The reputational and social network benefits of prosociality in an Andean community

Henry F. Lyle III[a,1] and Eric A. Smith[a,b]

[a]Department of Anthropology and [b]Center for Studies in Demography and Ecology, University of Washington. Seattle, WA 98195

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Several theories have emerged to explain how group cooperation (collective action) can arise and be maintained in the face of incentives to engage in free riding. Explanations focusing on reputational benefits and partner choice have particular promise for cases in which punishment is absent or insufficient to deter free riding. In indigenous communities of highland Peru, collective action is pervasive and provides critical benefits. Participation in collective action is unequal across households, but all households share its benefits. Importantly, investment in collective action involves considerable time, energy, and risk. Differential participation in collective action can convey information about qualities of fellow community members that are not easily observable otherwise, such as cooperative intent, knowledge, work ethic, skill, and/or physical vitality. Conveying such information may enhance access to adaptive support networks. Interview and observational data collected in a Peruvian highland community indicate that persons who contributed more to collective action had greater reputations as reliable, hard workers with regard to collective action and also were considered the most respected, influential, and generous people in the community. Additionally, household heads with greater reputations had more social support partners (measured as network indegree centrality), and households with larger support networks experienced fewer illness symptoms.

free-rider problem | signaling | social support | evolution of cooperation

A central issue concerning the evolution of cooperation is resolving conflicts between individual self-interest and collective benefits. If some individuals ("cooperators") pay costs to produce collective benefits which others ("free riders") can access cost-free, cooperation is unlikely to evolve or be maintained unless cooperators gain some additional benefit (1–3). Various solutions to this "tragedy of the commons" have been proposed in the social and biological sciences, including indirect reciprocity (4, 5), punishment of free riders and other institutional measures (6–9), signaling and partner choice (10–16), and intergroup competition (17, 18).

Here, we report evidence from an indigenous community in the highlands of Peru where those who contribute more to collective action gain positive social reputations for generosity, reliability, and related attributes. These reputations in turn yield social benefits in the form of larger social support networks, which are associated with improved health. This system exemplifies how contributions to collective action can signal socially valuable qualities that then are used by others to establish mutually beneficial alliances, as predicted in some game theoretical models (5, 13).

Setting

The research was conducted among Quechua agropastoralists in the high-altitude *altiplano* of southern Peru. The geography in this part of the Andes consists primarily of valleys and plateaus, with the dominant flora being grasses suitable for herding livestock, particularly alpacas, sheep, and llamas. This region presents severe challenges for human subsistence because of the high elevation (*ca*. 4,400 m above sea level) and resultant low oxygen pressure, severe climate, and difficult working conditions. Crop-destroying hail storms and overnight frosts can occur during spring and summer, and if winter snowfall is heavy, households can lose up to 50% of their herd (19, 20). These factors, along with the difficulty of modifying the environment, harsh living and working conditions, and, more recently, climate change, result in low ecosystem productivity and seasonal variability in nutrient intake (21–24).

Given the lack of governmental support, difficult living conditions, and inequalities associated with socioeconomic change in the region, it is not surprising that highland residents have experienced high infant mortality and adulthood morbidity for decades (21, 25). To cope, residents rely heavily on social support networks, which have been shown to alleviate social and environmental stressors (25, 26). Access to assistance with agricultural tasks, such as harvesting crops and animal husbandry, is particularly important for *campesinos* (rural farmers/herders), given their dependence on local crops and livestock for survival. Additionally, receiving help in tending the herd enhances householders' mobility when they need to sell or purchase goods or seek professional medical care.

Although support networks play prominent roles in highland communities, important questions about these networks remain under investigated: e.g., How do households build such networks? What factors influence decisions about whom to include in one's support network? Do larger support networks convey health benefits? To address these questions, and guided by the theoretical work cited above, we investigated four interrelated aspects of highland Quechua social life: contribution to collective action, social reputation, social network dynamics, and health.

Common property institutions, such as communally owned herds, gardens, and irrigation systems, play an important role in sustaining Andean households (19, 26, 27). However, such

Significance

Scientists have long debated how group cooperation can be maintained. From many standard evolutionary and economic perspectives, the best decision for an individual is to engage in free riding on the cooperation of others (i.e., share in the benefits but pay no costs). Such free riding, however, reduces the collective benefits of group cooperation and can unravel cooperation. Some propose that this "tragedy of the commons" can be solved if cooperators are compensated with reputational benefits. Our research in an Andean community found that cooperative households have better reputations for various qualities and have larger support networks, with the latter associated with healthier households. This finding supports the argument that positive reputations gained by cooperators can solve the tragedy of the commons.

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[1]To whom correspondence should be addressed. E-mail: lyle3@uw.edu.

institutions can generate social dilemmas when some participants pay higher costs to generate the collective good and others fail to pay their share or reap disproportionate benefits (28). Despite these challenges, successful management of common property systems is widely documented (9, 29). As noted above, one possible reason is that those who contribute more receive reputational benefits, whereas those who contribute less incur reputational costs. Helping with tasks that are vital for the survival of community members may signal one's value as a network partner, in terms of ability or willingness to contribute dyadic aid outside the context of collective action. Consequently, a positive reputation may enhance one's access to and support from social networks, and in turn the improved support can lead to better health.

We evaluate these arguments with data collected during 8 mo of fieldwork in 2010–2011. Specifically, we test three hypotheses: (*i*) that households that contribute more to communally beneficial collective action have heads with enhanced reputations for generosity, work ethic, reliability, respect, and influence; (*ii*) that households with such reputable heads have larger social support networks that provide agricultural assistance and advice; and (*iii*) that households with larger support networks experience fewer illness symptoms.

Study Population. This research was carried out in a village of 24 households in the Nuñoa District of southeastern Peru for which we use the pseudonym "Pucucanchita." Pucucanchita functions as what locals refer to as a "*comunidad*" or collective, in which there is no private land ownership. The major communally owned resources in Pucucanchita include herds, gardens, irrigation canals, and buildings for storage, meetings, and events. Each household also privately owns some livestock and a small garden. Indigenous crops, including tubers (e.g., oca, potatoes) and grains (e.g., quinoa), are the principal crops. Alpacas are the primary livestock, followed by sheep, llamas, and cattle. Although most of the calories a household consumes come from local crops and herds, families supplement this intake with food bought in the nearest town, Nuñoa. There is no electricity in Pucucanchita, and households obtain water from gravity-fed, hand-dug canals that channel rain and snow melt. In this paper, household refers to all of the people living in the household, whereas household head specifically refers to the male head of household (or female if there is no male head of household).

Collective Action in the Highlands. Herein, collective action is defined as instances in which households cooperate to manage or produce a collective good available to all members of the community. We observed many examples of collective action, ranging from the management of community herds to refurbishing community buildings. In caring for the community herds, members must engage in routine vaccination and other preventive health measures, selective castration, and other breeding programs. Depending on the season, *campesinos* come together and conduct these tasks several times a month. These tasks are physically demanding and require skill, expertise, and knowledge about animal husbandry, such as the ever-changing vaccination requirements for livestock in this region. Wool is an important income source for the community, and the coordination of several teams is required to shear the animals, gather the wool, and prepare it for transport and marketing.

As with herding, preparing communal fields and planting and harvesting crops require much effort and knowledge. Manure must be gathered and transported to the garden by hand or donkey over difficult terrain. Potatoes are planted on slopes as steep as 60°, in rows dug with hand plows. Determining the best time to plant is critical and requires knowledge of soil quality, microclimates, and the possibility of early frosts or late rains. The food produced in communal fields is distributed evenly among community households at harvest and also is consumed during community projects and meetings. Money earned through the sale of animals and wool also is distributed evenly among households. Other collective action tasks include refinishing and rethatching the community buildings and constructing, cleaning, and repairing irrigation canals (*acequias)* that distribute water essential for subsistence agriculture.

In many societies, collective action is stabilized by the punishment of free riders or by the allocation of differential shares of the collective good to those who contribute more (9, 30). However, in some systems, conspicuous free riding is tolerated, and some members pay higher costs without receiving greater shares of the benefits of collective action (31–33). From an evolutionary perspective, free riders in such systems would seem to have an adaptive advantage over those who contribute more to collective action. During field research, it became clear that unequal contribution to collective action occurs in Pucucanchita, so that some households pay the majority of the costs and others contribute very little at all. We further observed that free riders go unpunished and that households receive the same access to collective goods, regardless of their contribution to collective action, and incur no fine for lack of participation in collective action. Our research was designed to determine how successful collective action can occur in Pucucanchita despite the prevalence of unpunished free riding.

Results

The time invested in collective action was predictive of the reputation measures of reliability and work effort while helping with community projects, controlling for several factors. More significantly, the contribution to collective action also was predictive of reputation scores unrelated to investment in collective action for generosity, influence, and respect (Table 1). These findings all support hypothesis 1, that households that contribute more to communally beneficial collective action have heads with enhanced reputations for generosity, work ethic, reliability, respect, and influence. Age was a significant predictor of respect, influence, and generosity and was a marginally significant predictor of the overall reputation score. Health was predictive of a hardworking reputation: As household morbidity decreased, reputation score increased.

Hypothesis 2 predicts that household heads with better reputations will receive support from more households, measured as network ties involving help with subsistence (Fig. 1). This hypothesis is supported. The total reputation score was highly predictive of indegree network centrality, after controlling for other factors. Mean distance from other households and per capita herd size also were significant predictors of network size, whereas morbidity was marginally predictive of network size (Table 2).

Results from the linear regression models testing hypotheses 1 and 2 indicate that households that contribute more to collective action have reputable household heads and that reputable heads receive agricultural support from more households. However, these analyses do not provide a complete picture of the relationship between these highly correlated variables. A test of mediation with reputation as the mediator, investment in collective action as the independent variable, and social support as a dependent variable can tell us whether reputation acts as a pathway from collective action investment to social support (Fig. 2). This consideration is especially important because investment in collective action is strongly correlated with social support, raising the question of whether collective action investment enhances reputation, thereby leading to a larger support network (i.e., hypotheses 1 and 2) or instead collective action leads directly to a larger support network, regardless of its association with reputation.

Table 1. Standardized β coefficients from separate linear regression models for each reputation measure and the total reputation score as a function of investment in collective action, controlling for the listed covariates

	General reputation			Collective action reputation		Total reputation score
Independent variables	Respect	Influence	Generosity	Reliability	Hardworking	
Investment in collective action	0.691**	0.591**	0.806***	0.889***	0.706***	0.813***
Age	1.83†	2.47*	2.07*	0.325	0.193	1.39†
Morbidity	−0.116	0.032	−0.049	−0.141	−0.415***	−0.184†
Per capita herd size	−0.167	0.094	−0.139	−0.087	0.111	−0.015

The individual linear regression models for respect, influence, generosity, reliability, and hardworking and the total reputation score as dependent variables explained 56%, 57%, 73%, 79%, 82%, and 82% of the variation, respectively. All models are statistically significant: reputation ($P < 0.01$), influence ($P < 0.01$), generosity ($P < 0.001$), reliability ($P < 0.001$), hardworking ($P < 0.001$), and total reputation score ($P < 0.001$). ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$, $^{\dagger}P < 0.1$; one-tailed tests.

The direct effect from collective action investment to network size (controlling for reputation) is 0.266 (standardized) and is not statistically significant ($P = 0.297$), as expected. The bootstrap estimated indirect effect from collective action investment to network size equals 0.102 and is marginally significant ($P = 0.074$). The 95% bias-corrected bootstrap confidence interval (5,000 trials) is from −0.004 to 0.231. These results provide evidence that reputation has a slight mediating effect on the relationship between investment in collective action and social support.

Hypothesis 3 predicts that increased social support provides health benefits. We test this hypothesis most directly by examining the relationship between network indegree (number of network partners offering aid) and illness scores. Results indicate that indegree is a powerful predictor of morbidity, so that those who have larger support networks have healthier families (Table 3). These findings are consistent with past research on the health benefits of social support around the world, including highland Peru (25, 34, 35).

Discussion

The role of reputation in the evolution of cooperation has been addressed in a considerable number of theoretical analyses and in a fair number of experimental studies but in only a handful of naturalistic field studies in small-scale societies. We undertook the present research to help fill this gap because of the importance many researchers place on reputational factors in stabilizing group cooperation. We began with a model in which (*i*) high-level contributors to collective action are viewed as generous and hard-working; (*ii*) such reputations encourage others to include contributors in their support networks; and (*iii*) membership in such expanded networks provides tangible, fitness-correlated benefits such as improved health. Hypotheses designed for testing this model were upheld in analyses that controlled for other covariates and explored mediation effects. With only 24 households in the community we studied, it is difficult to test all of the effects definitively, but overall the evidence supports our model for how collective action produces benefits in the absence of well-defined punishment for free riding.

Although hypothesis 1 may seem obvious, our findings indicate that investment in collective action is linked to reputation for qualities such as social influence, generosity, and respect outside the context of collective action (Table 1). Generosity was more strongly associated with investment in collective action than were the other reputation measures, possibly indicating a more exact specification of the qualities that are signaled via contributions to collective action. Hypothesis 2 addresses the role of reputation in network formation and partner choice. Our results show that the aggregate reputation score predicts the size of the social network available for help and advice with subsistence tasks (Table 2). Finally, results from hypothesis 3 are consistent with findings in a number of cultural and ecological contexts: Social support translates into well-being. Taken together, these results support our overarching argument that the contribution of collective action can serve as a signal aimed at attracting social support partnerships that provide fitness-correlated benefits in improved health.

Is it possible that households experiencing poorer health have less reputable household heads because household members cannot contribute fully to collective action? We controlled for morbidity in our regression model predicting social reputation (Table 1) and found that investment in collective action was predictive of reputation when we held morbidity constant. Furthermore, household morbidity is not associated with time invested in collective action, nor does it decrease a household head's reputation in any category except hard-working. This outcome provides some assurance that our results are not confounding the effects of investment in collective action with the effects of unrelated differences in health status. However, it seems reasonable for investment in collective action and health to be related. Given the small sample size and multiple causal steps, it is not surprising (at least from a statistical perspective) that investment in collective action and health, two variables at opposite ends of the hypothesized causal chain, are not strongly correlated. Although it is plausible that poor health leads to greater social support (because of greater need), thus reversing our hypothesized causality, our findings indicate that healthier households receive more aid than sicker ones.

The key problem we address in this research is how group cooperation can be stabilized in the face of temptations to engage in free riding. Although there are several possible solutions to this puzzle, as noted in the introduction, we focus here on explanations highlighting the reputational benefits gained through contributions to collective action. Our findings support the argument that costly contributions to collective action can be profitable if they serve as a reliable signal of partner quality, resulting in social benefits extending beyond the collective action context itself (4, 5, 13, 33, 36, 37), in this case leading to a larger agricultural

Table 2. Multiple linear regression model with social support received (indegree network centrality) as the dependent variable and with reputation, distance, dependency, and years living in community as independent variables

Independent variables	Standardized β coefficient	*T* statistic	*P* value
Reputation	0.470	3.43	0.002
Distance, km	−0.313	−2.20	0.022
Morbidity	−0.186	−1.33	0.102
Years in community	0.075	0.559	0.292
Per capita herd size	0.267	1.92	0.037

The model is significant ($F = 11.68$, $df = 5$, $P < 0001$) and explains 80% of the variance in social support received.

Table 3. Multiple linear regression model with morbidity (average number of illness symptoms) as the dependent variable and with indegree network centrality, kinship, dependency, and per capita herd size as covariates

Independent variables	Standardized β coefficient	*T* statistic	*P* value
Indegree network centrality	−0.657	−2.79	<0.001
Kinship	0.157	0.779	0.200
Dependency	−0.078	−0.355	0.529
Per capita herd size	0.449	1.85	0.006

The model is marginally significant ($F = 2.33$, $df = 4$, $P < 0.1$) and explains 60% of the variance in morbidity.

support network. A critical consideration is that this energy-stressed population depends on subsistence products for survival. Low-quality and/or limited access to a subsistence support network can have serious repercussions on household nutrition and health.

There are three reasons why the signaling/partner choice explanation may have broad significance. First, although monitoring and punishing free riders entails individual costs to provide a collective benefit, choosing partners based on their contribution to collective action provides a private benefit rather than a cost, thus avoiding the second-order problem raised by punishment explanations (5, 13). Second, collective action is a venue in which qualities that are valued in social network members (e.g., knowledge, work ethic, generosity) can be broadcast efficiently community-wide (12). Most collective action tasks in our study population are subsistence-related, and observations indicate that individuals differ in skills such as shearing animals, performing physically demanding work, or knowledge of the latest vaccination and/or breeding programs. Even in a small but spatially dispersed community, accurately observing who has qualities that make a superior network partner through only dyadic interactions alone would be difficult. Thus, collective action provides an efficient means by which contributors can honestly broadcast adaptive information about their value as social network partners and thus secure more or higher-quality partnerships (12, 13).

Finally, the signaling/partner choice explanation provides a natural link between group cooperation (collective action) and models of direct and indirect reciprocity (4, 5, 13). Classic reciprocity models, being based on dyadic interactions, cannot be scaled up readily to handle collective action (38, 39). The explanation of the maintenance of collective action we examine in this study uses collective action as an arena for signaling, generating reputations that guide partner choice; the resulting dyadic interactions fit within the classic framework of direct and indirect reciprocity, as modeled by Panchanathan and Boyd (5). Free riding (low contribution to collective action) is an expected outcome of this signaling dynamic (13) and is unlikely to unravel group cooperation as long as the benefits to signalers and signal receivers from dyadic alliances compensate for the differential costs incurred in collective action.

A considerable body of social-science literature considers the connections among network measures such as centrality and social capital, trust, and reputation (e.g., refs. 40 and 41). Although mostly concerned with contemporary industrial societies and components such as firms and voluntary associations, in which the social scale and degree of cross-cutting ties are very different from those in small-scale societies, some aspects of this literature are relevant to our study. First, regarding the contested importance of trust in fostering cooperation (41–43), our findings align with the maxim "trust in signals" (44). Second, although there is considerable debate about the definition and usefulness of "social capital" (45), our results support the view that investing in reputation-building through collective action enhances social relationships, and "is well identified by conventional measures of network centrality" (46). Finally, our findings agree with Ostrom's (47) statement that "the world contains multiple types of individuals, some more willing than others to initiate reciprocity to achieve the benefits of collective action. Thus, a core question is how potential cooperators signal one another and design institutions that reinforce rather than destroy conditional cooperation" (p 138). We believe our study exemplifies these points quite closely.

In conclusion, our findings contribute to ongoing efforts to understand the forces shaping the evolution (cultural or genetic) of cooperation, particularly those related to group cooperation among nonkin (48, 49). In particular, they suggest that collective action can be maintained via individual benefits, given the low relatedness between households in this community and the fact that kinship was not correlated with our key variables. In future research, we plan to address several unanswered questions: How well do other forms of social support (exchange of food and other material) fit the pattern established here for the exchange of labor and advice? Do differences in social support persist even if a household's contributions to collective action decline? Can we measure the material and fitness effects of contributing versus free riding more directly? Future field studies in varied populations will be needed to see if our findings are upheld in diverse settings, with larger samples, and in prospective (longitudinal) as well as cross-sectional studies.

Methods

Field research was approved by the University of Washington Human Subjects Division.

Investment in Collective Action. Data on contributions to collective action were collected by observing participants, interviews, and archival data (covering the 2 y before fieldwork). A total of 2,444 person-hours over 22 collective action projects (some lasting several days) were obtained via observations (1,016 person-hours) and records and interviews with leaders (1,428 person-hours). Observational, interview, and archival data were combined to estimate the total number of hours contributed to collective action for each household in Pucucanchita ($n = 24$). The total hours invested per household ranged from 0 to 211 (median = 97.0). The observational data and archival/interview data on household contribution were highly correlated ($r = 0.791$, $n = 24$, $P < 0.001$).

Household Health, Composition, and Herd Size. The health of members of a household may affect its ability to contribute to collective action, either directly through illness or from the need to care for the ill. Health also is considered as a dependent variable, because having good health may result, in part, from having larger support networks. In lieu of clinical assessment, community members were asked if they had experienced any of 20 illness symptoms common in the area in the past month; they also were asked to name any other symptoms they had experienced in the past month. A measure of average household morbidity was calculated as the total number of symptoms experienced by each household member divided by the total number of household members. This measure (community-wide) averaged 8.29 (SD = 3.01) during the first recall period (May/June 2010) and 6.27 (SD = 1.67) for the second period (November/December 2010), for an overall average of 7.28 symptoms per household member (SD = 2.12, $n = 77$). The possible impact of household demographics on contributions to collective action is assessed using a dependency ratio measure. This measure is defined here as the ratio of people in a household <9 or >65 y of age to those 9–65 y of age.

Household work demand increases with larger herds, possibly constraining attendance at community projects. The average household herd size was 57 animals (28.0 alpacas, 23.6 sheep, 4.1 cattle, and 1.8 llamas), ranging from 0 to 153. Because work demand also is related to the number of people in the household who can help with animal husbandry tasks, we also calculated the ratio of helpers in the household to the size of the household's herd size (i.e., the per capita herd size) for use as a covariate. Per capita herd size, measured

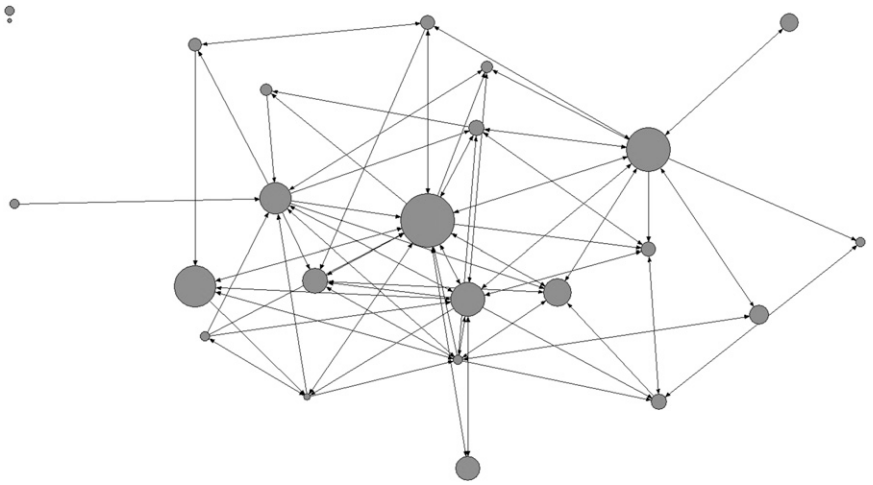

Fig. 1. Agricultural support network in Pucucanchita. Arrows indicate the direction of aid. Node size is proportional to the total reputation score. The reciprocity of the network is 0.52 in terms of the proportion of dyads that are reciprocal and is 0.68 in terms of the proportion of arcs (ties) that are reciprocated. Households with the greatest degree of network centrality are closer to the center of the graph. The two circles in the upper left hand corner represent isolates, households that did not give or receive agricultural support during the time frame of this study.

as herd size/household size also is considered as a measure of wealth, because no other obvious differences in wealth exist.

The sex of the household head possibly could impact our key variables, including investment in collective action, network centrality, and reputation. Unfortunately, there were too few households headed by females to address this possibility. Only three of the 24 households were headed by women. One widow was not healthy enough to contribute to collective action. The other widow and the third female household head are both former presidents of the community, and the latter was a high contributor to collective action and was one of the most respected people in the community. It is important to note that, although collective action tasks mostly involve manual labor, women are active in these tasks and also prepare the large lunches that always accompany these tasks. Thus, collective action is not necessarily a male-biased arena for demonstrating generosity and skill.

Reputation. Subjects were asked to name (*i*) the most reliable and (*ii*) the most hardworking members in their community when participating in collective action projects. The interviews also included three separate questions about which persons the interviewee thought were generally the most (*iii*) respected, (*iv*) influential, and (*v*) generous people in their community. For each set of questions a free-listing method was used in which participants could name as many people as they wished. Only one person was mentioned who was not a male or female head of household; his score (n = 2, hardworking) was awarded to his household head's score. The five reputation scores were summed for each household head to compute a total reputation score (range 1–77; median = 18).

Because reputation increases with age (50, 51), it is advisable to control for possible age effects on the link between investment in collective action and reputation. In our analysis, we used the age of the household head.

Social Networks. Social network data were collected on three types of subsistence help. Participants were asked whom they had aided and from whom they had received aid in performing agricultural tasks, watching herds, and animal husbandry advice. The support network constructed for this analysis includes directed, nonvalued ties for all three of these interactions. Network data were obtained from 23 of the 24 households, although network ties with the unsampled household that were mentioned by other households were included. The network density of the support network used in this analysis equals 0.17, meaning that, of the 552 possible ties in this network, 17% (n = 94) occurred. The average indegree (number of households from which aid was received) was 3.92. Valued ties were not used because multiple networks measures were combined to form the agricultural network and because in agricultural networks the width of the social network (i.e., network size) is more important than its strength (amount of support), since need is short-term, sporadic, unpredictable, and by no means a daily affair. Because help often is reciprocated, we considered controlling for outdegree when predicting indegree. In this study community one cannot build a network (i.e., indegree) by attempting to enhance his or her outdegree, because potential recipients can refuse the help without repercussions. Because a primary aim of this study is to understand why social support networks form (i.e., the variables governing partner choice), we feel it is unnecessary to control for outdegree.

We also included covariates that can impact the amount of support that a household receives, including the average linear distance of a focal household from other households in the community, the number of kin relations in the community, and the number of years the household has lived in the community (52).

Analyses. Data on participation in collective action and support given/received are considered at the household level, because the household is the principal unit of production and consumption among Andean agropastoralists (26). The agricultural support examined here benefits the household as a whole, because resources from the family's herd and garden and the money gained through the sale of wool are pooled. Furthermore, only one household representative is expected to attend a collective action event. In contrast, reputation measures focus on heads of households, because qualitative assessments and past research in the Andes indicate that the successes and failures of the male head of household strongly influence views that other community members have toward the household and its members (26, 53).

To test hypothesis 1, the relationships between investment in collective action (independent variable) and each reputation score (dependent variables) as well as the total reputation score (sum of the five reputation measures) were assessed individually using linear regression. Morbidity (reported illness symptoms) was marginally negatively correlated with reputation (r = −307, P = 0.144), and per capita herd size was marginally positively correlated (r = 0.356, P = 0.104) with reputation, so both were included in the model as covariates. We tested hypothesis 2, that good reputations increase household network size, by fitting a linear regression model with indegree (normalized) as the dependent variable and the total reputation score as the independent variable. Health was included as a covariate in the model because it was marginally correlated

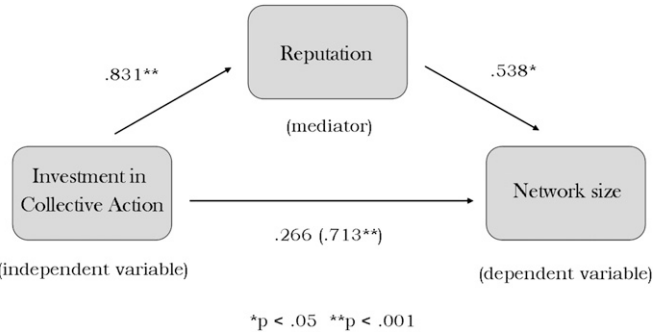

Fig. 2. Standardized β coefficients for the direct and indirect effects of the mediation model. Investment in collective action predicts reputation (β = 8.31) and network size (β = 0.713). Reputation is predictive of network size, controlling for investment in collective action (β = 0.538); however, investment in collective action is not predictive of network size when reputation is held constant (β = 0.266).

with indegree centrality ($r = -0.387$, $P = 0.062$), as was the number of years spent in the community ($r = 0.402$, $P = 0.052$). Distance between households was negatively correlated ($r = -0.453$, $P = 0.030$), and per capita herd size was positive correlated ($r = 0.550$, $P = 0.008$) with indegree centrality and were included as covariates.

We also ran a test of mediation to understand the exact relationship between three highly correlated variables in this research: investment in collective action, reputation, and social support. The mediation test incorporates bootstrapping (5,000 trials) using the Preacher–Hayes bias-corrected approach (54).

Correlation tests using Pearson's r are two-tailed; all other tests are one-tailed. Non-network data were analyzed using SPSS (19.0) with alpha set at 0.05. Network data were analyzed in UCINET (6.0). Fig. 1 was produced (via UCINET) with NetDraw 2.09. Distances between households were calculated using ArcGIS 10.0.

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