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FROM BIOLOGICAL EVOLUTION TO SOLIDARITY ORGANIZATION: ADAPTIVE BASES OF HUMAN COOPERATION

DE LA EVOLUCIÓN BIOLÓGICA A LA ORGANIZACIÓN SOLIDARIA: BASES ADAPTATIVAS DE LA COOPERACIÓN HUMANA

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Abstract

The article analyzes the adaptive foundations of human cooperation, integrating concepts from evolutionary biology and solidarity economics to understand how principles of cooperation and reciprocal altruism explain the emergence and sustainability of solidarity organizations in contexts of socioeconomic crisis. A qualitative and transdisciplinary approach was employed, with a documentary and hermeneutic design, based on a bibliographic review of specialized sources in evolutionary biology, solidarity economics, and theories of cooperation. Bibliometric search equations and thematic analysis were used to identify analytical and emerging categories, such as "cooperation as an evolutionary strategy" and "group selection." Cooperation, both in nature and in solidarity economics, is an evolutionarily advantageous strategy that enhances group resilience and adaptability. Solidarity organizations replicate biological mechanisms like reciprocal altruism and group selection, demonstrating greater efficiency and sustainability in systemic crises.

Resumen

El artículo analiza las bases adaptativas de la cooperación humana, integrando conceptos de la biología evolutiva y la economía solidaria para comprender cómo los principios de cooperación y altruismo recíproco explican el surgimiento y sostenibilidad de organizaciones solidarias en contextos de crisis socioeconómica. Se empleó un enfoque cualitativo y transdisciplinar, con un diseño documental y hermenéutico, basado en revisión bibliográfica de fuentes especializadas en biología evolutiva, economía solidaria y teorías de la cooperación. Se utilizaron ecuaciones de búsqueda bibliométrica y análisis temático para identificar categorías analíticas y emergentes, como "cooperación como estrategia evolutiva" y "selección de grupo". La cooperación, tanto en la naturaleza como en la economía solidaria, es una estrategia evolutivamente ventajosa que favorece la resiliencia y adaptabilidad grupal. Las organizaciones solidarias replican mecanismos biológicos como el altruismo recíproco y la selección de grupo, demostrando mayor eficiencia y sostenibilidad frente a crisis sistémicas.

KEYWORDS
Cooperation, reciprocal altruism, solidarity economics, group selection, resilience, adaptability, transdisciplinarity.

PALABRAS CLAVE
Cooperación, altruismo recíproco, economía solidaria, selección de grupo, resiliencia, adaptabilidad, transdisciplinariedad.

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1. INTRODUCTION

Evolutionary biology, a discipline that studies the mechanisms of change in biological populations over time, has provided fundamental concepts for understanding cooperative and altruistic dynamics present in human social systems (Andrade, 2019). Based on theories such as kin selection and group selection, it has been shown that cooperation is not merely a byproduct of individual interests but also an evolutionarily stable trait that favors the resilience and adaptability of collectives (Wilson & Sober, 1994; Razeto, 1993).

Similarly, solidarity economics emerges as an organizational model that prioritizes cooperation, reciprocity, and self-management over traditional capitalist accumulation logic. Inspired by principles of equity, sustainability, and collective well-being, solidarity economics can be interpreted, from an evolutionary perspective, as an adaptive socioeconomic strategy that maximizes the social "fitness" of human communities in scenarios of economic instability, exclusion, and environmental degradation (Rodríguez, 2025a; Osorio & Rojas, 2023).

Thus, the conceptual integration between evolutionary biology and solidarity economics allows for the identification of the emergence and persistence of organizational forms that, based on cooperation, seek to optimize the long-term viability and success of human systems (Gómez & Barbosa, 2022). This transdisciplinary perspective invites a reconceptualization of solidarity not only as an ethical value but also as an evolutionarily advantageous strategy in contexts of high ecological and social interdependence (Barbosa et al., 2012; Giraldo, 2018). Hence, the research question of this article is: To what extent do the evolutionary principles of cooperation and reciprocal altruism explain the emergence, sustainability, and success of solidarity economy organizations in contexts of socioeconomic crisis?

To address this question, the article begins with an introduction, followed by the qualitative methodology, methods, results, discussion, and concludes with brief conclusions and the bibliography used in the research.

2. METHODOLOGY

This research is framed within a qualitative, transdisciplinary approach aimed at the theoretical and interpretative analysis of the links between evolutionary biology and solidarity economics (Maldonado, 2016; Bunge, 1980). This approach is relevant as it allows for the understanding of complex social phenomena such as cooperation, altruism, and collective resilience from an integrated perspective that transcends traditional

disciplinary boundaries (Páramo, 2008). Specifically, a documentary and hermeneutic design is adopted, prioritizing the critical interpretation of secondary sources to build a robust conceptual framework that explains the emergence of solidarity practices in contexts of socioeconomic crisis (Maldonado, 2014a; Bunge, 1969).

For data collection, an exhaustive bibliographic review of specialized literature in evolutionary biology, ethology, solidarity economics, and theories of cooperation was conducted using bibliometric search equations (Tables 1 and 2). This review identified key authors and concepts systematically organized around predefined analytical categories: evolutionary biology, solidarity economics, cooperation as an evolutionary and economic strategy (Barbosa et al., 2020; Aguilera et al., 2020). From these categories, emerging categories enriched the interpretative analysis, such as cooperation as an evolutionary and economic strategy, reciprocal altruism and solidarity networks, and group selection and the success of solidarity structures (Table 3) (Camacho et al., 2023).

The analysis of information was conducted through a thematic and comparative strategy. This technique allowed for the establishment of conceptual relationships between evolutionary principles observed in biological species and cooperation dynamics present in solidarity economic organizations (Gómez, 2024a; Hale et al., 2019). An open and axial coding process was applied, facilitating the identification of patterns, analogies, and synergies between both fields of knowledge (Bensman & Leydesdorff, 2009). Thus, a coherent narrative was constructed that articulates theoretical findings from biology with social practices oriented toward equity, sustainability, and self-management (Acevedo et al., 2019).

To ensure research rigor, criteria of theoretical saturation, conceptual triangulation, and transferability were considered. Theoretical saturation was achieved by noting the recurrence of fundamental ideas across multiple sources (López et al., 2025; Maldonado, 2021). Triangulation was accomplished by integrating perspectives from biology, economics, and sociology, which allowed for contrasting and enriching interpretations (Rodríguez, 2025b). Finally, transferability was ensured through the analysis of cases and experiences that, while not empirically identified in this research, are suggested as possible scenarios for future application of the principles discussed here (Rincón & Gómez, 2023; Castro et al., 2017).

3. RESULTS

The dialogue between evolutionary biology and solidarity economics reveals how the principles of cooperation and altruism, fundamental in biological evolution, also underpin economic structures based on solidarity. This technical analysis explores the connections between both disciplines, highlighting how evolutionary mechanisms of cooperation inform and support the practices of solidarity economics (Barbosa et al., 2021; Maldonado, 2018).

Table 1. Example of a search equation for the category BIOLOGÍA EVOLUTIVA OR EVOLUTIONARY BIOLOGY

DATABASE	Search Equation
WoS	Tema: (("BIOLOGÍA EVOLUTIVA OR EVOLUTIONARY BIOLOGY")) Índices=SCI-EXPANDED, SSCI, A&HCI, ESCI Período de tempo=Todos os anos
	Tema: (("BIOLOGÍA EVOLUTIVA OR EVOLUTIONARY BIOLOGY")) Refinado por: Años de publicación: (2016 OR 2017 OR 2010 OR 2013 OR 2015 OR 2012 OR 2009 OR 2011 OR 2014 OR 2008 OR 2020 OR 2021 02 2022 OR 2019 OR 2018 OR 2006 OR 2005 OR 2004 0R 2003 OR 2002 02 2001 0R 2000) Índices=SCI-EXPANDED, SSCI, A&HCI, ESCI Período de tempo=Todos los años
	Tema: ("BIOLOGÍA EVOLUTIVA OR EVOLUTIONARY BIOLOGY") Índices=SCI-EXPANDED, ESCI, A&HCI, SSCI Período de tempo=Todos os anos
Scopus	TITLE-ABS-KEY ("BIOLOGÍA EVOLUTIVA OR EVOLUTIONARY BIOLOGY")
	TITLE-ABS-KEY (("BIOLOGÍA EVOLUTIVA OR EVOLUTIONARY BIOLOGY"))
	TITLE-ABS-KEY (("BIOLOGÍA EVOLUTIVA OR EVOLUTIONARY BIOLOGY")) AND (LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) OR LIMIT-TO (PUBYEAR, 2008) OR LIMIT-TO (PUBYEAR, 2000))

Source: Own elaboration based on.

Table 2. Ecuación de búsqueda de la categoría (ECONOMÍA SOLDARIA OR SOLIDARITY ECONOMICS)

DATABASE	Search Equation
WoS	Tema: (("ECONOMÍA SOLDARIA OR SOLIDARITY ECONOMICS)")) Índices=SCI-EXPANDED, SSCI, A&HCI, ESCI Período de tempo=Todos os anos
	Tema: (("ECONOMÍA SOLDARIA OR SOLIDARITY ECONOMICS)")) Refinado por: Años de publicación: (2016 OR 2017 OR 2010 OR 2013 OR 2015 OR 2012 OR 2009 OR 2011 OR 2014 OR 2008 OR 2020 OR 2021 02 2022 OR 2019 OR 2018 OR 2006 OR 2005 OR 2004 0R 2003 OR 2002 02 2001 0R 2000) Índices=SCI-EXPANDED, SSCI, A&HCI, ESCI Período de tempo=Todos os anos
	Tema: ("ECONOMÍA SOLDARIA OR SOLIDARITY ECONOMICS)") Índices=SCI-EXPANDED, ESCI, A&HCI, SSCI Período de tempo=Todos os anos
Scopus	TITLE-ABS-KEY ("ECONOMÍA SOLDARIA OR SOLIDARITY ECONOMICS ECONOMICS)")
	TITLE-ABS-KEY (("ECONOMÍA SOLDARIA OR SOLIDARITY ECONOMICS)"))
	TITLE-ABS-KEY (("ECONOMÍA SOLDARIA OR SOLIDARITY ECONOMICS)")) AND (LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) OR LIMIT-TO (PUBYEAR, 2008) OR LIMIT-TO (PUBYEAR, 2000))

Source: Own elaboration based on (Rodríguez, 2025a; Gómez y Barbosa, 2024; Gómez, 2023; Maldonado, 2014ª).

Tabla 3. Relationship between analytical and emerging categories

General objective	Analytical categories	Emerging categories
Analyze the adaptive foundations of human cooperation, from its roots in biological evolution to its expression in forms of solidarity social organization, to understand the mechanisms that favor collaboration in the human species.	Evolutionary Biology, Solidarity Economics	Cooperation as an evolutionary and economic strategy. Reciprocal altruism and solidarity networks. Group selection and success of solidarity structures. Selección de grupo y éxito de estructuras solidarias

Source: Own elaboration based on (Rushforth, 2016 ;Maldonado, 2014b; Bunge, 1969).

3.1 COOPERATION AS AN EVOLUTIONARY AND ECONOMIC STRATEGY

From the perspective of evolutionary biology, cooperation is a widely documented phenomenon shaped by selective forces over millions of years. This mechanism explains the existence of highly cooperative societies, such as eusocial insects (bees, ants), where most individuals forgo reproduction to benefit the colony (Maldonado, 2022; Andrade, 2019). However, cooperation also extends beyond genetic ties through indirect reciprocity, where reputation and repeated interactions promote collaboration among unrelated individuals (Martínez et al., 2024; Nowak, 2006).

In the socioeconomic realm, these principles find a parallel in solidarity economics, which is structured around collaborative networks rather than individualistic competition. Coraggio (2011) argues that models such as worker cooperatives or fair trade systems replicate evolutionary dynamics by prioritizing collective benefit over private profit maximization. Empirical research shows that these organizations exhibit greater resilience to economic crises, as the equitable distribution of resources and participatory decision-making reduce vulnerabilities. This suggests that, as in nature, cooperation in economic systems is not merely an ethical ideal but a functional strategy for group survival (Garzón et al., 2023; 2022).

The synergy between these two fields allows for understanding cooperation as a transdisciplinary phenomenon, where mechanisms such as role specialization and reciprocity strengthen both biological groups and human communities (Gómez, 2024c). Studies in evolutionary economics (Gowdy & Krall, 2013) indicate that societies with high levels of mutual trust and cooperation tend to develop more stable and adaptive institutions. Thus, solidarity economics not only benefits from these principles but also reinforces them, creating virtuous cycles of collaboration that enhance long-term sustainability (Gómez et al., 2023; Martínez, 2023).

3.2 RECIPROCAL ALTRUISM AND SOLIDARITY NETWORKS

The concept of reciprocal altruism, proposed by Trivers (1971), explains how cooperation can arise among unrelated individuals when there is the possibility of future exchanges. This phenomenon has been observed in various species, such as vampire bats (Desmodus rotundus), which share blood with previously helpful companions, ensuring reciprocity in times of need (Martínez, 2017). The effectiveness of this mechanism critically depends on the ability to recognize and remember individuals who fulfill their commitments and to sanction those who engage in opportunistic behaviors (Axelrod & Hamilton, 1981). These findings underscore that cooperation does not necessarily require kinship but rather feedback systems that reward collaboration and punish defection (Bourke, 2011).

In the context of solidarity economics, reciprocal altruism manifests in practices such as time banks or social currencies, where the exchange of goods and services is based on mutual trust rather than traditional money (Saravia, 2020). These structures replicate biological reciprocity mechanisms, as participants rely on their reputation to access collective benefits. Ostrom (2009) demonstrated that communal resource management systems—such as forests or fisheries—are more efficient when clear norms of cooperation and sanctions for violators exist. This reinforces the idea that, both in nature and in economics, cooperation requires institutional frameworks to ensure its sustainability (Rodríguez et al., 2016; Passet, 1996).

Similarly, digitalization has enabled the scaling of these principles through collaborative platforms (e.g., platform cooperatives or P2P credit systems), where reputation is managed via algorithms that assess participant reliability. These developments show that reciprocal altruism is not a relic of the past but a mechanism adaptable to modern environments. Solidarity economics, by integrating these dynamics, not only promotes equity but also generates economic systems more resistant to traditional market failures (Rodríguez et al., 2018; Rendón & Gómez, 2020).

3.3 GROUP SELECTION AND THE SUCCESS OF SOLIDARITY STRUCTURES

The multilevel selection theory (Wilson & Sober, 1994) posits that evolution acts not only at the individual level but also at the group level, favoring collectives with greater internal cohesion. This framework explains why species such as ants or humans have developed advanced forms of cooperation that benefit the group as a whole. In ancestral human societies, groups with strong norms of reciprocity and redistribution (e.g., hunter-gatherers) had adaptive advantages over less organized groups. These findings suggest that cooperation is not an exception but a key factor in the evolutionary success of our species (Rodríguez, 2025; Rauchecker & Chan, 2016).

Solidarity economy organizations embody this principle by prioritizing collective well-being over individual profit. For example, worker cooperatives have demonstrated greater capacity to withstand economic crises compared to conventional businesses, thanks to their organizational

flexibility and equitable distribution of losses and gains (Barbosa et al., 2021; Laverde et al., 2020). Similarly, fair trade networks have managed to maintain stable prices for producers in contexts of market volatility, showing that cooperation can be a more efficient strategy than deregulated competition (Rodríguez & Ramírez, 2016). These cases support the hypothesis that, in unstable environments, cooperative groups have higher survival probabilities (Purvis et al., 2019; Maldonado, 2017).

In a world marked by climate crises, growing inequality, and financial collapses, solidarity economics emerges as an evolutionarily robust alternative (Martínez, 2023). Solidarity structures, by combining ancestral knowledge with institutional innovations, offer a viable model for transitioning toward more just and resilient economies. Thus, group selection is not merely a biological theory but a framework for understanding—and improving—the design of economic institutions (Osorio, 2023; Laville, 2016).

4. DISCUSSION

From the perspective of evolutionary biology, cooperation emerges as an adaptive strategy that enhances inclusive fitness, benefiting both individual and group survival (Nowak, 2006). This behavior is observed in social species, from eusocial insects to mammals, where cooperative actions strengthen collective viability (Bourke, 2011). Analogously, solidarity economics is based on networks that prioritize common benefit over individual maximization, replicating evolutionary mechanisms in contexts of scarcity or systemic crises (Laville & Cattani, 2009).

Reciprocal altruism (Trivers, 1971) explains how unrelated individuals cooperate expecting future benefits, generating trust networks essential for group stability. In solidarity economics, this logic manifests in practices such as time banks, credit cooperatives, and local barter systems, where reciprocity and reputation are structural pillars (Laville & Gaiger, 2013). Similarly, group selection suggests that collectives with higher cooperation outperform those dominated by conflicts. Solidarity organizations, based on equity and participation, exhibit greater resilience to external crises, demonstrating an evolutionary advantage beyond ethical-normative considerations (Cueto et al., 2018; Craviotti & Soleno, 2016).

Specialization and division of labor in cooperative systems increase collective efficiency (Rodríguez et al., 2021; Dávila et al., 2018). Solidarity economics reproduces this principle through differentiated networks (producers, financial cooperatives, etc.), strengthening adaptability in the face of neoliberal capitalism. Thus, cooperation emerges as a key evolutionary mechanism for designing sustainable and equitable economic systems, reaffirming its relevance in contexts of global crisis (Gómez, 2024b; Díaz, 2020).

5. CONCLUSIONS

The integration of evolutionary biology and solidarity economics provides a robust theoretical framework for understanding human cooperation as both a biological and socioeconomic phenomenon. The

analysis demonstrates that cooperation, reciprocal altruism, and group selection—principles deeply rooted in evolutionary processes—are equally fundamental to the resilience and sustainability of solidarity-based economic organizations. These structures replicate adaptive strategies observed in nature, such as mutual aid, reputation-based reciprocity, and collective decision-making, proving more effective in crisis scenarios than traditional competitive models.

From a transdisciplinary perspective, this study highlights that solidarity is not merely an ethical ideal but an evolutionarily advantageous strategy, fostering long-term social and ecological viability. Future research should explore empirical applications of these principles in diverse socioeconomic contexts, reinforcing the role of cooperation as a cornerstone for equitable and resilient systems in an era of global instability.

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