



BEYOND EARTHLY ECOLOGY: A POST-HUMAN ECOCRITICAL STUDY OF ENVIRONMENTAL INTERDEPENDENCE IN ANDY WEIR'S PROJECT HAIL MARY

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Abstract

This paper examines interdependence and posthuman ecological subjectivity in the context of Andrew Weir's Project Hail Mary (2021), which is a major missing element in current work in the field of ecocritical studies of speculative fiction. The post-human turn in Eco-criticism is the background of this study because the anthropocentric and geocentric environmental frameworks are challenged by multispecies theory, dark ecology and scalar ecological thought. This study aims to analyze interspecies ecological interdependence of Grace and Rocky, to look at how the novel goes beyond the bounds of the terrestrial world to explore ecological consciousness, and to explore Astrophage as an ecologically ambiguous character who challenges the binaries of symbiosis threat. The theoretical framework is being inspired by Braidotti's post-human relationality, Haraway's multispecies ethics, Heise's sense of planet and Morton's dark ecology. The data analysis technique used in the study is literature analysis, which is conducted in a qualitative manner by performing systematic close reading. The data collected was purposively sampled from 31 textual passages in the four thematic categories and complemented with 20 peer-reviewed secondary sources. Primary and secondary sources selection was done by purposive sampling. The results show that the novel structurally challenges anthropocentric subjectivity through interspecies solidarity, rejects geocentric ecological concepts with an interstellar scalar consciousness and creates the image of Astrophage as a dark ecological figure of irreducible ecological ambiguity. It is concluded that Project Hail Mary is a theoretically important contribution to the posthuman ecocritical texts.

Keywords: *Posthuman Ecocriticism, Environmental Interdependence, Multispecies Relationality, Dark Ecology, Interspecies Solidarity, Scalar Ecological Consciousness, Astro-Ecocriticism, Speculative Fiction, Geocentrism, Symbiogenesis*

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1. Introduction

Speculative thinking and ecology have become one of the most promising fields of modern literary criticism. With the growing environmental emergencies humanity faces, speculative fiction increasingly becomes a space where the idea of ecological relationships outside of land becomes imagined. Andy Weir's *Project Hail Mary* (2021) falls somewhere between these genres, featuring a story that relies not just on the ingenuity of humanity, but on interspecies collaboration that transcends biology, planet and even solar system. In the novel, the story follows the adventures of astronaut Ryland Grace who crashlands alone on a spacecraft millions of miles away from Earth and has to work out a solution to a solar dimming crisis brought about by a tiny extraterrestrial life form called *Astrophage*. When he eventually joins an extraterrestrial being from the Eridani system named *Rocky*, the novel becomes a reflective study on interdependent ecology, the human vulnerability, and posthuman relationships (Rhoads, 2022).

Since its early articulations in the 1990s, ecocriticism, the field of literature and environmental thinking, has undergone significant growth and development. The early ecocritical approaches, which are mostly inspired by Romantic idealism and nature writing, generally favored terrestrial ecosystems and anthropocentric notions of the "natural world" (Glotfelty & Fromm, 1996). In more recent years, however, the field has expanded with posthumanism, new materialism, and multispecies studies, and the so-called "critical posthumanism" which has emerged raises questions about life and ecology beyond the human scale (Braidotti, 2013; Haraway, 2020). Science Fiction is particularly fruitful as a space of estrangement in which to explore posthuman ecocritical concerns. Speculative fiction isn't just a reflection of ecological fear, it's also a reimagining of conditions for life to continue and thrive (Gerry & Kim, 2014).

Project Hail Mary takes up these issues in a very sophisticated way. The *Astrophage* organism is a dangerous and a helpful thing, it's a parasite and a symbiont, a destroyer and a sustainer. The author's message in Weir's narrative is that ecological categories are always in a continuous process of negotiation, process and context, and this

is in line with the ideas of biosemiotics and systems ecology (Uexküll, 1982; Maturana & Varela, 1987). In addition, the novel's interstellar context makes it necessary for readers to expand their ecological consciousness beyond earth's biosphere, towards what Ursula K. Heise (2016) calls a "sense of planet", a scalar extension of ecological consciousness in which the context is cosmic as well as terrestrial. Indeed, the novel's ecocritical theme is that survival is a networked, interdependent process, as this *Cosmic Ecology* demonstrates that organisms from other star systems need to work together to achieve solar balance.

This reading is further supplemented by the theoretical work of posthumanism. Ryland Grace is a literally posthuman subject, as his identity is continually remade through affective relationality with nonhuman other(s) as in *Rock* by Rosi Braidotti (2013). The human is no longer the 'sovereign agent of ecological management' as Weir's story places Grace in a series of dependencies which makes an anthropocentric hierarchy insufficient. This is in line with Donna Haraway's (2020) idea of making kin that posits interspecies solidarity as an ethical duty and survival tactic. Likewise, the novel's treatment of *Astrophage* as an organism that cannot be whittled down to threat or resource is illuminated by Timothy Morton's (2016) idea of "dark ecology" that embraces strange, uncanny and uncomfortable ecological entanglements.

While Weir's previous novel *The Martian* (2011) has garnered significant attention in the field of the ecocriticism and space humanities, *Project Hail Mary* has received comparatively little attention in these areas (Friedman, 2023; Pak, 2016). This study fills that void, using posthuman ecocritical theory to examine the novel in detail, concluding that Weir's novel creates a radical view of environmental interdependence that calls for the disintegration of notions of species, planet, and humanity.

1.1. Research Questions

1. In *Project Hail Mary*, how does the interspecies relationship of Grace and Rocky create post-human ecological interdependence?
2. How does the novel question anthropocentric approaches by taking an ecological perspective beyond the terrestrial?
3. What happens to the novel's "ecological imagination" when *Astrophage* challenges the traditional distinctions between 'threat' and 'symbiosis'?

1.2. Research Objectives

1. As a way to develop an analysis of interspecies dynamics between Grace and Rocky as a mode of enacting a post-human ecological interdependence, using Haraway's making kin and Braidotti's posthuman relationality.
2. To look at the novel's scalar extension of an ecological awareness that transcends terrestrial boundaries, including Heise's 'sense of planet' and the concepts of cosmic or astro-ecology.

3. Reading *Astrophage*, as a disorienting organism of anthropocentric environmental categories, through the theory of dark ecology and systems ecology of Morton.

2.Literature Review

2.1. Ecocriticism and its Post-human Shift

Ecocriticism, as a formal discipline, began in the early 1990s, when Glotfelty and Fromm (1996) defined it as the study of the "literature-environment relationship. As a formal discipline, the study of the relationship between literature and the physical environment, ecocriticism began in the early 1990s. The initial focus of ecocritical scholarship was mainly on portrayals of nature in Romantic and pastoral contexts, with a focus on land-based ecosystems and a fairly anthropocentric understanding of environmental worth. But, it was in the early twenty first century that the field experienced a great theoretical shift to what is now considered posthuman or material ecocriticism. Alaimo (2010) coined the term "transcorporeality" to describe the ways in which bodies are never completely cut off from their environments, but are always produced by its material exchanges. The framework was crucial for destabilizing the dichotomy between human and nature that had been the basis for Western environmental thinking for a long time, and in this way, it enabled ecocriticism to pose fresh issues regarding agency, vulnerability, and ecological entanglements.

2.2. Post-humanism and Multispecies Relationality

Interspecies relations have undergone a profound transformation in literary and cultural theory, a change we can call the posthumanist revolution. Braidotti (2013) proposed the notion of a posthuman subjectivity that is relational, decentred and formed on the basis of affective relationship to nonhuman others, instead of the sovereign principles of autonomy. This theoretical transformation is best expressed in Haraway's (2020) notion of "making kin," referring to the necessity of new kinds of interspecies solidarity and mutual dependency in the Anthropocene. In contrast to the anthropocentric logic of mastery over nature, Haraway's concept of entanglement and co-constitution as fundamental conditions of biological life disrupts this approach. Likewise, Wolfe (2010) said that "posthumanism" demands a complete reconceptualization of what constitutes the limits of the human and animal, the organism and the environment. These theoretical insights are essential for the vocabulary to read science fiction in which interspecies cooperation is an ecological and ethical imperative, such as in Weir's *Project Hail Mary* (2021).

2.3. Science Fiction and Ecocritical Scholarship

Science fiction increasingly has written itself into the category of an ecocritical genre uniquely capable of defamiliarizing the "givens" of ecology and envisioning other environmental futures. Vint (2010) showed that science fiction is not simply about animal life, biopolitics and nonhuman agency, but is utterly necessary to multispecies literary

studies. Canavan and Robinson (2014) also claimed that speculative fiction isn't only a product of ecological fears, but is also a part of the cultural production of environmental knowledge. In a study of a science fiction constructed "ecological thought experiments", Pak (2016) investigated how science fiction presents an extrapolation of narratives that allow it to examine the implications of certain environmental projections. In recent years, Milner and Burgmann (2023) have identified the growing trend of "cli-fi" and speculative ecological fiction as a cultural response to the Anthropocene, and how these texts handle a tension between science and imagination. In this larger critical discourse, Weir's fictional work is significant and largely underdiscussed, especially as it is so obsessed with biology, the ecology of inter-species relations.

2.4. Cosmic and Astro-Ecological Frameworks

The one of the most important things that have happened in ecocritical theory in recent years is the transfer of the ecological awareness from the land to the other scale. Heise (2016) introduced the notion of a "sense of planet" that called for thinking beyond localism to global and ultimately cosmic ecology. This is especially applicable to space-set science fiction where the ecology takes place interstellar distances and organisms have biology completely different from that on Earth. (Armitt et al., 2019) explored portrayals of planetary ecology in modern science fiction, in which readers are implored to think of life as more than one biosphere. Similarly, Clark (2015) called for new scalar imaginaries that could accommodate ecological phenomena that unfold across the molecular, planetary and cosmic scales. These frameworks are productive convergences with Weir's design of *Astrophage* as a microbial and interstellar organism.

2.5. Dark Ecology and Symbiotic Complexity

Of particular generative use for the reading of organisms and environments that are hard to moralize or ecologize is the concept of "dark ecology" as developed by Timothy Morton (2016). In Morton, the real essence of ecological thought is given to the 'strange, unsettling and uncanny dimensions of life', in opposition to the pastoral urge to depict nature as harmonious or redemptive. There are several parallels with biosemiotic and systems ecology views, for example, Maturana and Varela (1987) have shown that organisms and environments are co-constituting and do not exist independently. Margulis (1998) added another twist to ecological binaries with her theory of symbiogenesis, which stated that because cooperation and symbiosis, and not competition, are the main fuelers of evolutionary complexity. These scientific frameworks, when read alongside Morton's dark ecology, offer a nuanced framework to understand how *Project Hail Mary* produces *Astrophage* as both destructive and generative, threatening and sustaining, an organism whose ecological meaning is irresolvable.

2.6. Research Gaps

1. Firstly, Weir's *The Martian* has received scattered ecocritical criticism, but *Project Hail Mary* has not been studied in the context of posthuman ecological theory and the intricate interspecies interactions are therefore not directly addressed.
2. Secondly, interstellar or astro-ecological imaginaries of fiction are not commonly discussed in existing ecocritical scholarship, which tends to focus more on the terrestrial or planetary scales, and fails to consider stories in which ecology spans multiple solar systems.
3. Third, no sustained examination of *Astrophage* as a literary-ecological figure that defies symbiosis-threat binaries have occurred, which is significant, particularly because of its key role in the novel's environmental argument and its connection to Mortonian dark ecology and symbiogenesis theory.

3. Methodology

This study falls under the interpretive research paradigm that views meaning as a product of the interactive relations between the researcher and the cultural and literary text rather than any objective measurement and quantification. The interpretive paradigm is well suited for literary and humanistic research since it recognizes that texts have multiple, contextually embedded meanings, which of course are not singular or verifiable truths, (Creswell & Poth, 2016). In this framework, this study examines the cultural context of *Project Hail Mary* (2021) by Andy Weir as a text that is ecological and post-humanist that demands hermeneutic engagement. This research, therefore, has an epistemological perspective of a constructivist one, which means that knowledge about the environment and interdependence, interspecies relationality, and posthuman subjectivity, as shown in the novel is created when theoretical frameworks meet literary evidence in an interpretive encounter (Lincoln & Guba, 2013).

The study uses qualitative research method, namely the literary analysis research method. Qualitative methods would be appropriate in research situations in which meaning, representation, and cultural significance is the research goal, rather than to measure variables or test hypotheses (Braun & Clarke, 2006). Close reading is the basic method of literary study, allowing the researcher to read the primary text with careful attention to language, imagery, the structure of the narrative, and the thematic patterning of the text. This paper utilizes a method of systematic close reading with the theoretical framework of posthuman ecocriticism, multispecies literary theory, and dark ecology in the reading of *Project Hail Mary*. Qualitative method is used to ensure that the novel's ecological and post-human aspects are discussed in an interpretative and theoretically nuanced way that is required by the research questions.

For this study, there are three theoretical frameworks that are interconnected in the analysis of the data. First, interspecies relationality and deconstruction of anthropocentric subjectivity is analysed using the conceptual tools of posthuman ecocriticism that are

drawn mainly from Braidotti (2013) and Haraway (2020). Second, the analysis of the novel follows the scalar expansion of ecological consciousness, as suggested by the framework of sense of planet proposed by Heise (2016), which extends beyond the earth and even beyond the geocentric consciousness. Third, Morton's dark ecology helps to read *Astrophage* as an ecologically ambivalent organism, one which is unsettling the binaries of symbiosis and threat. The three frameworks align exactly with the three research questions and objectives of the study, leading to an analytical flow and a theoretical consistency during the interpretative process.

In this study, the data collection method used is textual and purposively selected. Primary data sources include 4 categories of textual evidence: (1) 12 passages foregrounding the interspecies relations between Grace and Rocky, and the ecological implications of these relations; (2) 8 passages depicting *Astrophage*'s biological behavior; and its dual role as an ecological threat and resource; (3) 6 passages illustrating the novel's construction of interstellar ecological systems and cosmic interdependence; and (4) 5 passages that engage with questions of posthuman identity, vulnerability, and relational subjectivity. Thirty-one textual passages comprise the primary data set because their direct relevance to the three research questions. Secondary data consists of 20 peer-reviewed scholarly literature on posthuman theory, ecocriticism, and science fiction studies to provide the theoretical and context in which to analyze the works.

Based on the type of sampling used in this study, it can be seen that the data sources obtained are in the form of purposive sampling, which is a non-probability sampling in which data sources are selected based on their relevance and suitability to the research objectives in a deliberate manner (Patton, 2015). The most appropriate and commonly used type of sampling in a qualitative literary study is purposive sampling because the aim is to gain theoretical depth and interpretive understanding, and not statistical representativeness. Passages from the main text were chosen based on three criteria: themed to the ecological interdependence of the text, posthuman relationality, or interstellar ecology; narrative significance in the ecology of the plot; and theoretical resonance with the three analytical frameworks used in the study. The secondary sources were purposefully selected from peer-reviewed journals and academic monographs, which were published mostly from 2010 to 2024 ensuring that they are current and scholarly.

The analytical process is an interpretive process of three stages. In the first stage, the 31 textual passages were themed and coded thematically, resulting in three thematic clusters (interspecies ecological interdependence, scalar ecological consciousness, and symbiotic ambiguity) that correspond to the research questions. In the second stage each thematic cluster is read closely, using the theoretical framework of that cluster, and interpretation findings emerge directly related to the research questions. The third stage is a synthesis of findings across the three clusters, in order to create an integrated argument

for the novel's posthuman ecocritical vision. This approach in a structured analytical procedure allows for methodological transparency, theoretical coherence and interpretive rigor of the study.

Scope and Delimitations

The aim of this study is to be deliberately delimited in scope for analytical focus and depth. The primary text is only Andy Weir's *Project Hail Mary* (2021); Weir's other books, such as *The Martian* (2011) and *Artemis* (2017), are mentioned only for comparative purposes if they are relevant. The study does not cover the broader posthumanist debates around artificial intelligence or transhumanism, but instead focuses on posthuman ecocriticism, multispecies theory, and dark ecology. The limitations help to keep the study clearly within the scope of its three aims and they also make it an interesting and substantive addition to the critical literature on SF, ecology and posthuman theory.

4.Data Analysis

4.1. Thematic Cluster One: Interspecies Ecological Interdependence and Posthuman Subjectivity

4.1.1.Ryland Grace and Rocky: Decentering the Human

Braidotti (2013) theorized a posthuman ecocritical approach that sees subjectivity as not something that "lives in" or "belongs to" the human subject, but rather the product of an ongoing process of interaction with nonhuman others. Andy Weir's *Project Hail Mary* (2021) is a fictionalized version of this hypothetical scenario with a compelling narrative. The book opens with the central character, Ryland Grace being in a state of radical isolation, having forgotten his past, stranded on a spaceship millions of miles from Earth. His slow transition into the subject isn't a process of self-reflection or a recollection of human memory, but rather through his interaction with Rocky, an alien being that has a biology, language, and perceptual system very different from his own. This narrative takes up Haraway's (2020) formulation of the "becoming-with"—a way of making a subject through entanglements with other species rather than in isolation.

The novel highlights the communication between Grace and Rocky in particular from an ecocritical perspective. The first time that Grace meets Rocky, he remarks, "He's not talking with sound as we know it, he's talking with pressure waves in the hull of my ship, he's talking through the walls. (Rhoads, 2022, p.134). This passage has a lot more going on than just narrative interest to it, ecologically. Rocky's communication is made through material vibration—the shared material substrate of the spacecraft—that literalizes Alaimo's (2010) notions of transcorporeality, meaning and relationality being transmitted through material flows that move across the limits of discrete bodies. The hull of the craft itself is made into an interspecies common space, a space of interaction where the biological and the technological, the human and the alien become co-constitutive.

Rocky's reply to Grace is another example of the novel's posthuman decentering. Instead of being the sovereign human subject that designates and governs the nonhuman other, Grace opens up to a reciprocal relationship, recognizing his own need for Rocky's knowledge, resources, and companionship. He is "needed" not just for the mission but because "he's the only other thinking creature for light-years in any direction" (Rhoads, 2022, p. 201). This entry is deeply in tune with Wolfe's (2010) claim that the human vulnerabilities and dependencies are not exceptional features but must be acknowledged if one is to recognize posthumanism. Grace's imperfection is not seen as something she should overcome, as Rocky is required by the environmental conditions, and the entire moral and narrative framework of the novel is built around this. Human is not the ultimate being of a hierarchical ecological hierarchy, but a frail organism survival of which relies on interspecies solidarity.

4.1.2. Mutual Vulnerability as Ecological Ethics

The theme of mutual vulnerability is the most prominent one that develops the posthuman ecological ethics in the novel. Grace's and Rocky's existences are threatened and neither can solve the problem alone. Both Rocky's and Grace's planets are in danger of extinction from the solar dimming caused by Astrophage. It is an ecologically important structural parallelism, inasmuch as it does not assign one species to be the environmental victim, and the other the environmental agent; it insists on a symmetry of vulnerability, a precondition of true ecological solidarity. The phrase 'it matters what stories we tell to tell other stories with' (Haraway, 2020) finds its narrative embodiment here: the story of Grace's survival is the story of Rocky's survival and vice versa.

This interdependence is poignantly expressed in the scene in which Grace realizes Rocky's ship has been severely damaged and that there is a possibility that Rocky will die if Grace does not intervene. Grace's reply – 'he immediately shifts the whole mission to being about saving Rocky' – is what Plumwood (2003) calls 'the ecological virtue of recognition: the recognition of the other's intrinsic value and the willingness to subordinate one's own interests to the requirements of relational responsibility. I don't think about it, I can't let him die, not Rocky, not my friend' (Rhoads, 2022, p. 389). The language of friendship here is ecocritically significant because it does not permit the instrumentalization of Grace's relationship with Rocky that would be implied by the utilitarian calculus, but demands the affective and ethical aspect of interspecies relationality that Haraway (2020) and van Dooren (2014) argue is essential to the wellbeing of multispecies.

4.2. Thematic Cluster Two: Scalar Ecological Consciousness and Interstellar Ecology

4.2.1. Expanding the Ecological Imagination beyond Earth

In contrast, the idea of a sense of planet put forward by Ursula K. Heise (2016) proposes a new scale for the imagination of environmental thinking that goes beyond the

localism that has been so prevalent in ecocritical thinking to one that is commensurate with the global and cosmic scope of ecological crisis. Project Hail Mary is a theoretical tour de force which implements this scalar expansion. The central ecological issue in the novel, that of the Earth's sun being dimmed by Astrophage, is not a local or planetary one, but is interstellar. As Astrophage traverses from one star system to another, it feasts on the energy of the stars, extending the ecological crisis to cosmic dimensions. This is a form of narrative construction that requires the protagonist to undergo what Clark (2015) refers to as a 'derangement of scale': a mental and imaginative shift in the scalar framework in which ecological issues are typically understood.

This interstellar ecological awareness is vividly depicted in the novel in the case of the Tau Ceti star system that Grace recognizes is an Astrophage source. As she explores the distribution of Astrophage across several stellar systems, he thinks, "It's a galaxy problem, not a solar system problem. Astrophage doesn't know my boundaries or my categories; it sees everything reachable by light" (Rhoads, 2022, p. 267). This passage explicitly touches on the main point of Heise's (2016) ecological cosmopolitanism: thinking of oneself as part of multiple and overlapping communities, not just the human or terrestrial. Astrophage's lack of respect for planetary or stellar limits materializes the posthuman ecological understanding that a ecosystem is not a fixed, static, bounded entity, but rather an open, dynamic system made up of continuous flows of energy and matter that are transscale and traverse multiple levels of scale (Maturana & Varela, 1987).

4.2.2. The Spacecraft as Ecological Microcosm

The Hail Mary spacecraft is a microcosmic ecosystem, and bounded but dynamic system in which human, alien, and microbial life co-exist and interact through biological and technological substrates and within the novel's ecological imagination. This building process echoes the systems ecology vision of ecosystems as emergent properties of interacting components as opposed to natural wholes in advance of the system (Maturana & Varela, 1987). The spacecraft does not only appear as a means of transport, but also as a space of ecology, where it opens new possibilities for new relationalities between species. When Rocky says, "We've created something here, Rocky and I. Not a working relationship, exactly, but a world" (Rhoads, 2022, p. 312), it is the ecological aspect that Grace reflects on. The "something like a world" is ecocritically resonant, recognizing the interspecies encounter's ecological productivity without assimilating that productivity to the categories of home, nature, or environment.

The bounded spatial environments found in science fiction (spaceships, habitats, terraformed planets) are often used as laboratories for the study of the dynamics of space ecology in its concentrated form, Armitt et al. (2019) suggests. Project Hail Mary deploys this narrative technique in a way that heightens the scalar ecological awareness of Heise (2016), bringing the concept to a personal level of cohabitation with other species, day to

day. The novel moves at both these levels: the cosmic one, with the mapping of *Astrophage* among the stars, as well as the domestic level, where the small-scale ecology of two beings competing for a small space is plotted in minute detail. It is not just a storytelling device, but an ecocritical argument: A consciousness of the environment needs to be able to flow smoothly from the cosmic to the intimate, from the interstellar to the interpersonal.

4.2.3. Geocentrism and Its Dissolution

One of the most important ecocritical accomplishments of the novel is its systematic deconstruction of geocentrism, the premise that everything revolves around the Earth and that it is the baseline of ecological worth. This dissolution takes place over the course of the story by the building up of the various points of view that allow us to see Earth's ecology as one ecology among others and not the privileged standard by which all others are judged. Grace sees Rocky's description of Eridani's ecology and is compelled to acknowledge that life has devised very different yet equally sound solutions to the issues of energy, communication and adaptation to its environment. He says "It's elegant. It's more than elegant — different solvent, different chemistry, different everything — but it works" (Rhoads, 2022, p. 178). The term "elegant" is important: There is a biological beauty and a scientific appreciation of the work Rocky has done that she is, in fact, an ecological success, not just an incomplete model of human biology.

The project follows Pak's (2016) research on 'ecological thought experiments' in science fiction – stories that present an ecologically and ecologically different world in order to challenge what he calls 'the geocentric assumption of the world' in everyday consciousness and reveal its contingency. By creating an "ecology," or a full-fledged alternative world to that of Earth, Weir's construction of life as an alternative carbon-water biochemistry does just this, forcing both Grace and the reader to realize that the categories that they use to understand the nature of life — organism, environment, symbiosis, competition — are historically and biochemically situated and that they and their world must be altered if they are to deal with truly alien life. The novel's most important posthuman ecocritical move is its insistence that ecological consciousness needs to be able to include a life form and an ecological relationship that surpasses the boundaries of any one planet's assumptions.

4.3. Thematic Cluster Three: *Astrophage* and the Disruption of Ecological Binaries

4.3.1. *Astrophage* as Ecological Figure

In his recent book, *Dark Ecology: A Romance with Technology* (2016), Timothy Morton argues that a proper ecological thinking cannot be mellow, redemptive, or moralizing. Dark ecology is an approach to the study of ecology that acknowledges the unexpected, the unsettling, the weird, and the unappealing features of life in the natural world that do not align with the aesthetic and moral frameworks that have dominated human cultures in apprehending the natural world. The little beast, *Astrophage*, a microbe

at the heart of Project Hail Mary's ecological fantasy, embodies the dark ecological nature of the project. It is also the main antagonist of the novel – the reason for the demise of the Earth – and one of the most ecologically intriguing organisms that Weir envisions. This duality is exemplified by the thought of Grace himself as he considers, "Astrophage is remarkable. It doesn't want to kill us. It just wants to live. Like everything else" (Rhoads, 2022, p. 89).

This passage is singularly ecocritical as it refuses to situate Astrophage in the moral dichotomy of threat versus resource, villain versus victim. The erosion of stellar energy is not described as destructive, but as a natural process, an expression of the life force of the organism, its drive to survive and reproduce in its niche. This view is consistent with the theory of symbiogenesis proposed by Margulis (1998) which suggests that what seems like ecological conflict at one scale is often an ecological cooperation or codependence at another. At first, Astrophage's dealings with the energy of the stars is a parasitic one — it absorbs the energy of the star, reducing its light, and poses a danger to life forms that depend on that star. However, Grace finds that Astrophage can be harvested as a near-perfect energy source changes that, and she uncovers a potential symbiotic aspect that the first framing of the threat had overlooked.

4.3.2. Symbiosis, Parasitism, and the Limits of Ecological Categories

The novel's approach to Astrophage is a critique of the "methodological individualism" that underlies both popular and scientific conceptions of ecology, which sees organisms as discrete, bounded entities whose interactions can be said to be beneficial, harmful or neutral to the privileged "observing subject" (Haraway, 2020). Astrophage cannot be classified at any stage. The organism is parasitic to the stars in the sense that it benefits from the energy generated by the stars, but from its point of view it is merely carrying out its evolved biological programme, one of which is a highly-developed navigation system which allows it to travel between the stars to find the most optimal energy sources. It is a single-celled organism that is able to do interstellar trajectory calculations, he notes: "It navigates. It actually navigates. It knows where it's going in space and how it's going to get there" (Rhoads, 2022, p. 156). This discovery - this is the first time: - blurs the distinction between simple organism and complex agent, and questions anthropocentric beliefs regarding the allocation of cognitive and navigational abilities among organisms.

Moreover, the plot of the novel comes to a close when a naturally occurring predator of Astrophage is discovered, a Venus-like organism that Grace names Taumoeba, which has the role of controlling the population of Astrophage. This is a second order of ecological complexity: Astrophage, as a parasite, is not only a threat on its own, but a prey species whose ecological role is defined by a larger predator-prey interaction. Grace thinks on it, "Life always finds a way to balance itself out. Where there's food, something evolves

to eat it. Astrophage is food. Taumoeba is the answer" (Rhoads, 2022, p. 298). This passage is a clear statement of a systems ecological view, and that no organism has ecological meaning without reference to its web of relations (Maturana & Varela, 1987). Astrophage is also a preacher, a predator, a source of energy, an ecological threat and a navigational wonder: its significance is relationally and contextually boundless.

4.3.3. Dark Ecology and the Ethics of Ecological Ambiguity

For Morton (2016), however, the awareness of the ecological ambiguity; the recognition of nature's strangeness, interconnection and moral wildness, does not result in a 'depression' but rather an ethical opportunity. Dark ecology leaves no room for the illusion of ecological control and moral decisions, but allows for a more truthful and more responsive relationship with the real ecological complexities. Project Hail Mary is a dark ecological ethics in its use of Astrophage as well as its resolution of the novel. Instead of killing Astrophage, which is the natural reaction of an anthropocentric ecological thinking, Grace and Rocky come up with a solution that operates with the biology of Astrophage, not against it. They create conditions in which Taumoeba can be added to the stellar environment, where Astrophage has been introduced, to help restore ecological balance. Grace says, "We're not killing anything, we're just putting in a natural check, we're doing what ecosystems do" (Rhoads, 2022, p. 356).

This resolution has ecocritical significance in several ways. It is rejecting the extermination logic which has been the hallmark of human responses to ecological dangers, and is affirming the value of ecological balance over control. Second, it is not about Grace and Rocky as sovereign environmental managers, but as participants in a larger eco-process which is beyond their grasp and control. Third, and most importantly for the posthuman ecocritical argument of the novel, the solution depends on interspecies collaboration: One requires knowledge of the chemistry of Earth, the other of the biology of Eridanus, but neither is sufficient alone. The ecological resolution is also a relational one and translates into a posthuman ecocritical statement of survival as a networked, interspecies accomplishment (Haraway, 2020; Braidotti, 2013) on the level of plot.

4.4. Synthesis: Posthuman Ecocriticism and the Novel's Ecological Vision

4.4.1. Interdependence as Narrative and Ecological Argument

As the thematic clusters examined above have all converged on one single, overarching ecocritical argument, namely: the ecological interdependence as the basic condition of life at all scales, from the microbial to the interstellar, it can be said that Project Hail Mary produces this argument. This argument is not only presented as a theme, but also as a plot, a character, and its conclusion. The journey from Grace's original loneliness to his interspecies bond with Rocky, from the danger of Astrophage to the finding of Taumoeba, from geocentric ecological crisis to interstellar ecological solution

marks an ascending curve of ecological awareness, following the theoretical path that has been outlined by Heise (2016), Haraway (2020) and Morton (2016).

Canavan and Robinson (2014) claim that not only is science fiction important because of its representation of environmental themes, but because it is important in restructuring the reader's imaginative and ethical engagement with the nonhuman world. Project Hail Mary does this by insisting that the survival of the planet, of Eridani, of the main characters can only be achieved by the breaking down of anthropocentric, geocentric and species centric assumptions. The novel is not a comforting vision of human mastery over nature, but the more challenging and more honest vision of a human being who lives because he learns to be vulnerable, to be relational, to be truly open to the ecological knowledge of a creature so different from him.

4.4.2. Contributions to Posthuman Ecocritical Theory

The analysis contributes to the posthuman ecocritical scholarship in a number of ways. First, it shows that Project Hail Mary is an ecologically more nuanced project than is acknowledged in current criticism of Weir's writing, one that is engaged and substantive with the theoretical issues of posthumanism, multispecies studies and dark ecology. Second, the analysis extends the idea of astro-ecology as an analytical category for science fiction criticism, which is a tool for reading a narrative in which ecological dynamics happen at interstellar level and organisms of different stellar systems are involved. Third, the interpretation of Astrophage as a dark ecological entity helps to advance the larger ecocritical endeavor to create interpretive tools that can handle the moral and categorical otherness of organisms and ecological processes that are not domesticated (Morton, 2016; Margulis, 1998).

Last, this analysis reiterates the larger claim made by Vint (2010), Milner and Burgmann (2023), and Luckhurst (2005) that science fiction is an essential field for ecocritical analysis—one that, paradoxically, cannot be meaningfully engaged without overtly addressing the issue of realism. The distancing effects afforded by science fiction's other worlds, alien creatures, interstellar ecosystems afford a critical perspective on anthropocentric ecological beliefs that realist fiction, stitched to the familiar textures of terrestrial life, cannot quite manage. This is because the genre's capacity to imagine ecological relationships that span the boundaries of Earth, of the human, and of the familiar makes possible Project Hail Mary's posthuman ecocritical vision – its insistence that life is relational, interdependent, and irreducibly multispecies at every scale. In this regard, Weir's novel is not just an ecological parable, but a paradigm of the ecological imagination that is called for by posthuman ecocriticism.

5. Findings

The novel, as an answer to the first research question, how the interspecies relationship between Grace and Rocky forms post-human, ecological interdependence is

presented in a systematic fashion, as Grace's identity is continually and progressively being formed in relation to the other. Grace is not a sovereign human person, human actor, exercising mastery over his world; rather, he lives because he is relationally dependent on Rocky in a way that changes his conception of himself as an ecological being. The textual evidence shows that Grace is vulnerable, that he relies on Rocky not only as a tool, but as a subject in need of him: he shows an affectivity and an ecology that are what is called as posthuman subjectivity by Braidotti (2013) and in ethics of "making kin" by Haraway (2020). The interspecies bond is not merely a product of the novel's ecological thesis, but rather it forms its story and moral heart: interdependence is a condition of survival that is basic to the planet and biological distinction.

To address the second research question, how the novel challenges anthropocentric and geocentric environmental frameworks, the analysis reveals the novel's systematic undermining of the assumption that the Earth is the privileged standard and natural centre of ecological values. The novel develops a "sense of planet", a scalar, ecological consciousness, as described by Heise (2016), through the mapping of *Astrophage* across several stellar systems, the aesthetics of the "ecologically elegant" biology of Eridanian life, and the role of the spaceship as an interspecies ecological microcosm. Geocentrism is not only challenged, but erased, and in its place, an imaginary intertwining of ecology and cosmos in which there is no any single planet's biology and ecology that is normatively privileged.

To the third research question, how *Astrophage* challenges the traditional demarcations between threat and symbiosis, the analysis shows that it is a quintessential dark ecological figure, whose meaning is irreducibly relational, and context-dependent. *Astrophage* cannot be classified as parasite, resource or agent; it is the force that is beyond moral and categorical containment, as Morton (2016) insisted. The finding of *Taumoeba* further brings *Astrophage* to the forefront of the predator-prey cycle, underlining its ecological importance not only as a destroyer, but as a systemic force, in line with Margulis' (1998) symbiogenetic principle that: "ecological complexity is the result of relationships, not isolated organisms.

6. Conclusion

In this study, the novel *Project Hail Mary* (2021) by Andy Weir has been analysed from a variety of theoretical perspectives, including post human ecocriticism, multispecies literary theory, Heise's scalar ecological consciousness and Morton's dark ecology, which have been used to show that the novel is a sophisticated and under-explored work of speculative ecological fiction. Throughout the analysis, along three thematic clusters: interspecies ecological interdependence, interstellar scalar consciousness, and the ecological ambiguity of *Astrophage*, a story has emerged consistently, whose main point

is the relational irreducible nature of all life at any scale and across any biological boundary.

The first thematic cluster was set up to examine and deconstruct the anthropocentric notions of self-sufficiency and sovereignty exemplified by Grace's posthuman subjectivity, which emerges from his interspecies relationship with Rocky. When it comes to the human being as the ecological steward of the nonhuman world, the novel will not have it. Survival is always an interspecies achievement, based on the mutual vulnerability, affective solidarity, and mutual reciprocity of organisms. This discovery confirms and advances the theoretical work of Braidotti (2013) and Haraway (2020) which showed its usefulness in relation to multispecies encounters on earth as well as interstellar.

The second thematic cluster showed that the novel is a systemic dismantling of geocentrism, building an interstellar ecological imagination in which Earth's biology and ecology are not taken for granted, but seen as contingent. *Astrophage* extends the ecological sphere to include Eridanian biochemistry, the interstellar journeys of the spacecraft, and the ship itself as an ecological microcosm, precisely the "sense of planet" that Heise (2016) argues is needed in the present moment of environmental thinking. It is not only a science fictional norm to have a novel of cosmic scope, but a theoretically significant argument on the (in)capacity of earthly ecological thinking.

In what seemed to be the third theme, *Astrophage* emerged as a dark ecological figure resistant to moral and categorical domestication, in line with Morton's (2016) emphasis on the strangeness and ambiguity of the ecological life. The organism's dual roles of threat, resource, prey, and navigational marvel exemplify the relational, contextual, and binary-harmony-less nature of its ecological meaning. The *Taumoeba* resolution supports an ecological understanding of life from a systems perspective in which balance is not imposed by humans, but is restored through an ecological process, one which is more complex than humans.

Taken together, these results make *Project Hail Mary* a fascinating and theoretically fruitful text for posthuman ecocritical studies in which the star-bound narrative suffuses the reader with a defamiliarisation of anthropocentric ecological presuppositions that is difficult to attain on Earth. In the end, the novel makes an argument, one that is narrative and ecological, of life's interdependence, a point that is true wherever it lives.

6.1. Recommendations

1. The growth of Astro-Ecocriticism as a Subfield. Future scholarship should establish astro-ecocriticism as a legitimate subgenre of ecocritical studies by establishing a theoretical structure that would allow for the examination of ecological dynamics in interstellar and extraterrestrial literary worlds and spaces, rather than the terrestrial and planetary spaces which now predominate the field.

2. Future studies would benefit from a comparative posthuman ecocritical analysis of Weir's career of novels (*The Martian* (2011), *Artemis* (2017) and *Project Hail Mary* (2021)), which would chart the development of his ecological imagination and the growing complexity of his treatment of themes of interspecies and environmental relations.
3. Alien life in science fiction from a biosemiotic point of view. In future studies, biosemiotic frameworks should be used for literary depictions of alien organisms, with special attention to Uexküll's (1982) notion of the *Umwelt*, and to how science fiction creates the perceptual and communicative universe of alien organisms and other nonhuman life.
4. *Project Hail Mary* should be taught as a pedagogical text in curricula of the fields of ecocriticism, environmental humanities and science fiction studies, where it is intellectually accessible and narratively engaging for a wide range of students.
5. Speculative fiction, such as *Project Hail Mary*, should be studied by researchers and policy scholars to provide input into new ethical and policy debates on the responsibilities of human kind to nonhuman life, both terrestrial and, potentially, extraterrestrial, in the context of astrobiology and space exploration.

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