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Tracing herding strategies in the Samarkand Oasis: Isotopic and proteomic insights from Kafir Kala (Samarkand, Uzbekistan)

Elena Armaroli*, Federico Lugli, Eleonora Serrone, Beatrice Demarchi, Marlisa Mazzola, Sarah Sandron, Samaretdin Suyunov, Amriddin Berdimuradov, Hubert Vonhof, Simone Mantellini, Anna Cipriani

*** Corresponding author**
Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, 41125 Modena, Italy
elena.armaroli@unimore.it

Online Resource 2

Supplementary Text

The Samarkand Oasis has stood out for centuries as a crossroads of civilizations, knowledge, and trade. It has also long been associated with pastoral traditions and the crucial role that sheep and goats played in the daily lives of ancient communities.

The data collected reveal far more than a simple dietary preference. They point to a coherent economic strategy, an environment structured to integrate pastoralism with irrigated agriculture, and a community capable of adapting to social, political, and environmental change. Within this framework, sheep and goats emerge as a constant, versatile resource that supported the local economy in both small seasonal settlements and more complex administrative centers. A remarkable continuity in the use of these animals can be observed, not only at the site of Kafir Kala – the main focus of this study – but also in broader archaeological research across Central Asia, from the Bronze Age through to the Islamic period (Bocherens et al., 2006; Lhuillier and Mashkour, 2017; Mashkour, 1998; Mashkour et al., 2013; Portero et al., 2022; Taylor et al., 2019).

In recent years, research in the Samarkand Oasis has expanded to include several other sites, both large and small, investigated by the University of Bologna and the University of Naples "L'Orientale". One such study involved the analysis of approximately 1,300 faunal remains from three different settlements (see Fig. 1 in the main text).

Kojtepa, a site characterized by a 9-meter-high conical central mound surrounded by a bastion, has been systematically investigated since 2008 by the University of Naples "L'Orientale" under the direction of Bruno Genito (Genito and Abdullaev, 2014; Genito and Pardaev, 2021). The archaeozoological analysis was conducted on 1,153 faunal remains. The data were evaluated by comparing two broad phases of occupation: the Hellenistic and post-Hellenistic period (4th–1st century BC), and the post-Hellenistic or “nomadic” period (1st–4th century AD). In both phases, sheep and goats were the most commonly exploited species, with 254 remains and a Minimum Number of Individuals (MNI) of at least 23 in the first phase and 19 in the second. These were followed by a smaller number of cattle (MNI = 4 in the first phase and 7 in the second), pigs (MNI = 1 and 6, respectively), horses (present only in the second phase, with a minimum of 2 individuals), and donkeys (one individual in the Hellenistic phase and two in the post-Hellenistic phase). While the overall economy remained highly conservative, a trend toward diversification is evident in the post-Hellenistic phase. In the earlier phase, the faunal assemblage is almost exclusively composed of sheep and goats, which were often slaughtered at a young age. From the post-Hellenistic period onward, however, a broader range of meat resources appears, marked by a noticeable increase in pigs and cattle in the diet, along with a more varied exploitation of sheep and goats, which were now slaughtered across all age groups (Maini and Serrone, 2021).

The Kurgan Kadirbek, by contrast, consists of a small, low mound with evidence of two main phases of occupation: the first between the 2nd and 1st centuries BC, and the second between the 6th and 7th centuries AD. Excavations conducted by the Uzbek-Italian Archaeological Project (UIAP) have uncovered wells and lithic tools such as millstones, mortars, and pestles, suggesting that this small settlement was used for seasonal

agricultural activities (Mantellini, 2017). The faunal sample from the site is very limited, comprising 166 remains, of which only 52 could be identified to the species level. In both the Late Hellenistic and Early Medieval phases, sheep and goats are the most represented taxa (40 remains, corresponding to at least 7 individuals), followed by cattle (5 remains from a single individual) and 2 pig remains. No wild species or horses were identified, supporting the interpretation of the site as a seasonal and agriculture-oriented settlement. Although the small sample size limits further interpretation, the data nonetheless reinforce the primary role of sheep and goats in the subsistence economy of the area.

This pattern is also evident at another site near Kafir Kala, SAM-174, which has likewise been investigated by the Uzbek-Italian Archaeological Project (UIAP). This site is particularly important for the dating of the Dargom-Yaghìarik irrigation system, owing to the analysis of its alluvial deposits (Malatesta et al., 2012). Identified as a small mill, SAM-174 yielded only 50 faunal remains, of which 28 could be identified to the species level. Despite the limited sample size, sheep and goats are again the most represented taxa (at least 5 individuals), followed by a single bovine and an equid, likely a donkey used for labour.

The analysis of faunal remains from various sites in the Samarkand oasis underscores the central role of sheep and goats in the ancient local economy, spanning from the Hellenistic period to the early Middle Ages. These species emerge as the most commonly reared, reflecting a strategic economic decision driven by their versatility and sustainability. Their consistent presence across the analyzed contexts, despite the limitations of small sample sizes, indicates a deeply ingrained pastoral strategy, effectively integrated with agricultural practices, particularly in seasonal settlements. This highlights a flexible and adaptive production system that maintained functional coherence over time. At the main site of Kafir Kala, as well as in smaller contexts such as Kurgan Kadirbek and Sam-174, sheep and goats represent a key resource, often prioritized over other domestic animals. The data reveal significant continuity in the breeding and use of these species, alongside some temporal variations, such as the increasing diversification of animal sources in later phases, reflecting an evolution in subsistence strategies. Overall, the Samarkand oasis stands as a natural laboratory for studying the long-term dynamics of human, environment, and animal interactions in Central Asia.

Supplementary Figures

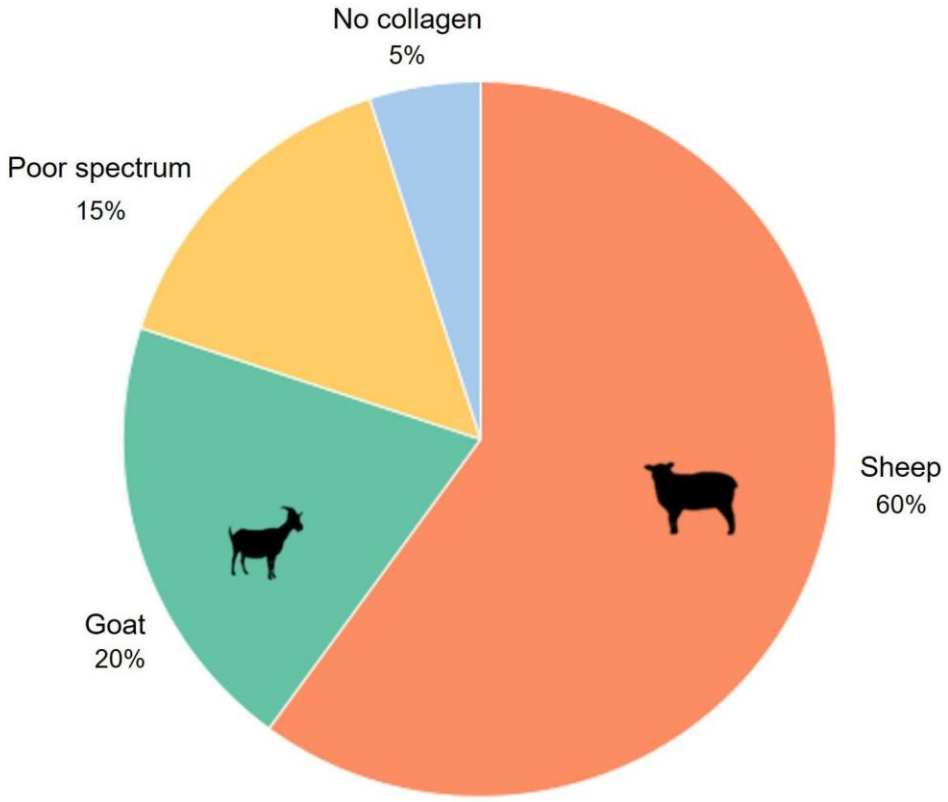

Fig. S1 Proportion (%) of sheep and goats in the dataset. 60% of samples (n = 12) were identified as sheep, while 20% (n = 4) were identified as goats; 15% of the samples (n = 3) yielded poor spectra, and 5% (n = 1) no collagen.

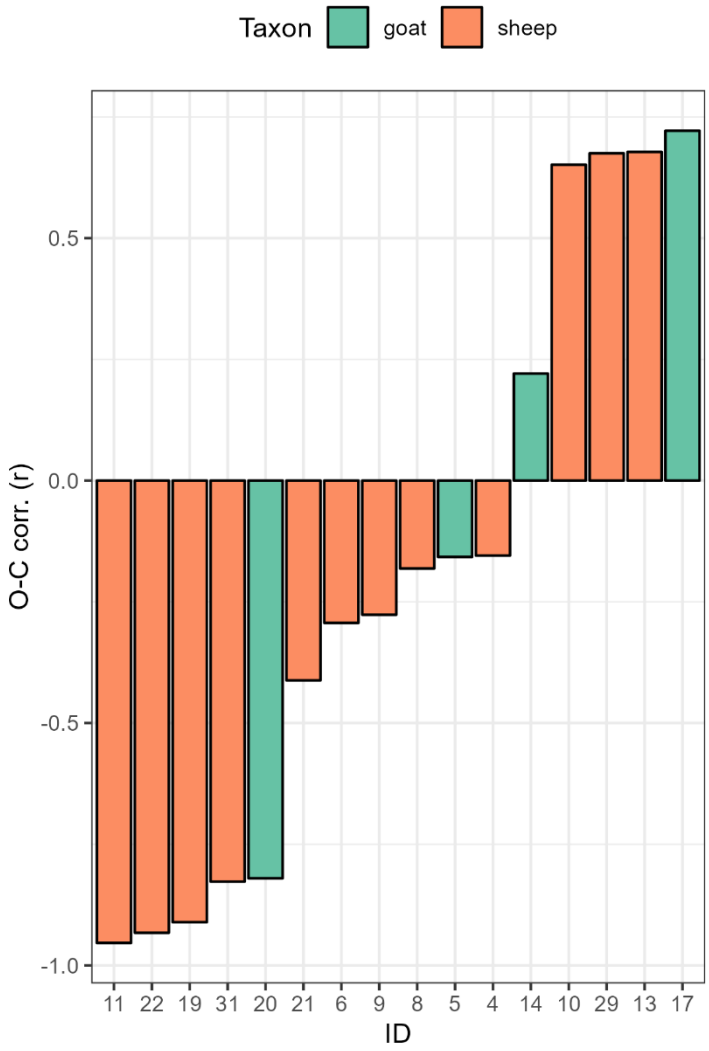

Fig. S2 Linear correlation between $\delta^{18}O$ and $\delta^{13}C$ values of goats (green) and sheep (orange). The correlation coefficient r > 0.5 indicates a strong positive correlation (i.e., C-O covariation), while r < 0.5 indicates a strong negative correlation (i.e., C-O anti-covariation)

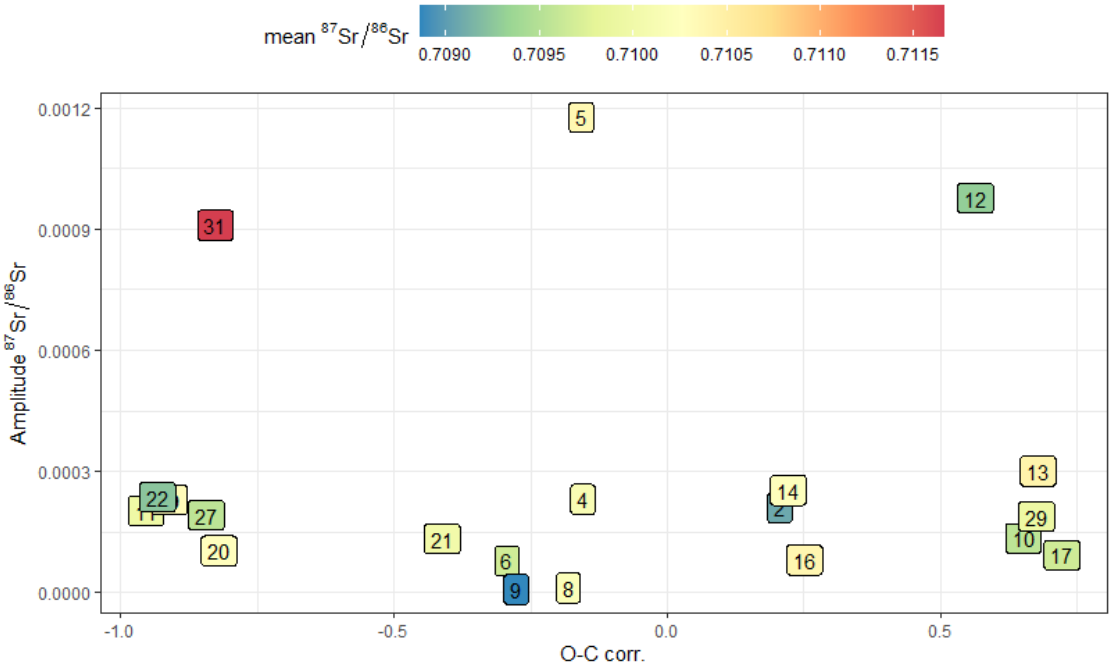

Fig. S3 Strontium amplitude (y-axis) vs. C-O correlation (x-axis). The correlation coefficient r > 0.5 indicates a strong positive correlation (i.e., C-O covariation), while r < 0.5 indicates a strong negative correlation (i.e., C-O anti-covariation). Each sample is coloured according to its mean $^{87}Sr/^{86}Sr$ value

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