizona Press.
54. Irons W. 1975 The Yomut Turkmen: a study of social organization among a central Asian Turkic-speaking population. In *Anthropological Papers, No. 58*. Ann Arbor, MI: University of Michigan.
55. Kuehnast KR, Dudwick N. 2004 Better a hundred friends than a hundred rubles? social networks in transition—the Kyrgyz Republic. In *World Bank Working Paper No. 39*. Washington, DC: World Bank.
56. Frohlich B, Hunt DR. 2006 A history not to be forgotten: mass burials in Mongolia. *AnthroNotes* **27**, 1–5. (doi:10.5479/10088/22415)
57. Dorzhu Z, Irgit O. 2017 Political repressions in the Tuva People's Republic: was it possible to avoid them? *J. Siberian Fed. Univ. Hum. Soc. Sci.* **7**, 957–964. (doi:10.17516/1997-1370-0104)
58. Ziker JP. 2003 Assigned territories, family/clan/communal holdings, and common-pool resources in the Taimyr Autonomous Region, northern Russia. *Hum. Ecol.* **31**, 331–368. (doi:10.1023/A:1025024804641)
59. Ziker JP, Schnegg M. 2005 Food sharing at meals: kinship reciprocity, and clustering in the Taimyr Autonomous Okrug, northern Russia. *Hum. Nat.* **16**, 178–210. (doi:10.1007/s12110-005-1003-6)
60. Ziker JP, Rasmussen J, Nolin DA. 2016 Indigenous Siberians solve collective action problems through sharing and traditional knowledge. *Sustain. Sci.* **11**, 45–55. (doi:10.1007/s11625-015-0293-9)
61. Rao MP, Davi NK, D D'Arrigo R, Skees J, Nachin B, Leland C, Lyon B, Wang SY, Byambasuren O. 2015 Dzuds, droughts, and livestock mortality in Mongolia. *Environ. Res. Lett.* **10**, 074012. (doi:10.1088/1748-9326/10/7/074012)
62. Hooper PL. 2020 Quantitative description of the pastoral economy of western Tuvan nomads. *New Res. Tuva* **4**, 19–27. (doi:10.25178/nit.2020.4.2)
63. Balinova N *et al.* 2022 Analysis of polymorphism of uniparental markers in reindeer-herding populations: the Tozhu Tuvans of Russia and the Tsaatans of Mongolia. *Coll. Antropol.* **46**, 79–86. (doi:10.5671/ca.46.2.1)
64. R Core Team. 2022 *R: a language and environment for statistical computing*. Version 4.0.5. Vienna, Austria: R Foundation for Statistical Computing. See <https://www.R-project.org/>.
65. Esarey J, Menger A. 2018 Practical and effective approaches to dealing with clustered data. *Polit. Sci. Res. Methods* **7**, 541–559. (doi:10.1017/psrm.2017.42)
66. Bates D, Mächler M, Bolker B, Walker S. 2015 Fitting linear mixed-effects models using lme4. *J. Stat. Softw.* **67**, 1–48. (doi:10.18637/jss.v067.i01)
67. Signorell A *et al.* 2020 DescTools: tools for descriptive statistics. R package version 0.99.34. See <https://cran.r-project.org/package=DescTools>.
68. Behnke R, Robinson S, Milner-Gulland EJ. 2016 Governing open access: livestock distributions and institutional control in the Karakum Desert of Turkmenistan. *Land Use Policy* **52**, 103–119. (doi:10.1016/j.landusepol.2015.12.012)
69. Moritz M *et al.* 2018 Emergent sustainability in open property regimes. *Proc. Natl Acad. Sci. USA* **115**, 12 859–12 867. (doi:10.1073/pnas.1812028115)
70. Ziker JP. 2002 *Peoples of the tundra: northern Siberians in the post-communist transition*. Prospect Heights, IL: Waveland Press.
71. Ventsel A. 2006 *Reindeer, Rodina and reciprocity: kinship and property relations in a Siberian village*. Münster, Germany: LIT Verlag.
72. Gurven M, Borgerhoff Mulder M, Hooper PL *et al.* 2010 Domestication alone does not lead to inequality: intergenerational wealth transmission among horticulturalists. *Curr. Anthropol.* **51**, 49–64. (doi:10.1086/648587)
73. Kaplan HS, Hooper PL, Gurven M. 2009 The evolutionary and ecological roots of human social organization. *Phil. Trans. R. Soc. B* **364**, 3289–3299. (doi:10.1098/rstb.2009.0115)
74. Shenk MK *et al.* 2010 Intergenerational wealth transmission among agriculturalists: foundations of agrarian inequality. *Curr. Anthropol.* **51**, 65–83. (doi:10.1086/648658)
75. Mattison SM, Shenk MK, Thompson ME, Borgerhoff Mulder M, Fortunato L. 2019 The evolution of female-biased kinship in humans and other mammals. *Phil. Trans. R. Soc. B* **374**, 20190007. (doi:10.1098/rstb.2019.0007)
76. Hooper PL, Gurven M, Winking J, Kaplan HS. 2015 Inclusive fitness and differential productivity across the life course determine intergenerational transfers in a small-scale human society. *Proc. R. Soc. B* **282**, 20142808. (doi:10.1098/rspb.2014.2808)
77. Hooper PL, Reynolds AZ, Jamsranjav B, Clark JK, Ziker JP, Crabtree SA. 2023 Inheritance and inequality among nomads of South Siberia. GitHub repository. (<https://github.com/systemscience/inheritance>)
78. Hooper PL, Reynolds AZ, Jamsranjav B, Clark JK, Ziker JP, Crabtree SA. 2023 Inheritance and inequality among nomads of South Siberia. Figshare. (doi:10.6084/m9.figshare.c.6662587)