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Wealth of nomads – an exploratory analysis of livestock inequality in the Saami reindeer husbandry

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The evolution of political complexity is a perennial issue in humanities and social sciences. While social inequality is pervasive in contemporary human societies, there is a view that livestock, as the primary source of wealth, limits the development of inequalities, making pastoralism unable to support complex or hierarchical organisations. Thus, complex nomadic pastoral organisation is predominantly caused by external factors: historically, nomadic political organisations mirrored the neighbouring sedentary population's sophistication. Using governmental statistics from 2001 to 2018 on reindeer herding in Norway, this study demonstrates that there is nothing apparent in pastoral adaptation with livestock as the main base of wealth that levels wealth inequalities and limits social differentiation. This study found that inequality generally decreased in terms of the Gini coefficient and cumulative wealth. For example, the proportion owned by the wealthy decreased from 2001 to 2018, whereas the proportion owned by the poor increased. Nevertheless, rank differences persisted over time with minor changes. In particular, being poor is stable; around 50% of households ranked as poor in 2001 continued to be so in 2018. In summary, the results of this study indicate that pastoral wealth inequality follows the same pattern as all forms of wealth. Wealth accumulates over time, and while the highest earners can save much of their income (i.e., newborn livestock), low earners cannot. Thus, high-earners can accumulate more wealth over time, leading to considerable wealth inequality.

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Introduction

In 1242, Europe was on the brink of destruction as the Mongol armies stationed in Hungary and Serbia prepared to conquer the remainder of the continent (May, 2007). Only the death of the Great Khan stopped the Mongol advance, preventing Europe from facing an inevitable conquest (Chaliand, 2004). Twenty-five years later, the Mongol Empire, known as the Yuan dynasty (1271–1368, Atwood, 2023:xxxix), peaked and became the largest in history (Chaliand, 2004, May, 2007).

Like empires, the evolution of political complexity is among the endless questions of the humanities and social sciences (Kradin, 2008). For example, the debate surrounding the political organisation of nomadic pastoralists has been sparked by the rise and fall of Central Asian nomadic empires (Kradin, 2008, Kradin, 2011, Kradin, 2017, Kradin, 2019, Sneath, 2008, Barfield, 2020, Barfield, 1989, Barfield, 1991, Barfield, 2001, Turchin, 2003, Turchin, 2007, Turchin and Gavrilets, 2009). The leading view is that nomadic political organisations mirrored the sophistication of the neighbouring sedentary population (Barfield, 1989, Barfield, 1993, Barfield, 2020). Nomadic empires have thus been viewed as 'shadow empires' because they developed in the shadow of agricultural civilisations (Barfield, 2001). Consequently, the most complex and centralised organisations emerged in the Eurasian Steppe and then as a response to powerful states, such as China. In contrast, pastoralists in East Africa, who only faced stateless rivals, had decentralised political organisations (Barfield, 1993). Thus, the evolution of political complexity is decoupled from the internal demands of organising pastoral production. Instead, it was shaped by the necessity to come to terms with the outside world (Barfield, 1989, Barfield, 2001, Barfield, 2020, Khazanov, 1994). Underlying this is the idea that the people on the Eurasian steppe depended on agricultural products from their sedentary neighbours (Beckwith, 2009), resulting in

> "… a model of state formation among early nomads in which nomadic insufficiencies and needs are transformed into a "push" force that placed a continuous pressure upon sedentary people, made nomads compete with large sedentary states, and provided the incentive to import and adapt institutions from them" (Di Cosmo, 2015:51).

One of the critical characteristics of pastoralism is its susceptibility to catastrophic losses of livestock as a result of environmental factors such as diseases, droughts, and snow (Borgerhoff Mulder et al., 2010, Barth, 1964, Bradburd, 1982, Dahl and Hjort, 1976, Sandford, 1983, McPeak, 2005, McPeak, 2006, Næss and Bårdsen, 2010, Næss and Bårdsen, 2013, Næss and Bårdsen, 2015, Næss et al., 2011, Næss, 2013). Moreover, because livestock fluctuations, due to losses induced by predation and environmental stochasticity, do not distinguish between the poor and the rich, they have been argued to decrease economic differentiation (Barth, 1961, Barth, 1964, Bradburd, 1982) and diminish household inequalities (Dahl, 1979, Salzman, 1980). Black (1972:621), for example, argued that

> "… the hazards and uncertainties of a nomadic pastoral existence in a hostile environment had acted as a leveller to preserve a considerable degree of homogeneity between family fortunes".

Bradburd (1982) argued that there is a general agreement that livestock have the potential for both increase and loss. Thus, livestock is an unstable form of wealth (cf. Borgerhoff Mulder et al., 2010, Næss, 2010, Næss, 2012 for livestock as wealth) and Dahl (1979:270–271) argued that in contexts where diversification is possible,

> "… the wealthy herd-owner can escape the risks of pastoralism by transferring some of his resources into projects that are not vulnerable to drought or disease".

Thus, agriculture is often the favoured factor shaping the evolution of political complexity (Ringen et al. 2021). Nevertheless, an analysis of 89 hunter-gatherer communities along the Pacific coast of North America found that hierarchies, marking the beginning of organisational complexity, emerge when the availability of economically beneficial resources can be regulated rather than being directly influenced by the degree of conflict (Smith and Codding, 2021). Similarly, a cross-cultural study of 186 non-industrial societies found that increased resource use intensity rather than agriculture resulted in higher technological and social differentiation (Ringen et al., 2021). Empirical evidence also indicates that livestock losses due to environmental stress exacerbate rather than limit wealth inequalities (Fratkin and Roth, 1990, Grandin, 1983, Borgerhoff Mulder and Sellen, 1994, Bradburd, 1982). Moreover, livestock accumulation is an efficient strategy for countering environmental catastrophes among pastoralists in Norway and Kenya (McPeak, 2005, Næss and Bårdsen, 2010, Næss and Bårdsen, 2013). Thus, herd accumulation significantly affects long-term household survival in stochastic environments (Mace, 1993, Mace and Houston, 1989), and serves as a critical reservoir for investment in the future (Borgerhoff Mulder et al., 2010).

In short, environmental stochasticity does not negate wealth inequalities. Without natural enemies and institutions promoting wealth equality, chance alone can result in significant disparities. Moreover, even if no individual is inherently superior to others, inequality can emerge if wealth is subject to random loss or gain.[1] This is particularly pertinent when gains and losses are multiplicative, as in the case of stock market returns and population growth rates (Scheffer et al., 2017:13154, Fig. 1).

Additionally, comparative evidence indicates that pastoral households can own animals without looking after them by leasing livestock to other herders. Among Turkmen, this was

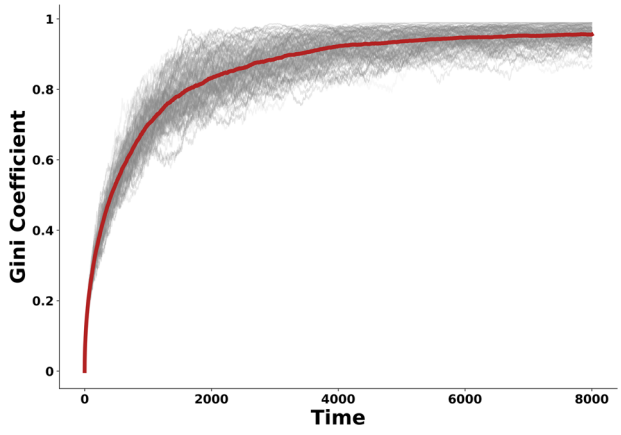

Fig. 1 Significant inequalities can develop purely by chance, even in a world with unlimited resources. The simulation was initialised with 100 individuals (i) with 100 units of wealth and ran 150 times, each running for 8000 years. Following Scheffer et al., (2017), at each time step, we draw the return rate on wealth, r_i, for everyone independently from a normal distribution: $r_{i,t}$~N(0.05, 0.05). In effect, for any individual, changes in wealth are defined as $Wealth_{i,t+1} = Wealth_{i,t} \times r_{i,t} + Wealth_{i,t}$ at each time step. In effect, it simulates gain or loss as multiplicative in an unlimited world (see Scheffer et al., 2017 for an example where resources are capped, meaning there is a limit on total wealth, but the effect is similar). The wide red line shows the yearly average across simulations.

called *emanet*, *saun* among the Kazakhs, and *süreg tavikh* in Mongolia (Sneath, 2008). Among the Rendille in Kenya, a similar system, *ma*, exists where female camels are shared between different owners (Spencer, 1973:37). Among the Basseri in present-day Iran, Barth (1961:13-4) documents a variety of contracts whereby wealthy herders farm parts of their herds to propertyless shepherds. Among the Maasai straddling the Kenya-Tanzania border, Hedlund (1979:19) found that wealthy households distributed a large part of their herds to poorer families, only returned to their original owners during prolonged droughts. Moreover, wealth accumulation was an essential prerequisite for what Beckwith (2009) calls the 'Central Eurasian Culture Complex': the necessity for lords to support their *comitatus* warriors (a war band of friends sworn to defend the lord to death) by supplying them with luxury products and a high standard of living.[2] The fact that livestock was a source of wealth was also demonstrated by raiding patterns. The nomads of the steppe zone in central Eurasia typically targeted livestock and people rather than agricultural produce during their attacks (Beckwith, 2009:325). Similarly, Mathew and Boyd (2011) argue that Turkana in East Africa engages in raids to acquire cattle from neighbouring ethnic groups.

Furthermore, livestock differentials can persist across generations and pass down as an inheritable form of wealth (Borgerhoff Mulder et al., 2009), allowing unequal distribution of resources to accumulate and persist over time (Haynie et al., 2021). Thus, material wealth is closely linked to socioeconomic inequalities (Gurven et al., 2010, Smith Eric et al., 2010), especially in agricultural and pastoral societies (Borgerhoff Mulder et al., 2009, Smith Eric et al., 2010). In short, livestock as a form of material wealth is defensible, accumulable, durable, and transferable, all critical contributors to the development and persistence of wealth inequalities (Hooper et al., 2023, Mattison et al., 2016, Smith Eric et al., 2010).

While pastoral wealth inequalities have been documented previously (e.g., Roth, 1990, Borgerhoff Mulder et al., 2010, Fratkin and Roth, 1990, Catley and Ayele, 2021), few studies have explored the long-term dimensions of pastoral wealth inequalities. Here, we analysed a long time series, spanning from 2001 to 2018, within a pastoral setting to investigate the potential disparities in wealth among reindeer herders in Norway. Additionally, our data do not represent a sample of reindeer herders but encompass the entire population of licenced reindeer herders in Norway. First, we explore temporal trends in livestock wealth by investigating (1) temporal trends in the Gini coefficient and (2) cumulative wealth ownership. Second, we explore (3) the relationship between herd size at the start and end of the time series, (4) changes in rank and position over time, and (5) the distribution of livestock for wealthy and poor households in both 2001 and 2018 across all years. Finally, because there is a known regional difference between reindeer herders in northern and southern Norway (see below and S1), this study also aimed to explore regional differences in wealth inequalities.

Materials and methods

The Saami reindeer husbandry in Norway. Reindeer herding is a crucial aspect of the Sami culture in northern Fennoscandia (Bostedt, 2001). Reindeer pastoralism traditionally relied on families or households that followed their herds year-round. The pastoral economy predominantly depended on reindeer products (Vorren, 1978, see S1 for more details). While Saami reindeer herding is a comparable small industry, it is essential for the Saami economy and culture. Approximately 40% of Norway's total area is used by reindeer herders (Norwegian Agriculture Agency, 2021), with regional contrasts in socio-ecological factors (see below for details).

The Norwegian Ministry of Agriculture and Food and the Norwegian Agriculture Agency manage reindeer husbandry in Norway. Reindeer husbandry is divided into six separate areas: (1) East-Finnmark, (2) West-Finnmark, (3) Troms, (4) Nordland; (5) North-Trøndelag, and (6) South-Trøndelag/Hedmark. East- and West-Finnmark pasture areas account for approximately 70% of reindeer husbandry in Norway.[3]

Within these areas, Sami reindeer herders are organised into three layers. The '*siida-share*' is a licence granted by the Government allowing owners to manage a herd of reindeer within a specific area, i.e., a reindeer herding household. An individual or multiple licence holders are affiliated with a *siida*, a cooperative herding group comprising autonomous households. It was traditionally organised around kinship (siidas can also include non-kin, Næss et al., 2021). Norway has 99 summer siidas and 150 winter siidas (Norwegian Agriculture Agency, 2018:23). Lastly, *siidas* are organised into *districts*: formal administrative units delineated by the government (cf. Næss and Bårdsen, 2013, Næss and Bårdsen, 2015, Næss et al., 2021).

Comparative aspects of reindeer herding. Riseth and Vatn (2009, see also Næss and Bårdsen, 2015) argue that reindeer herders in northern Norway experience greater coordination challenges than in southern Norway. Næss (2020) has argued that this stems from historical differences. In the past, competition among herders in the northern region of Norway was mainly intra-group, while those in the southern areas faced stiff competition from an expanding farming sector. As a result of the history of intra-group rivalry, herders in the northern regions have been grappling with heightened conflicts and a noticeable lack of mutual trust (for details, see Næss, 2020). In contrast, herders in southern Norway had to contend with the encroachment of an expanding agricultural sector for the use of land. As a result, a unified approach was necessary to address the pressure from the farming community (Holand, 2003). Thus, in southern Norway, a history of herder-farmer conflicts has led to increased coordination and trust among herders (Næss, 2020). Fisktjønmo et al. (2021) found that cooperation is structured differently in the northern and southern parts of Norway, with kinship being more crucial in the north and cooperation around individuals being more critical in the south.

Apart from coordination and cooperation, the apparent regional difference concerns reindeer abundance (Riseth, 2003, Tveraa et al., 2007). Abundance in the northern parts increased between 2000 and 2010, peaked in 2010/2011 and decreased to a stable level after that (Norwegian Agriculture Agency, 2018: fig. 4.1). In contrast, abundance appears to have decreased in the southern parts during the early 2000s (Næss and Bårdsen, 2015, Fig. 1a) and stabilised between 2010 and 2018 (Norwegian Agriculture Agency, 2018: fig. 4.3). Additionally, herders in southern Norway tend to slaughter more calves than those in northern Norway, despite a relatively similar temporal trend in net meat kilo prices (Næss and Bårdsen, 2015).

Study protocol and statistical analyses. As in previous studies, e.g., Næss et al., (2011, 2012) and Næss and Bårdsen (2010, 2013), the data used in this study are based on annual statistics compiled and published by the Norwegian Agriculture Agency (31st of March).

In this study, we used data for all Saami reindeer husbandry in Norway, covering the period between 2001 and 20018. This is in contrast to previous studies that focused only on (1) East- and West-Finnmark (Næss et al., 2009, Næss and Bårdsen, 2010, Næss et al., 2010, Næss et al., 2011, Næss et al., 2012, Næss and Bårdsen, 2013, Thomas et al., 2015, Thomas et al., 2016, Thomas

et al., 2018), (2) the contrast between East-/West-Finnmark and North-Trøndelag/South-Trøndelag/Hedmark (Næss and Bårdsen, 2015, Næss, 2020), or (3) the contrast between West-Finnmark and South-Trøndelag/Hedmark (Fisktjønmo et al., 2021, Næss et al., 2021). Thus, in this study, *North* encompasses West-Finnmark, East-Finnmark, Troms and Nordland reindeer husbandry areas, while *South* encompasses North-Trøndelag and South-Trøndelag/Hedmark reindeer husbandry areas (Fig. 2).

The exploration is split into two parts to elicit inequality in Saami reindeer husbandry. First, we explore temporal trends in livestock as wealth by investigating (1) temporal trends in Gini and (2) cumulative wealth ownership (see Table 1 for n and the selection criterion). The Gini coefficient ranges from 0, where all individuals own equal wealth, to 1, where one individual possesses all the wealth (see S1 for details of the calculations). While the Gini approach examines the distribution of reindeer for all households for all years, cumulative wealth investigates ownership profiles for the top and bottom 15% (measured in reindeer numbers) of the households in the North ($n = 61$) and South ($n = 10$) in 2001 and 2018. It investigates the proportion of reindeer owned by wealthy and poor herders in both regions. This approach makes it possible to examine the distribution of livestock inequality in reindeer husbandry. In effect, it provides descriptive patterns of livestock as wealth in the reindeer husbandry.

Second, we explore (3) the relationship between herd size at the start (N_{2001}) and end (N_{2018}) of the time series, (4) changes in rank and position over time, and (5) the distribution of reindeer for the wealthy and poor households in both 2001 and 2018 across all years. This approach sheds light on the underlying rationale for herd accumulation (see also Næss and Bårdsen, 2010, Næss and Bårdsen, 2013, Næss and Bårdsen, 2015, Næss et al., 2011). In effect, if changes in rank occur infrequently or if herd size at the start and end are correlated, having an initial large herd secure having a large herd over time.

Python 3.9.13 (Van Rossum and Drake, 2009) was used for (1) making data ready for analyses using the *pandas* 1.5.2 (McKinney, 2010) and *numpy* 1.23.5 (Harris et al., 2020) libraries; (2) statistical analyses performed using ordinary least squares (OLS) in the *statsmodel* 0.13.5 library (Seabold and Perktold, 2010); (4) plotting and visualisation of statistical results with the use of *matplotlib* 3.5.2 (Hunter, 2007) and *seaborn* 0.12.1 (Waskom, 2021) libraries. We computed the Gini coefficient by modifying the function developed by Olivia Guest (https://github.com/oliviaguest/gini/blob/master/gini.py).[4]

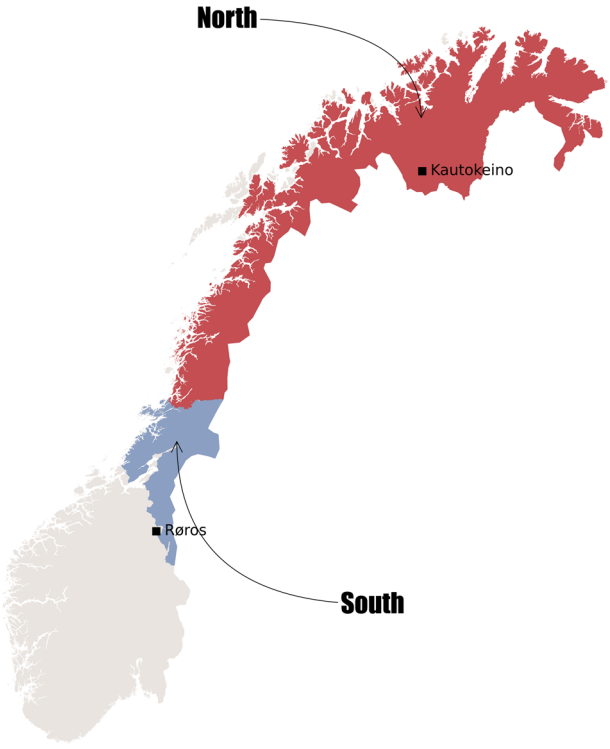

Fig. 2 Map of the study area in Norway (source: Norwegian mapping authority and Geonorge). *North* (marked in light red) designates East-Finnmark, West-Finnmark, Troms and Nordland reindeer husbandry areas. *South* (marked in light blue) designates North-Trøndelag and South-Trøndelag/Hedmark reindeer husbandry areas. Map created in Python 3.9.13 (Van Rossum and Drake, 2009) with background map from GADM (https://gadm.org/maps/NOR.html) and official reindeer pasture areas from NIBIO's kilden (https://kart8.nibio.no/nedlasting/dashboard).

Results

Temporal trends in livestock wealth. The temporal trends in Gini for the reindeer husbandry in Norway (Fig. 3) and the North and South (Fig. 4) decreased from 2001 to 2018. The average Gini coefficient for reindeer husbandry in Norway for all years was 0.34 (range: 0.29–0.41, Fig. 3). In the North, the across-year average Gini was 0.36 (range: 0.31–0.44), while this estimate was 0.15 (range: 0.12–0.19) in the South (Fig. 4). Year was a negative predictor for Gini in both regions [effect *Year*: −0.0047 for the North and −0.0048 for the South, see Fig. 4 for details] and the predicted decrease in Gini from the start (2001) to the end (2018) of the time series was 20% in the North and 43.2% in the South (Fig. 4).

As for cumulative wealth, in 2001, the top 61 households owned 34.4% of all reindeer in the North (a total of 42,995 reindeer), while the bottom 61 owned 3.1% (3863 reindeer). In 2018, this decreased to 30.5% (48,577 reindeer) for the top and increased to 4.7% (7357 reindeer) for the bottom (Fig. 5). In the South, the top ten households owned 21% (5208 reindeer) in 2001 of all the reindeer in the region, while the bottom ten owned 6.4% (1587 reindeer). In 2018, this had decreased to 19.4% (5055 reindeer) for the top and increased to 8% (2087 reindeer) for the bottom ten households (Fig. 5).

Table 1 The number of households used in different analyses and the selection criteria used, that is the minimum threshold for the number of reindeer a household needed to be included in each analysis.

	All	North	South	Selection criteria
Analyses				
Gini	680	605	75	≥0 reindeer
Cumulative Wealth	471	406	65	>10 reindeer in 2001 & 2018
N_{2001} & N_{2018}	440[a]	376	64	>70 reindeer in 2001, same as in Næss and Bårdsen (2010)

See Table S1 for number of households per year.
[a]Based on households present in both 2001 and 2018 only. 481 was present at both times; thus, 41 households had <70 reindeer in 2001 and were excluded from the analysis.

Temporal trends in rank and position. Initial herd size was a positive predictor of final herd size [effect N_{2001}: 0.54 for the North and 0.28 for the South; see Fig. 6 for details], i.e., households with more animals in 2001 tended to have more animals in 2018 (Fig. 6).

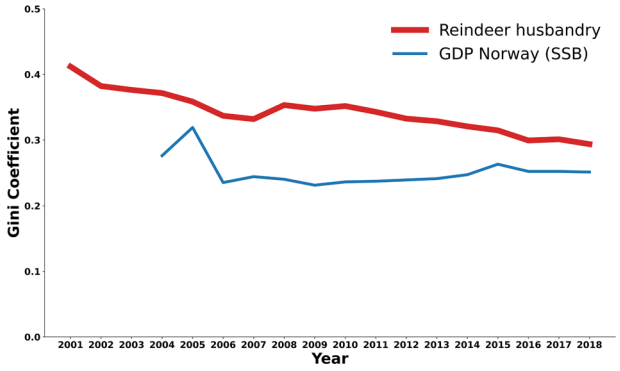

Fig. 3 Temporal trends in wealth inequality were measured as reindeer numbers in Saami reindeer husbandry in Norway. Data on Norway's Gross Domestic Product (GDP) were downloaded from the Statistics Norway (SSB: https://www.ssb.no/)[5].

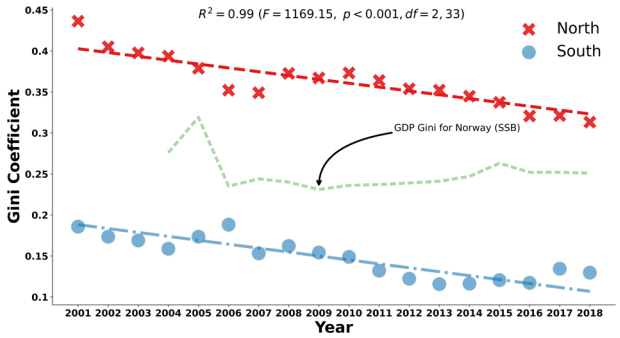

Fig. 4 Showing the linear relationship between the Gini coefficient and year for the North and South. Model parameters: *North* - the effect of *Year* = −0.0047 (95% CI: −0.0057, −0.0036). *South* - the effect of *Year* = −0.0001 (95% CI: −0.00011, −0.00010). Note that parameters for the South represent the estimated *difference* from those for the North. The model was fitted in Python 3.9.13 (Van Rossum and Drake, 2009), using OSL from the *statsmodels* 0.13.5 package (Seabold and Perktold, 2010).

In the North, 22 households (36.1% of the wealthy in 2001) were ranked wealthy in 2001 and 2018, while 32 (52.5% of the poor in 2001) were ranked poor in 2001 and 2018. Only one household changed rank from wealthy to poor from 2001 to 2018, while three changed from poor to wealthy (Fig. 7). In the South, three households (30%) were ranked wealthy in 2001 and 2018, while five (50%) were ranked poor in 2001 and 2018. No households changed from wealthy to poor from 2001 to 2018, whereas one changed from poor to wealthy (Fig. 7).

The average herd size across all years for the 22 households ranked as wealthy in 2001 and 2018 in the North was 1071.4 (±1 SD = 446.8) reindeer. For the 32 households ranked as poor in both 2001 and 2018, the average herd size was 126.6 (±1 SD = 85.1) reindeer (Fig. 8). In the South, the average herd size for the three households ranked as wealthy in both 2001 and 2018 was 490.3 (±1 SD = 30.3) reindeer. For the five households ranked as poor in both 2001 and 2018, the average herd size was 230.1 (±1 SD = 111.5) reindeer (Fig. 8).

Discussion

From 2001 to 2018, livestock inequality, measured by the Gini coefficient, decreased nationally and regionally. Furthermore, the cumulative wealth distribution follows a similar pattern in both regions: the proportion owned by the wealthy decreased from 2001 to 2018, whereas the proportion owned by the poor increased. Nevertheless, rank differences persist in both regions with minor changes, especially among the poor; around 50% of households ranked as poor in 2001 continued to be so in 2018.

Moreover, being wealthy or poor differed between regions. For example, households classified as poor in the South had, on average, larger herds than those in the North. Furthermore, compared to the South, wealthy households in the North had, on average, substantially more reindeer while at the same time experiencing more variation in reindeer numbers.

A large herd also secures a large herd in the future: a 1% increase in 2001 herd size predicts a ~0.54% increase in 2018 herd size for the North and ~0.27% for the South (as both variables were $\log_e$-transformed). Thus, herd accumulation is an effective strategy for countering the negative impacts of environmental hazards. This supports previous studies of Saami reindeer herders in northern Norway: wealthy households maintain their relative position over six years (Næss and Bårdsen, 2010: Fig. 1c) and before and after experiencing catastrophic losses (Næss and Bårdsen, 2013: Fig. 2b).

This study shows that being wealthy or poor differed between regions and that wealth in reindeer is more equally distributed

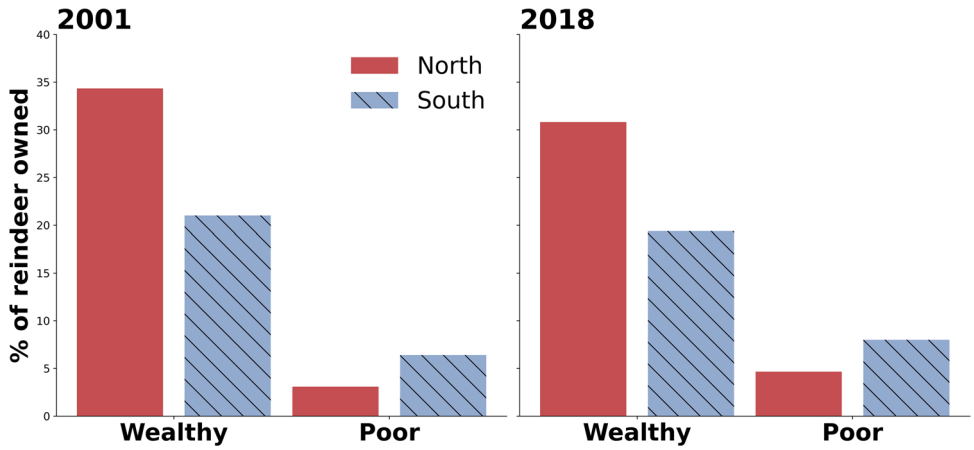

Fig. 5 Ownership profiles. Cumulative ownership for wealthy and poor households in 2001 and 2018 for the North (n = 61; 15% of the population in the North) and South (n = 10; 15% of the population in the South).

among herders in the South compared to the North. Riseth and Vatn (2009) have argued that due to their larger population, herders in the North face more significant challenges in coordinating pasture use. Competition for pastures might thus explain why herders in the North, and not in the South, have focused on having large herds as the dominant risk-management strategy (Næss, 2020, Næss and Bårdsen, 2010, Næss and Bårdsen, 2013). In the 1970s, the Norwegian state became more directly involved in reindeer husbandry through various subsidies and regulations. During this time, reforms were implemented to promote co-management and optimise production (Riseth and Vatn, 2009), a process that is still ongoing. Although herd growth in the North started before these reforms, Riseth and Vatn (2009) argue that instead of curbing herd accumulation, these reforms incentivised an increase in herd size in the region. In contrast, herders in the South participated actively and, in several instances, played a vital role in the institutional changes introduced by the authorities (Riseth and Vatn, 2009). As a result, the new policies aligned with the herders' goals by prioritising increased meat production over herd accumulation (Næss, 2020). Additionally, in a study using gift-giving to elicit differences in cooperative patterns between the North and the South, Fisktjønmo et al., (2021) found that in the South, higher levels of cooperation around an individual result in gifts being evenly distributed among other herders. In terms of cooperation, herders in the South adhere to the principle of equality when distributing gifts, while kinship is the primary factor influencing distribution in the North. While herders in the North aim to distribute gifts equally, this is limited to close kin, resulting in even distribution among related herders (Fisktjønmo et al., 2021). These results align with the diverging history of the regions: in the northern parts of Norway, the history of reindeer herding has been marked by competition between herders, leading to conflicts, lack of trust, and coordination issues. In contrast, in the southern parts of the country, herders competed mainly with farmers, resulting in high levels of coordination and trust between herders (Næss, 2020). Thus, the results from this study suggest that there is a link between wealth inequality and cooperation.

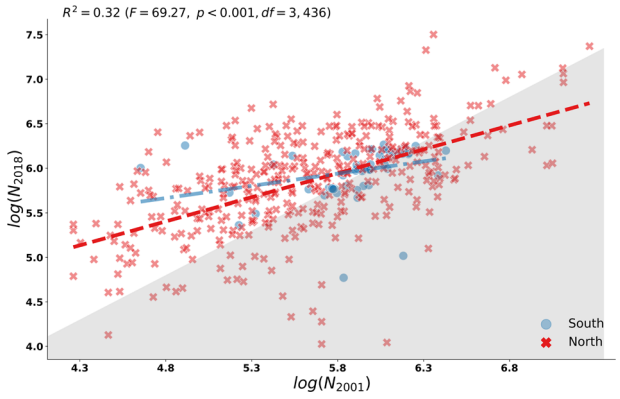

Fig. 6 Showing the linear relationship (on log_e-scale) between herd size at the start of the time series (N_{2001}) and at the end of the time series (N_{2018}). Points above the shaded area indicate herd increase, a point on the 45-degree line means that the start and stop herd sizes were equal, and points in the shaded region show a decrease. Model parameters: *North* - Intercept = 2.82 (95% CI: 2.40, 3.25) and slope $N_{2001} = 0.54$ (95% CI: 0.46, 0.61). *South* - Intercept = 1.52 (95% CI: −0.53, 3.57) and slope $N_{2001} = -0.26$ (95% CI: −0.61, 0.08). Note that parameters for the South represent the estimated *difference* from those for the North. Confidence intervals encompass 0 for the South, indicating no difference in the relationship between the North and South (see Fig. S1.1 for model diagnostics). *Model with no area or area interaction* - Intercept = 2.91 (95% CI: 2.50, 3.31) and slope $N_{2001} = 0.52$ (95% CI: 0.45, 0.59). All models were fitted in Python 3.9.13 (Van Rossum and Drake, 2009), using OSL from the *statsmodels* 0.13.5 package (Seabold and Perktold, 2010).

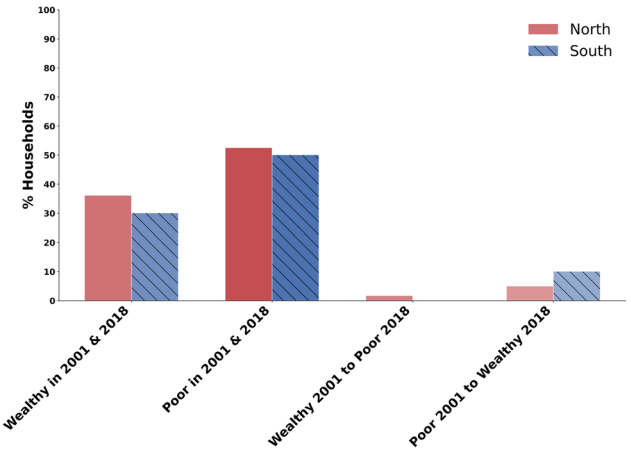

Fig. 7 Rank and position over time. The percentage of households being wealthy in both 2001 and 2018 ($n = 3$ for South and $n = 22$ for North), poor in 2001 and 2018 ($n = 5$ for South and $n = 32$ for North), changed rank from wealthy in 2001 to poor in 2018 ($n = 0$ for South and $n = 1$ for North), and changed rank from poor in 2001 to wealthy in 2018 ($n = 1$ for South and $n = 3$ for North).

Pastoral wealth inequalities have been described as a modern characteristic that contrasts with the traditional pastoral ethos of egalitarianism (present among reindeer herders, see e.g., Næss et al., 2021). For example, inequality has been found to be increasing among pastoralist populations that currently face restricted grazing, land privatisation, and unequal access to markets (Fratkin and Roth, 1990, see also, Borgerhoff Mulder et al., 2010). While these processes are also relevant for reindeer husbandry (cf. Næss, 2017, Næss and Bårdsen, 2015, Næss et al., 2021), this study indicates that wealth inequality is decreasing in both regions.

Traditionally, reindeer pastoralism was based on families or households that followed their herds throughout the year, with the pastoral economy being reliant on products derived from reindeer (Vorren, 1978). The more recent history of Sami reindeer husbandry can be summarised as being influenced by increased meat and market adaptation and industrialisation (Riseth, 2006). Sedentarisation, technological changes (primarily through the adoption of snowmobiles and later all-terrain vehicles during the late 1960s, see Riseth and Vatn, 2009), and the need to constantly maintain fences have resulted in a substantial increase in the costs associated with reindeer herding, thus increasing the demand for monetary income. According to Hausner et al., (2011), monetary income in reindeer husbandry mainly comes from (1) meat production, (2) government subsidies (as much as 46% Hausner et al., 2011 p. 8), and (3) spouses' wage income.[6] A survey undertaken by Hausner et al., (2011 p. 8–9) shows that 60% of respondents ($n = 77$) reported that spouses' wages are an essential part of household income, primarily from women, since most men work daily with the herds.

As indicated earlier, Dahl (1979:270–271) argued that, in environments where diversification is possible, wealthy herders can transfer resources into assets not susceptible to drought or disease (see also Barth, 1961, Barth, 1964 arguing the wealthiest households might find it more productive to invest the capital profit from livestock in other "adaptations" and end up leaving the nomadic way of life). This indicates that while the possibility of pastoral wealth differences exists, they are primarily contingent

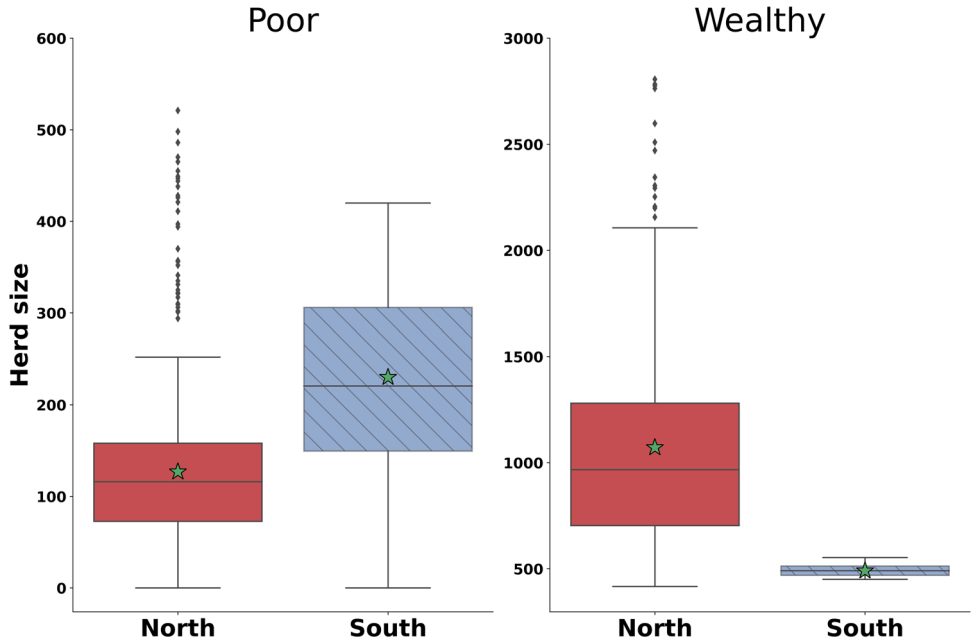

Fig. 8 Herd size distribution. The distribution of reindeer for wealthy and poor households in 2001 and 2018 (Fig. 7) for all years. Star shows the average.

upon circumstances beyond the realm of pastoral adaptation. In effect, the volatility of livestock as wealth necessitates the conversion of livestock wealth to other forms of wealth for wealth differentials to persist over time.

By failing to consider other vital sources of income and wealth in reindeer husbandry, it could be argued that the wealth inequalities observed in this study are partially an artefact of reindeer herders living in a modern welfare state with access to support systems absent in other pastoral regions. Nevertheless, comparative evidence reveals even more significant wealth inequalities among nomadic pastoralists without the same support system as in the Norwegian reindeer husbandry. For example, among the Rendille in Kenya, Roth (1990:446) found that the Gini coefficient for camel ownership was 0.57 while that for cattle was 0.85. Borgerhoff Mulder et al., (2010: 42) found that the average Gini coefficient for four pastoral populations was 0.51 (range = 0.346–0.694). Among the nomadic pastoralists in the Yenisei River in Tuva and northern Mongolia, Hooper et al., (2023:6) found the Gini coefficient for livestock wealth across households to be 0.47. As Fratkin and Roth (1990) observed among the Ariaal Rendille in Kenya, drought exacerbated socio-economic disparities, with wealthy households maintaining their affluence while middle and low-income households either remained at the same level or became impoverished. Similarly, Bradburd (1982) documented the impact of a particularly challenging year and a relatively prosperous year among Komanchi nomads in south-central Iran. While the wealthiest herd owners owned 59% of the tribe's total herd, they suffered only 19% of total losses (Bradburd, 1982:99). In contrast, the poorest owned only 6% of the tribe's animals but suffered 24% of the tribe's losses (Bradburd, 1982:99). Significantly,

> "… while wealthy herd owners lost 1.9% of their holdings, poor herd owners suffered losses that represented 25.6% of theirs" (Bradburd, 1982:99).

Thus, it was concluded that the net effect of experiencing good and bad years was that the wealthy experienced an increase in wealth, whereas the poor experienced a decrease in wealth (Bradburd, 1982:99). A recent study of agro-pastoralists in Karamoja found that 50% of the population owned 11.2% livestock. In contrast, the wealthiest 30% owned 69.3% of the livestock (Catley and Ayele, 2021:6). Moreover, as previously stated, historical evidence indicates that when nomads of the steppe zone in central Eurasia raided their neighbours, they usually took livestock and people, not agricultural produce (Beckwith, 2009:325). Similarly, Larson (1930) argued that, for the Mongols,

> "… wealth is counted according to the number of horses they own. Many princes possess thousands, in addition to numberless sheep, camels, and cattle. As there are no banks in Mongolia, a nobleman, when he has some money, at once turns it into animals of some kind".

Thus, comparative evidence indicates that persistent economic inequality characterises pastoral societies (Borgerhoff Mulder et al., 2010, Borgerhoff Mulder et al., 2009).

Evidence from the reindeer husbandry in Norway also indicates that additional sources of income are converted to livestock: Næss and Bårdsen (2015), for example, examined the impact of rising meat prices on slaughter strategies employed by Saami reindeer herders. Pastoralists may view livestock as investments, or "banks on the hoof", i.e., as insurance in unpredictable environments. Alternatively, they might adhere to the "law of supply", which suggests that suppliers should provide more of the product for sale when prices increase (Næss and Bårdsen, 2015:425). Concerning the first, when meat prices increase, pastoralists can slaughter fewer animals for the same financial gain, thus increasing herd size. While slaughter strategies varied regionally, the results indicate that reindeer herders consider both, supporting the general hypothesis that slaughter strategies balance the benefits of increasing herd size against monetary income through meat sales. In another study, Næss et al., (2011) investigated how predation compensation affected households' future herd size. The main finding was that predation compensation had a positive effect on households' future herd size, supporting Bulte and Rondeau's (2005:17) argument that "[w]ith the risk of predation covered by compensation, it is optimal to increase the stocking rate". Notably, the effect of predation compensation was positive after controlling for reindeer density, indicating that

households that received more compensation for predation losses performed better in terms of future herd size compared to those that received less compensation (Næss et al., 2011).

Following Dyson-Hudson (1977), the ultimate goal of pastoralists can be viewed as the survival of the pastoralist and their family (see also Mace, 1993). Results from this study (and other studies from the reindeer husbandry, cf. Næss and Bårdsen, 2010, Næss and Bårdsen, 2013, Næss and Bårdsen, 2015, Næss et al., 2011) strongly indicate that investing in livestock as wealth positively affects household survival. This again provides the rationale for why both reindeer herders (Næss et al., 2010, Næss et al., 2009) and pastoralists, in general (Næss, 2012, Næss, 2019, Næss, 2021), invest labour to increase herd size. Nevertheless, livestock as wealth may also stem from cultural values such as prestige or status (Herskovits, 1926, Nilsen and Mosli, 1994), conspicuous display (Paine, 2009), and provision of bridewealth (McCabe, 2004). However, the results from this study demonstrate the economic rationale for investing in livestock as wealth. Herders in the North also share this point of view: 51% of the herders 'agree' or 'strongly agree' that herd size is an essential risk-reducing strategy. In comparison, only 26% 'agree' or 'strongly agree' that herd size is vital for social status (Johannesen and Skonhoft, 2011: table 4). Wealth in livestock also translates to power: Riseth et al., (2004), for example, argue that from 1957 to 1997, some herders in the North expanded their relative share of winter pastures at the cost of others, mainly due to differential use of technology and variations in herd size. Larger herds use more extensive pasture areas and may exclude others from grazing in the same area.

In sum, pastoral wealth inequalities are better understood as an outcome of the overall socioeconomic system and livestock as wealth (see Borgerhoff Mulder et al., 2010 for a similar argument). The results of this study indicate that pastoral wealth inequality follows the same pattern as that of all forms of wealth. Wealth accumulates over time, and while the highest earners can save much of their income (i.e., newborn livestock), low earners cannot. Thus, high earners can accumulate more wealth over time.

Conclusion

While single-species and modern pastoral adaptation, the results of this study can be used as an analogy for general pastoral wealth inequalities. Specifically, the persistence of wealth inequalities and limited changes in rank over time can be used to nuance the current view of pastoral egality, which is assumed to limit the evolution of political complexity. As this study demonstrates, there is nothing apparent in pastoral adaptation, with livestock as the main base of wealth that levels wealth inequalities and limits social differentiation.

Current thinking concerning state and empire formation has given precedence to agriculture and industry. Thus, urbanisation and sedentarism have been seen as triggers for pastoral political organisation: only when facing a strong sedentary neighbour did political complex organisations arise, and then mainly to effectively deal with these competitors (Barfield, 1989, Barfield, 1993, Barfield, 2020, Turchin, 2003, 2007, Turchin and Gavrilets, 2009). Using the Arab philosopher Ibn Khaldun's concept of *asabiya* – meaning collective solidarity or group members' ability to cooperate – Turchin (2007) has argued that one of the critical factors for the Mongols' extensive conquest and success was their ability to collaborate when facing a powerful Chinese state (Turchin, 2007). For Turchin (2003), inter-group conflict is the primary factor that increases a group's ability to cooperate, especially on *metaethnic frontiers* (Turchin and Gavrilets, 2009). The border between sedentary peasant states and the steppe nomads has been argued to be a meeting place of significant others, fuelling intense conflicts and competition (Turchin, 2003, 2007, Turchin and Gavrilets, 2009). While nomads viewed their sedentary neighbours as nothing more than 'grass-eating people' not too far removed from livestock (Weatherford, 2004), Chinese sources characterised the nomads as the 'devil horsemen from the steppe' (Beckwith, 2009). Thus, the metaethnic frontier served as a proxy of warfare intensity, resulting in large-scale societies on both sides (Turchin and Gavrilets, 2009).

The notion of having two separate systems meeting along political, cultural and ecological frontier zones has, according to Di Cosmo (2015: 51), been the cornerstone of theories explaining the rise of nomadic empires. This rests on two assumptions: First, the existence of economic differences between a sedentary and a nomadic economy. Notably, the nomadic economy has been construed as lacking self-sufficiency, necessitating nomads to seek the products they lacked from neighbouring sedentary states. Second, institutions sustaining nomadic empires, states, and eventually, khanates and empires were appropriated from the more sophisticated sedentary states (Di Cosmo, 2015:51). As Di Cosmo (2015:52) argues, such a focus gives precedence to the interaction between nomads and sedentary societies, e.g., frontier relations and interactions, rather

> "… than to the dynamics internal to the nomadic world, or between nomads and other polities that were neither sedentary nor "empires"".

Furthermore, it takes nomadic empires or states for granted, although the most challenging stage in, for example, the evolution of the Mongol Empire was the unification of Mongolia itself (May, 2007). Much of Chinggis Khan's life dealt with intra-tribal conflicts and war (McLynn, 2015). During the 12th century, Mongolia experienced a turbulent time with constant warfare between the Chinese and the nomads, concurrent with extensive warfare between the five significant people of Mongolia, namely the Mongols, Merkit, Tatars, Kereit and Naiman. Additionally, this period was characterised by constant feuding within the Mongol tribe, e.g., between the Borjigid and Tayichiud clans (McLynn, 2015). Thus, before a more comprehensive conquest was possible, Chinggis Khan had to consolidate the Mongolian society by ending constant internecine conflicts over slaves, women, horses and grazing (Gabriel, 2004).[7] Furthermore, the Chinese actively played nomadic groups against each other to decrease the threat of strong nomadic forces threatening the Chinese borders. Ultimately, Chinggis Khan consolidated his power by erasing old kinship ties[8] characterising the Mongols, Tatars, Kereit, and Naiman. Subsequently, Mongolia's steppe nomads were part of the *Qamuq Monggol Ulus*, meaning 'All of' or the 'Whole Mongol Nation' (May, 2007:32). A similar pattern has been described by Di Cosmo (1994) concerning the rise of the Xiongnu empire. It came into existence after decades of relentless Chinese expansion into the northern steppe. In the third century B.C., the northern Chinese states made substantial territorial gains in the northern regions, culminating in the Chinese conquest of the whole Ordos region (present-day Inner Mongolia), inhabited by Xiongnu nomads (Di Cosmo, 1994:116). Di Cosmo (1994:1116, emphasis added) writes:

> "… the Xiongnu bore the brunt of the Qin expansion into the Ordos region. Their weakness seems to have induced other nomads, such as the Eastern Hu, to seek advantage from the situation …. *The shrinking of pastoral resources and displacement of nomads from their ancestral lands (in particular from the Ordos region) ignited a period of crisis that was characterised by violent inter nomadic struggles. From this struggle the Xiongnu gradually emerged as the winning side and, in the course of several decades, expanded their political power over the whole steppe region to the north of China, as far as Lake Baikal and Tuva, and to the west as far as the Ili region and beyond*".

In general, Di Cosmo (2015:51) argues that

> "… the dynamic of the formation of nomadic states is always, in every historically documented case, the result of inter-nomadic warfare, and therefore conflicts with sedentary states appear to have been far less relevant than they are often assumed to be".

Thus, internal consolidation or coordination is not an outcome of societal conflict but rather a precursor. In short, to successfully wage a war of conquest, a certain level of internal consolidation is necessary: raising a force to be reckoned with – to compete and to win – requires coordination. This gives rise to the somewhat perplexing situation whereby large-scale conflicts between already integrated societies have been scrutinised more closely than internal factors shaping societal integration.

For example, while livestock transfers between separate households have often been explained as a risk management strategy (e.g., Aktipis et al., 2016, Hao et al., 2015, Dyson-Hudson, 1966), they can reinforce patron-client relationships undermining equality, as among the Himba where big men dominate over corporate matrilineal descent groups (cf. Borgerhoff Mulder et al., 2010). Thus, the persistence of livestock inequalities, as demonstrated in this study, can fuel patron-client relationships documented for nomadic groups across the Old World, from northwestern Africa to Mongolia (Honeychurch, 2014). Livestock inequalities might have provided the basis for aristocratic power and state-like administration processes that were significant features of the broader organisation of life on, for example, the steppe in Inner Asia (Sneath, 2008). This resonates with modelling work showing that the internal dynamics of nomadic pastoral societies are sufficient to produce high degrees of livestock inequality and hierarchical herding networks through the formation of patron-client relationships (Shultz and Costopoulos, 2019).

Data availability

The data that support the findings of this study are available from the Norwegian Environment Agency and the Ministry of Agriculture and Food; however, restrictions apply to the availability of these data. Empirical data, which were used under licence for the current study, pertaining to individual-level herd size per year are potentially identifiable and are thus not publicly available. However, data are available from the authors upon reasonable request and if the requesting parties have been granted permission from the Norwegian Environment Agency and the Ministry of Agriculture and Food to access individual-level data.

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Notes

1 While it is often assumed that humans evolved inequality from equality, Grove (2020:167) argues that the widespread social inequality observed among all primate species suggests that the ancestral state was also one of inequality. In short, Grove (2020:167) argues that "… egalitarianism was simply never a feature of human evolution". Instead, if one assumes that individuals are self-interested, inequalities in access to food, mates, and other resources automatically follow (Grove, 2020). From this point of view, the problem is not so much with explaining the evolution of inequality but rather cases not characterised by inequality.

2 According to Beckwith (2009:12-3), the comitatus and its oath have existed as early as the Scythians. They are similar to the oath of blood brotherhood to the death known to have existed through the medieval era. The core consisted of a small number of friends. Chinggis Khan is said to have had four: Khubilai, Jelme, Jebe and Subotai, often called 'the four wolves of Chinggis' by enemies. The core group customarily engaged in ritual suicide to join the lord in death and were interred with weapons to be prepared for combat in the afterlife. Subotai, for example, apparently pledged himself to Chinggis by saying, "I'll like a rat and gather up others I'll be like a black crow and gather great flocks. Like the felt blanket that guards the tent from the wind, I'll assemble great armies to shelter your tent" (The Secret History, cited in Gabriel, 2004:8). The comitatus warriors gave their oath freely and broke their connections to clan or nation. They pledged their allegiance to him and were granted immense privileges and recognition for their unwavering loyalty throughout their lives (Beckwith, 2009:13-4). According to Beckwith (2009:15-6), the comitatus is found both directly and indirectly in historical sources dealing with the Hittites, the Achaemenid Persians, the Scythians, the Khwarizmians, the Hsiung-nu, the ancient and medieval Germanic peoples, the Sasanid Persian, the Huns, the Hephthalites, the Koguryo, the early dynastic Japanese, the Turks (e.g., Uighurs), the Sogdians, the Tibetans, the Slavs, the Khitans, the Mongols etc.

3 This has changed with the new county designation as of 2020 (see e.g., Næss et al., 2021). However, the official statistics covering the period in this study follow the old designation.

4 Based on http://www.statsdirect.com/help/default.htm#nonparametric_methods/gini.htm (Accessed 11.11.2021).

5 Downloaded from Statistics Norway (SSB), Table 09114: Measures of income dispersion. Household equivalent income (EU-scale) between persons, by contents, region and year https://www.ssb.no/en/statbank/table/09114/tableViewLayout1/. Accessed: 25.06.2021.

6 For an overview of subsidies and compensations available to Saami pastoralists, see Hausner et al., (2011, APPENDIX 1). In general, they are separated into (1) operating subsidies for increasing net income by direct payment to siida-shares and districts, (2) production subsidies aiming to increase production and delivery at slaughterhouses, (3) preventive measures aiming to cover expenses for preventive measures to reduce losses to predators or adverse winters and (4) compensation aiming to offset economic losses resulting from predators or unfavourable winter conditions. Keep in mind that these are open for negotiations and thus have varied over time.

7 Atwood (2023:xii) writes in the introduction to his translation of the Secret History of the Mongols that Chinggis Khan first undertook a series of battles with rivals in present-day eastern Mongolia and the neighbouring parts of southern Siberia and Inner Mongolia. The unification of the Mongolian plateau was concluded with two lengthy campaigns against the Naiman in western Mongolia and then the Merkit in northern Mongolia. Subsequently, Chinggis Khan turned to the world beyond the Mongolian plateau, starting with the Golden Khan, the ruler of North China in 1211, a campaign that ended with the sacking of Zhongdu (present-day Beijing) in 1215.

8 For example, most of those who rallied to Chinggis initially were commoners, many of whom were barely above the status of slaves. In Chinggis, they saw someone who did not cater only to the aristocracy's interests (May, 2007).

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Author contributions

MWN conceptualised, wrote the first draught of the text, and conducted analyses. BJB secured access to the data from the Norwegian Environment Agency and the Ministry of Agriculture and Food. Both authors contributed to the analyses and interpretation of the data, edited and revised the manuscript, approved the final version, and agreed to be accountable for all aspects of the work.

Competing interests

The authors declare no competing interests.

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Additional information

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