Interpretation of Nature Fauna and Flora in the Agricultural Culture of Aymara People: A Qualitative Study

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Abstract

The beings that inhabit this vital environment grow in collaboration and harmony with nature, as happens with the evolution of knowledge. The objective of the research was to systematize the information from the interpretation of fauna and flora and the use made by the Aymara during the year; which was described by Van and Enríquez (2002), who used astronomical observation techniques and their sixth sense, in other words, pure Aymara intuition. They believed that the agroclimatic forecasting techniques of the Aymara of the north and south of the Altiplano allowed them to anticipate the months of the year to obtain a good harvest volume and ensure agricultural yields. The research corresponds to a qualitative approach with an ethnographic method with a descriptive nature aimed at interpreting the nature and use made by the Aymara throughout the year. The in-depth interview technique was applied, characterized by face-to-face dialogued interactions and participant observation in the Aymara area of Huancané in the north and the Aymara area of Ilave-Juli in the south. Ten Aymara speakers from both Huancané and Ilave-Juli areas were interviewed, aged between 45 and 80, preferably monolingual in Aymara and also included bilingual Aymara-Spanish speakers. The results show that reading the signs of nature's flora and fauna contributes to agricultural production in different months of the year.

Keywords: n Aymara, teaching, nature, harvest, fauna.

The Andes, cradle of various ancient cultures, harbor an invaluable heritage of ethnoecological knowledge that has allowed its inhabitants to adapt and thrive in an ecologically complex environment. Among these cultures, the Aymara stands out for its deep connection with nature and its sophisticated interpretation of biological and climatic phenomena as a guide for its agroecological practices. Since the discovery of America, understanding Andean thought has posed a challenge to Western epistemology, as the Aymara worldview transcends the limits of traditional philosophy, offering a more holistic view of the relationship between humans and their environment.

This unique relationship between the Andean man and nature is characterized by deep respect and symbiotic coexistence. As Rengifo (2003)

points out, this interaction is not based on domination but on mutual care and ecological reciprocity. In this context, Pachamama or Mother Earth is not a mere abstract concept but a living entity that provides vital ecosystem services, fostering biodiversity and agricultural productivity.

The complexity of this relationship is reflected in the words of Churata (1949): "The man who lives in perpetual dialogue with static nature learns, like a rebound of thought, that the mountains return with force, penetrating the thinking subject him-self; he learns to deepen his own rebounded thought (p.28)".

This quote illustrates the Aymara conception of the world as an interconnected socioecological system where humans are not mere observers but active participants in a constant dialogue with their biophysical environment.

The Andean "knowledge," far from being static, is characterized by its practical and dynamic nature. Jamioy (1997) emphasizes that this ethnoecological knowledge is intimately linked to the application of "doing," seamlessly integrating theory and praxis in agroecosystem management. This wisdom, transmitted orally from generation to generation, constitutes a valuable repository of traditional ecological knowledge.

A notable characteristic of Aymara culture is its ability to adapt and appropriate new knowledge without losing its cultural identity. Bastidas et al. (2009) describe how the Aymara relate to different environments, selectively adopting agroecological innovations. This process involves a "dialogue of knowledge," where traditional knowledge and new technologies intertwine synergistically, strengthening the resilience of Andean agricultural systems.

1.1. Nature of flora and fauna

The interpretation of nature's signs by the Aymara is based on meticulous and prolonged observation of their environment. These signs, which include phenological, ethological, and meteorological indicators, constitute a complex system of bioindicators that guide agricultural decisions. Berkes (1999) has documented similar systems in other indigenous cultures, highlighting the sophistication and precision of this ethnoecological knowledge.

In the specific context of Andean agriculture, bioindicators play a crucial role. Soejarto et al. (1996) have demonstrated how farmers use biological indicators to determine the optimal times for planting and harvesting, allowing fine adaptation to the climatic and ecological variations characteristic of Andean agroecosystems.

The diversity in production, climate, and customs is typical of the Altiplano. In ancient times, even before the Incas, the Aymara settled on the shores of the highlands, dedicating themselves to harvesting andean tubers and grains such as potatoes, corn, quinoa, kiwicha, cañihua, and tarwi, among others. Viguera et al. (2017) argue that understanding natural behavior in relation to climatic changes helps community members adapt and plan annual agricultural production.

A fundamental aspect of the Aymara worldview is the sacredness attributed to all elements of the ecosystem. Grillo (1993) expresses it as follows:

"In the Andes, there is no act, place, person, thing, or date that is not sacred, that does not suggest worship. Everything is a reason for affection, celebration, and respect. Not only is Pachamama the reason for ritual celebration, but also the seeds, the fallow land, the planting, and the consumption of food. There is no symbolic moment opposed to and different from another empirical moment, but rather sequences of the same loving act. Andean communities experience everything that exists as a sacred collectivity." (p. 14)

This holistic and sacred view of nature profoundly influences agroecological practices, infusing them with a ritual and symbolic character that transcends the mere production of food.

The relationship between the Aymara farmer and nature transcends the Western notion of domination over the environment. Van & Enríquez (2002) explain:

"For the Andean, coexistence between humans and the elements of nature is fundamentally different. He does not consider himself the owner or king of creation but rather a brother to other beings because he basically shares the same universal life, coming from the same Mother Earth" (p.59).

1.2. Nature of fauna

The interpretation of animal signs is particularly rich and complex in Aymara culture. Farmers observe and interpret the behavior of indicator species such as foxes, amphibians, and birds, considering them reliable bioindicators of environmental conditions and their influence on agroecological cycles. This ancestral wisdom, transmitted from generation to generation, constitutes a valuable repository of traditional ecological knowledge that, combined with modern scientific advances, can contribute to the design of sustainable and resilient agroecological systems in the highlands of the Peruvian Andes.

In the context of fauna, the observation and understanding of the signs or communication of its nature are crucial for guiding agricultural practices and maximizing productivity sustainably. As Nugent & Laporte (2017) note, traditional farmers have used the behaviors and patterns of wildlife for centuries as reliable indicators of seasonal changes and favorable environmental conditions for the various stages of the agricultural cycle. Similarly, Fernández-Llamazares et al. (2017) found that Amazonian hunter-gatherers use the tracks and signs of mammals as indicators of resource availability and habitat quality, which influences their management and sustainable land use practices.

Moreover, for the Andean man, it is necessary to perform rituals that help communicate with nature. These rites are celebrated before the Andean New Year, as Gow & Condori (1982) point out: "Two of the main fertility celebrations take place near Corpus Christi, the festival of the Lord of Quyllur Rit'i, which are: Trinity for cattle and San Juan for alpacas and sheep" (p.7).

During these festivals, rituals with candles, coca, prayers, and other offerings are performed to affirm the power of superior ajayus over Pachamama's fertility. Then, gratitude rituals are held after the Andean New Year.

For Andean agriculture, no organism or electronic device is more effective than the reading of nature by the custodians of the fields. The foxes, flamingos, lapwings, cacti, herbs, winds, lightning, stars, moon, frost, and more will speak clearly, and the runa will have to read these symbols, signs, and indicators of the ajayus correctly and experiencedly.

1.3. Nature of flora

Regarding flora, the Aymara have developed a deep understanding of the phenological cycles of native plants, using them as indicators of edaphoclimatic conditions and suitability for different crops. Altieri (1999) has documented how traditional Andean agriculture has coevolved with local biodiversity over millennia, resulting in diverse and resilient agroecological practices.

According to Fernández-Llamazares et al. (2017), in some indigenous communities in Latin America, the appearance of certain plant species or herbs is interpreted as a sign that good harvests are approaching. For example, Tsimane' farmers in Bolivia consider the presence of the herb "chuchio" as an indication that the growing season will be productive. On the other hand, Mapuche farmers in Chile interpret the abundance of the herb "ñocha" as a harbinger of poor harvests (Berkes et al., 2000). These traditional observations are based on empirical knowledge accumulated over generations.

Additionally, regarding the characteristics of plants as indicators of nature's behavior, it is known that ritual festivals are so numerous that a daily festive calendar of the community can be discussed. These do not constitute moments of a different nature from the acts of daily life. On the contrary, they are deeply respected because the

seeds are the kausay, the seminal, the vivifying, the feminine deity “qipa mamata” that allows the regeneration of life or, as the Aymara say, "the fabric where the diversity of life forms nests" (Asociación Paqalqu, 1997).

As Don Santos Vilca Cayo reiterates: "The tinkhas are made to live harmoniously within the ayllu, for good health, and for the field to grow healthy and produce well" (Chambi et al., 1997). Likewise, "the festival of the Ispallas is a ritual celebration of receiving new crops; in this festival, women are “Ispallas”, potato deities, and men are “Mucho's”, grain deities. People from other communities who visit are received as Yoqcha ispallas, potato daughters-in-law, or Tollqa muchos, grain sons-in-law. In this festival, the Ispallas are the same Pachamama" (Chambi et al., 1997).

Beltrán (2003) argues that all communities have had a calendar to regulate agricultural and religious activities. In the Andes, agriculture was the main activity of the highland cultures; the cultivation of the land required basic planting, irrigation, and harvesting techniques according to an annual schedule or agricultural calendar developed through the experience accumulated over thousands of years by pre-Inca and Inca peoples.

The importance of this ethnoecological knowledge transcends the local sphere. In a context of global climate change and increasing pressure on ecosystem services, Aymara ecological wisdom offers valuable lessons on adaptation and sustainability. Therefore, the urgent need arises to document, understand, and preserve this ancestral knowledge.

In this regard, the objective of the research is to systematize the information derived from the interpretation of the fauna and flora, as well as the use that the Aymara people make of them throughout the year, based on ethnoecological knowledge transmitted intergenerationally. This knowledge pertains to bioindicators, interspecific communication patterns, and methods for interpreting the phenology of Andean fauna and flora.

The relevance of this study lies in its potential to optimize decision-making processes in agroecological management and significantly contribute to improving cultivation and harvesting practices in Andean agroecosystems. Additionally, by documenting this knowledge, we contribute to its preservation and potential integration with modern scientific approaches, promoting an intercultural dialogue that can enrich our collective understanding of Andean ecosystems and their sustainable management.

Materials and methods

2.1. Research approach and design

This research was developed under a qualitative approach using an ethnographic design (Cotán, 2020; Hualampa, 2022; Ticona et al., 2022). This approach allows for a deep articulation of historical, cultural, and contextual aspects (Bermejo & Maquera, 2022), facilitating a holistic analysis of linguistic units in the Aymara language (Halliday, 1985). The choice of this approach and design responds to the need to capture the richness and complexity of Aymara ethnoecological knowledge that cannot be fully understood through quantitative methods.

2.2. Categories of analysis

Two main categories of analysis were identified, aligned with the research objectives:

a) Ontological understanding of the interpretation of animal behavior as indicators of nature’s behavior by the Aymara.

b) Ontological understanding of the interpretation of plant behavior as indicators of nature’s behavior by the Aymara.

These categories allowed for a systematic and in-depth exploration of Aymara ethnoecological knowledge related to local fauna and flora.

2.3. Participants

Participant selection was conducted following ethical principles (Villamañán et al., 2016; Esparza-Reyes et al., 2020) and criteria of cultural relevance. Twenty individuals from

Aymara zones, specifically from the regions of Huancané, El Collao, and Juli in the Puno region, participated. Inclusion criteria included: native speakers of Aymara language, belonging to Aymara culture, active community members engaged in agricultural and/or commercial activities, and aged between 45 and 80 years.

The diversity in age and occupation allowed for capturing a wide range of knowledge and experiences. As noted by Blanco & Castro (2007), in qualitative research, the focus may center on cases with intrinsic interest to discover meanings or reflect multiple realities; thus, generalization is not a primary goal.

2.4. Data collection techniques and instruments

The following techniques and instruments were employed:

1) In-depth interview: This technique facilitated the organization and ordering of information for subsequent interpretation. The interviews were semi-structured, al-lowing for an open conversation where participants could freely express themselves (Zúñiga et al., 2023). This approach is valuable for maintaining precision in the descriptions and interpretations of the interviewees' experiences (Robles, 2011).

2) Field notebook: It was used to record each linguistic unit in Aymara and Spanish that responded to the research interest. This instrument allowed for capturing detailed observations and immediate reflections during the data collection process (Teixeira et al., 2023). The fieldwork followed the following stages: selection of key informants, obtaining informed consent and acceptance to participate in the research, coordination of time and space for conducting the interviews, assertive and spontaneous application of the interviews, closing the interviews with thanks and cordiality, and finally, immediate transcription of the interviews for later interpretation.

2.5. Data analysis and interpretation procedure

Data analysis was performed using the content analysis method (Krippendorff, 2002; Liberona, 2015; Quispe, 2022) following these steps:

1. Identification and selection of perceptions according to the study theme.

2. Classification and understanding of the information based on predefined categories.

3. Capture the meaning of the collected communications.

4. Submission of each analysis unit to a semantic matrix considering the speaker's intention and context.

5. Re-reading and interpretation of transcribed texts.

6. Assignment of codes to identify participants.

This analysis process allowed for a deep and contextualized interpretation of the data, respecting the richness and complexity of Aymara ethnoecological knowledge.

The methodology used in this study was designed to comprehensively capture Aymara ethnoecological wisdom, allowing a profound understanding of how this community interprets and uses nature's signs in their agricultural practices. The qualitative and ethnographic approach, together with the data collection and analysis techniques employed, provide a solid foundation to explore and document this valuable traditional knowledge.

Results

The findings of this ethnographic study on the interpretation of nature’s signs by Aymara people are presented, organized into emergent categories from the content analysis. This section preserves the authentic interpretation of the voices of Aymara participants. The data is presented in three sections: data on flora nature, species characteristics observed, and ethnoecological interpretation; and in the case of fauna nature: species, Aymara name, scientific name, observed behavior, observation period, and ethnoecological interpretation.

3.1. Systematization of information on natural indicators

Tables 1 and 2 provide a systematic overview of how the Aymara people interpret the specific behaviors of various species of flora and fauna as bioindicators of upcoming climatic and agricultural conditions.

Table 1 Systematization of information on flora behavior as indicators of nature's behavior throughout the Aymara agricultural year

Species observed	Characteristics	Ethnoecological interpretation
Lirio (*Sisyrinchium andicola Kook*)	1. Flowering unaffected by frosts in its usual season. 2. Flowering damaged by frosts in its usual season.	1. Favorable year with abundant rains. 2. Adverse, dry year with frequent frosts.
Mula siqui (*Liabum ovatum*)	1. Abundant flowering of large size and intense yellow color. 2. Sparse and reduced size flowering.	1. Year with abundant rains and good harvest. 2. Year of low agricultural production.
Algae- Laqo (*Ulvophyceae*)	1. Intense green color. 2. Light green color.	1. Year with abundant rainfall. 2. Year with scarce rains.
Sankalayo	1. Pods with large grains.	1. Year of abundant harvest, especially of quinoa.
Qariwa/ Waycha	1. Healthy flowering in March, September, and January. 2. Flowers affected by frosts. 3. White flowers.	1. Favorable year with a good harvest. 2. Year with frequent frosts. 3. Good tuber production.
Achacana/ Sank'ayo	1. Early flowering. 2. Flowers burned by frost with subsequent re-flowering. 3. Small sank'ayos. 4. Sank'ayos root infested. 5. Large-sized sank'ayos fruits.	1. Risk of frost for crops. 2. Delay in sowing. 3. Low potato production affected by frosts. 4. Potato production susceptible to pests. 5. Abundant and high-quality harvest.
Kanlla	1. Intense red flowering.	1. Good harvest, especially of barley, oats, and wheat.
Qhela - K'era	1. Abundant sprouting. 2. Lack of flowering.	1. Abundant grain harvest. 2. Insignificant agricultural production.
Paja / Chiwilla	1. Fruiting at the top of the plant. 2. Fruiting at the bottom of the plant.	1. Sufficient rains for production. 2. Lack of rains.
Papa- Ch'oqe	1. If the new potato sprouts within February and is small. 2. If potatoes are already sprouting during hilling.	1. There will be no rain. 2. Announces early sowing.
Liqiq'ero	1. Observation of inflorescence.	1. White flowers indicate a good year for grain production, especially large quinoa.

Table 2 Systematization of information on the behavior of fauna as indicators of nature's behavior throughout the Aymara agricultural year

Species	Aymara name	Scientific name	Observed behavior	Observation period	Ethnoecological interpretation
Toad	Jamp'ato	Rhinella spinulosa	1. Skin coloration (green or yellowish).	August to november	1. Green skin: rainy year. Yellowish skin: dry year with few rains.

			2. Nutritional state (fat or thin).		2. Fat toad: good year. Thin toad: dry and poor year.
Fox	Qamaqe	Lycalopex culpaeus	1. Vocalization (cry, howl). 2. Consistency and integrity of feces.	August to October	1. Complete howl: good rainy year. Interrupted howl: intermittent rains. Afternoon howl: bad year. Morning howl: good year. 2. Solid feces: good year for potatoes and quinoa.
Andean Horsefly	K'apuri	Tabanus sp.	1. Presence next to sank'ayo.	September to November	1. Abundance of horseflies next to sank'ayo announces a good year for tubers.
Weaver Spider	Kusi Kusi	Argiope sp.	1. Web location. 2. Web shape.	August to October	1. High web: rainy year. Low web: dry year. 2. Bell-shaped web announces a rainy year.
Leqecho	Leqe Leqe	Vanellus resplendens	1. Egg coloration. 2. Nest location. 3. Nest construction. 4. Song.	August to November	1. Predominantly black eggs: hailstorms. Greenish eggs: normal rains. 2. High nest: rainy year. Mid-furrow nest: normal rains. Low nest: dry year. 3. Nest built with metal objects: year with many lightning strikes. Nest with sheep manure: good production. 4. Group song in May: announces upcoming frosts.
Quail	Puku Puko	Nothoprocta pentlandii	1. Nest construction.	September to November	1. If eggs are inside ch'illiwas, it will be a good year.
Andean Goose	Wallata	Chloephaga melanoptera	1. Nest location	May to July	1. Nest on high rocks: rainy year.
Ant	Qhanlli	Camponotus sp.	1. Ant flight. 2. Egg or larva size.	September to November	1. If they fly, it is a sign of no rains for a certain time, even with possible frosts. 2. If the eggs are large, it will be a great season for potatoes.
Flamingo	-	Phoenicopterus chilensis	1. Behavior.	October to December	1. Arrival in large numbers to the river and their dance announces a good production of tubers and grains.
Andean Sparrow	Pesqe Llawchi / Pichitanka	Zonotrichia capensis	1. Vocalizations.	December to March	1. "Juiphich'is" song: night frost. "P'esqe llauch'is" song: good quinoa production. "Chijchi llauch'is" song: hailstorm.
Common Miner	K'iti K'Iti	Geositta cunicularia	1. Nest composition.	September to December	1. Nest with beautiful stones announces a good production year. Deformed stones indicate a year of frosts.

3.2. Ontological understanding of the interpretation of animal and plant behavior as indicators of nature's behavior during the months of the year by the Aymara

The analysis of testimonies reveals a complex and deep Aymara ethnoecological knowledge system. This system integrates detailed observations of fauna, flora, and atmospheric phenomena to predict climatic conditions and guide agricultural practices.

3.2.1. Interpretation of signals

BMA provides an illustrative example of the interpretive complexity of faunal signals:

"¿Kunjamsa yatiyatha? Aka pachana jani wali jutawipa qhanpañarakinsa llumpaqa (Agosto) phaxsita janiwa jallu puriwaykiti ukatha qamaqi qhanpacha yatiychistu. jallu utjañapataki qamaqixa lapaka phaxsita waqaqxiwa. jichhaxa qamaqi janipuniwa waqaqkiti kikiparakiwa liqiliqi yatiyxchistu k'awnapa ch'uxñawa ukaxa jallu puriñapataki yatiychistu. jallu jani puriñapataki K´awnapaxa janq'uwa jichhaxa káwñapa janq'urakisa sapa urunaka thayawa ukata juyphi utjaniwa. Kariwa panqara sank'ayu panqara janiwa panqarapkiti ukhamarakiwa jawiranakana janiwa ch'uxnaptatakiti waña marjamakiniwa."

(Translation: How did you know there would be drought? The weather was clear. It didn't rain in August, the fox announces it, the fox cries before November, but now the fox hasn't cried; the lequeleque also warns you. Its egg is green; when the lequeleque's egg is green, it means it will rain; when it won't rain, the egg is white; and now the lequeleque's egg is white. There will be frost because it is always cold. We also look at the plants like kariwa, which does not bloom, the sankayo; the rivers also indicate when there is grass around and it is green, which means it will be a good year. When there is drought, the surroundings are dry).

This testimony shows the integration of multiple bioindicators in climate interpretation. The observation of the fox and lequeleque's behavior is combined with plant phenology and landscape changes to form complex climate predictions. Riviere (1997) and Claverías (1990) confirm this practice, noting that natural indicators "aim not only to anticipate events in the near or distant future but also to interpret irregularities and failures in both present and past cycles" (p. 30-31).

3.2.2. Intergenerational transmission of ethnoecological knowledge

MMD provides a detailed example of intergenerational transmission of knowledge:

"Tatituna pankapana waña maraniwa siwa ukhamarakiwa awatirinaka sapxarakixa. awatirixa Chaski uksa allyutawa llumpaqa phaxsina purxañapawa ukatha janipuniwa purkiti. Nayra urunaka pä kuti purxatawayi ukatha aka llumpaqa phaxsina walipuniwa puriñapaxa. juyphi pacha puriniwa uka ch'uqi laq'utawa. Kuna phaxsina sataña kuna pachansa jiwra phawaña jawasa sataña achachilanakaxa yatipxapuninwa jupanakaxa kuna phaxsina yapuchañataki kukata yatxatapxana ukata kurmi uñstaniri ukhaxa wali suma maraniwa achachilaja sirixa. Ukhata qamaqina jamapa muchintataki ukhaxa suma maraniwa sapxiwa yaqhipanaka arsupxarakiwa: qamaqina jamapa chu'uñojamaki ukaxa janiwa suma marakaniti. Anuthaya saraqaniwa uwixanaka wallpanaka apasixa waña maraniwa sapxixa"

(Translation: Shepherds say that there will be drought, like the Bible, the shepherd is from the Chasqui community. It should have rained in August, and it is not raining. Although it has rained twice, it should rain more in August. Frost came, and the potato is infested with worms. My grandparents knew the time for planting potatoes, when to plant quinoa, and when to plant beans. The grandparents look at the coca leaf to determine the exact time for planting coca. My grandfather would read that if a rainbow appeared, it meant that it would be a good year for quinoa production. The fox announces it when its droppings contain barley grains, indicating a good barley crop, and when it produces droppings with many potato peelings, it means there will be a good potato crop. The skunk comes down and takes sheep and chickens, which means there will be a drought.)

This account illustrates the richness of traditional knowledge that encompasses everything from interpreting atmospheric

phenomena to the detailed observation of animal behavior and droppings. The teachings from the elders highlight the importance of oral transmission in preserving this ethnoecological knowledge.

3.2.3. Interpretation of nature: Flora

GCE provides valuable information on interpreting floristic signals:

"Achaka panqar qhariwa janipuniwa pampanakana utjkiti sank'ayu panqara itapillu ukanaka sata taypisata uka phaxsinakana uñstanxiriwa"

(Translation: Some herbs, the achaca and the kariwa, are not found in the fields; the sank'ayu flower and itapillu should bloom between September and October.)

This testimony aligns with the findings of Rist & Dahdouh-Guebas (2006), who document how Andean farmers use the flowering of certain plants as indicators of climatic conditions and agricultural productivity. Sánchez et al. (2020) add that some farmers use lunar phases and signals from specific plant species to determine the appropriate periods for sowing and harvesting.

3.2.4. Interrelation between natural phenomena and ritual practices

PVF illustrates the interrelation between natural phenomena and ritual practices:

"Achuqa phaxsina San José uka urunakana jallu wali purintani ukhaxa marpacha jallu purintani sapxixa ukatha uka ununma jani purkani janiwa suma maraniti sapxarakixa. Tata Liqichuku qalanakana k'awnani ukhaxa chhixchi jutaniwa sapxixa Yapu sukanaka k'awnki ukhaxa suma maraniwa ukhama yatiychistu. Ukhmaraki waña chiqanakaru kawnki ukhaxa waña maraniwa sapxiwa"

(Translation: In March, during San José, if it rains and rains all night, then that year will be a good year. If it does not rain, there will be drought. When the lequeleque bird lays eggs on rocks, hail is expected. If it lays eggs within furrows, there will be rain; if it lays eggs in dry areas, there will be drought.)

This tale demonstrates how natural observations are intertwined with the festive and agricultural calendar. Tschopik (1968) notes the importance of these phenomena, mentioning that "Frogs are not special animals of this spirit, but they need water, and the Father Atoja (the tutelary hill of the Chucuito sector) does not like animals to suffer" (p.128).

JMG provides additional information about the interpretation of aquatic bird signals:

"Wallatampi pariwanampi jawiranakanki ukhaxa suma maraniwa sapxiwa. Mimaraxa San José Phunchawina achuqa phaxsina jallu janiwa puriwaykiti Ukatha jiccha maraxa jallu purintawayi. Ukatha yapu apthapiña nayraqatankaniwa. Willkakuti phaxsina Jurp'uxa jawiranakaru purini jallu utjaniwa sapxi"

(Translation: When the huayllata and parihuana are in the river, they say it will be a good year. Last year during the feast of San José in March, it did not rain, but this year it did rain. So, the harvest will start earlier. In October, because the huayllata and parihuana are in the river, when smoke appears like frost or mist during San Juan, rain will come.)

This testimony highlights the importance of aquatic birds as climatic indicators, consistent with Gómez-Baggethun et al. (2013), who noted how the presence of birds such as "puquial" and "huallata" is seen as a sign of good harvests in the Puno region.

JGYH provides a concise but significant observation:

"quta tuqi Jilawi markata. Achuqa phaxsina jallu juk'aki purinixa yapunakata ukhakiraki apthapiñanixa"

(Translation: The rain of San José in March was scarce, so the harvest will be small.)

This observation reinforces the importance of March rains in predicting the harvest, a crucial aspect of Aymara agricultural knowledge. Grillo (1993) points out that in Andean culture, not only living beings are considered as such, but also landscape elements, reinforcing the interconnectedness of all aspects of the environment.

RNI offers another perspective on interpreting climatic signals:

"Jani wali achuqawi utjkixa juyphi sintiniwa sapxiwa. Ukatha sata (setiembre) phaxsita anata (febrero) phaxsikama jallu wali purintani ukaxa achuqa phaxsita yatiychistu. Ukhata aka san jose phaxina isk'akieisa purixa achuqawi jani waljakiniti. kikitiki suma tapapa luri ukhaxa suma maratakiwa"

(Translation: When there is a poor potato harvest, the frost is strong. It will rain from September to February. This is forecasted during the San José feast in March. In this month of San José, it rained a little, so there will be a small potato harvest. When the kikitiki bird makes a good nest, it announces that there will be a good production.)

This testimony underscores the importance of observing birds like the kikitiki in predicting agricultural productivity, consistent with the observations of Gómez-Baggethun (2009) on interpreting signals from species such as the lequeleque, toads, and frogs in some communities in Cusco.

Finally, NCJ provides information on the relationship between rainfall and sowing cycles:

"Tata San José phunchawina ukhamaraki Tata San juan phunchawina nayraqatapa jallu puri ukhaxa mä kutiki yapuchapxiwa"

(Translation: When it rains during the San José and San Juan feasts, sowing is done before the San Juan month; if it rains later, only one sowing is done.)

This testimony shows how agricultural decisions are based on careful observation of rainfall patterns in relation to religious festivities, demonstrating the integration of ecological and cultural knowledge in Aymara agricultural practices.

3.3. Integrated analysis of the results

The collected testimonies reveal a complex and deep Aymara ethnoecological knowledge system. This system integrates:

Detailed observations of fauna: The behavior of species such as the fox, lequeleque, and other birds is interpreted as reliable climatic indicators.

Phenology of flora: The flowering and other changes in specific plants are used to predict climatic and agricultural conditions.

Interpretation of atmospheric phenomena: Rain patterns, cloud formation, and other meteorological events are carefully observed and interpreted.

Integration with the ritual calendar: Natural observations are intertwined with religious festivities and spiritual practices, reflecting a holistic view of the natural and cultural world.

Intergenerational transmission: Knowledge is orally transmitted from generation to generation, ensuring its preservation and continuous adaptation to local conditions.

Redundancy of indicators: The Aymara do not rely on a single signal but integrate multiple indicators to reach more robust conclusions about upcoming climatic conditions.

This knowledge system demonstrates a sophisticated understanding of local ecology and reflects a millenary adaptation to the environmental conditions of the Andes. The diversity of indicators used suggests a redundancy strategy that likely increases the reliability of climatic and agricultural predictions.

The integration of natural observations with cultural and spiritual practices reveals a worldview where the natural and cultural are closely intertwined. This holistic view could offer valuable perspectives for contemporary approaches to environmental management and sustainable agriculture, especially in the context of global climate change.

The testimonies reveal a close relationship between climatic predictions and subsistence practices. For example, JMC's observation of the need to drink “water with salt” from rivers during droughts demonstrates how ethnoecological knowledge directly translates into adaptation strategies to adverse conditions.

The importance of aquatic birds as climatic indicators, as mentioned by JMG, highlights the complexity of this knowledge system. The Aymara not only observe terrestrial species but

also pay attention to interactions between different ecosystems, such as the presence of certain birds and their relationship with rain patterns.

RNI's testimony about the relationship between frost and crop quality shows how this ethnoecological knowledge is directly applied to agricultural management. The ability to predict adverse conditions allows Aymara farmers to take preventive measures and adapt their cultivation practices.

NCJ's observation of the relationship between rainfall and sowing cycles illustrates how ethnoecological knowledge integrates with the agricultural calendar. This integration allows flexible adaptation to interannual climatic variations, contributing to the resilience of Aymara agricultural systems.

In conclusion, Aymara ethnoecological knowledge represents a complex and dynamic system that integrates precise observations of the natural environment with a rich cultural tradition. This knowledge has practical value for sustainable agriculture in the Andean region and offers a unique way of understanding and relating to the natural world.

The sophistication of this knowledge system is evident in the Aymara's ability to interpret multiple natural signals and combine them to form complex climatic predictions. This ability to "read" the landscape and its inhabitants demonstrates a profound understanding of ecological interrelationships in Andean ecosystems.

Furthermore, the close link between natural observations and cultural and spiritual practices suggests that for the Aymara, environmental management and cultural identity are inseparable. This integral vision could offer valuable lessons for modern conservation and sustainable resource management approaches.

The resilience and adaptability of this traditional knowledge in the face of socioeconomic and environmental changes are remarkable. However, it also faces challenges such as cultural erosion and the impacts of global climate change, which may alter the natural patterns on which these predictions are based.

In this context, documenting and valuing this traditional knowledge is important not only for cultural preservation but also for significantly contributing to climate change adaptation strategies and sustainable resource management in the Andean region and beyond. Integrating this ethnoecological knowledge with modern science could open new pathways to address contemporary environmental challenges, leveraging the wisdom accumulated over millennia by Aymara communities.

Discussion

Natural signals from flora and fauna throughout the year play a crucial role in understanding and adapting to the ecosystems and human communities of the Aymara people. This ethnographic study reveals the complexity and richness of Aymara traditional knowledge about interpreting these signals to guide their agricultural practices, demonstrating a sophisticated Traditional Ecological Knowledge (TEK) system that deserves in-depth analysis.

The acquisition and transmission of this knowledge are characterized by their holistic and dynamic nature. Rodríguez (2010) and Jahuira (2012) note that this knowledge develops spontaneously, without a rigid curriculum, through daily life, family interactions, markets, festivals, and rituals. This integral learning method contrasts markedly with Western educational systems and underscores the importance of cultural context in transmitting ecological knowledge. This finding aligns with observations by Berkes (1999) in other indigenous cultures where ecological knowledge is similarly transmitted, suggesting a common pattern in traditional societies that could offer valuable insights for contemporary environmental education approaches.

The interviewees in this study confirm that nature still effectively guides agricultural development, corroborating observations by Van

& Enríquez (2002). These authors explain that signals are not unequivocal but rather suggestive, requiring flexibility in reading, imagination, and creative fantasy in understanding. This contextual interpretation of signals demonstrates sophisticated adaptation to the Andean environment, offering valuable lessons for environmental management in the context of global climate change. The interpretative flexibility observed in the Aymara contrasts with conventional scientific approaches that seek direct causal relationships, suggesting an alternative paradigm for understanding complex systems like Andean ecosystems.

The relationship between the Andean man and nature, as described by Rengifo (2003) and Torres et al. (2018), is characterized by mutual respect and coexistence. This vision of Pachamama as a protective and providing entity contrasts strongly with the anthropocentric perspective's dominant in many industrialized societies and offers an alternative paradigm for sustainable environmental management. This approach aligns with Toledo (2002), highlighting the close relationship between indigenous communities and their natural surroundings, suggesting that this type of relationship could be crucial for developing more effective and culturally appropriate conservation strategies.

In line with Salas (1996), a dialogue between Aymara ancestral knowledge and recent changes is evident, allowing these communities to adapt and adopt technology without losing their cultural identity. This ability to integrate and adapt, also noted by Bastidas et al. (2009), could be crucial for facing contemporary environmental challenges. The Aymara's capacity to integrate new knowledge without losing their cultural essence offers a potential model for other communities facing similar change pressures.

Regarding plants, their value as indicators of nature's behavior throughout the year is evident, consistent with the contributions of Riviere (1997) and Claverías (1990). Interviewees referred to native species such as kariwa, sankayo, and totora, highlighting changes in their growth and flowering. This information is used to guide soil preparation and predict whether the sowing will be suitable for tubers or cereals depending on the probable availability of rain. These findings align with studies by Altieri (1999) on the coevolution of traditional agriculture with nature, suggesting that this knowledge could be valuable in developing more resilient and climate-adapted agricultural practices.

On the other hand, concerning animals, the importance attributed to the fox and toad is confirmed, as documented by Inquilla & Apaza (2021). The Aymara interpret their vocalizations, location, and behavior as signals about the start of sowing and harvest prospects. Similarly, birds such as kikitiki and lequeleque are observed for their nests and eggs. This close interaction reflects the Andean worldview that grants spirituality to nature, as expressed by Grillo (1993) and Mamani-Bernabé (2015). These findings align with studies by Gómez-Baggethun (2009) on the importance of biodiversity in traditional knowledge systems, suggesting that biodiversity conservation is crucial not only for ecological reasons but also for cultural reasons.

Another relevant aspect that emerges from the testimonies is the spiritual dimension of reading signs as part of the Aymara worldview. As Macedo (2015) indicates, this worldview integrates humans into a continuous dialogue with nature and the different ecological zones that make up the Andean universe. Interviewees refer to the "signs of the ajayus," indicating the interrelation between the material and spiritual elements of their environment. This spiritual dimension of ecological knowledge, also observed by Berkes et al. (2000) in other indigenous cultures, suggests that conservation and environmental management approaches could benefit from incorporating more holistic perspectives that recognize the importance of spiritual aspects in human-nature relationships.

In this sense, the research corroborates that in the Andes, agriculture is not purely a technical practice but is imbued with rituality, as proposed by Grillo (1993) and the Asociación Paqalqu (1997). This is evident in testimonies that link the reading of signs with ceremonial festivities such as San José or San Juan. Correctly interpreting these signs is part of the Aymara farmer's duties towards their deities and Pachamama in the quest for harmony and fertility. This integration of agricultural and ritual practices reflects a holistic approach to natural resource management that could offer valuable insights for developing more sustainable and culturally appropriate management strategies.

Following this line, Salas (1996) and Torres et al. (2018) highlight that in the Andean worldview, all components of nature are considered sacred. The interviewed Aymaras refer to animals and plants in those terms, attributing agency and spirituality to them. Their testimonies evoke an ethic of profound respect towards these beings, who are considered valid interlocutors with their own messages. This perspective aligns with the arguments of Van & Enríquez (2002) about the brotherhood relationship between humans and other beings of nature in the Andean worldview, suggesting an alternative paradigm for environmental ethics that could inspire more respectful and sustainable approaches to natural resource management.

Regarding the implications for environmental management, Saylor et al. (2017) and Peralvo & Salinas (2019) emphasize the need to integrate traditional ecological knowledge into sustainable management strategies. The results of this research provide evidence of the contributions of Aymara wisdom in understanding and adapting to ecosystems. Incorporating these perspectives through genuine intercultural dialogue can enrich environmental and agricultural policies in the Puno region. This integration could be particularly valuable in the context of climate change, where traditional knowledge could complement scientific data to develop more effective and culturally appropriate adaptation strategies.

It is important to acknowledge the limitations of this study. The qualitative nature and ethnographic approach imply that the results are not generalizable to the entire Aymara population but offer a situated perspective on the particularities of the interviewees. Furthermore, by focusing on the interpretation of signs, it does not exhaustively address other aspects of the Aymara relationship with nature. The relatively small and geographically limited sample also presents challenges for generalizing the findings. Additionally, possible memory bias in the collected testimonies could affect the accuracy of some observations.

Future studies could address these limitations through mixed designs with probabilistic sampling and the incorporation of other methods such as participant observation. Longitudinal studies documenting observations and predictions in real-time over multiple agricultural seasons would also be valuable, providing more accurate data on the effectiveness of these practices. Additionally, future research could explore how climate change is affecting the reliability of traditional indicators and how Aymara communities are adapting their practices in response to these changes.

Conclusions

The research provides evidence of the persistence and value of traditional ecological knowledge in Aymara culture, specifically regarding the interpretation of nature's signs. From an epistemological perspective, it is confirmed that this knowledge constitutes its own system of knowledge, constructed from respectful interaction with the environment and transmitted through oral tradition and daily practice. Far from being "primitive" knowledge, the complexity of sign reading demonstrates the

depth of Aymara thinking regarding natural cycles and ecosystemic interrelations. This dynamic and situated knowledge is valid on its own terms according to the worldview from which it originates. Moreover, it is supported by scientific evidence showing the close relationship between the biological cycles of fauna and the climatic and phenological patterns that determine crop success (Bixler et al., 2020).

Methodologically, the qualitative approach allowed for the study of the categories from the perspective of the actors themselves, consistent with the assumed epistemological approach. The ethnographic method made it possible to capture the meanings, logics, and senses that guide the Aymara relationship with nature, enriching the understanding of the studied topic. While the results are not generalizable, they shed light on cultural particularities in a situated context. Future research could complement this approach with mixed methodologies to compare findings in representative samples.

In summary, the study shows that in Aymara communities, deeply rooted ways of knowing persist, necessarily contextualized in their cosmology. This research seeks to value the contributions of this knowledge, highlighting its importance for intercultural dialogue and sustainable environmental management. Further exploration of alternative epistemologies is needed, as they have enabled indigenous peoples to inhabit their environments harmoniously and develop more sustainable agricultural practices adapted to local conditions, contributing to food security and the preservation of natural ecosystems (Altieri, 1999).

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Conflicts of interest

The authors declare no conflicts of interest.

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