PHILOSOPHICAL TRANSACTIONS B

royalsocietypublishing.org/journal/rstb

Research

Cite this article: Starkweather KE, Reynolds AZ, Zohora F, Alam N. 2022 Shodagor women cooperate across domains of work and childcare to solve an adaptive problem. *Phil. Trans. R. Soc. B* **378**: 20210433. https://doi.org/10.1098/rstb.2021.0433

Received: 9 February 2022
Accepted: 3 May 2022

One contribution of 17 to a theme issue 'Cooperation among women: evolutionary and cross-cultural perspectives'.

Subject Areas:
behaviour, ecology, evolution

Keywords:
cooperation, women, childcare, economics

Author for correspondence:
K. E. Starkweather
e-mail: kstark20@uic.edu

Electronic supplementary material is available online at https://doi.org/10.6084/m9.figshare.c.6251148.

THE ROYAL SOCIETY PUBLISHING

Shodagor women cooperate across domains of work and childcare to solve an adaptive problem

K. E. Starkweather[1,2], A. Z. Reynolds[3], F. Zohora[4] and N. Alam[4]

[1]Department of Anthropology, University of Illinois Chicago, Chicago, IL 60607, USA
[2]Department of Human Behavior, Ecology, and Culture, Max Planck Institute for Evolutionary Anthropology, 04103 Leipzig, Germany
[3]Department of Anthropology, University of New Mexico, Albuquerque, NM 8731, USA
[4]Health Systems and Population Studies Division, ICDDR,B, Dhaka 1212, Bangladesh

KES, 0000-0002-1554-4567

Across human societies, women's economic production and their contributions to childcare are critical in supporting reproductive fitness for themselves, their spouses and children. Yet, the necessity of performing both work and childcare tasks presents women with an adaptive problem in which they must determine how best to allocate their time and energy between these tasks. Women often use cooperative relationships with alloparents to solve this problem, but whether or not women cooperate across different domains (e.g. work and childcare) to access alloparents remains relatively under-explored. Using social network data collected with Shodagor households in Bangladesh, we show that women who need childcare help in order to work draw on cooperative work partners as potential alloparents, and that all women rely heavily on kin, but not reciprocal cooperation for childcare help. These results indicate that Shodagor women strategize to create work and childcare relationships in ways that help solve the adaptive problem they face. We discuss the implications of our results and the example provided by Shodagor women for a broader understanding of women's cooperative relationships, including the importance of socio-ecological circumstances and gendered divisions of labour in shaping women's cooperative strategies.

This article is part of the theme issue 'Cooperation among women: evolutionary and cross-cultural perspectives'.

1. Introduction

The unique human life-history pattern, which includes short interbirth intervals, high fertility and long periods of childhood dependence, results in mothers who have multiple, highly dependent children at a time who are in need of both direct care and resources. In most societies, mothers are responsible for providing the majority of childcare—especially for infants—and their economic contributions (whether through procuring or processing resources) are crucial in supporting the survival and reproduction of all household members, including their own. If energy invested in one activity is not available for another (see [1]), then human mothers experience a trade-off between the competing demands of childcare and subsistence work, and they must decide how to allocate time and energy in ways that support their own reproductive success [2–6].

Prominent evolutionary and economic models of household divisions of labour suggest that mothers should solve this problem by engaging in subsistence work that allows them to simultaneously care for children. That is, the economic tasks done by women should be focused on low-risk activities close to home, which do not require her undivided attention and could easily be interrupted and resumed [7]. Mothers should, therefore, be accompanied by children during their work and provide all or most of their care throughout the day, while

fathers provide complementary resources through economic tasks that are incompatible with childcare. This model suggests minimal trade-offs for mothers between work and childcare, and emphasizes the importance of the pair-bond in meeting all household needs. However, this trade-off—and women's need for help outside of the pair-bond to address its challenges—has been well-established and thoroughly discussed by a number of scholars [2–5,8]. And while numerous ethnographic and empirical accounts indicate that women's work is often more compatible with childcare than men's work, evidence from many subsistence-based societies indicates that women curtail or adjust their subsistence activities due to childcare constraints [9–12], and that they often need assistance in caring for young children so that they can work (e.g. [13–16]). This suggests that most mothers face trade-offs at some point in their lives and that, in order to ensure all of the household economic and childcare needs are met, women often need help beyond what the pairbond can offer. In this paper, we examine how women use relationships beyond the pairbond to meet these needs.

One of the most often-studied areas of female–female cooperation in humans is childcare. While this is certainly not the only domain in which women form cooperative relationships with one another [17], it often provides a solution to the adaptive problem we've laid out here. In many socio-ecological contexts, alloparental care (any care provided by someone other than the biological parents of a child) reduces mothers' time devoted to childcare and allows them to engage in other tasks—like subsistence tasks—unencumbered. For example, among Aka foragers of the Central African Republic, grandmaternal caregiving was associated with a reduction in maternal childcare and an increase in maternal foraging activities [18]. Similarly, women use alloparental care while working among Martu Aborigines [19], /Du/da ! Kung [13] and Ye'kwana communities [9]. And a recent study of Maya and Pumé women showed that allocare reduces mothers' allocation of time and energy to childcare, and that they mostly reapportion that time towards household economic and leisure activities [14].

While alloparental help is typically beneficial to parental fitness, it often comes at a great cost to the alloparent. For this reason, much work has been done to explain how alloparents can benefit from caring for other people's children, and most questions about cooperation in childcare (e.g. Why cooperate? With whom?) are approached from the perspective of the alloparent (e.g. [20–23]). However, entrusting dependent children to the care of an alloparent is not without risk. If the care provided is suboptimal, children may face negative outcomes, including fitness-influencing outcomes like poorer nutrition and growth [24–26], or even death [27–29]. For this reason, we expect mothers to be discriminating in their choice of alloparents, but who mothers choose—especially when they need help in order to work—has not been investigated heavily and remains poorly understood.

In this article, we investigate how women use cooperative relationships with kin and non-kin to help solve the adaptive problem posed by work that is incompatible with childcare. We examine the importance of cross-culturally well-established drivers of cooperation in childcare—kinship and reciprocity—among Shodagor women in Bangladesh. However, we are primarily interested in the role of cooperation across domains (between work and childcare) in solving this adaptive problem, and how such cooperation overlaps (or not) with kinship. We compare the childcare networks of two groups of Bangladeshi Shodagor women whose work differs in its compatibility with childcare, and ask whether women whose work is incompatible with childcare are more likely to name their work partners as potential alloparents than are women whose work is compatible with childcare. We also ask whether these cross-domain cooperative relationships are more likely to occur among kin than among non-kin.

(a) Study population

In Bangladesh, Shodagor fisher-traders are culturally distinct from the agricultural, settled majority Bengali communities. The mostly rural subdistrict of Matlab, Bangladesh (figure 1), where this research was conducted is home to approximately 500 Shodagor families, but is primarily inhabited by the majority Bengali ethnicity, totalling around 230 000 individuals who are majority Muslim, minority Hindu and primarily work as agriculturalists, wage labourers and housewives [30]. Branches of the Meghna River, one of the three largest and most voluminous rivers in a country with approximately 700 rivers—which total over 22 150 km in length [31]—make up the northern and southern boarders of the region. Matlab is also bisected by the Dhonagoda River, as well as its streams and canals. At the time of data collection in 2017, this river, its canals and banks were home to around 150 Shodagor families who are the primary focus of this study. These families resided on small, wooden houseboats, clustered within five distinct groups along the rivers and in the canals, or had moved onto the land within the previous 10 years and lived in make-shift houses on the riverbanks.

Shodagor households are largely organized around the nuclear family and are traditionally semi-nomadic, although just half of all families interviewed in 2014 changed group residence throughout the year. Postmarital residence patterns are multilocal with almost half (49%) of couples living near the husband's family after marriage, 21% living near wife's family, 16% living near both spouses' families and 14% living near neither spouse's family [32]. The result of these residence patterns and household mobility is that most Shodagor live near some members of their extended family for most of the year. Households are also organized around the nuclear family. The majority of childcare is done by children's parents, and men's and women's resources are pooled at the household level. There are no systematic, community-wide norms of sharing daily acquired resources beyond the nuclear family household, though some individuals or families may occasionally share with relatives on special occasions or when they are in need. Despite the fact that the nuclear family household is central to Shodagor social organization, adults from different households report cooperating with one another to help with boat repair, to build houses, in childcare, and to host religious ceremonies throughout the year (though we might expect this cooperation to take place on a much smaller scale than in some other human societies).

(i) Shodagor women's work

Shodagor women primarily work as fishers (45%) and traders (52%). These occupations provide important resources for women's families, but differ in two significant ways. First, while fishing is a task that is compatible with care for children of all ages, trading is totally incompatible with

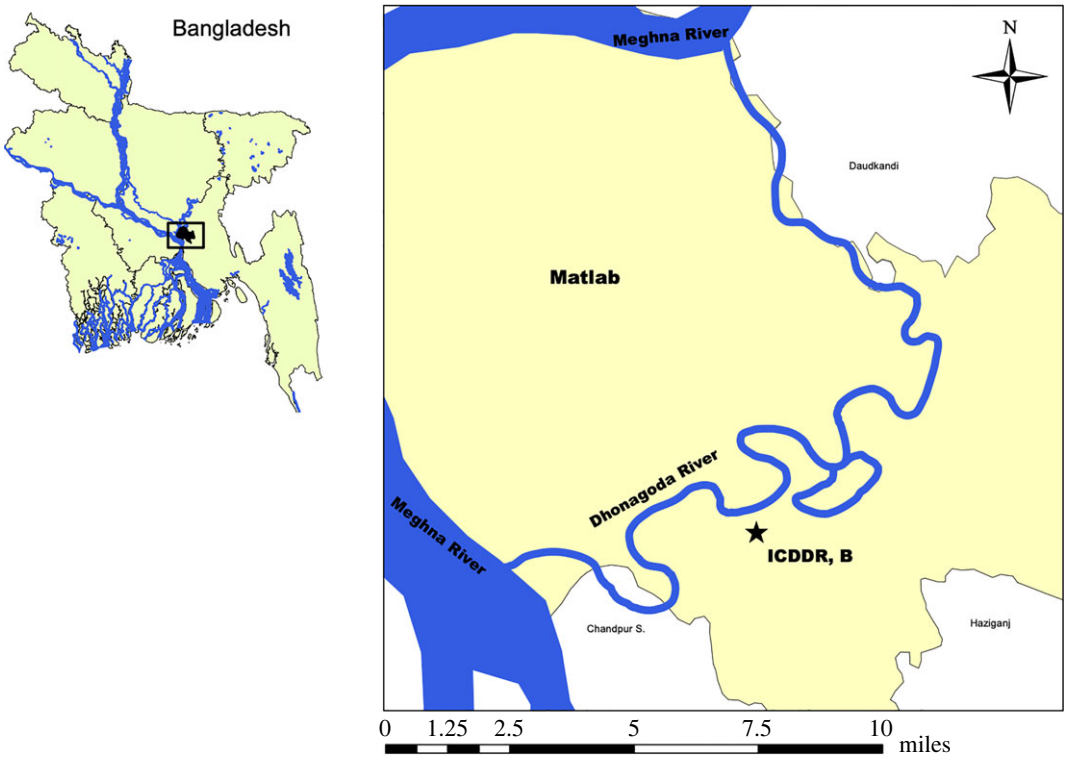

Figure 1. Map of Matlab, Bangladesh. (Online version in colour.)

childcare and women who trade need childcare help in order to work [32,33]. Women who fish often return to work one to two months after giving birth, and bring nursing infants and children of all ages along with them. Traders do not work for 1–2 years following the birth of a child, returning to work only after the child is weaned, and report never bringing dependent children with them when they go trading. Trading is a physically demanding task in which women carry large, heavy baskets full of trade goods on their heads and travel into the rural villages of Matlab to sell their goods. Due to this incompatibility, data from previous studies show that traders rely on childcare help from their husbands and alloparents in order to go to work, while fishers do not [34]. Second, women who fish report that they primarily cooperate in work with their husbands and older children, working on the fishing boat together and cooperating to care for any young children. Traders report working in small groups with other women, cooperating with one another to make logistical decisions (e.g. trading destination for the day, what time to start work). Although profits are not shared, costs of trading (e.g. hiring transportation) are shared evenly among group members. Traders who work together spend a great deal of time together each day and report developing trusting relationships around physical safety, financial information and reputational maintenance.

(ii) Shodagor childcare

In all Shodagor households, mothers and fathers provide the majority of direct care for their dependent children [33]. Here, we define *direct care* as feeding, carrying, soothing, watching (or 'babysitting'), grooming, teaching or any other type of physical interaction directed towards a child [35–37]. Alloparents play a much smaller (but still important) role for most households, though they are especially critical for trading households. In many trading households with young children, while mothers work as traders during the dry season (approx. October–March), fathers stay at home and care for children. But when care from alloparents is given in addition to paternal care in trading households, it is an important predictor of women's trading [32,34] and of child growth [33], suggesting that alloparents help to free-up women so they can engage in work that is incompatible with childcare. At the same time, previous data suggest that alloparents may play a less prominent role in fishing households and are not necessary in order for parents to work.

(b) Predictions

Prediction 1: In general, humans tend to choose cooperative partners who are trustworthy and reliable: those who are likely to agree to cooperation (i.e. for whom it will pay to cooperate) and those who are likely to produce positive results (e.g. good hunters, competent care providers for children). Kin selection, in which carers benefit their inclusive fitness by caring for related children, and in-kind reciprocity, in which childcare is exchanged for childcare, as well as reciprocity among kin, are well-established mechanisms through which alloparents may recoup losses of time and energy invested in caring for other people's children and make alloparental care an evolutionarily stable strategy [22,38–42]. While we aim to explain mothers' choices in alloparents, maternal preferences cannot easily be disentangled from alloparental motivations. That is, mothers are probably most likely to ask people to help who will be most likely to agree. Therefore, we expect that kinship and reciprocity will both play a role in mothers' decisions about who to ask for help with childcare. We have no *a priori* reason to expect differences in these strategies between Shodagor traders and fishers, and therefore predict that: *(1a) kinship and (1b) reciprocity will be important predictors of a tie in the childcare network for all Shodagor women, regardless of their occupation*.

Prediction 2: Cooperation between different domains (e.g. between sick care and childcare [40]; exchanging food for allocare [38]) also plays a crucial role in structuring community-wide cooperation and helps individuals maximize fitness in many subsistence-based societies (e.g. [40,43–45]). If women develop cooperative relationships in one domain of life they may be able to call on these relationships for help with childcare when it is most needed. One domain in which women may develop or solidify such relationships is cooperative subsistence work. In many types of subsistence systems and across societies, women often work in the company of, or in cooperation with, other women [17]: foraging is rarely an activity done by a solitary woman [10,13,38], women often participate in gardening or agricultural work together [9,16,46] and women who hunt typically do so in groups (e.g. [47,48]). While the extent of coordination among cooperative partners may vary, women who work together often spend long periods of time in the company of one another and may trust each other with their personal safety or important personal or economic information (e.g. how productive was woman X today?). Through this, women may be able to discriminantly use relationships with those people when they need help in caring for their own children. Several ethnographic examples suggest this is the case across cultural contexts. For example, /Du/da ! Kung women who work together take turns staying in camp, providing allocare for each other's young children [13], and Ye'kwana mothers and daughters trade-off gardening and childcare work [9]. Among polygynously married Agta women, co-wives cooperate in short-term reciprocal networks in which women take turns hunting and caring for children [48]. Given that Shodagor women's trading is not compatible with childcare, that women traders require help with childcare to work, and that previous studies using data collected at different time points show that traders receive help from more alloparents than do fishers [33,34], we expect that Shodagor traders will use cooperative trading partners as potential alloparents in order to solve their adaptive problem. If this is the case, *we predict that a tie between two women in the work network will predict a tie between those two women in the childcare network (Prediction 2).*

Prediction 3: Finally, we examine the role of kin in cross-domain cooperative relationships for Shodagor women. While we expect kinship to be an important predictor of allocare for all Shodagor women (Prediction 1a), the role that kin play in patterning cooperation across domains remains unclear. In some societies, such as among Martu Aborigines [19,47], women work with and share childcare responsibilities primarily with relatives, effectively strengthening existing relationships and creating redundancies within their networks. However, in other cases, women rely on unrelated work partners to watch their children. For example, Tamang women in Nepal routinely cooperate within agricultural labour groups, which are made up of kin and non-kin, to provide childcare for one another [16]. Rather than creating multiple layers of redundancies within one's network (e.g. [49]), this type of cross-domain cooperation among non-kin should create broader networks with more ties. Some accounts of female–female cooperation in humans, though, suggest that women are more likely to cooperate with kin than with non-kin in various activities [41,47,50], and some have theorized that women's reproduction may have benefited more from investment in intimate, dyadic relationships (i.e. fewer, stronger network ties) with kin than from investment in building larger coalitions [51–54]. Thus, we might expect overlapping kinship with cooperative relationships in work and childcare to be the most likely strategy for women to employ when they need to solve the adaptive problem presented by childcare-incompatible work. *If Shodagor women cooperate across the domains of work and childcare (and we primarily expect to see this occur among traders; Prediction 2), we predict that these cooperative relationships will be most likely to occur among kin (Prediction 3).*

2. Methods

(a) Data collection and study sample

This study is based on interviews conducted in 2017 as part of the ENDOW Project (NSF grant no. SMA-1743019), as well as demographic data collected over 18 months in 2014 and 2017. The ENDOW Project is a cross-cultural examination of social networks, wealth and inequality, in which each study site elicited information on cooperative relationships in several different domains of life from a complete community sample (i.e. all households in the community). Male and female heads-of-household were interviewed together whenever possible and separately when necessary. Using the 'name generator' approach [55], respondents were asked to free-list individuals who regularly provided 10 types of economic or social support (for example, 'Which households would share food/meals with you and your household if you needed?' and 'Who are the people you usually spend time talking with?'). Each gendered head-of-household answered gender-specific questions for themselves, indicating their own social ties. Specific questions about social ties associated with work and childcare were used in this analysis. The fieldwork protocol was approved by the University of Missouri's Institutional Review Board, the Max Planck Institute for Evolutionary Anthropology's Department of Human Behaviour, Ecology and Culture, and the Ethical and Research Review Committees at the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B).

ENDOW interviews were conducted with male and female heads of household from 48 unique households, and all women of all ages were asked questions about who they cooperate with in work and childcare. We define *childcare* in the same way that we defined *direct care* above (and described it to respondents as such): any physical interaction directed toward a child, such as feeding, carrying, soothing, watching (or 'babysitting'), grooming, or teaching. However, some opted not to answer these questions. Therefore, the analyses used in this paper come from a sample of 42 women who answered the 'childcare' question and 35 of those women who answered the 'work with' question. Six women opted not to answer the 'childcare' question because they had only adult children at the time of the survey and either said they did not want to answer the question or did not remember who had helped them with childcare when their children were younger (while other women with adult children did opt to answer this question). Twelve women opted not to answer the 'work with' question because they are older and not currently working (and, again, either did not want to answer the question or did not remember who they worked with when they were younger), or because they have never worked outside the home and classify themselves as housewives without any work partners to name. One woman opted not to answer the 'work with' question because she had been injured for several months and was not working at the time of the survey. Descriptive statistics of the women who answered these two questions can be found in table 1. A full description of the sample used for the network analysis can be found in §2b 'Data analysis' below.

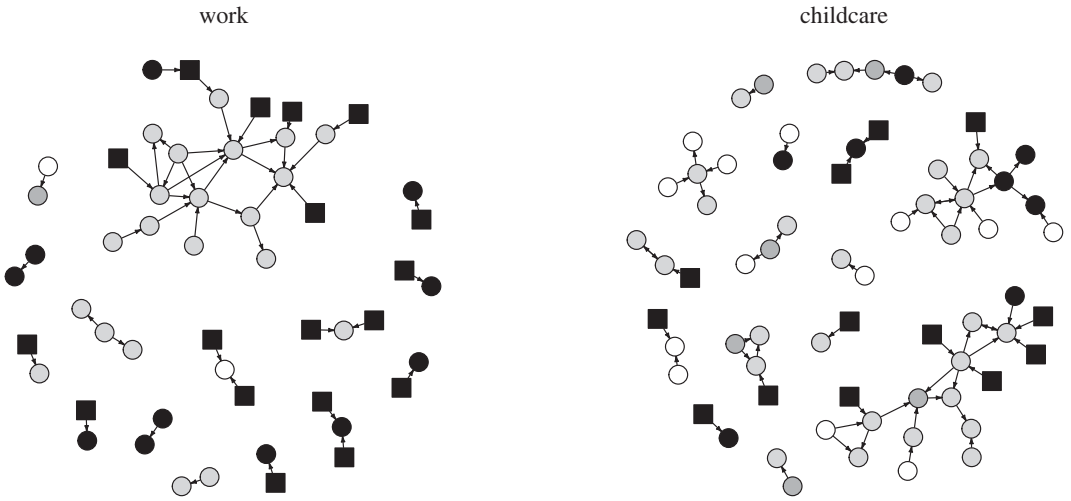

Figure 2. Network graphs showing Shodagor women's work and childcare relationships. Nodes of different shapes represent different genders: circles are women, squares are men. Occupation is indicated by the shade of the node, with traders in black, fishers in light grey and housewives in dark grey. White circles were women named as ties but who are not represented as Egos in the dataset and their occupations are unknown. Isolates who named zero work or childcare ties are not shown.

Table 1. Summary statistics (mean, minimum and maximum for continuous variables, and *N* for categorical variables) describing the characteristics of women who answered the work and childcare questions.

	work ($N = 35$)	childcare ($N = 42$)
age (years)	34.5 (17, 65)	34.5 (17, 71)
number of children	3 (1, 8)	3.1 (1, 8)
age of youngest child (years)	8.36 (0.10, 31)	7.7 (0.10, 31)
occupation:		
trade	24	24
fish	11	8
housewife	n.a.	10

(i) Measures: characteristics of work and childcare partners

Interviews in 2017 asked questions about women's occupations, work and childcare partners, and sought demographic information about those partners, as well as information about each household's members and the heads-of-households' genealogies. All of the measures used in our analyses come from those data, except for relatedness, which also incorporates interview data collected in 2014. For women in this sample, their occupation (trade, fish, housewife) was coded based on women's self-report of their primary occupation. The numbers of partners in childcare and work were determined using a name generator approach, where participants were asked to free-list individuals in response to the following two questions: (i) 'If you needed help caring for your children, who outside of this household could you ask for help?'; and (ii) 'Please list all the people you normally work with.' The numbers of partners in each domain (work and childcare) were determined by counting the number of people whom participants listed in response to each of these questions.

Specific network measures that were used in the model and in the network graphs (figure 2) were based on the answers to these questions. The primary outcome variable of interest in the model is 'childcare tie', which indicates a tie in the childcare network. Two people are considered to have a tie if either woman names the other as someone she could ask for help in childcare. One of the predictor variables, 'work 'together, is determined in the same way: if either of two women names the other when asked who they work with, they are considered to have a tie. Reciprocity in childcare was determined if Woman A named Woman B as a potential childcare helper and Woman B also named Woman A as a potential childcare helper.

As a part of this interview, kinship data were collected in two ways, which were used to determine 'relatedness'. First, each adult respondent was asked to name their parents and grandparents (maternal and paternal). People with shared parents were coded as siblings and assigned a relatedness coefficient of 0.50. People who shared grandparents were coded as cousins and assigned a relatedness coefficient of 0.125 [56]. Second, during the process of asking participants who they cooperate with in various tasks, they were asked their relationship to anyone they named. Relatedness coefficients were assigned in the same way. These data were triangulated with each other, along with complete population census data that were collected in 2014, to determine the biological relatedness of each adult in this sample to every household in the community, as well as all of the cooperative partners named. In the model, the maximum relatedness coefficient between two households was used for the 'relatedness' variable. In other words, if the husband in Household A is brother to the husband in Household B, the two households were assigned a relatedness of 0.50. Likewise, if a wife in Household A is the niece of the husband in Household B, the two households were assigned a relatedness of 0.25. This assignment of relatedness was designed to capture women's relatedness to affinal relatives (in-laws), as well as consanguineal relatives (genetically related), and provides the most conservative estimate of relatedness possible. These data were also used to determine whether the named individuals were kin (both consanguineal or affinal relatives were considered kin) or not kin (i.e. not related by genes or marriage), and percentages listed in electronic supplementary material, table S1 were calculated based on this.

Interviews also asked all respondents to list the current members of their household. Any cooperative partners they named who were on the list were coded as 'household members', any cooperative partners named who were not on the list were coded as 'non-household members'. Although respondents were encouraged to only name cooperative partners who did not live in their household, some women indicated that their only cooperative partners lived in the same household and opted to name those individuals anyway.

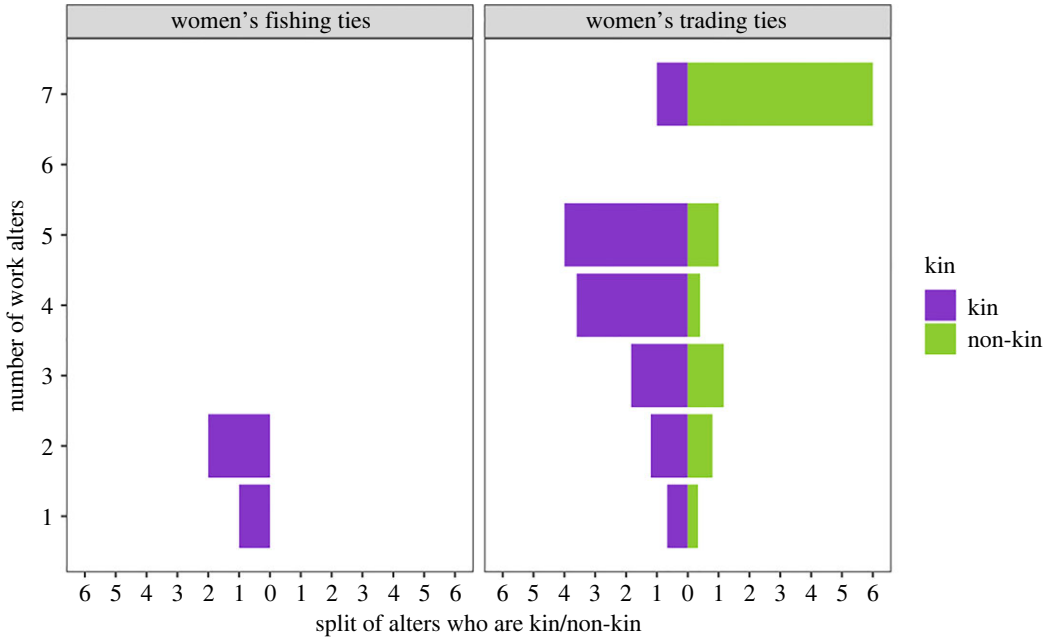

Figure 3. Number of work alters who are kin and non-kin for traders ($n = 24$) and fishers ($n = 11$). (Online version in colour.)

(b) Data analysis

To examine relationships between women's occupations and their cooperative relationships in work and childcare, we conducted unequal variance independent *t*-tests to assess mean differences in the numbers of work and childcare partners, the relatedness of partners, numbers of partners who are kin, numbers who are not kin, and numbers of named partners who share a household with the respondent, between women who fish and trade. All bivariate analyses used data from all women who answered the work and childcare questions and whose primary occupation is either trade or fish (i.e. women whose occupations are either housewife or who do not work were excluded), including any cooperative partners named who lived outside of the community. The total number of women for whom cooperative work ties were included in these analyses is 34, and the total number for whom cooperative childcare ties were included is 32. In order to determine whether women's work networks are a source of social support ties that also provide help with childcare and to determine the independent and interactive effects of kinship and reciprocity (including across the domains of work and childcare), we use an exponential random graph model (ERGM) [57] to predict the log-likelihood of a directed tie between each pair of individuals in the childcare network, given the relatedness between those individuals and whether the same tie is present in the work network. ERGMs are well-suited to network analysis because they model the log-likelihood of each possible relationship in a network, depending on variables at multiple levels, including attributes of individuals, other kinds of relationships between pairs of individuals, and higher-order structural properties of the network.

The ERGM was conducted using the Statnet package [58] in R v. 4.1.0 [59]. The network sample used for the ERGM analysis included all women participants who were interviewed, as well as any individuals discovered on the name generator questions who lived within the community of study. Alters who were discovered on name generators but lived outside the community were excluded. This resulted in a final network of 83 individuals and 260 ties (44 childcare, 62 work and 154 relatedness) that were used in the ERGM analysis. To determine whether women rely on kin and other women they work with for help with childcare, we used the 'edgecov' function in Statnet [58] to test whether the weight of a tie in the relatedness network or the presence of a tie in the work network predicted the log-likelihood of the same tie existing in the childcare network. To determine whether relatives who work together are more likely to provide childcare help, we also used the 'edgecov' function to model a term for the interaction of these two effects. As controls, we included the overall number of edges in the network, as well as terms for reciprocal childcare help and household (since reliance on within- versus between-household relationships varies starkly for women who fish compared to women who trade, and since some women opted to name ties from their households and others did not). Reciprocity was modelled using the 'mutual' function in Statnet [58], which estimates whether the presence of a tie in one direction predicts the occurrence of the same tie in the opposite direction. Household was modelled using the 'nodematch' function in Statnet [58]. Terms for in-degree(0) and out-degree(0) were included to account for the number of women who were unconnected in the childcare network—that is, they either did not nominate others who help them with childcare (in-degree) or were not themselves nominated as childcare helpers for others (out-degree). Data and code used for these analyses can be found here: https://github.com/kstarkweather8/WomensNetworks_2022.git.

3. Results

Descriptive results are presented in electronic supplementary material, table S1. Results from unequal variance independent *t*-tests show that women who trade name more work partners as childcare givers on average than women who fish ($t_{29} = 4.65$; $p < 0.0001$), that traders name more alloparents than fishers ($t_{27} = 3.06$; $p < 0.01$) and that traders are more likely to work with individuals who are not kin (neither consanguineal nor marital kin) than fishers ($t_{22} = 4.60$; $p < 0.001$; figure 3). Traders named significantly more kin as potential alloparents than did fishers ($t_{27} = 2.35$; $p < 0.05$), but also named more non-kin alloparents ($t_{23} = 2.01$; $p = 0.056$; figure 4). Traders did not differ significantly from fishers on the number of work partners they named who were kin ($t_{29} = -0.31$; $p = 0.75$), and fishers' and traders' cooperative work and childcare partners did not differ from one another

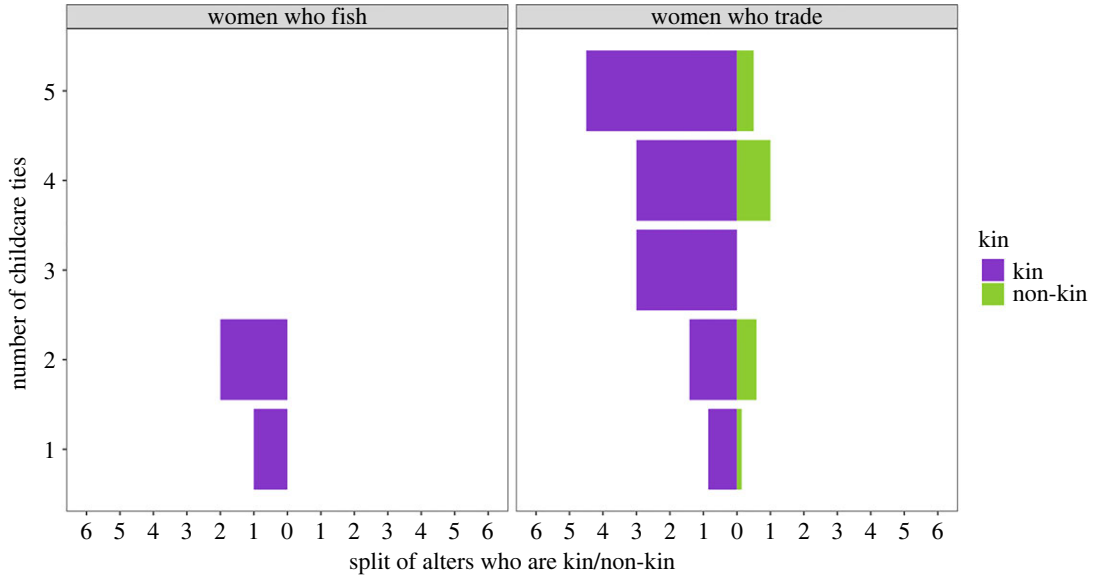

Figure 4. Number of childcare alters who are kin and non-kin for traders ($n = 24$) and fishers ($n = 8$). (Online version in colour.)

in average relatedness (work: $t_{18} = 0.17$; $p = 0.86$; childcare: $t_9 = 0.26$; $p = 0.80$). Women who fish named zero non-kin as either work partners or childcare helpers, while women who trade reported a mix of kin and non-kin ties in both work and childcare networks. Specifically, 61% of work partners and 9% of potential alloparents named by traders are non-kin (electronic supplementary material, table S1, figures 3 and 4). Additionally, while traders and fishers did not name a significantly different number of childcare partners with whom they shared a household (29% of traders' and 36% of fishers' childcare partners shared a household with the respondent; $t_{11} = 0.55$; $p = 0.59$; electronic supplementary material, table S1), traders named fewer work partners with whom they shared a household than fishers ($t_{11} = -6.22$; $p < 0.0001$), for whom all but one cooperative work partner shared a household with the respondent (2% of traders' and 92% of fishers' work partners shared their household; electronic supplementary material, table S1). This difference in the number of work partners sharing a household with the respondent has important implications for interpretation of our model results (below).

Network graphs of women's work and childcare relationships are shown in figure 2. Results from our ERGM (table 2) show that, as predicted, relatedness (Prediction 1a) is the strongest predictor of childcare help for all women ($\beta = 11.975$, 95% CI: 8.807–15.032, $p < 0.001$), but that reciprocity does not predict cooperation in the childcare network ($\beta = 0.225$, 95% CI: −1.336–1.745, $p > 0.05$), which was unexpected (Prediction 1b). Model results also show that, as predicted, a tie between two individuals in the women's work network produces an increased log-likelihood of the same tie in the childcare network ($\beta = 2.203$, 95% CI: 1.107–3.227, $p < 0.001$) (Prediction 2). Contrary to our expectation (Prediction 3), though, the interaction between working together and relatedness did not predict cooperation in the childcare network ($\beta = -1.287$, 95% CI: −2.979–0.323, $p > 0.05$), meaning that relatives who work together are no more likely to be named as potential alloparents than non-relatives who work together or than relatives who do not work together. In the model, we controlled for ego and alter sharing a household (which increased the likelihood of a tie in the childcare network for all women (table 2)), which narrows our interpretation of these last two results to primarily apply to traders. As fishers were significantly more likely to name work partners with whom they shared a household, with all but one alter living with the respondent, and as traders overwhelmingly named work partners whom they did not share a household with, controlling for alter and ego sharing a household means that results in which a tie in the work network is a predictor (i.e. results for Predictions 2 and 3) are interpretable only for traders.

Table 2. Results from exponential random graph model (ERGM) predicting Shodagor women's childcare ties.

	estimate	s.e.	Pr(>|z|)
edges	−5.157	0.313	< 0.001***
relatedness	11.975	1.631	< 0.001***
work together	2.203	0.538	< 0.001***
relatedness * work together	−1.287	0.852	0.131
reciprocity in childcare	0.225	0.778	0.773
household	1.122	0.433	0.009**
in-degree(0)	1.229	0.388	0.002**
out-degree(0)	−0.780	0.394	0.048*

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4. Discussion

Women across cultures and subsistence systems face a similar adaptive problem: how to allocate time between economic and childcare labour. Cooperation among women in childcare is often key to solving this problem, and seems to be especially critical when women are unable to engage in economic and childcare tasks simultaneously. Previous studies of Shodagor families show that both cooperation within the pair bond and additional alloparental help are important in allowing women to do childcare-incompatible work (i.e. trading), but that in fishing families in which work and childcare are

compatible, the pair bond between husband and wife seems to be the key cooperative unit and alloparents are less critical in supporting women's work. In this study, we investigate who Shodagor women choose as cooperative childcare partners and ask whether this differs for traders and fishers to determine whether women's cooperative relationships differ between when their work is not compatible with childcare (trading) and when it is (fishing). Specifically, we ask whether traders, who typically work cooperatively with other women, draw on those cooperative work relationships to expand their pool of potential childcare helpers, and what role kinship plays in patterning these relationships. Below, we discuss our results, including potential cross-cultural and evolutionary implications and what they suggest about female–female cooperation, more broadly.

(a) Kinship, but not direct reciprocity, predicts alloparents for all Shodagor women

Kin selection and reciprocity are often cited as the two most powerful drivers of cooperation, with both playing a critical role in structuring alloparenting relationships across cultures (kin selection: [22,38,39,41,42]; reciprocity: [22,40]). Both of these mechanisms can explain why individuals should help to care for others' children, which may make them more attractive potential cooperative partners for mothers. Therefore, we expected that both relatedness and direct reciprocity would help explain who Shodagor women choose to help them with childcare. As predicted (prediction 1a), our results show that for Shodagor women, relatedness is the strongest predictor of two people having a tie in the childcare network (table 2). Bivariate analyses similarly show that both traders and fishers named significantly more kin than non-kin as potential alloparents (figure 4; electronic supplementary material, table S1). However, contrary to our prediction 1b, direct reciprocity (childcare-for-childcare) did not increase the likelihood of a tie between two people in the childcare network. There are two possible explanations for this result.

First, in societies where reciprocity predicts cooperation in childcare, direct reciprocity seems to provide the best explanation for cooperation among non-kin (e.g. [22,39]; this is consistent with what [60] and [61] found in other domains of cooperation, as well). Data from the sample of Shodagor women used in this paper reveal that most of the alloparents named by traders and fishers are kin members, even though traders name more unrelated alloparents (9% of those named) than fishers (0%). So, if direct reciprocity is a mechanism that primarily motivates cooperation among non-kin, the fact that Shodagor women in this sample simply do not name a lot of non-kin as cooperative childcare partners shows that it is likely there are not enough partners available with whom women can engage in reciprocal childcare relationships.

Second, while some studies have found evidence for the simultaneous importance of kin selection and direct reciprocity in patterning alloparental care (e.g. [22]), others suggest even more complexity. For example, Hames [9] showed that Ye'kwana women cooperated over different time scales to care for children via both reciprocal relationships occurring across generations, with cooperation between mothers and daughters, as well as shorter-term cooperative relationships between women with and without dependent children. Shodagor women may also be engaged in intergenerational, reciprocal childcare relationships, especially given that grandparents and siblings appear to be the most commonly named alloparents for fishers and traders ([33]; electronic supplementary material, figure S1). In sum, we think it is likely that for Shodagor women, kinship co-occurs with reciprocal cooperation over a longer time scale, rather than with simultaneous, direct reciprocal exchange of childcare help, which explains why kinship and not direct reciprocity increase the likelihood of a childcare tie in our model. It may also be the case that direct reciprocity is not an important predictor of childcare cooperation in this community because women are cooperating across different domains to meet their childcare needs.

(b) Cooperation across domains as an adaptive strategy for women

Human relationships cross-cut many different areas of life, with friends and relatives working together, providing childcare for one another and engaging in shared social activities. Researchers have recently demonstrated that maintaining cooperative relationships across different domains (e.g. childcare and sick care) was likely an important evolutionary strategy, ensuring access to care, help and resources when needed (e.g. [40,42–44]). What remained unaddressed, though, was whether or not women specifically use this type of cross-domain cooperation to help solve the adaptive problem associated with work that is incompatible with childcare. In other words, are women using their cooperative work ties as a source of potential alloparents?

Our results indicate that, as predicted (prediction 2), Shodagor women are cooperating across the domains of work and childcare, and that the cooperative relationships women build with one another while working together helps traders meet their specific childcare needs. Specifically, our model results show that a tie between two women in the work network predicts a tie between them in the childcare network (table 2), even after controlling for relatedness. Given that we have controlled for alter and ego sharing a household, and that women who fish share a household with all named alters but 1, these results tell us specifically about traders' cross-domain cooperation, and thus, we do not observe the same pattern of fishers overlapping cooperative work ties with other women with cooperative childcare ties.

This result is consistent with multiple cross-cultural examples showing that women tend to draw on work ties for help with childcare when they are unable to do both tasks simultaneously—either because the work itself cannot be done efficiently while caring for children of any age [16,19,34], or because children's age and mobility level make simultaneous care difficult for a period of time [10,13,38]. While it is unsurprising that alloparents provide necessary help so that women can work, our results as well as cross-cultural accounts suggest that women use the relationships they develop with one another through cooperative economic activities for a specific purpose, which is to address a problem that arises from the incompatibility of those activities with childcare. Additionally, at least in the Shodagor case, this does not appear to be a strategy that is used widely by women who are able to work and care for children at the same time.

(c) Shodagor traders and fishers employ very different strategies to meet childcare needs

In addition to the cross-cultural importance of kin selection and reciprocity as independent drivers of cooperation, evolutionary models routinely predict that these two mechanisms should reinforce each other, leading to the strongest cooperative ties occurring between relatives who maintain reciprocal relationships [22,62,63], and we expect this to extend to cooperation that occurs across different domains, as well. Hames [9] suggests this is the case for Ye'kwana women, describing a complex exchange of garden labour and childcare among mothers and daughters, as well as among other kin. In another example, Martu women appear to use cooperative hunting ties with kin for help with childcare [19,47]. Thus, we expected that Shodagor women who cooperated in work and childcare would would be most likely to do so with kin (prediction 3). However, our model results did not support this prediction for traders (and the model is uninformative on fishers for this prediction, as discussed above). Instead, the model results indicate that relatives who work together as traders are no more likely to be named as potential alloparents than are relatives who do not work together or than unrelated work partners. While this model result is informative for traders and important for testing our prediction, bivariate results from this study, as well as results from previous work [33], allow for a more nuanced interpretation of the nature of Shodagor women's cooperative relationships with kin and non-kin across the domains of work and childcare, and suggest that the relationships women develop and maintain depend on their occupation and its compatibility with childcare, as well as other socio-ecological factors.

Shodagor women who fish appear to opt for an 'overlapping ties' strategy when creating networks of alternative carers for their children that is more consistent with our prediction 3 and with other ethnographic accounts of women's cooperation across domains. Bivariate results from this study show that fishers name fewer work and childcare cooperative partners than traders and that all of their named partners in both domains are relatives (electronic supplementary material, table S1). Additionally, all of the work partners named by women who fish were either their spouse or their children (electronic supplementary material, figure S2), all but one of whom shared a household with the respondent at the time of the survey (electronic supplementary material, table S1). While the potential alloparents they named during this study fall into more kin categories than spouse and children (electronic supplementary material, figure S1), data presented by Starkweather *et al*. [33] reflecting women's twice-monthly self-reports of who provided care for their children (defining *care* in the same way we defined *childcare* and *direct care* above) over 3 years between 2017 and 2019 showed that in fishing households, mothers and fathers are responsible for 97.5% of care for their children, with siblings providing the majority of remaining care. In other words, these data indicate that the majority of cooperative work and childcare relationships in fishing families occur between members of the nuclear family, with mothers and fathers working together and providing the majority of childcare, and older siblings helping out.

We expect that this kind of cooperative strategy should result in smaller cooperative networks for women fishers (at least in work and childcare) that are made up of stronger ties, which have been linked to greater reproductive success for females in multiple species (e.g. [64–67]). This strategy may also be optimized to the particular socio-ecological and economic niche that Shodagor fishers fill [34], in which it is possible for a mother to work and care for children simultaneously, and for most of a household's needs for care and resources to be met nearly exclusively by members of the nuclear family. This is consistent with the predictions of an economy of scale model of the sexual division of labour [68,69], as well as data from groups like Tsimane horticulturalists, which show that when the majority of a household's economic and childcare needs can be met by members of the nuclear family, women tend to have smaller networks, made up largely of close relatives [50,70]. Therefore, an 'overlapping ties' strategy that primarily includes nuclear family members and a few other, very close kin, may be most likely to be observed under similar socio-ecological conditions.

Our data suggest that Shodagor women traders, who live in the same community and cultural setting as fishers, are employing a very different strategy when it comes to the kinds of cooperative networks they appear to be forming. If, rather than creating redundancies in their networks, women were strategizing to create larger networks with a diverse set of cooperative partners, we would expect them to name more partners in total, to name unrelated partners, and not to overlap work partnerships with kin when selecting alloparents. This is exactly the strategy we see Shodagor women traders employing. On average, they name significantly more work (figure 3) and childcare (figure 4) partners than fishers, indicating larger network sizes in these domains. They also name more partners in work and childcare who are non-kin, meaning they are not related to respondents genetically or through marriage (electronic supplementary material, figures S1,S2 and table S1). And while traders name more kin as alloparents than fishers (probably owing to traders naming more alloparents overall, as well as the fact that kin are the most important alloparents for all women), a breakdown across kin categories shows that traders are naming alloparents from more kin categories than fishers (electronic supplementary material, figure S1). For example, traders, but not fishers, named their grandparents, aunts and uncles, and distant kin members as potential alloparents, in addition to their spouses, children and parents. These results are consistent with the data that Starkweather *et al*. [33] reported, in which mother and father account for 84.45% of all childcare, with their parents, older children and others accounting for a larger proportion of care than in fishing families. These results—in which women rely on childcare help from large, diverse networks of alloparents, who include non-kin—are also consistent with patterns of alloparenting across three groups in Sub-Saharan Africa [71] and with Agta women's alloparenting networks in the Philippines [72]. Finally, while our model result does not show a conclusive result about whether traders overlap work and childcare ties with kinship or not, it does generally suggest that traders are not favouring related trading partners as potential alloparents. Considered together, these results suggest that traders are drawing from different pools of potential alloparents—which include their spouses, kin with whom they do not work, and both kin and non-kin work partners—to ensure their households' childcare needs are met while they are working.

While the need for childcare in order for women to work is undoubtedly a strong motivator for traders building the types of networks they do, there is not strong evidence (yet) that women in other contexts and cultures whose work is incompatible with childcare rely on similar types of networks. For instance, while Martu women have large cooperative work networks, women are cooperating most with other female kin in both work [47] and childcare [19] and they seem to be overlapping these cooperative relationships across domains. Tamang women's childcare helpers in rural Nepal [16] may be the closest paralel to Shodagor women traders' cooperative childcare relationships, in which women work with kin and non-kin, primarily cooperate in childcare with kin, but also draw on some cooperative work relationships with non-kin for help with childcare when they are engaged in work that is not fully compatible with childcare. In addition to meeting childcare needs, there are two other potential reasons why Shodagor traders may be interested in building a larger pool of potential helpers than are Shodagor women who fish, or than women in other socio-ecological contexts.

The first reason may be that Shodagor women traders often have a consistent carer in their children's father during the season when women work [33], and thus, alloparents are likely to play a more auxiliary role as carers. Shodagor parents report that fathers do the majority of high-intensity care activities, like feeding, bathing and soothing, and alloparents often watch children for short periods of time while fathers are engaged in other types of activities, like going to the bazaar to buy food. Alloparents may also assist fathers in various ways, for example by helping to keep an eye on older children while they are playing in groups. Despite the possibility that many Shodagor alloparents are engaged in less-intensive childcare tasks (e.g. [72]), their care is important. Shodagor women who have more alloparents available and also have a husband who provides childcare during the dry season are more likely to have reported currently working as traders [34], and children who receive care from both fathers and alloparents during the season when mothers trade experience better growth outcomes than children whose fathers provide care alone [33]. Page *et al*. [72] similarly show that Agta women who live in settled camps have more alloparents who provide low investment types of care than do women living in mobile camps. So, when alloparents are important, but also provide slightly less-intensive types of care, mothers may be motivated to create networks with more potential alloparents in them who are drawn from different pools of mothers' relationships, including unrelated or distantly related individuals. This way, they can ensure that if one alloparent is unavailable to help, they still have more options.

Residence and mobility patterns may also influence Shodagor women traders' decisions to build a larger cooperative childcare network that includes people from more kin categories, as well as non-kin. A few recent, robust studies of women's cooperation indicate that while the number of cooperative partners varies across cultures, both the Tsimane [50,70] and Martu [47] women were less likely than men to cooperate with unrelated individuals. In both cases, this is attributed to residence patterns. In the case of the Tsimane, von Rueden *et al*. [50] suggest that men have fewer opportunities than women to create ties with kin because couples tend to live matrilocally, near the bride's family, after marriage. Martu foragers also have a long history of matrilocal residence patterns [19], to which Bliege Bird *et al*. [47] attribute cooperative relationships among female kin in domains like childcare and hunting. However, patrilocally dwelling women from a diverse set of communities in northern Bangladesh were less likely to live near kin and, thus, reported substantially more non-kin friends than did women living in their natal home who did not migrate for marriage [73]. Batek women commonly forage with unrelated women, which Kraft and colleagues [70] partially attribute to high levels of mobility and changing group membership. While Shodagor residence patterns can be difficult to characterize given the semi-nomadic nature of some families in the group, at the time of data collection in 2017, 56% of Shodagor women traders lived near their husband's family, 25% lived near their own family (matrilocally) and 12.5% lived near members of both their husband's and their own families. By contrast, 27% of Shodagor women fishers lived near their husband's family, 38% lived matrilocally and 11% lived near members of both families. This lack of maternal kin may help explain why traders seek out unrelated individuals to cooperate with in work and childcare. Additionally, if household mobility changes group composition regularly, this may result in only some women living near kin some of the time, which presents a challenge for women when building and maintaining alloparenting networks and could motivate them to build larger networks with multiple types of kin and non-kin.

(d) The Shodagor example (and others) challenges common characterizations of women's cooperation

The primary purpose of this paper was to determine whether and how women may be using cooperative relationships to solve the adaptive problem associated with trade-offs in women's responsibilities in subsistence and childcare activities and so our model focused on explaining the factors that predicted ties between two people in the childcare network. However, our data and results, as well as the larger example provided by Shodagor women, can also contribute to a broader understanding of female–female cooperation in humans in a few other ways. To date, characterizations of female–female cooperation in humans have emphasized findings that show women (i) cooperate primarily in childcare, (ii) are more likely to cooperate with kin than with non-kin, (iii) are less likely to cooperate with non-kin than men, and (iv) cooperate in smaller groups than men, on average [47,50,51,54,74]. To that end, Wrangham & Benenson ([74], pp. 518–519) stated, 'In humans and chimpanzees, males both cooperate and compete more than females do' and '…female investment in other females tends to be focused on kin and a few close friends. By contrast, males tend to invest more in relationships with same-sex peers…', which they attribute to men's involvement in hunting, meat-sharing and warfare, and the adaptive problems those pose. Theoretical treatments of these characterizations suggest that they are a result of sexually selected social strategies in which women's reproductive success benefits more from investment in intimate, dyadic relationships with kin than from investment in building larger coalitions [51,54]. While we do not argue that existing data do reveal some of these trends in female–female cooperation (particularly when compared directly to male–male cooperation), nor do we dispute the importance of the formation of small cooperative networks comprised of strong ties among kin in some cases (e.g. [66,67]), we do suggest that there is mounting evidence to

challenge the cross-cultural or evolutionary ubiquity of these characterizations. The Shodagor case, which includes data we have presented in this paper, contributes to a growing number of studies that offer a nuanced perspective on each of these characterizations of female–female cooperation in humans.

(i) Women cooperate in domains beyond childcare

First, our data contribute empirical evidence showing that women often cooperate in subsistence work (e.g. [17]), and our results offer a potential theoretical explanation for this behaviour.

Most of the work on the evolution of female–female cooperation to date has focused largely on cooperative childcare (or alloparenting). While alloparenting and cooperation in childcare are undoubtedly critical pieces of the human evolutionary puzzle, and although our paper clearly aims to contribute to this literature, women's cooperation in other areas of life should also have played an important role throughout human evolution. Despite ethnographic accounts of cooperation among women in various activities, including subsistence activities, the importance of such cooperation has been 'vastly underrepresented' in empirical work and theoretical constructions of the evolution of human cooperation ([17], p. 4). Meanwhile, a great deal of work has been done to explain men's cooperation in tasks like hunting. One reason for this discrepancy may be that hunting large game animals presents an immediately obvious adaptive problem in which cooperation may be necessary to kill the animal and/or acquire its resources, and that without cooperation in food sharing, the stochasticity of hunting success would leave most families without animal protein in their diet most of the time. Therefore, direct reciprocity (hunting help for hunting help, food sharing for food sharing) often helps explain how big game hunters (who are most often men) solve their adaptive problem. By contrast, women's subsistence work and the types of resources they tend to target do not lend themselves well to a direct reciprocity explanation: resources come in small, reliable packages and do not usually require cooperation to acquire. And, since prominent evolutionary models of divisions of labour posit that women focus on resources that allow them to simultaneously care for children, the problem that women must solve is not always apparent.

However, as we have argued, women's work does present an adaptive problem. Previously, both Wiessner [75] and Bleige Bird *et al*. [47] have hypothesized that cooperative breeding plays a role in the formation and/or maintenance of cooperative relationships in productive tasks. Among Martu foragers in Australia, women cooperate in subsistence tasks more than men, and Bleige Bird *et al*. [47] suggest that this type of cooperation may play a critical role in supporting women's reproductive fitness when work ties can be called upon for help with childcare. Our results show that while Shodagor women fishers primarily cooperate with spouses and other members of the nuclear family, traders cooperate in work with significantly more people than fishers, and with a wider array of people, including distantly related and unrelated individuals. Additionally, while our model focuses on predicting women's cooperative childcare relationships (i.e. we are not explicitly testing what explains women's cooperative work ties), the model result showing that women overlap work and childcare ties offers some preliminary support for Wiessner's and Bleige Bird and colleagues' hypothesis about the interdependence of cooperation in productive tasks with cooperation in childcare. Our results may also indicate that, just as in-kind reciprocity may provide an adaptive solution to the problems associated with hunting, cooperation across domains can provide an adaptive solution for problems associated with women's productive tasks. In other words, one reason why women cooperate in work may be so that they can guarantee access to childcare help when they need it.

(ii) Women's cooperative networks vary in size and composition

Our results, and the Shodagor example more generally, also provide evidence to support other empirical studies of women's cooperative relationships showing that their networks vary between- and within-cultures in their size and composition. That is, women do not always cooperate in dyads or small groups, and a number of examples (including the Shodagor example) show that women regularly cooperate with non-kin. We suggest that at least some of this variation is domain-dependent and can be explained by differences in socio-ecological circumstances.

The domain in which women are cooperating may play a role in their strategies for forming cooperative networks [76]. For example, Martu women cooperate more while hunting than Martu men, but are also more likely than men to work with relatives [47], and cooperate primarily with kin members in childcare [19]. Similarly, even though Shodagor women traders cooperate with more non-kin in both work and childcare than women fishers, and name more non-kin than kin as trading partners, women in both occupations name more kin than non-kin as potential childcare helpers, and traders name significantly more kin as possible alloparents than fishers (electronic supplementary material, table S1). Preliminary examinations of Shodagor men's cooperative work data show that women traders also name more cooperative work partners than Shodagor men who fish (which is the primary occupation of 95% of the men in this sample) and that women traders work with more unrelated individuals than men (electronic supplementary material, figure S3). This is not an unusual pattern across cultures. Kramer [17] points out that in foraging societies, women regularly work in larger groups than men. For example, among Hadza foragers, women routinely forage in groups composed of three to eight women, total, while men hunt alone by day and in pairs at night [77]. These examples suggest that women across cultures may be more likely to cooperate with kin in the domain of childcare, even if they also cooperate with some non-kin (see [71,72]). They also indicate that, within the domain of subsistence work, women may be more likely to form larger cooperative networks that consist of more non-kin, even when compared to men, which may be due (at least in part) to the adaptive explanation we offer above.

In addition to domain, the social and ecological contexts in which people live are also likely to shape women's cooperative strategies. These contexts can influence both the types of resources—and thus, economic strategies—and cooperative partners available to people in a given society, both of which we expect to influence the composition of women's (and men's) cooperative networks. Tsimane women tend to cooperate in work and childcare in small networks made up mostly of kin, both when compared to

Tsimane men [50] and when compared to Batek women in the Philippines [70]. This has been attributed to the economic opportunities available to women, which make cooperation with more people unnecessary, as well as matrilocal residence patterns that result in kin members being available to women, but not men, as cooperative partners. Batek women, by comparison, form larger networks of cooperative foraging partners, comprised of many unrelated individuals, which Kraft and colleagues [70] suggest is a result of high levels of mobility and often-changing group composition. In a comparison between Aché and Hiwi women, Hurtado *et al*. [4] find that seasonal, ecological differences and differences in availability of allomaternal help lead Hiwi women to cooperate more than Aché women. While we do not specifically test the impact of socio-ecological variables on Shodagor women's cooperation in this paper, previous work has shown that local, ecological conditions influence whether women trade or fish as their primary occupation, and that the availability of paternal and alloparental help allows women to go to work as traders, as discussed at length above [33,34]. We expect it is highly likely that these socio-ecological conditions play a major role in shaping the differences we observe in Shodagor women fishers' and traders' cooperative networks.

(iii) Shodagor women use cooperation to circumvent constraints

Finally, one of the prominent evolutionary explanations for characterizations of women's cooperative networks as smaller and more kin-biased than men's cooperative networks is that they reflect sexually selected social strategies, which contribute to a sexual division of labour that is based on biological sex differences, and that these sex differences as well as the types of work that women do as a result (i.e. low-risk activities, close to home, like foraging) may constrain women's ability to form larger networks that regularly include non-kin [50,74]. While, again, we do not dispute the utility of this explanation in some circumstances, nor the evolutionary importance of pregnancy and lactation in shaping sex differences in behaviour to an extent, the Shodagor example (as well as many other examples we have already discussed in this paper) provides a challenge to its broader, cross-cultural applicability for understanding women's cooperation and to its utility for explaining the evolution of women's cooperation.

First, previous studies of Shodagor divisions of labour show substantial within-society variation in how households divide economic and childcare labour [32,34]. These differences largely occur in response to social, ecological and broader cultural circumstances, and not due to women being constrained by lactation or care for young children [34]. In fact, we argue that Shodagor women traders, specifically, are using allomothers as a way to remove these constraints so they can do work that is not compatible with childcare [34]. Here, we show that traders are developing cooperative relationships in both work and childcare with a wide array of kin, as well as many non-kin. By contrast, Shodagor women who fish—whose work is not constrained by lactation or care for young children—do not build such networks, though there is no evidence that they are prevented from doing so, only that it is not a necessity. These divergent strategies may indicate that Shodagor women are purposefully and strategically building social networks primarily in response to differences in socio-ecological circumstances and in response to a need for help with childcare, and not that they reflect sexually selected social strategies.

This example of Shodagor women provides only one data point, as do examples from any other one community. However, our findings and arguments are consistent with data from other cultural contexts. These show that divisions of labour by sex and gender vary widely across human societies [78], with many straying far from the 'classic' characterization in which men hunt and women forage and care for children (e.g. [34,79–81]). There is also growing evidence to suggest that divisions of labour—even ones that closely resemble the 'classic' human sexual division of labour (men hunt, women forage and care for children)—do not routinely constrain women's ability to form social networks across cultures [17,47,70,77]. And finally, numerous examples show that women routinely use cooperative relationships to temporarily free themselves from constraints associated with care for young children so that they can work or engage in other activities [13–16].

All of these cross-cultural examples suggest that women's cooperative relationships and the networks they comprise are a great deal more variable than they are often portrayed. They may also suggest that women evolved to make strategic decisions about who they cooperate with and what kinds of networks they build, and that they may do so particularly in response to their local socio-ecological contexts. In general, much more empirical data that both compare women to men and compare among women are needed in order to understand what drives the variability in female–female cooperation in humans, including what role social or biological constraints may play, and what the relevance of these cooperative relationships may have been throughout human evolutionary history.

Ethics. This research was reviewed and approved by the University of Missouri's Institutional Review Board, the Max Planck Institute for Evolutionary Anthropology's Department of Human Behavior, Ecology and Culture, and the Ethical and Research Review Committees at the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B).

Data accessibility. Code and data are available at: https://zenodo.org/record/7352387#.Y35uPuzMKX1.

The data are provided in electronic supplementary material [82].

Authors' contributions. K.E.S.: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, supervision, writing—original draft, writing—review and editing; A.Z.R.: conceptualization, formal analysis, visualization, writing—original draft, writing—review and editing; F.Z.: data curation, investigation, project administration, writing—original draft, writing—review and editing; N.A.: data curation, methodology, project administration, writing—original draft, writing—review and editing.

All authors gave final approval for publication and agreed to be held accountable for the work performed therein.

Conflict of interest declaration. We declare we have no competing interests.

Funding. We thank the ENDOW Project for providing funding for data collection.

Acknowledgements. The authors would like to thank the Shodagor communities in Matlab, Bangladesh for their participation in this project, as well as their generosity, kindness and friendship. We would also like to thank Siddiqudzaman, Laila Parveen and Ummahani Akter for their assistance with data collection and various other tasks in the field, as well as Taslim Ali, and the HDSS staff at ICDDRB in both Matlab and Dhaka for providing logistical support. Finally, we thank Silke Atmaca, Brett Beheim and the team of hiwis at MPI EVA for all of their help during the process of data entry and curation.

References

1. Stearns SC. 1992 *The evolution of life histories*. Oxford, UK: Oxford University Press.
2. Hawkes K, O'Connell JF, Blurton Jones NG. 1997 Hadza women's time allocation, offspring provisioning, and the evolution of long postmenopausal life spans. *Curr. Anthropol.* **38**, 551–577. (doi:10.1086/204646)
3. Hrdy SB. 1999 *Mother nature: A history of mothers, infants, and natural selection*. New York, NY: Pantheon Books.
4. Hurtado AM, Hill K, Kaplan H. 1992 Trade-offs between female food acquisition and child care among hiwi and ache foragers. *Hum. Nat.* **3**, 185–216. (doi:10.1007/BF02692239)
5. Kramer KL. 2005 Children's help and the pace of reproduction: cooperative breeding in humans. *Evol. Anthropol. Issues, News Rev.* **14**, 224–237. (doi:10.1002/evan.20082)
6. Lancaster JB. 1991 A feminist and evolutionary biologist looks at women. *Yearbook of Physical Anthropol.* **34**, 1–11. (doi:10.1002/ajpa.1330340603)
7. Brown J. 1970 A note on the division of labor by sex. *Am. Anthropol.* **72**, 1073–1078. (doi:10.1525/aa.1970.72.5.02a00070)
8. Hrdy SB. 2009 *Mothers and others: The evolutionary origins of mutual understanding*. Cambridge, MA: Harvard University Press.
9. Hames RB. 1988 The allocation of parental care among the Ye'kwana. In *Human reproductive behavior* (eds L Betzig, MB Mulder, P Turke), pp. 237–252. Cambridge, UK: Cambridge University Press.
10. Hurtado AM, Hawkes K, Hill K, Kaplan H. 1985 Female subsistence strategies among Ache hunter-gatherers of eastern paraguay. *Hum. Ecol.* **13**, 1–28. (doi:10.1007/BF01531086)
11. Jarvenpa R, Brumbach HJ. 1995 Ethnoarchaeology and gender: Chipewyan women as hunters. *Res. Econ. Anthropol.* **16**, 39–82.
12. Kramer KL. 2004 Reconsidering the cost of childbearing: the timing of children's helping behavior across the life cycle of Maya families. In *Socioeconomic aspects of human behavioral ecology* (eds M Alvard), pp. 335–353. Amsterdam, The Netherlands: Elsevier.
13. Draper P. 1976 Social and economic constraints on child life among the !Kung. In *Kalahari hunter-gatherers: studies of the !Kung San and their neighbors* (eds RB Lee, I DeVore), pp. 199–217. Cambridge, UK: Harvard University Press.
14. Kramer KL, Veile A. 2018 Infant allocare in traditional societies. *Physiol. Behav.* **193**, 117–126. (doi:10.1016/j.physbeh.2018.02.054)
15. Meehan CL. 2009 Maternal time allocation in two cooperative childrearing societies. *Hum. Nat.* **20**, 375. (doi:10.1007/s12110-009-9076-2)
16. Panter-Brick C. 1989 Motherhood and subsistence work: the Tamang of rural Nepal. *Hum. Ecol.* **17**, 205–228. (doi:10.1007/BF00889713)
17. Kramer KL. 2022 Female cooperation: an evolutionary, cross-cultural & ethnographic history. *Phil. Trans. R. Soc. B* **378**, 20210425. (doi:10.1098/rstb.2021.0425)
18. Meehan CL, Quinlan R, Malcom CD. 2013 Cooperative breeding and maternal energy expenditure among Aka foragers. *Am. J. Hum. Biol.* **25**, 42–57. (doi:10.1002/ajhb.22336)
19. Scelza B, Bird RB. 2008 Group structure and female cooperative networks in Australia's Western Desert. *Hum. Nat.* **19**, 231–248. (doi:10.1007/s12110-008-9041-5)
20. Kokko H, Johnstone RA, Wright J. 2002 The evolution of parental and alloparental effort in cooperatively breeding groups: when should helpers pay to stay? *Behav. Ecol.* **13**, 291–300. (doi:10.1093/beheco/13.3.291)
21. Martin JS, Ringen EJ, Duda P, Jaeggi AV. 2020 Harsh environments promote alloparental care across human societies. *Proc. R. Soc. B* **287**, 20200758. (doi:10.1098/rspb.2020.0758)
22. Page AE *et al.* 2019 Testing adaptive hypotheses of alloparenting in Agta foragers. *Nat. Hum. Behav.* **3**, 1154–1163. (doi:10.1038/s41562-019-0679-2)
23. Rosenbaum S, Kuzawa CW, McDade TW, Bechayda SA, Gettler LT. 2022 Neither environmental unpredictability nor harshness predict reliance on alloparental care among families in Cebu, Philippines. *Dev. Psychopathol.* **25**, 1–12. (doi:10.1017/S0954579421001711)
24. Hagen EH, Clark Barrett H. 2009 Cooperative breeding and adolescent siblings: evidence for the ecological constraints model? *Curr. Anthropol.* **50**, 727–737. (doi:10.1086/605328)
25. Nelson RG. 2016 Residential context, institutional alloparental care, and child growth in Jamaica. *Am. J. Hum. Biol.* **28**, 493–502. (doi:10.1002/ajhb.22819)
26. Prall SP, Scelza BA. 2017 Child fosterage and sex-biased nutritional outcomes among Namibian pastoralists. *Am. J. Hum. Biol.* **29**, e23058. (doi:10.1002/ajhb.23058)
27. Nitsch A, Faurie C, Lummaa V. 2014 Alloparenting in humans: fitness consequences of aunts and uncles on survival in historical Finland. *Behav. Ecol.* **25**, 424–433. (doi:10.1093/beheco/art126)
28. Sear R. 2008 Kin and child survival in rural Malawi. *Hum. Nat.* **19**, 277. (doi:10.1007/s12110-008-9042-4)
29. Voland E, Beise J. 2002 Opposite effects of maternal and paternal grandmothers on infant survival in historical Krummhörn. *Behav. Ecol. Sociobiol.* **52**, 435–443. (doi:10.1007/s00265-002-0539-2)
30. ICDDRB. 2018 *Health and demographic surveillance system - Matlab: annual report*. Scientific Report 103. Mohakhali, Dhaka: IDCCRB.
31. Ahmed AMMM, Roy K. 2007 Utilization and conservation of water resources in Bangladesh. *J. Dev. Sustain. Agric.* **2**, 35–44. (doi:10.11178/jdsa.2.35)
32. Starkweather KE. 2017 Shodagor family strategies: balancing work and family on the water. *Hum. Nat.* **28**, 138–166. (doi:10.1007/s12110-017-9285-z)
33. Starkweather KE, Keith MH, Prall S, Alam N, Thompson ME, Zohora F. 2021 Are fathers a good substitute for mothers? Paternal care and growth rates in Shodagor children. *Dev. Psychobiol.* **63**, 1–24. (doi:10.1002/dev.22148)
34. Starkweather KE, Shenk MK, McElreath R. 2020 Biological constraints and socioecological influences on women's pursuit of risk and the sexual division of labour. *Evol. Hum. Sci.* **2**. e59. (doi:10.1017/ehs.2020.60)
35. Anderson KG, Kaplan H, Lancaster J. 1999 Paternal care by genetic fathers and stepfathers I: reports from Albuquerque men. *Evol. Hum. Behav.* **20**, 405–431. (doi:10.1016/S1090-5138(99)00023-9)
36. Marlowe FW. 2000 Paternal investment and the human mating system. *Behav. Process.* **51**, 45–61. (doi:10.1016/S0376-6357(00)00118-2)
37. Woodroffe R, Vincent A. 1994 Mother's little helpers: patterns of male care in mammals. *Trends Ecol. Evol.* **9**, 294–297. (doi:10.1016/0169-5347(94)90033-7)
38. Crittenden AN, Marlowe FW. 2008 Allomaternal care among the Hadza of Tanzania. *Hum. Nat.* **19**, 249–262. (doi:10.1007/s12110-008-9043-3)
39. Ivey PK. 2000 Cooperative reproduction in Ituri forest hunter-gatherers: who cares for Efe infants? *Curr. Anthropol.* **41**, 856–866. (doi:10.1086/317414)
40. Jaeggi AV, Hooper PL, Beheim BA, Kaplan H, Gurven M. 2016 Reciprocal exchange patterned by market forces helps explain cooperation in a small-scale society. *Curr. Biol.* **26**, 2180–2187. (doi:10.1016/j.cub.2016.06.019)
41. Kramer KL. 2010 Cooperative breeding and its significance to the demographic success of humans. *Annu. Rev. Anthropol.* **39**, 417–436. (doi:10.1146/annurev.anthro.012809.105054)
42. Meehan CL. 2008 Allomaternal investment and relational uncertainty among Ngandu farmers of the Central African Republic. *Hum. Nat.* **19**, 211. (doi:10.1007/s12110-008-9039-z)
43. Atkisson C, Górski PJ, Jackson MO, Hołyst JA, D'Souza RM. 2020 'Why understanding multiplex social network structuring processes will help us better understand the evolution of human behavior. *Evol. Anthropol. Issues News Rev.* **29**, 102–107. (doi:10.1002/evan.21850)
44. Dyble M, Thompson J, Smith D, Salali GD, Chaudhary N, Page AE, Vinicuis L, Mace R, Migliano AB. 2016 Networks of food sharing reveal the functional significance of multilevel sociality in two hunter-gatherer groups. *Curr. Biol.* **26**, 2017–2021. (doi:10.1016/j.cub.2016.05.064)
45. Power EA. 2018 Collective ritual and social support networks in rural South India. *Proc. R. Soc. B* **285**, 20180023. (doi:10.1098/rspb.2018.0023)
46. Akresh R, Chen JJ, Moore CT. 2016 Altruism, cooperation, and efficiency: agricultural production

in polygynous households. *Econ. Dev. Cult. Change* **64**, 661–696. (doi:10.1086/686668)

47. Bliege Bird R, Scelza B, Bird DW, Smith EA. 2012 The hierarchy of virtue: mutualism, altruism and signaling in Martu women's cooperative hunting. *Evol. Hum. Behav.* **33**, 64–78. (doi:10.1016/j.evolhumbehav.2011.05.007)
48. Estioko-Griffin AA, Bion Griffin P. 1981 Woman the hunter: the Agta. In *Woman the gatherer*, pp. 121–152. New Haven, CT: Yale University Press.
49. Atkisson C, Finn K 2020. Redundant relationships in multiplex food sharing networks increase food security in a nutritionally precarious environment. arXiv:2011.12817.
50. von Rueden C, Alami S, Kaplan H, Gurven M. 2018 Sex differences in political leadership in an egalitarian society. *Evol. Hum. Behav.* **39**, 402–411. (doi:10.1016/j.evolhumbehav.2018.03.005)
51. Benenson JF, Markovits H. 2014 *Warriors and worriers: The survival of the sexes*. Oxford, UK: Oxford University Press.
52. Linney C, Korologou-Linden L, Campbell A. 2017 Maternal competition in women. *Hum. Nat.* **28**, 92–116. (doi:10.1007/s12110-016-9279-2)
53. Low BS. 1992 Sex, coalitions, and politics in preindustrial societies. *Politics Life Sci.* **11**, 63–80. (doi:10.1017/S0730938400017214)
54. Yanca C, Low BS. 2004 Female allies and female power: a cross-cultural analysis. *Evol. Hum. Behav.* **25**, 9–23. (doi:10.1016/S1090-5138(03)00065-5)
55. Marsden PV. 1990 Network data and measurement. *Annu. Rev. Sociol.* **16**, 435–463. (doi:10.1146/annurev.so.16.080190.002251)
56. Hamilton WD 1964 The genetical evolution of social behaviour. *J. Theor. Biol* **7**, 1–17. (doi:10.1016/0022-5193(64)90038-4)
57. Robins G, Pattison P, Kalish Y, Lusher D. 2007 An introduction to exponential random graph (p*) models for social networks. *Soc. Netw.* **29**, 173–191. (doi:10.1016/J.SOCNET.2006.08.002)
58. Hunter D, Handcock M, Butts C, Goodreau S, Morris M. 2008 ergm: a package to fit, simulate and diagnose exponential-family models for networks. *J. Stat. Softw.* **24**, 1–29. (doi:10.18637/JSS.V024.I03)
59. R Core Team. 2021 *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. See https://www.R-project.org/
60. 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)
61. Koster J. 2011 Interhousehold meat sharing among Mayangna and Miskito horticulturalists in Nicaragua. *Hum. Nat.* **22**, 394–415. (doi:10.1007/s12110-011-9126-4)
62. Allen-Arave W, Gurven M, Hill K. 2008 Reciprocal altruism, rather than kin selection, maintains nepotistic food transfers on an Ache reservation. *Evol. Hum. Behav.* **29**, 305–318. (doi:10.1016/j.evolhumbehav.2008.03.002)
63. Nolin DA. 2010 Food-sharing networks in Lamalera, Indonesia. *Hum. Nat.* **21**, 243–268. (doi:10.1007/s12110-010-9091-3)
64. Brent LIN, Heilbronner SR, Hovarth JE, Gonzalez-Martinez J, Ruiz-Lambides A, Robinson AG, Skene JHP, Platt ML. 2013 Genetic origins of social networks in rhesus macaques. *Scientific Rep.* **3**, 1042. (doi:10.1038/srep01042)
65. Ramp C, Hagen W, Palsbøll P, Bérubé M, Sears R. 2010 Age-related multi-year associations in female humpback whales (*Megaptera novaeangliae*). *Behav. Ecol. Sociobiol.* **64**, 1563–1576. (doi:10.1007/s00265-010-0970-8)
66. Silk JB, Alberts SB, Altmann J. 2003 Social bonds of female baboons enhance infant survival. *Science* **302**, 1231–1234. (doi:10.1126/science.1088580)
67. Silk JB, Seyfarth RM, Cheney DL. 2018 Quality versus quantity: do weak bonds enhance the fitness of female baboons? *Anim. Behav.* **140**, 207–211. (doi:10.1016/j.anbehav.2018.04.013)
68. Becker GS. 1985 Human capital, effort, and the sexual division of labor. *J. Lab. Econ.* **3**, S33–S58. (doi:10.1086/298075)
69. Kaplan H, Hill K, Lancaster J, Hurtado AM. 2000 A theory of human life history evolution: diet, intelligence, and longevity. *Evol. Anthropol.* **9**, 156–185. (doi:10.1002/1520-6505(2000)9:4<156::AID-EVAN5>3.0.CO;2-7)
70. Kraft T *et al.* 2022 Female cooperative labour networks in hunter-gatherers and horticulturalists. *Phil. Trans. R. Soc. B* **378**, 20210431. (doi:10.1098/rstb.2021.0431)
71. Helfrecht C, Roulette JW, Lane A, Sintayehu B, Meehan CL. 2020 Life history and socioecology of infancy. *Am. J. Phys. Anthropol.* **173**, 619–629. (doi:10.1002/ajpa.24145)
72. Page AE, Migliano A, Viguier S, Smith D, Dyble M, Hassan A. 2022 Sedentarisation and maternal childcare networks: role of risk-buffering, gender and demography. *Phil. Trans. R. Soc. B* **378**, 20210435. (doi:10.1098/rstb.2021.0435)
73. Hruschka D, Munira S, Jesmin K. 2022 Starting from scratch in a patrilocal society: how women build networks after marriage in rural Bangladesh. *Phil. Trans. R. Soc. B* **378**, 20210432. (doi:10.1098/rstb.2021.0432)
74. Wrangham RW, Benenson J. 2017 Cooperative and competitive relationships within sexes. In *Chimpanzees and human evolution* (eds MN Muller, RW Wrangham, DR Pilbeam), pp. 509–547. Cambridge, MA: Harvard University Press.
75. Wiessner P. 2002 Hunting, healing, and hxaro exchange: a long-term perspective on !Kung (Ju/'hoansi) large-game hunting. *Evol. Hum. Behav.* **23**, 407–436. (doi:10.1016/S1090-5138(02)00096-X)
76. Mattison S, MacLaren N, Sum C-Y, Shenk M, Blumenfield T, Wander K. 2022 Does gender structure social networks across domains of cooperation? An exploration of gendered networks among matrilineal and patrilineal Mosuo. *Phil. Trans. R. Soc. B* **378**, 20210436. (doi:10.1098/rstb.2021.0436)
77. Marlowe FW. 2010 *The Hadza: hunter-gatherers of Tanzania*. Berkeley, MA: University of California Press.
78. Bliege Bird R, Codding BF. 2015 The sexual division of labor. In *Emerging trends in the social and behavioral sciences* (eds RA Scott, SM Kosslyn), pp. 1–16. New Jersey, NJ: John Wiley & Sons.
79. Haas R *et al.* 2020 Female hunters of the early Americas. *Sci. Adv.* **6**, eabd0310. (doi:10.1126/sciadv.abd0310)
80. Hilty A. 2015 *Jeju haenyeo: stewards of the sea*, vol. 1. Jeju City, South Korea: Jeju National University Press.
81. Milgram BL. 2001 'Situating handicraft market women in Ifugao, Upland Philippines: a case for multiplicity. In *Women traders in cross-cultural perspective: mediating identities, marketing wares* (ed. LJ Seligmann), pp. 212–224. Redwood City, CA: Stanford University Press.
82. Starkweather KE, Reynolds AZ, Zohora F, Alam N. 2022 Shodagor women cooperate across domains of work and childcare to solve an adaptive problem. Figshare. (doi:10.6084/m9.figshare.c.6251148)