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Multiple reputation domains and cooperative behaviour in two Latin American communities

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Reputations are a ubiquitous feature of human social life, and a large literature has been dedicated to explaining the relationship between prosocial reputations and cooperation in social dilemmas. However, humans form reputations in domains other than prosociality, such as economic competency that could affect cooperation. To date, no research has evaluated the relative effects of multiple reputation domains on cooperation. To bridge this gap, we analyse how prosocial and competency reputations affect cooperation in two Latin American communities (Bwa Mawego, Dominica, and Pucuchanchita, Peru) across a number of social contexts (Dominica: labour contracting, labour exchange and conjugal partnership formation; Peru: agricultural and health advice network size). First, we examine the behavioural correlates of prosocial and competency reputations. Following, we analyse whether prosocial, competency, or both reputation domains explain the flow of cooperative benefits within the two communities. Our analyses suggest that (i) although some behaviours affect both reputation domains simultaneously, each reputation domain has a unique behavioural signature; and (ii) competency reputations affect cooperation across a greater number of social contexts compared to prosocial reputations. Results are contextualized with reference to the social markets in which behaviour is embedded and a call for greater theory development is stressed.

1. Introduction

Reputations are a set of beliefs, perceptions and evaluations that individuals within a social group form about other members' behavioural tendencies [1–5]. These beliefs are generated through direct and indirect experience (e.g. eavesdropping [6,7] and gossip [8]). The latter reduces transaction costs associated with social interaction by providing individuals with information about others' behavioural propensities without the cost of direct experience, thereby increasing the number of individuals with whom one can cooperate [4,5,9–13]. Reputational beliefs come in two varieties: (i) beliefs about others (answering the question: 'what do I think of individual X?') and (ii) beliefs about what others think of the self (answering the question: 'what do other people think of me?') [4,14]. While the former facilitates ego's decision-making regarding social partner choice, the latter regulates ego's behaviour relative to the presence of an audience (i.e. impression management) [15,16].

Over the past two decades, researchers in the social, behavioural and physical sciences have emphasized the role of other-regarding beliefs, specifically prosociality, in the evolution and stability of cooperation in social dilemmas [1,5,17–24]—i.e. situations where short-term individual self-interest is in conflict with long-term group interests [25–27]. This research has occurred largely under two distinct intellectual traditions: Indirect Reciprocity [1,18,19,28–31] and Market Models, which include competitive altruism [21,23,32–35], biological market theory [36–39] and costly signalling theory [10,12,40–46]. Both sets of models assume that actors have preferences for prosocial individuals; however, they differ in fundamental ways. While indirect reciprocity models emphasize the role that prosocial reputations play in the evolution of cooperation in randomly paired, non-repeated

interactions, market models emphasize how prosocial reputations, partner choice and the size of the marketplace affect partnership formation, the level of investment in repeated and non-repeated encounters, and the stability of cooperation. Furthermore, indirect reciprocity models assume that cooperative behaviour is strategic and reputations represent moral assessments about previous behaviour [47], while market models assume that cooperative behaviour is quality-dependent and reputations represent beliefs about underlying quality [10,32,36,48]. Both classes of models demonstrate that reputations can stabilize cooperation in social dilemmas; however, market models provide a useful framework for describing patterns of social exchange in small populations where both reputations and repeated interactions exist simultaneously [47].

Although these models have made great strides in revealing the role that prosocial reputations play in the evolution and stability of cooperation, issues remain. A notable absence in this area of research is the effect of multiple reputation domains on cooperation. Human communities form reputational judgements across a number of domains, including aggression, leadership and skill [11,13]. Can reputation domains other than prosociality affect cooperation?

One domain that has been identified as widely valued, highly variable, a signal of quality and important for cooperation is economic competency (e.g. skill or effort) [10–12,49–52]. One way in which economic competency could affect cooperative outcomes is through prestige-biased transmission [11,53]. Under prestige-biased transmission, highly skilled individuals, who are valued for their knowledge and expertise, are sought out by those who wish to acquire ecologically relevant knowledge and skills. To curry the favour of competent individuals, naive learners may provide a variety of benefits to skilled individuals, including labour, services or companionship. The cost that naive learners are willing to pay for access to skilled individuals in such a prestige market depends on a variety of factors, including the number of skilled individuals available, the level of skill variability between models, the number of naive learners willing to compete for access to skilled individuals, and whether social learning represents a zero-sum game [11,36–38,53]. All things equal, prestige-biased transmission processes should result in naive actors who seek out and provide benefits to skilled individuals in an effort to increase competency.

A second way in which economic competency might affect cooperation is through the private, public, club and/or common-pool goods produced by highly skilled individuals [48,54]. Economically competent individuals have a greater ability to produce strategic resources relative to less competent individuals. These resources can be used to provision others directly (facilitating partnership formation or maintenance) and also signal one's underlying quality, which can lead to alliance formation, deference and mating opportunities. Cross-cultural research demonstrates that economically competent males achieve more marriage partners and/or more extra-pair copulations, have more community influence, and larger political and social support networks compared to less competent men [10,13,49,52,55,56]. However, if productivity and generosity are correlated, as is found in many small-scale societies [53,57], it could be that generosity, rather than competency, is the valued trait that others use for partnership formation [10,56]. Supporting this claim, Barclay [58] demonstrates that females prefer altruistic males for romantic partnerships relative to stingy ones, while a number of studies show that individuals with better prosocial reputations have larger social support

networks and receive more labour and monetary rewards compared to low prosocial individuals [18,20,23,24,34,35,59]. Without controlling for the shared variance between competency and generosity, it is unclear whether one reputation, the other, or both are salient for partnership formation.

To our knowledge, this issue has not been theoretically or empirically addressed. In an attempt to fill this gap in the literature, we examine prosocial giving and economic competency reputations in two rural, Latin American communities (Bwa Mawego, Dominica, and Pucuchanchita, Peru). Our research was guided by two general questions: (i) what are the behavioural correlates of prosocial and competency reputations; and (ii) do prosocial or competency reputations better explain variation in cooperative behaviour and the flow of benefits in ethnographically relevant social contexts? To address these questions, we first outline the organizational structure of cooperation in specific domains of socio-economic life (Dominica: labour contracting, labour exchange and conjugal partnership formation; Peru: agricultural and health advice network size). Second, we examine the behavioural correlates of prosocial and competency reputations within these economic domains. Third, we consider the impact that different reputation domains have on cooperation.

2. Study site and organizational context

(a) Bwa Mawego, Dominica

Bwa Mawego (pseudonym) is a poor, rural village on the southeast coast of the independent Caribbean nation of Dominica [60]. The village contains approximately 180 households and 500 residents who are largely derived from Indigenous Carib, European and African ancestry. Consistent with other poor Afro-Caribbean populations, social life has a matrifocal orientation [61] with men experiencing local resource competition [62,63] and women forming the core of household social relationships. The adult sex ratio is male biased, as females are more than twice as likely to leave the community for education and labour opportunities [64,65] and female in-migration is rare. Formal marriage as an institution is on the decline; however, villagers do form stable conjugal relationships with approximately 30% of mothers in long-term conjugal partnerships [65]. Conjugal partner switching occurs but is gossiped about if it occurs while the forsaken partner is co-resident in the village. Many adults engage in promiscuous mating relationships and it is common for both women and men to have children from multiple sexual partners. Jealousy and sexual antagonism are not uncommon for individuals in fluid sexual relationships and women often complain when sexual partners do not provide monetary resources for their children. Most adults hope to achieve conjugal partner stability, parenthood and eventually the respect that comes with formal marriage.

Village economy includes subsistence horticulture, fishing, cash cropping and petty commodity production. The primary cash crop cultivated is the native Caribbean bay tree (*Pimenta racemosa* [Miller] J.W. Moore), the leaves of which are harvested and steam distilled to produce bay oil—a commodity that is purchased and refined by the nation's lone essential oils cooperative and sold on the international commodities market (S.J.M. 2010, unpublished thesis). Although no institutionalized sexual division of labour exists, production largely is a male task and a major component of daily social life

[23]. Corporate patrilineal kin groups own all land in the village, and by extension bay trees; however, individuals manage plots of land on a usufruct basis. Considerable inequalities exist in land holdings. Some individuals have usufruct rights to 12 acres, other adults have access to no land, and the average adult has access to a quarter acre. Once an individual holds a plot of land through inheritance and usufruct, they can make the land productive themselves or they can allow others to manage it for them. In the former, the individual, not the kin group, has total rights to the goods produced. If the latter situation arises (because the landholder has too much land to work themselves, becomes too old to work the land, or if they emigrate from the community), norms in the community dictate that land managers and landowners should split the cash earnings from a distillation event at a rate of 1/3 to 2/3, respectively. A bay leaf distillation event results in a gross cash distribution of approximately \$176 US. Bay oil distillation is gruelling work and individuals seeking to produce it (referred to here as a 'Chief-for-a-day' or CFAD) require assistance from community members. However, individuals providing assistance have no stake in the oil or money that is generated from a distillation event. CFADs incentivize labour from others by offering alcohol, cigarettes and food to helpers; however, community members are additionally incentivized to provide assistance, as they will require assistance from others in the future when they distil bay oil themselves. Individuals who have received labour from a CFAD in the past are supposed to provide assistance. Owing to the village's small size and the highly conspicuous nature of the task, people realize when they should provide assistance; however, a temptation to shirk one's reciprocal labour obligations is always present. Village members who do not owe labour may opt to assist a CFAD if they seek a new labour partnership. The more labour a CFAD receives, the easier the process; as such, an economy of scale is present with median group sizes equal to three individuals [23] (S.J.M. 2010, unpublished thesis). Interviews with CFADs suggest that assistance from two individuals efficiently manages the trade-offs between sufficient help for completing the task while minimizing reciprocal labour obligations to others. However, many CFADs prefer slightly larger groups as larger groups tend to involve more socializing and festivities. In summary, bay oil production can require cooperation at two stages: (i) labour contracting—where landowners partner with individual community members to manage plots of land and distil bay oil; and (ii) bay oil distillation—where community members assist CFADs. Whereas labour contracting represents a patron–client relationship and therefore a principal–agent dilemma, bay oil distillation is best typified as an N -player, sequential, iterated, mutual aid game. In conjunction with our research focus, we probe two questions: (i) what are the behavioural determinants of prosocial and economic competency reputations relative to bay oil production; and (ii) how do prosocial and economic competency reputations affect cooperation and the flow of benefits?

3. Material and methods

(a) Labour, contracts and reputations

One village resident and S.J.M. performed daily instantaneous scan samples of the village's eight distilleries over a 20-month period (1 July 2008 to 1 March 2010) divided into two 10-month time periods (the amount of time for bay trees to re-generate sufficient leaves for harvest; hereafter, T_1 and T_2 , respectively).

Table 1. Descriptive statistics associated with Dominican bay oil distillation.

	<i>N</i>	mean (s.d.)	median	min/max
age	53	45 (13.5)	42	18/80
# CFADs assisted	53	3 (3.4)	2	0/15
# days as CFAD	53	3 (3.1)	3	0/14
prosocial reputation	53	0.7 (0.3)	0.75	0/1
labor competency	53	3.7 (0.8)	3.75	2/5
reputation				
# contracts	53	3 (4)	1	0/20
received				
# patrons	53	1 (1.2)	1	0/5
average # of	37	2 (0.6)	2	1/3
helpers				

During distillery scans, we recorded the CFAD in charge of distilling bay oil, their sex, age, and conjugal status, the number of assistants present, their age and sex, as well as the landowner associated with the bay leaves. Four hundred and sixty-five distillation events were recorded across the 20-month time frame ($T_1 = 193$ events; $T_2 = 272$ events), involving 149 people, 129 of whom were males. Fifty-three of these males were selected to have their reputations analysed (table 1). Of the 465 distillation events, 330 (71%) involved a landowner who contracted a land manager ($T_1 = 126$ events; $T_2 = 204$ events).

Reputations for labour competency and prosociality were assessed using peer-rated pile sort tasks near the midpoint between the two time periods. This allows us to determine: (i) the effect of behaviour during the first 10-month time period on reputation formation, and (ii) the effect of reputations on cooperation and the flow of benefits in the second 10-month time period. In June 2009, S.J.M. asked four community members (two males and two females) to rate the 53 men on their bay oil distillation labour competency using an emically derived five-point ordinal scale (1 = least competent; 5 = most competent) using the French patois prompts 'Oin twiver wed' and 'har cor', Dominican phrases roughly translated as 'a hard/competent worker'. The task required raters to place 53 cards, each of which contained the name of an individual male, into one of the five categories. In July 2009, a field assistant asked four community members (two males and two females) to rate the same 53 men on their prosocial tendencies using the French patois prompt 'Koudmen', a Dominican term referring to one who gives labour freely to others in need. The task required raters to place the same 53 cards into one of two categories: (i) ego would not provide labour to another in need; or (ii) ego would provide labour to another in need. Using standards associated with inter-reliability for nominal- and ordinal-level data and multiple reviewers, peer assessments had moderate (prosociality: Gwet's $AC_1 = 0.6$; $p < 0.001$; $n = 53$) to fair (labour competency: Gwet's $AC_1 = 0.14$; $p = 0.006$; $n = 53$) inter-rater reliability [66]. Ratings were averaged across the four reviewers within each task, resulting in two ordinal-level scales.

4. Results

(a) What are the behavioural correlates of reputations in Dominica?

Consistent with previous analyses regarding prosocial reputations in this population [5,23] (S.J.M. 2010, unpublished thesis),

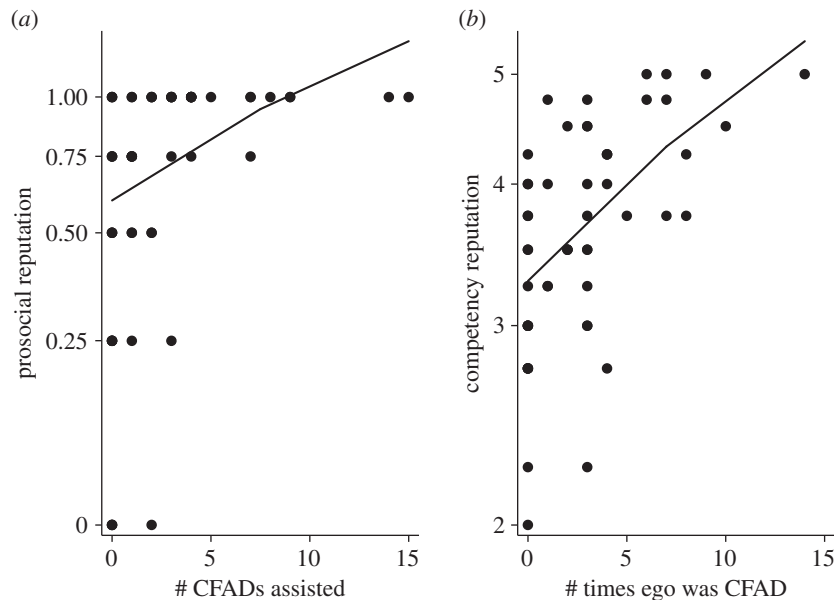


Figure 1. Scatterplot relationship showing the behavioural correlates of reputations. (a) The number of CFADs ego assisted in the first 10-month time period and his reputation for prosociality (y -axis on log scale). (b) The number of days ego was a CFAD in the first 10-month time period and his reputation for labour competency (y -axis on log scale).

ordered logistic multiple regression shows that prosocial reputations are the product of an individual's age and the number of CFADs he assisted in the previous 10 months, controlling for the number of times a man acts as a CFAD (pseudo $R^2 = 0.21$; $n = 53$, $p = 0.0001$; natural log # of CFADs assisted: odds ratio (OR) = 8.2; $z = 4$; $p < 0.001$; age: OR = 0.9; $z = -2.1$; $p = 0.03$; natural log # times CFAD: OR = -0.6; $z = -1.5$; $p = 0.13$; figure 1a). Younger men and men who help more CFADs have better prosocial reputations.

On the other hand, ordered logistic multiple regression shows that labour competency reputations are the product of the number of times an individual acts as a CFAD and the number of CFADs assisted in the previous 10 months (pseudo $R^2 = 0.13$; $n = 53$, $p = 0.0003$; natural log # times CFAD: OR = 3.6; $z = 3.3$; $p = 0.001$; natural log # of CFADs assisted: OR = 2.4; $z = 2.3$; $p = 0.02$; age: OR = 0.9; $z = -1.2$; $p = 0.2$; figure 1b). Dominican men become recognized for their competency in bay oil distillation by acting as a CFAD and by assisting other CFADs. While each reputation has a unique behavioural signature, assisting CFADs simultaneously affects a man's perceived competence and prosociality.

(b) How do multiple reputations differently affect cooperation and the flow of benefits in Dominica?

Bay oil production represents a multistage process that can require cooperation at two levels: (i) between landowners (patrons) and CFADs (clients) who form labour contract relationships; and (ii) between CFADs and assistants who form labour exchange relationships. Here, we examine how prosocial and labour competency reputations differently affect cooperation at each stage. Potentially, landowners/patrons could seek highly competent individuals, highly prosocial individuals, or both for allocating labour contracts. Whereas a competent male knows how to complete the job successfully, a prosocial man may have the social capital necessary to generate a sufficient labour pool. A Poisson multiple regression analysis reveals that greater competency leads

to a greater number of patrons (model pseudo $R^2 = 0.14$; $p = 0.0001$; $n = 53$; competency reputation: incident rate ratio (IRR) = 2.1; $z = 3.4$; $p = 0.001$; prosocial reputation: IRR = 1.3; $z = 0.6$; $p = 0.6$; age: IRR = 0.9; $z = -0.5$; $p = 0.6$; constant: IRR = 0.05; $z = -2.7$; $p = 0.008$). In fact, for every one unit increase in competency reputation, the incident rate of achieving another patron more than doubles (figure 2a). One benefit to creating a labour partnership with a landowner/patron is that clients have access to a greater number of labour contracts and therefore wealth. As such, we predict that competent individuals should also receive more labour contracts. A Poisson multiple regression analysis demonstrates that competent labourers do receive more labour contracts compared to prosocial individuals (not shown); however, the relationship between competency reputations and the number of labour contracts received is fully mediated once the effect of number of landowners/patrons is controlled (model pseudo $R^2 = 0.48$; $p < 0.001$; $n = 53$; competency reputation: IRR = 1.4; $z = 1.5$; $p = 0.15$; prosocial reputation: IRR = 0.7; $z = -0.7$; $p = 0.5$; number of landowners/patrons: IRR = 1.8; $z = 5.6$; $p < 0.001$; constant: IRR = 0.3; $z = -1.2$; $p = 0.2$; figure 2b). In summary, the more an individual is perceived as competent, the more landowners/patrons are willing to form labour partnerships with him, and the more labour partnerships an individual forms, the more contracts (and wealth) he receives.

Once a labour contract is in hand, CFADs must generate sufficient help to produce bay oil. Previous analyses suggest that CFADs with better prosocial reputations achieve larger groups and more days of labour compared to those with poor prosocial reputations [23]. However, according to the mechanism of prestige-biased transmission, individuals without land or other economic prospects may opt to work for a competent CFAD to learn the process himself in the hope that such labour results in improved skills, a better competency reputation and eventually landowners/patrons seeking his services in the future. If this is correct, then reputations for labour competency should moderate or mediate the relationship between prosocial reputations and the number of people who assist a CFAD. Thirty-seven of the

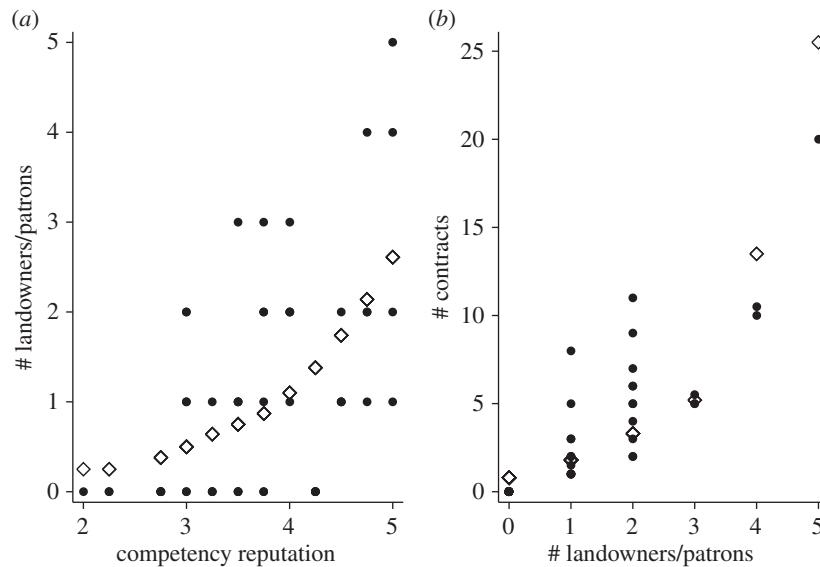


Figure 2. Scatterplot relationships between competency reputation, the number patron–client relationships and the number of contracts received in the second 10-month time period. (a) Competency reputation and the number of labour partnerships with landowners. (b) The number of labour partnerships and labour contracts. Filled circles, observed; diamond, predicted.

Table 2. Model coefficients associated with generalized estimating equation (GEE) linear model predicting the number of assistants a CFAD receives per distillation event.

	<i>B</i>	<i>z</i>	<i>p</i>
prosocial reputation	0.9	2.6	0.01
labour competency reputation	0.2	1.1	0.26
CFAD age	0.001	0.2	0.86
event involved a labour contract (0 = no; 1 = yes)	0.002	0.01	0.9
constant	0.8	0.9	0.4

53 individuals acted as a CFAD in the second 10-month time period, resulting in an analysis that is restricted to these individuals alone. Because CFADs distil more than a single batch of oil over the 10-month time period, they can be represented in the dataset multiple times. As a result, a generalized estimating equation is required to account for the data's structural autocorrelation around CFADs [67]. A Gaussian-family generalized estimating equation (using an exchangeable correlation structure) shows that CFADs with better prosocial reputations, not competency reputations, attract more assistants per event (model Wald $\chi^2 = 20.8$; n -observations = 211; n -groups = 37; $p < 0.001$), even after controlling for whether the event involved a labour contract or not (table 2). Whereas men who are regarded as highly competent have more patrons and therefore more labour contracts, men who are regarded as highly prosocial receive more assistance in bay oil distillation.

Last, we examine the relationship between multiple reputation domains and the odds of a conjugal partnership formation as a further index of cooperation and the benefits therein. Thirty-one of the 53 men were in a conjugal relationship during the data collection period. Research suggests that females prefer prosocial males to less social ones and economically competent males to less competent ones [10,13,52,54,56,58,68]. However, it is unclear whether females would prefer a prosocial male to a competent one.

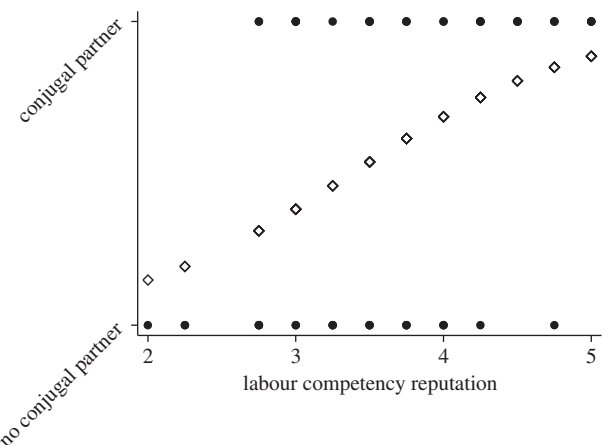


Figure 3. Scatterplot relationship between labour competency reputation and conjugal partner status. Filled circles, observed; diamonds, predicted.

Logistic regression shows that Dominican females prefer competent men to prosocial ones for conjugal partnerships (pseudo $R^2 = 0.18$; $p = 0.02$; $n = 53$; competency reputation: OR = 5.3; $z = 2.9$; $p = 0.004$; prosocial reputation: OR 0.7; $z = -0.3$; $p = 0.79$; age: OR 1.0; $z = 1.6$; $p = 0.11$; constant: OR = 0.001; $z = -2.7$; $p = 0.006$; figure 3). For every unit increase in competency reputation, the odds of being in a conjugal relationship increases by a factor of five. The relationship between competency reputations and conjugal partnership formation remains even after controlling for his number of patrons (pseudo $R^2 = 0.18$; $p = 0.02$; $n = 53$; competency reputation: OR = 4.9; $z = 2.8$; $p = 0.005$; number of landowners/patrons: OR = 1.05; $z = 0.2$; $p = 0.86$; age: 1.05; $z = 1.6$; $p = 0.1$; constant: OR = 0.0005; $z = -2.6$; $p = 0.008$). Thus, females prefer competent men for conjugal partnership formation even after controlling for a primary determinant of wealth.

5. Study site and organizational context

(a) Pucucanchita, Peru

Pucucanchita (pseudonym) is an agropastoral village of 24 households (hereafter 'HH') in the Andes of southeastern

Peru. Located in the high-altitude *altiplano* (14 500 ft., 4420 m), this village functions as a collective, in which there is no ownership of land. There are several communally owned resources in Pucucanchita, including herds (principally alpacas), gardens, irrigation canals, and buildings for storage, meetings and events. In addition to their share of the communal resources, HHs own small herds and gardens, which require social support.

(i) Collective action

Common-pool resources such as communally owned herds and gardens play an important role in the sustainability of life in the highlands of Peru [69,70]. In Pucucanchita, collective action (hereafter 'CA') is diverse and frequent. By far the greatest number of CA tasks concern agriculture. Depending on the season, *campesinos* (herder/farmer) must organize and conduct these tasks several times a month. Residents shear the animals, and administer routine vaccinations and breeding programmes. Community members meet twice a year for *cosecha* (planting) and *sembria* (harvesting), though each may span several days. *Acequias* (irrigation canals) are common-pool resources that distribute water to members of the community to support vital subsistence agriculture and provide water for HH consumption. The dams, structures and canals of the *acequias* must undergo routine maintenance, and emergency repairs. Finally, several mid-sized, thatched adobe structures (used to conduct meetings, store the community truck and store food) must be maintained, a process referred to as *refacción*. Each of these requires a wide range of skills and is physically laborious.

Free riding and overappropriation occur in Pucucanchita CA, but the latter is less of a concern owing to the lack of competition for land and water. The unequal investment in CA tasks in Pucucanchita is, however, a cause for concern; some HHs contribute very little at all and there is no formal punishment of HHs that free ride. As such, CA for most agricultural tasks in Pucucanchita are best represented as *N*-person, iterated, social dilemmas.

(ii) Social support networks

The *altiplano* region of highland Peru is a harsh environment, and the indigenous people of this area have evolved a suite of cultural and biological adaptations to deal with high-altitude stressors, low ecological productivity and a lack of point-of-need healthcare [71–76]. Reciprocity and exchange in contexts other than CA are one means of dealing with the difficult living conditions of the *altiplano* [77–80]. In Pucucanchita, help with agricultural labour and health-related advice constitute the majority of sharing/aid in the area.

Social support in the form of help with agricultural tasks is of particular importance for HH production; however, not all HHs have the same degree of access. HH farming tasks, such as preparing and planting gardens, lead to higher yields with help from outside of the HH. At several points during the year, the herd must be corralled for tasks that are difficult for a single HH to do on its own: for instance, slaughter and herd evaluation prior to slaughter, earmarking, vaccinations, pregnancy examinations, *esquila* and castration. In addition to direct aid, receiving advice and information about breeding methods and vaccination programmes is especially helpful since *campesinos* are detached from modern sources of information and cannot afford aid from veterinarians. Routine,

correctly administered vaccinations can prevent the myriad diseases animals face, but a herder must know the latest vaccinations for the most current illnesses/diseases. Simply put, successful agriculture and farming require recurrent access to reliable and viable network members. There are two qualities that are particularly valuable in agricultural network support members. First, a person should be reliable and provide support in times of need (i.e. prosocial). Inconsistent support from network members can disrupt the delicate timing and coordination involved with critical agricultural events. Second, the person must have a good work ethic, high level of physical fitness and strength, and be knowledgeable (i.e. competent) in order to engage in these labour-intensive tasks.

Locals rely more on traditional medicines than on treatment from the local healthcare system. The nearest professional healthcare centre is hours away and the more accessible rural health centres are open sporadically, provide minimal care, and lack electricity and sterile working conditions. Because of these circumstances, coupled with a lack of money to pay for pharmaceuticals, HHs depend greatly on advice about health-related issues from members of their community. Health advice networks in their very essence are asymmetrical, since advice is passed from someone who has knowledge to someone who does not; that is, the recipient (unless also an expert) cannot reciprocate expert health advice. Asymmetry in aid of this nature may lead to other forms of aid to the healer, such as agricultural assistance.

In line with our research goals, analysis of the data from Peru will be guided by the following questions: (i) How are CA reputations (prosocial and competency) shaped? (ii) Which reputation—prosociality or competency—confers the greater social network benefits in the form of agricultural aid and health advice?

6. Material and methods

Fieldwork was conducted from May 2010 to January 2011. Data on investment in CA were collected via participant observation, interviews and archival data over a two-year period. Investment in CA was measured in total time (hours) contributed by each HH. Community members were asked to name members of their community who were the most reliable (those who seldom miss a CA task—i.e. prosocial individuals) and, in a second question, were asked who were the most hardworking (those with a strong work ethic, high level of skill, physical fitness and strength—i.e. competent individuals) in their community when participating in CA projects. For each set of questions, a free-listing method was used in which adults could name as many people as they wished.

Social network data were collected for agricultural support networks and medical advice networks. For the agricultural support network, social network data were collected on three types of help with agricultural life. First, community members were asked whom they had aided and from whom they had received aid with agricultural tasks (animal husbandry, farming) during the past *el tiempo de cosecha* (harvesting season) for the first interview set and *el tiempo de siembra* (planting season) for the second interview set. Second, participants were asked if they had watched or cared for anyone else's animals in the six months prior to the interview. Finally, participants were asked to whom they gave and from whom they received animal husbandry advice during the past *tiempo de siembra*. The agricultural support network included directed ties combining all three agricultural social relations described above. For the health advice network, subjects were

Table 3. Descriptive statistics associated with Andean reputations and social support.

	<i>N</i>	mean (s.d.)	median	min/max
time invested in CA	24	101.8 (57.3)	97	0/211
prosociality/reliability reputation	24	4.7 (4.2)	2.5	0/15
competency/hardworking reputation	24	8.0 (6.4)	7	0/21
agricultural support network: indegree	24	17.0 (13.1)	17.4	0/52.2
medical advice network: indegree	24	18.8 (10.5)	19.6	4.3/34.8
medical advice network: in-closeness	24	41.6 (8.9)	44.7	22.1/53.5
age of household head	23	60.1 (16.1)	63	32/85

asked to whom they had given health advice and from whom they had received health advice in the month prior to the interview.

Two types of network centrality are considered here, *indegree* and *in-closeness* (table 3) [81]. Indegree is a measure of the total number of HHs from which aid is received. This measure is used to assess an HH's access to agricultural support and health advice. In-closeness *centrality* is a measure of the 'network distance' that a focal node is from all other nodes in a directed network, considering only the indegree on the node. The shorter the distance (in terms of network paths) a focal node is from all other nodes, the more central it is in the network. While in-closeness is not a compelling network position with regard to access to agricultural support, it is particularly useful when examining the value of a focal node's position in terms of availability of information, such as health advice [82].

Social support networks were assessed at the HH level, since the exchange of goods and information, such as agricultural support and health advice, occurs between HHs rather than between individuals. Analysis of CA is also assessed at the HH level, since a representative of the HH is expected to attend (this is both a cultural norm and how leaders record CA attendance), rather than each adult in the community. The reputation measures focus instead on the HH head. Qualitative assessments and past research in the Andes indicate that the successes and failures of the head of the HH influence the attitudes that other community members have towards the HH and its members [78]. Simply put, the reputation of the HH head determines how the HH is perceived as a whole, as he (and sometimes she) is responsible for decisions regarding agricultural pursuits and CA delegation, and voting and attendance at community meetings. Unsurprisingly, 96% of those mentioned during the reputation questions were either the male or female HH head.

7. Results

(a) What are the behavioural correlates of reputations in Peru?

Time invested in CA is predictive of reputations for both prosociality (i.e. reliability) and competency (i.e. hardworking) (table 4). This could be owing to the fact that both reputations have shared variance and time invested in CA is predicting this shared variance. To account for this possibility, we use a multiple linear regression model with bootstrapped confidence intervals to explore whether each reputation domain uniquely explains variation in time invested in CA. Analyses suggest that time spent in CA is related to prosocial reputations; however, the relationship between competency reputations and time spent in CA is fully mediated after controlling for prosocial reputations (model $R^2 = 0.74$; $n = 24$; $p < 0.0001$;

prosocial reputation: $B(\pm \text{bootstrapped standard errors (BSE)}) = 11.9(3.8)$; $z = 3.2$; $p = 0.002$; competency reputation: $B(\pm \text{BSE}) = -0.1(2.4)$; $z = -0.1$; $p = 0.96$; constant: $B(\pm \text{BSE}) = 47.4 (11.2)$; $z = 4.3$; $p < 0.001$). Thus, it appears that time spent in CA predicts prosocial/reliability reputations, while the behavioural correlates of competency are left unresolved.

(b) Do different reputations lead to different social support outcomes?

Simple correlation analyses demonstrate that the HH's prosocial and competency reputations are related to their agricultural network size (competency-indegree: $\rho = 0.63$; $p = 0.001$; prosocial-indegree: $\rho = 0.60$, $p = 0.002$) and to their health advice network size and position (competency-indegree: $r = 0.64$, $p = 0.001$; prosocial-indegree: $r = 0.48$, $p = 0.02$; competency-in-closeness: $r = 0.5$, $p = 0.01$; prosocial-in-closeness: $r = 0.41$, $p = 0.05$). In each case, stronger correlations are found between competency reputations and network size and centrality relative to prosocial reputations. However, we seek to know whether a prosocial, a competency reputation, or both better explain variation in social support outcomes. To answer this question and account for the small sample size, we employ generalized linear models with bootstrapped confidence intervals (five simulations per model) for each network measure. Across all three network measures, a competency reputation, not a prosocial reputation, predicted variation in network size and position (figure 4 and table 5).

8. Discussion

We performed these analyses to assess the behavioural foundations of prosocial and economic competency reputations and to determine the relative impact of each on cooperation and the flow of benefits across a number of ethnographically relevant social contexts. Our analyses reveal that: (i) although prosocial and economic competency reputations show unique behavioural signatures, some behaviours affect both reputation domains simultaneously; and (ii) across several domains, reputations for economic competency was a better predictor of cooperation relative to prosocial reputations, despite a focus on the latter in much of the literature.

(a) Context-specific explanations

Dominica: consistent with Caribbean ethnography [83,84], rural Dominicans evaluate men's behaviour along at least two dimensions: prosociality and economic competency.

Table 4. Model coefficients associated with labour and reputations. Model 1: Poisson regression model (using bootstrapped CIs and five simulations) predicting competency reputations. Model 2: Poisson regression model (using bootstrapped CIs and five simulations) predicting prosocial reputations.

	IRR	BSE	z	p
	—	range	range	range
model 1: competency reputation ^a				
age	1.004	0.009–0.007	0.61–0.47	0.64–0.54
time in CA	1.01	0.0018–0.0015	6.5–5.4	<0.001
constant	2.01	1.2–0.88	1.6–1.14	0.26–0.11
model 2: prosocial reputation ^b				
age	0.99	0.008–0.006	–0.7 to –0.5	0.62–0.49
time in CA	1.01	0.003–0.002	8.3–4.7	<0.001
constant	1.20	0.54–0.78	0.4–0.3	0.78–0.69

^aLog likelihood = –64.4; $n = 23$; pseudo $R^2 = 0.30$; model $p < 0.0001$, Wald χ^2 range = 50.5, 33.7.

^bLog likelihood = –45.4; $n = 23$; pseudo $R^2 = 0.38$; model $p < 0.0001$, Wald χ^2 range = 71.0, 22.9.

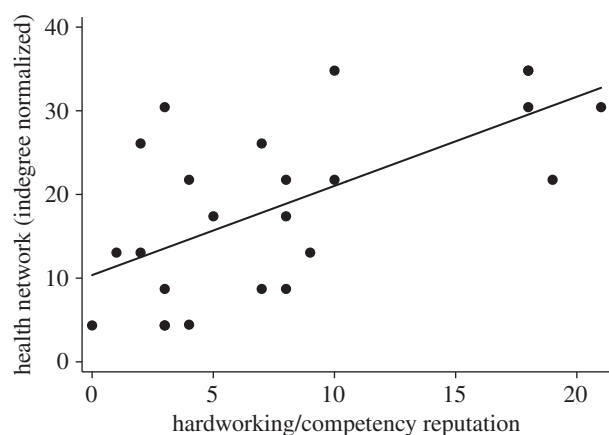


Figure 4. Scatterplot relationship between competency reputation and health network indegree centrality.

Both dimensions are partially realized within the socio-economic context of bay oil production. Bay oil production is a multi-staged process that requires cooperation at two stages (labour contracting and labour exchange). The first stage represents a patron–client relationship, whereby landowners form arrangements with community members to manage plots of land and distil oil. Our results indicate that landowners prefer to form patron–client relationships with individuals who are perceived as highly competent. Highly competent individuals are those who spend more time acting as a CFAD and who assist many different CFADs. Although the division of profits between a landholder and a labourer are unequal, both are better off financially by forming a labour partnership with one another. Interviews with landowners and CFADs suggest that landowners prefer to contract labour with competent men, as these individuals are perceived as having exceptional skills necessary for completing the job in a timely manner and for leading a crew of workers. Prosocial men, on the other hand, are not recognized as leaders of others, only as helpers to others. The second stage of bay oil production represents a mutual aid game, whereby CFADs require assistance from community members to distil bay oil. Community members have no stake in the oil or money that is produced; however, individuals are incentivized to labour

for one another because they may require assistance in the future if they act as a CFAD or if they seek to learn the process. Individuals who assist a greater number of CFADs throughout the year also become recognized for their prosociality and accumulate a number of reciprocal labour obligations. As a result, individuals with high prosocial reputations receive more labour and larger group sizes when they distil oil. Because bay oil distillation has an economy of scale, the process is easier for men with better prosocial reputations. Although a temptation to shirk one's reciprocal labour obligations is always present, individuals who act on this temptation are likely to be labelled as low quality and reap the 'benefits' of their myopia—labour supply reduction. Contrary to expectations generated from prestige-biased transmission processes, the most competent men did not receive help from more people. While labouring for others certainly improves a man's knowledge and skill, and therefore his reputation for competency, it seems that it is not necessary to learn from the best to become competent in this context. This suggests that the costs to learning are low or that there is little knowledge differentiation between skilled individuals. Interestingly, one behavioural signal—assisting CFADs—contributed to both reputation domains simultaneously. It is possible that this single act indicates multiple types of information (i.e. 'I am competent and prosocial') or that two classes of individuals exist, each of which are sending a different message (i.e. 'I am prosocial or competent'). A subset of males are regarded as highly prosocial and highly competent. These individuals perform the most labour and receive the most benefits in terms of patron–client labour contracting and mutual aid in labour exchange. Consistent with market models, the highest quality individuals reaped the most benefits in bay oil production. Furthermore, women prefer men who are competent labourers for conjugal partnership. Previous research indicates that in the absence of other information, females prefer cooperative to uncooperative males and competent to non-competent men. Our results suggest that when females have access to two kinds of reputational information, competent, but not prosocial, males are preferred for conjugal partnerships. A possible reason for this finding is that Bwa Mawego has a skewed sex ratio favouring adult males, resulting in a situation where females can leverage their scarcity into greater choosiness over conjugal partners [85].

Table 5. Model coefficients associated with reputations and social support. Model 1: Poisson regression model (using bootstrapped CIs and five simulations) predicting agricultural network size (indegree normalized). Model 2: multiple linear regression model (using bootstrapped CIs and five simulations) predicting health advice network (in-closeness normalized). Model 3: Multiple linear regression model (using bootstrapped CIs and five simulations) predicting health advice network size (indegree normalized).

	IRR	BSE	z	p
		range	range	range
model 1: agricultural network size ^a				
prosocial	1.02	0.05–0.03	0.62–0.41	0.68–0.54
competency	1.07	0.04–0.03	2.4–2.0	0.05–0.02
constant	7.82	2.03–1.82	8.9–7.9	<0.01
model 2: health advice network (in-closeness normalized) ^b				
prosocial	–0.3	0.9–0.6	–0.6 to –0.4	0.71–0.56
competency	0.9	0.4–0.3	2.7–2.0	0.05–0.008
constant	36.1	3.9–2.7	12.3–9.4	<0.001
model 3: health advice network size (indegree normalized) ^c				
prosocial	–1.2	0.8–0.6	–2.0 to –1.6	0.12–0.05
competency	1.8	0.5–0.3	5.6–3.7	<0.001
constant	10.3	3.1–2.5	4.2–3.3	<0.01

^aLog likelihood: –114; $n = 24$; pseudo $R^2 = 0.35$; Wald χ^2 range = 30.0–20.7.

^b $R^2 = 0.25$; $n = 24$; Wald χ^2 range = 16.6–8.9; p -value range = .01–0.0002.

^c $R^2 = 0.46$; $n = 24$; p -value < 0.0001; Wald χ^2 range = 59–28.

As several women indicated via informal interviews, highly prosocial males spend a large portion of their time in the company of other men in bay tree farms and bay oil distilleries where they may drink and smoke to excess, and thereby redirect resources away from the household. Additionally, we find that age had a negative relationship with prosocial reputations and no relationship with competency reputations. With regard to prosociality, individuals start off with good reputations that decrease over time at varying rates depending on the amount of help given to others [5]. It is possible that people either assume the best of others until they prove otherwise or younger individuals have greater strength and ability to deal with the demands of energetically taxing work relative to older individuals. With regard to competency, no relationship existed between age and reputation. This is somewhat surprising as research from other small-scale societies shows an increasing concave down relationship between age and skill [86]. Two possible reasons for the lack of a relationship between age and competency in Dominican bay oil distillation include: (i) low costs to learning and (ii) occupational change throughout the life course (e.g. from fishing to bay oil production to carpentry), which can affect the age at which individuals first engage in bay oil production. Determining whether one or the other better captures variance in this relationship requires further investigation. Finally, the level of agreement between individuals who rated others varied considerably, with people in greater agreement on prosocial reputations compared to competency reputations. Why this is the case is unclear and presents both empirical and theoretical challenges to understanding the evolutionary ecology of reputations. One explanation for this variability is that some behavioural signals may be more public than others, resulting in perceptual differences in one reputation domain relative to another. Another explanation involves the speed at which information flows

through social networks [5]. Some individuals may occupy more structurally favourable positions in social networks, which provides greater flows of information relative to others, resulting in variation in reputation assessments. A third possibility concerns the fact that reputations represent an amalgam of both direct and indirect experience. Because individuals experience the world differently, they may hold divergent beliefs about others. From a theoretical perspective, uncovering the mechanisms that drive variability in reputation assessments is important to the evolution of cooperation, as formal models indicate that reputation-based cooperation can only evolve in contexts where they perform as well as direct experience [22]. Translating the findings of these formal models to ‘real-world’ settings has received very little attention; however, reconciling such issues may shed light on how leaders, leadership and political factions emerge and stabilize within social settings.

(i) Peru

The lack of formal punishment of free riders in this community coupled with the fact that HHs benefit equally from the fruits of CA appears to be, at first glance, a recipe for a tragedy of the commons. The success of CA in Pucanchita in the face of these challenges hinges on the fact that CA tasks involve the same agricultural work that HHs must recruit and provide help for. Because CA tasks occur often and throughout the year, they provide up-to-date information about the current status (e.g. health, skill, knowledge, prosociality, etc.) of fellow community members. Consequently, CA is an arena in which qualities needed in a HH’s social support networks are signalled and evaluated.

If the potential reputational and social network benefits of CA participation are so important that some HHs allow others

to free ride on their labour, why does free riding occur? The costs of routinely participating in CA and/or exhibiting a strong work ethic are simply too high for certain HHs. CA in Pucucanchita can lead to (i) time costs/conflicts, (ii) risk of injury/overexertion and (iii) energetic costs. First, the time that is allocated to CA could be used towards HH agricultural tasks, and can thus negatively impact HH production. Like in other poverty-stricken areas of the world, when production diminishes, mortality and illness increase in the Andes [77,87,88]. Second, agricultural tasks by their very nature are dangerous. Field observations noted musculoskeletal injuries, cuts, scrapes, burns and contusions during CA, and few walked away from these tasks completely unscathed. In Pucucanchita, each task poses a risk, whether it is re-roofing precariously high in the rafters of a community building or wrestling and shearing a struggling alpaca with sharp hand shears. An injury sustained during CA could seriously impact HH production. The energetic and high force demands required during CA are, at times, extreme. This can lead to overexertion (the second leading cause of injury in US agricultural jobs), which can result in a number of negative health effects in addition to increasing the possibility of future injury [89]. Finally, every calorie counts for *campesinos* and the energy invested in CA detracts from energy that could be invested at home. In light of these costs, only those who are truly prosocial are willing to risk reduced HH production resulting from the time investment, time conflicts, injury and overexertion by contributing to public goods. Furthermore, only those healthy, physically fit individuals can handle the laborious work involved in CA. As a result, the signals demonstrated through CA are honest (i.e. represent actual underlying qualities), since those lacking these skills and/or dispositions can ill afford the high signal costs.

Through observations and conversations it became clear that two different types of reputation could be achieved via CA signalling: a reputation as a reliable or prosocial community member and a reputation as hardworking or economically competent community member. Ideally, a HH would have network partners with both reliable and hardworking qualities. However, when they do not co-occur (which is most often the case), a strong work ethic provides different information about a potential network partner from one who is a reliable contributor. An important distinction is that a reputation as a competent CA contributor can be achieved despite irregular attendance to CA tasks, so long as a strong work ethic and willingness to take on any work are demonstrated during CA. Conversely, a reputation for prosociality can be achieved by consistently attending and completing CA events, despite involvement in less difficult and risky tasks.

Results indicate that a competency reputation leads to larger support networks. A competency reputation, built through agricultural effort during CA, provides information to fellow *campesinos* about an individual's value as a partner. In terms of production, HHs benefit more so from competent helpers than reliable/prosocial helpers, and this is especially true for those HHs that lack skilful, hardworking and knowledgeable agricultural helpers. It is important to note that these agricultural networks are highly reciprocal and thus competent individuals receive considerable aid in return, which increases their HH's agricultural production. What is less clear is why those with a competency reputation have larger health advice networks. It is plausible that those who have specialized knowledge strategically provide advice to

competent *campesinos* more often, knowing that they will receive a greater return on their generosity.

(b) Towards a global explanation

In Dominica and Peru, reputations for economic competency affected cooperation and the flow of benefits across more social contexts compared to prosocial reputations (competency: labour contracting, conjugal partnerships, and agricultural and health network support; prosociality: labour exchange). Why? One reason is that in socio-economic contexts where cooperation involves two stages—production and distribution—competent individuals have greater opportunities to provide economic goods that others desire through greater productivity. Prosocial individuals may not have as many opportunities to cooperate because they produce economic goods at a lower rate or quality compared to highly skilled and knowledgeable individuals.

A second reason highlights data collection. Our methods and analyses evaluated cooperative behaviour and reputation domains within a narrow range of socio-economic life. It is very likely prosocial reputations affect cooperation in other culturally relevant socio-economic contexts that we did not examine (e.g. child rearing, religious participation). Furthermore, reputations are multi-dimensional constructs, constituted along a number of behavioural signalling pathways [13]. The data collection process evaluated cooperative behaviour and reputation domains within a subset of these pathways. As such, our constructs may be under-specified.

Last, local differences in socio-economic contexts may differently shape the associations between behaviour, reputations and cooperation. In Dominica, the act of providing labour to others impacted both prosocial and competency reputations, while in Peru it only affected prosocial reputations. Furthermore, in Dominica, prosocial reputations predicted the amount of help received, while in Peru the same outcome was predicted by competency reputations. Local differences in the meaning and costs of behavioural signals, the economic contexts in which behaviour is enacted, and the size and topology of information networks likely account for some of the variation in our findings. Uncovering how these relationships manifest themselves in additional contexts will help clarify which features are universal and which are context-dependent.

This study was motivated by a perceived lack of theory and empirical analyses regarding reputation domains other than prosociality. To our knowledge, our research represents the first quantitative analysis comparing the relative effects of prosocial and competency reputations on cooperation. The analyses suggest that economic competency reputations may be equally important as, if not more so than, prosocial reputations for cooperation. Furthermore, the diverse results across Dominica and Peru demonstrate how socio-ecological differences impact the interplay between behaviour, reputations and cooperation. While our analyses answered a few questions, others remain. To what extent do evolved psychological predispositions, ecology, institutions and/or historical inertia affect the reputation domains that communities find salient? Why are different reputation domains evaluated using different metrics (e.g. binary versus scalar measures)? How should researchers measure reputations in ethnographic and laboratory settings? What factors affect community agreement concerning reputation assessments? What is the relationship between reputation cultural consensus, prestige, leadership and within-community social factions? Very little

theory or empirical research has been developed to deal with such questions. We hope our analyses motivate research towards this direction.

Ethics. Research performed by S.J.M. was approved by the Institutional Review Board of Washington State University, IRB no. WSU 09673-003. Research performed by H.F.L. was approved by the Institutional Review Board of University of Washington, IRB no. UW 37621.

Data accessibility. All data used in the analyses can be accessed via the electronic supplementary material.

Authors' contributions. S.J.M. and H.F.L. designed and performed research, analysed data and wrote the paper.

Competing interests. We have no competing interests.

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