Causality and interdisciplinarity in the philosophy of science in practice : The cases of ecology and environmental conservation

The Routledge Handbook of Causality and Causal Methods

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CAUSALITY AND INTERDISCIPLINARITY IN THE PHILOSOPHY OF SCIENCE IN PRACTICE

The Cases of Ecology and Environmental Conservation

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Key messages:

- *Conceptual tools of analytic philosophy of science* are not enough to understand what causality and mechanisms entail in distinct empirical contexts such as the ones dealing with complex environmental phenomena or indigenous and traditional knowledge of nature.
- *Practices* matter in furthering philosophical discussions.
- *Philosophy of science in practice* shows that how we study mechanisms and causality makes a difference in how we understand mechanisms and causality.
- Causal reasoning and mechanistic explanations are not exclusive of academic knowledge or philosophical debates. What counts as a mechanism or causal reasoning is determined by *distinct epistemic practices*.
- *Interdisciplinary* work of philosophy of science in practice when focused on distinct epistemic practices for producing and validating knowledge can help shed light on the plurality of ways in which causality and mechanisms are perceived in different epistemic communities, and therefore important in multiple contexts and approaches.
- Different from the normative take of the traditional philosophy of science, mechanistic explanations in ecology are context-sensitive as they reflect a pragmatic orientation of a research agenda that aims to uncover practicable and efficient points of intervention in the environment. Although with similar resemblances to philosophical mechanistic accounts, it is not entirely strict to the theoretical framework elaborated by the standard philosophy of mechanism. The identification and number of components, activities, organization, and even what counts as causal evidence of a mechanism is contextual according to the purposes of the epistemic practices involved.

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- These pluralities of mechanism and causal reasoning can be strategic not only for management and environmental conservation but also to enrich philosophical reflections about causal reasoning in ecology and in methodological practices in philosophy of science at large.

Key readings:

- Ankeny, R. *et al.* (2011) 'Introduction: Philosophy of science in practice', *European Journal for Philosophy of Science*, 1(3), pp.303–307. Available at: https://doi.org/10.1007/s13194-011-0036-4
- El-Hani, C.N., Poliseli, L. and Ludwig, D. (2022) 'Beyond the divide between indigenous and academic knowledge: Causal and mechanistic explanations in a Brazilian fishing community', *Studies in History and Philosophy of Science*, 91, pp.296–306. Available at: https://doi.org/10.1016/j.shpsa.2021.11.001
- Machamer, P., Darden, L. and Craver, C.F. (2000) 'Thinking about mechanisms', *Philosophy of Science*, 67(1), pp.1–25.
- Nadasdy, P. (2003) '*Hunters and bureaucrats*. Vancouver: UBC Press.
- Pâslaru, V. (2009) 'Ecological explanation between manipulation and mechanism description', *Philosophy of Science*, 76(5), pp.821–837.
- Pâslaru, V. (2015) 'Causal and mechanistic explanations, and a lesson from ecology', in I.D. Toader, G. Sandu and I. Pârvu (eds.), *Romanian studies in philosophy of science*. Dordrecht: Springer Verlag.
- Poliseli, L. *et al.* (2022) 'Philosophy of science in practice in ecological model building', *Biology and Philosophy*, 37(4), pp.0–21.
- Raerinne, J. (2010) 'Causal and mechanistic explanations in ecology', *Acta Biotheoretica*, 59(3), pp.251–271.

44.1 Introduction

We often hear scientists using mechanisms to explain certain phenomena, *the mechanism of natural selection*, *the cell working as a mechanism*, *the plant mechanism to attract butterflies*, and so on. While this "mechanism talk" (Darden 2013) is quite common in science, philosophers of science are more cautious in doing so. These are causal mechanisms. The overall view in the traditional philosophy of science holds that a mechanism is composed of its individual components, and the interactions between these components, reflected in its causal processes, produce a product or behavior (Bechtel & Richardson 2010; Machamer et al. 2000; Craver 2002, 2007; Darden 2002, 2006; Craver & Bechtel 2006; etc.). This is commonly applied in neurobiology, chemistry, physics, and several subfields within biology but less frequently in ecology. Even though mechanisms in ecology have been increasingly investigated since the 1980s, a philosophical framework committed to identifying, describing, and elucidating mechanisms in ecology is still taking place (see Pâslaru 2009, 2015; Raerinne 2010; Matthewson & Calcott 2011). One of the reasons might be that in ecology there is a paramount interest in identifying target explananda that reflects a pragmatic agenda of looking for effective points to intervene in an ecological system to fulfill some purpose, for instance, to improve the sustainability of productive practices or to support a better choice of conservation strategies (Poliseli et al. 2022). Furthermore, when ecology is compared to other domains where mechanistic explanations are more prominently and well delimited such as the fields above-mentioned, ecological causal explanations seem to be invariant generalizations whose mechanistic features are still to be discovered (Raerinne 2010).

With new philosophical tools on the horizon, such as the philosophy of science in practice (here on PSP) (Ankeny et al. 2011), more attention is paid to the specificities of research practices across domains allowing new reflections to take place. This is only possible because the PSP approach can pay attention to the role of scientists during research practices (Boon 2017), as also discussed in the first section of this volume. In this sense, new questions can enter the mechanistic debate: how do distinct researchers and research practices make sense or use causal reasoning according to their specific field? How does mechanistic and causal reasoning occur across domains dealing with complex phenomena? Moreover, considering the knowledge gap of ecological mechanisms, how can this interdisciplinary approach between PSP and ecology help us acquire more knowledge about causality and mechanisms in an ecological context? This chapter focuses on this last question.

Let's investigate ecology and environmental conservation. Both fields can deal with complex ecological phenomena where systems operate within systems occurring on distinct temporal and spatial scales, and most importantly, dealing with different sources of data (Leonelli 2009), e.g. molecular, species interactions, evolutionary history, landscape, society, and indigenous and local knowledge (ILK). Thus, how can one identify the components and parts of a mechanism in an ecological system? More importantly, is it crucial to identify all the components so we can understand the importance of mechanistic behavior within a system, especially when most of these explanations will be considered for environmental conservation and policymaking? In this chapter, we will see that interdisciplinary works of PSP with ecology can analyze causality and mechanism distinctly (being mechanisms perceived here as a special case of causality), according to different ecological research practices, and that these pluralities of reasoning can be strategic not only for management and environmental conservation but also to enrich philosophical reflections about causal reasoning in ecology.

It is worth for us to note that the previously mentioned approach, PSP, can occur in at least two distinct forms: philosophy of science *in practice* and philosophy of *science in practice* (Boumans & Leonelli 2013). In the first one, philosophers can engage empirically with scientists during their research practices, whereas the last one focuses on the scientific activity that is performed by the scientists without philosophy necessarily engaging with them (Boumans & Leonelli 2013; Kosolosky 2012). For the following, let's consider both approaches. We will start with an interdisciplinary case study of philosophy of science working together, in practice, with ecology to create a mechanistic model of bee pollination services in agricultural systems. And, in the sequence, we will look at how philosophy of science can help understand mechanistic and causal reasoning in indigenous and traditional ecological knowledge. As a bonus, this approach will help us reflect on philosophical methodologies at large. PSP will show us that how we study mechanisms and causality makes a difference in how we understand mechanisms and causality. For instance, in this chapter, we will see that we can't understand indigenous and traditional knowledge about causality if we only apply the conceptual tools of analytic philosophy of science. The same can be said for other contexts such as those dealing with complex environmental phenomena.

44.2 Case 1: Interdisciplinarity and mechanisms in ecology

The philosophy of mechanism is a rich field in the philosophy of science, with several accounts developed throughout the years (see Bechtel & Richardson [1993] 2010; Machamer et al. 2000; Craver 2002, 2007; Darden 2002, 2006; Craver & Bechtel 2006; etc.). More recently, Glennan and Illari (2017) developed a minimum definition of a mechanism considering the philosophical, historical, and practical significance of mechanisms, where "a mechanism for a phenomenon consists of entities and activities organized in such a way that they are responsible for the phenomenon" (p. 120). To the present, mechanistic perspectives can deal with multilayered systems possessing complex features such as hierarchical organization and non-linearities (see Bechtel & Richardson [1993] 2010; Wimsatt 1994; Glennan 1996, 2002; Craver 2007; Bechtel 2015; Brigandt et al. 2018). Although this might suggest that mechanistic perspectives can aid in the process of building and explaining ecological models that deal with complex and non-linear phenomena (Poliseli et al. 2022); Pâslaru (2009, 2015), Raerinne (2010), and Halina (2017) show that mechanistic explanations possess several limitations for understanding ecological practices. A case in point is made by Matthewson and Calcott (2011) showing that entities and activities considered in mechanistic explanations are usually well-defined, being the models built with localizable parts that interact in distinctive ways, while models such as those built in population ecology include parts and interactions that are neither local nor discrete. This only punctuates the fact that ecological mechanisms are still not well known and that mechanistic explanations in ecology are often undermined due to a lack of sufficient data (Raerinne 2010).

We will add elements to this conversation by applying the discussions of the new mechanistic philosophy of science to an ecological phenomenon. One of the distinctions of this work is that it represents an interdisciplinary collaboration between a philosopher of science and an ecologist working together to develop a mechanistic model of bee pollination services in agricultural systems, at the agricultural pole of Mucugê-Ibicoara, located in the Chapada Diamantina National Park, Brazil (for a full description and assessment of this collaboration, see Coutinho 2018; Poliseli 2020; Poliseli et al. 2022). This was a four-year collaboration in which both scholars, through an action-research approach (Tripp 2005), came together to combine the knowledge from ecology and the new mechanistic philosophy of science into a "heuristic set" that would guide mechanistic model-building (Figure 44.1).

Special attention is required to the so-called heuristic set. This was a non-sequential set of activities that guided the ecologist during the mechanistic model-building – details about each heuristic and its overall applications will be further provided. These heuristics were rules of thumb for modeling and other epistemic actions used to grasp a phenomenon and the processes generating it. Hence, it was problem-specific fallible strategies framed with the mechanistic literature adapted to features of the ecological phenomena that helped the scientist to cope with modeling. Important to note that the construction of the general conception of this heuristic set was a collaborative work of both scholars; however, the elaboration of the theoretical framework of each heuristic was a task of the philosopher, whereas the process of application of these heuristics to the ecological phenomenon was a task of the ecologist. As a four-year continued collaboration, the information resulting from the applications of these heuristics was continuously revised and modified; thus, the theoretical framework of the heuristics oriented the heuristics application, but the heuristics application also oriented the theoretical framework.

A description of some heuristics and the activity elaborated by the scientists is presented in Table 44.1. We can briefly see how the heuristic was applied by the ecologist to the phenomenon

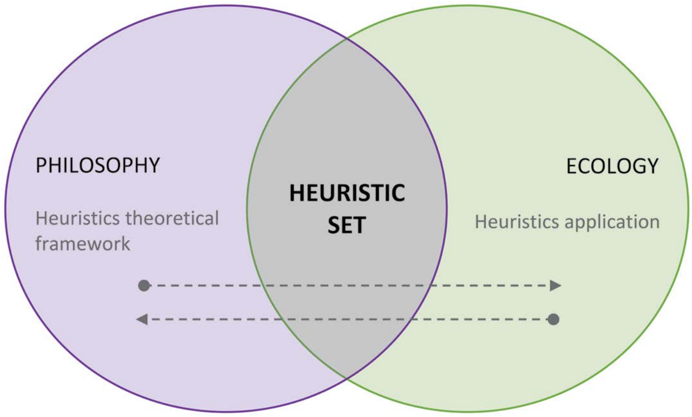

Figure 44.1 Interdisciplinary dynamics between the philosopher of science and the ecologist during the creation of the heuristic set. The general conception of the heuristic set was constructed by both ecologist and philosopher of science and it combined knowledge from theories in ecology and the new mechanistic philosophy of science. The philosopher of science was responsible for the development of the theoretical framework of each heuristic, whereas the ecologist was responsible for applying the heuristic to his case study. The heuristics application informed the heuristics theoretical framework, and vice-versa (for a detailed explanation of this dynamic, see Poliseli 2018; Poliseli et al. 2022).

Table 44.1 Brief description of the definition of some heuristics developed by both scholars and applied by the ecologist

Heuristic	*Brief definition*
Phenomenon characterization	Description of the *explanandum* and *explananda*.
Mechanism sketch	Development of diagrams (usually incomplete and disposable) that attempt to establish relations between the theoretical frameworks and the phenomenon.
Hierarchical structure	This heuristic enables visualizing the interaction between different spatial and temporal scales by creating a structure that identifies and locates the levels in which the mechanism (or mechanisms) is organized (and/or nested) in the phenomenon superstructure.
Enabling conditions	Usually characterized as factors and conditions sufficient to bring about a phenomenon. More generally speaking, variables involved in the activities of a mechanism are relevant to the production of the phenomenon.
Operational component distinction	Distinguishes the components and functions of the enabling conditions within the mechanism and specifies the relations and boundaries of these components. Whenever this distinction is not possible, the component/action is addressed as an operational component. If this information is not yet present in the literature, it is highly recommended that one carries out procedures of decomposition and localization, forward and backward chaining, and synthetic and analytic strategies to achieve this goal.
Changes in operational components	Allow the researcher to exploit alternative scenarios and predict possible courses of the system under investigation by modifying the operational components.
Mechanism schema	Mechanistic model obtained after the use of the heuristics above.

of bee service pollination in agroecosystems, which is the phenomenon for which the ecological mechanism is responsible.

This case study focused on the pivotal ecological processes as an attempt to explain the functional diversity of bees in agricultural systems. To do so, these agricultural systems were evaluated from a complex system perspective (see Solé & Goodwin, 2000; Cadotte et al. 2011; Filotas et al. 2014), complemented by a theoretical-methodological framework from mechanistic explanations. The process of model-building through the applications of the heuristic set presented above assisted the ecologist in detecting significant spatial-temporal scales of the phenomenon (Figure 44.2). Since the forms of interaction between these variables are not always clear in ecology, it's important to arrive at a more satisfactory level of explanation that might require reducing existing gaps, searching for intersections between theories, and considering spatial and environmental features along with attributes of the chosen phenomenon's life history (ecologist *personal communication*). The mechanistic model elaborated from this interdisciplinary combination of ecology with philosophy of mechanisms is presented below. For reasons of space, only the general mechanistic model is presented here, as detailed information and assessment of the "heuristics set" application as well as the ecological phenomenon can be found in Poliseli (2018), Coutinho (2018), Poliseli (2020), Poliseli et al. (2022).

Figure 44.2 shows the mechanism built by the ecologist after using the heuristic set, created through the interdisciplinary effort between philosophy of science and ecology. On the right side, the main spatial scales that influence pollination services are displayed: regional, landscape, patch, and flower scales. On the left side, the operation components of each level

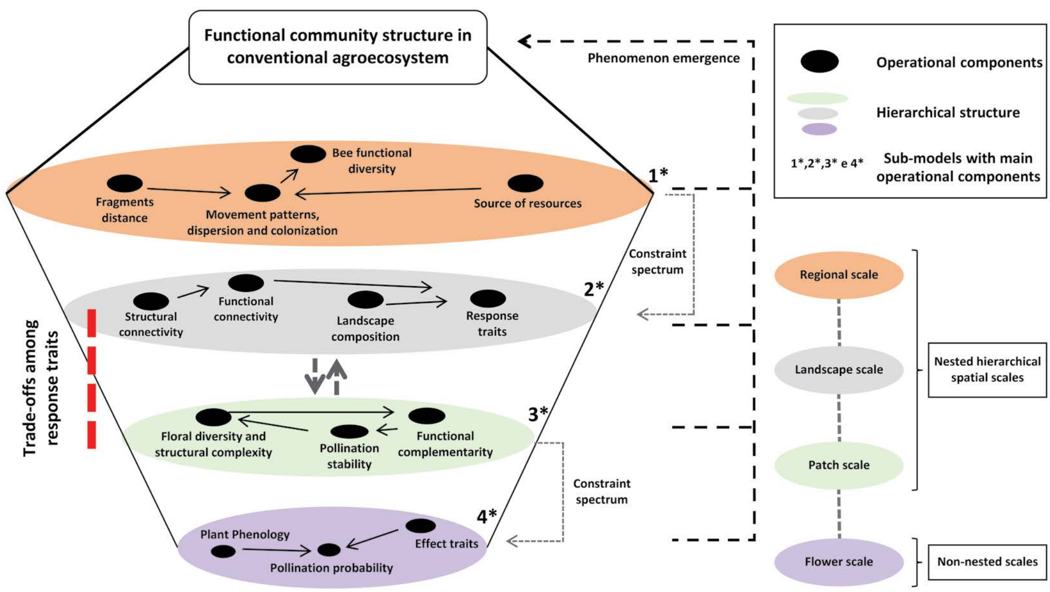

Figure 44.2 Mechanistic model indicating the main spatial scales influencing the pollination ecosystem service featuring its respective operational components. Constraint spectrum is a set of restrictions exerted by a hierarchical level above that influences the dynamic of ecological processes at the level below. Nested scales indicate a set of spatial scales where interrelated ecological processes occur in that system. Non-nested scale indicates a specific spatial scale where the phenomenon analyzed occurs.

Source: Material from Poliseli et al. (2022, 21), https://creativecommons.org/licenses/by/4.0/.

are exposed, as well as their causal relation. Level 1* indicates ecological components and processes at a regional scale, which provides the regional pool of species that operate at the smaller spatial scales. Level 2* includes aspects of the structure of the landscape that influence bee functional composition through the interaction with certain response traits, which are the traits that condition the response in richness and abundance of bees' species at the patch level to such landscape spatial aspects. Level 3* contains structural characteristics of habitat patches that influence the probability of complementarity of traits at this scale, influencing the spatiotemporal stability of the pollination service. And Level 4* is the smallest scale in this model and indicates that pollination success will ultimately depend on plant phenological attributes (e.g. supply of resources compatible with the needs of bee communities) and effect traits (e.g. bee traits related to the successful transfer of pollen grains).

Thus, what we can establish from this case study is that mechanistic explanations do not need to be reductionist and can be applied to complex ecological systems. However, its traditional framework as presented earlier in this section does not work as a cookbook for mechanism discovery and requires adjustments according to the phenomenon's context. For instance, phenomenon characterizations are ongoing processes and need to be redefined constantly, and manipulation strategies to discover the components or actions are not always applicable; thus, one needs to work with operational components, that is components and actions that cannot be entirely separated apart due to the complexity level in which the phenomenon is embedded. In this sense PSP helps us shed light on the specificities of ecological research practices when targeting mechanism discovery.

44.3 Case 2: Causal reasoning in traditional ecological knowledge

While this chapter focuses on causal reasoning in ecological thought, other chapters of this volume explore causal mechanisms in other fields of science such as Grin on policymaking, Weber on political sciences, and Pagliarin and Schoonebom on social sciences. However, in this section, we will not restrict this discussion only to the academic culture; if we wish to discuss ecological knowledge for environmental conservation, we ought to include other knowledge systems, such as ILK. Agrawal (2014), Drouin-Gagne (2014), Gorelick (2014), and Whyte (2013) acknowledge that there is no simple demarcation criterion that distinguishes academic ecological knowledge (AEK) from local and indigenous ecological knowledge (ILK). It is often stated that the contrast between these two knowledge systems relies on the idea that AEK possesses reductionistic (or mechanistic) features, whereas ILK tends to be holistic (Wood 1999; Dods 2004; Aikenhead & Ogawa 2007). This superficial discrepancy creates a division where the latter are usually assimilated by the first and quite often subject to scientific validation (see Nadasdy 2003; El-Hani & de Ferreira Bandeira 2008). However, both knowledge systems can use holistic, reductionistic, and mechanistic reasoning as part of their epistemic toolboxes to understand the natural world (see Ludwig & Poliseli 2018). To illustrate this, the previous section instantiated how mechanistic reasoning in ecology can help model a complex system and, therefore, does not need to be reductionist. Hence, we will now show that interdisciplinary work in philosophy of science can help us understand that ILK is not only holistic but can also make use of mechanistic reasoning to understand the world. It is of essential importance to highlight that the aim of this section is not to break apart these knowledge systems but to recognize the existence of (dis)similarities where different tools for producing and validating knowledge can also be substantial epistemic resources for the purpose of understanding the world, and the interdisciplinary work of philosophy of science has a fundamental role in bringing this to the surface.

We will now combine philosophical and empirical methods to engage with causal reasoning and explanatory practices of the traditional fishing village of Siribinha in the municipality of Conde, Brazil. Interviews were conducted with ten fisher experts to investigate the epistemic resources used in this fishing community. The interviews were carried out in a way that allowed to approach traditional experts in a manner to verify shared explanatory patterns among the traditional experts, interpreted as evidence that elicited explanation is broadly available among the fishers. Using this method, it was also possible to detect variations in the explanations among the fishers. For a full description of methodological aspects and a lengthy analysis of this case study (as well as other causal explanations in this community), see El-Hani et al. (2022). Worthy note, this case study is embedded into a wider and ongoing ethnographic research that engages with the unique fishing culture and its relationship with the environment.

Siribinha is part of the preserved mangroves of the Itapicuru estuary, located between the sea and the river, on the north shore of Bahia. Fishing communities in this area are gradually disappearing due to the growth of the tourism industry and the declining catches resulting from the impact of overfishing, pollution, and other environmental threats. Several estuaries, mangroves and restingas in that region, have suffered with the growth of human occupation, environmental contamination or severely threatened by changes in the riverine and estuarine systems, among other impacts (El-Hani et al. 2022). Despite these impacts, the mangroves and restingas of this estuary are still mostly conserved, although used by the local fishing communities for more than a century, suggesting that sustainable techniques are part of their fishing practices. Siribinha fishers use at least a dozen of different fishing techniques, each one with its own knowledge repository (El-Hani et al. 2022) but only one will be the focus here, i.e. the fishing of robalo (snook), more specifically, a specific phenomenon related to the fishing of robalo, the Robalo Water. Below, there is a partial ethnographic description of Robalo Waters followed by a discussion about causal reasoning and mechanisms in this context (for a full ethnographic description and a lengthy analysis, see El-Hani et al. 2022).

Robalo Water is an event that occurs when there is an abundance of robalo that leads to a good catch. In explanations of the phenomenon by the fishers, interactions between multiple causes were consistently identified during interviews. The first factor mentioned by the fishers to explain the Robalo water concerns the influx of freshwater into the estuary. This influx influences the robalos to leave their refuges in the direction of the ocean following patches of plant material that may offer additional protection during this trajectory, for example Baronesas (*Eichhornia crassipes*). Their safe places are commonly called "wells" and usually offer protection against fishers and predators. Due to the freshwater in the estuary, robalo juveniles leave the "wells" but this is not the only factor affecting the likelihood of robalo getting caught in nets. As explained by one of the fishers, muddy water is important, since it makes it more difficult for the fish to see the nets, but it is not the only variable affecting the catch. A third factor mentioned is the "burning water", an expression used by the villagers to refer to the bioluminescence observed both in the estuary waters and on the local beaches, which they report to be caused by jellyfish. Burning water is a common phenomenon in this estuary especially in the summer, during the spring tides, and when the night is darker. A fisherman explained the influence of the moon phase on the visibility of the faint jellyfish bioluminescence and the capture of fish like robalos. Therefore, when the moon is full, the influence of the bioluminescent jellyfish is smaller than during the new moon. Thus, freshwater has a double effect, both displacing the robalos and turning the water muddy, making it harder for the fish to see the nets. Bioluminescence makes it easier for the robalos to see the fishing artifact, but it is most effective when the night is dark, e.g. during the new moon. The full moon, in turn, overcomes jellyfish bioluminescence, the same as the muddy waters.

We have already seen in the introduction that a mechanism is described as composed of entities with properties and activities with their own functions. The activities are intrinsically related to the properties of the entities since they produce the action. The organization and the dynamics of the entities and activities establish the path through which the phenomenon is produced. Entities must be specifically situated, structured, and oriented. The activities in which they participate must be coordinated temporally, involving order, rate, and duration (Bechtel & Richardson 2010). When this mechanistic account is applied to the case of Robalo water (Figure 44.3), fishers in Siribinha identify all three components: entities and activities, organization, and responsibility for the target phenomenon. First, fishers explain Robalo water through several entities and activities, including the inflow of freshwater, the moon phases, and the tide. Second, these entities and activities are not understood as an unorganized set of elements but rather there is an explicit causal relation in their interactions. For instance, the ability of fish to detect the nets is recognized as crucial and is also shaped by different factors. One of these factors is the freshwater inflow from the river influencing the nets visibility; nets are less visible

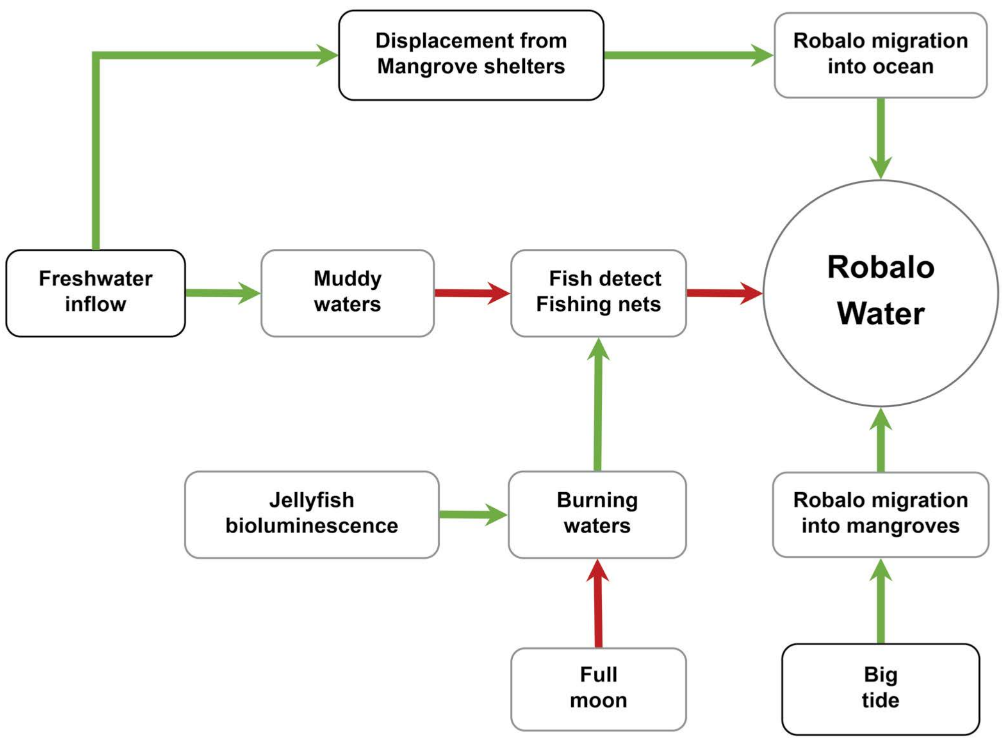

Figure 44.3 Representation of the ecological mechanism that causes "Robalo Waters" in the Itapicuru River estuary. Green and red arrows indicate a positive and negative causal effect on the target phenomenon.

Source: Material from El-Hani et al. (2022), https://creativecommons.org/licenses/by/4.0/.

through muddy waters. Another factor influencing the visibility of the nets is the full moon which reduces the effects of jellyfish bioluminescence that brightens the fishing water. Third, fishers clearly interpret these factors causally: the visibility of the fishing nets, for example, is not merely assumed to be correlated with Robalo water. Instead, it is a causal factor: robalos get caught because they cannot see the nets (El-Hani et al. 2022). As we can see, indigenous reconstructions are all permeated with causal reasoning; the question is whether their causal reasoning maps onto the Western traditional philosophical/scientific academic way of rendering causality, e.g. via causal inference, causal explanation, and control.

44.4 Causality and mechanism in the philosophy of science in practice

A hallmark of mechanistic reasoning is to understand a complex whole by decomposing it into component parts, and by localizing phenomenon of interest to certain parts of the system (Craver 2007; Bechtel & Richardson 2010). However, both ecological cases we presented in this chapter bring us distinct ways of dealing with this hallmark of identification of mechanism. In modeling agroecosystem, the new mechanistic philosophy of science did not possess a normative role but rather a heuristic one. The heuristics indeed contained problem-specific fallible strategies that helped the ecologist to cope with the construction of models and explanations about the phenomenon of interest. If the heuristics were not adjusted to the phenomenon in question, the mechanistic explanation per se would have not succeeded because the standard practice of identification of mechanisms, such as inhibitory and excitatory strategies, was not applicable to this specific complex phenomenon. This means that mechanistic modeling was a useful epistemic tool to explain the ecological complex system at stake, in contrast to a normative rule for describing it. The contributions from the philosophy of science helped in the analysis of the complex system by supporting the selection of components, activities, and properties that seemed most fundamental. In turn, the heuristics allowed to combine contributions from different fields to improve understanding, derive testable predictions, and generalize knowledge. This was only possible due to the interdisciplinary and collaborative effort in which philosophical and scientific expertise walked hand in hand. Thus, it is possible to overcome the limitations of identifying a mechanism in ecology by recognizing that mechanistic explanations are context-sensitive, considering it reflects a pragmatic orientation of a research agenda in ecology that aims to uncover practicable and efficient points of intervention in the environment. This can be attributed to the heuristic role of mechanistic philosophy as well as the interdisciplinary work (as presented in Figure 44.1), which allows this reflection to take place.

Now, the case of Robalo water illustrates not only the prevalence of complex ecological mechanisms in the Itapicuru River but also the resources of ILKs for addressing the intertwining of entities and activities which allowed for translation into mechanistic explanations. Rather than being incommensurable with causal and mechanistic reasoning in the biological sciences, this case suggests that fishers in Siribinha are often experts regarding these local causal systems. This result is especially important given the highly local character of ecological mechanisms as portrayed in Figure 44.3. The mechanism responsible for Robalo water is highly localized in the sense that the interplay of different factors is unique to the Itapicuru River and, even though relationships within it may be derivable from general ecological and biological principles, the specific way in which physical (e.g. freshwater inflow, moon phases, tide amplitude), behavioral (e.g. fish response to bioluminescence in the nets, fish's migration), physiological (e.g. bioluminescent responses by jellyfish), and cultural factors (e.g. fishing artifacts) interact is unique to the estuary where the fishers exert their activities. While intimate familiarity with this ecosystem is therefore a prerequisite for ascertaining the articulation of entities and activities represented in the figure (El-Hani et al. 2022), a dialogue between philosophy of mechanism with empirical ethnographic work was fundamental to recognizing such epistemic resources that otherwise could have been ignored.

The main lesson of this chapter is that interdisciplinary work of PSP when focused on distinct epistemic practices of ecological mechanism can help shed light on the plurality of ways in which causality, more specifically mechanisms, is perceived in distinct epistemic communities, and therefore important in multiple contexts and approaches such as those presented in ecological research of pollination systems but also in explaining fish migration by fishers. The cases presented in this chapter are evidence that causal reasoning and mechanistic explanations are not exclusive of academic knowledge or philosophical debates, and what should count as a mechanism, although with similar resemblances to philosophical mechanistic accounts, it is not entirely strict to the theoretical framework elaborated by the standard philosophy of mechanism. The identification and number of components, activities, organization, and even what counts as causal evidence of a mechanism is contextual according to the purposes of the epistemic practices involved. In the first case, the goal was to develop a mechanistic model to create predictions about the agroecological system and the pollination occurring at distinct levels, whereas the second was to understand how robalo behaves in the estuary to know when and how to fish. Both cases instantiate how philosophy of science can help shed light and understand the value of distinct epistemic toolboxes that take advantage of causal reasoning and mechanisms to address real-world problems, overall, in the context of ecological conservation and environment management. But to do so, it is necessary to augment philosophical agendas so we can bridge heterogeneous epistemic resources even if they differ substantially in their epistemic perspectives.

References

Agrawal, A. (2014) 'Indigenous and scientific knowledge: Some critical comments', *Antropologi Indonesia*. Available at: https://doi.org/10.7454/ai.v0i55.3331

Aikenhead, G.S. and Ogawa, M. (2007) 'Indigenous knowledge and science revisited', *Cultural Studies of Science Education*, 2(3), pp.539–620. Available at: https://doi.org/10.1007/s11422-007-9067-8

Ankeny, R. *et al*. (2011) 'Introduction: Philosophy of science in practice', *European Journal for Philosophy of Science*, 1(3), pp.303–307. Available at: https://doi.org/10.1007/s13194-011-0036-4

Bechtel, W. (2015) 'Can mechanistic explanation be reconciled with scale-free constitution and dynamics?, *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, 53, pp.84–93.

Bechtel, W. and Richardson, R.C. (2010) *Discovering complexity: Decomposition and localization as strategies in scientific research*. Princeton: MIT Press. (First published 1993).

Boon, M. (2017) "Philosophy of science in practice: A proposal for epistemological constructivism", in H. Leitgeb, I. Niiniluoto, P. Seppälä and E. Sober (eds.), *Logic, methodology and philosophy of science*. Proceedings of the 15th International Congress (CLMPS 2015), College Publications, 289–310.

Boumans, M. and Leonelli, S. (2013) 'Introduction: On the philosophy of science in practice', *Journal for General Philosophy of Science/Zeitschrift für Allgemeine Wissenschaftstheorie*, 44(2), pp.259–261.

Brigandt, I., Green, S. and O'Malley, M. (2018) 'Systems biology and mechanistic explanation', in S. Glennan and P.M. Illari (eds.), *The Routledge handbook of mechanisms and mechanical philosophy*. London: Routledge, pp. 362–374.

Cadotte, M.W., Carscadden, K. and Mirotchnick, N. (2011) 'Beyond species: Functional diversity and the maintenance of ecological processes and services: Functional diversity in ecology and conservation', *Journal of Applied Ecology*, 48(5), pp.1079–1087. Available at: https://doi.org/10.1111/j.1365-2664.2011.02048.x

Coutinho, J.G.E. (2018) *Diversidade funcional de abelhas em sistemas agrícolas: Aportes teóricos, empíricos e epistêmicos*. Ph.D. dissertation, Federal University of Bahia.

Craver, C.F. (2002) 'Interlevel experiments and multilevel mechanisms in the neuroscience of memory', *Philosophy of Science Supplemental Volume*, 69(3), pp.S83–S97.

Craver, C.F. (2007) *Explaining the brain: mechanisms and the mosaic unity of neuroscience*. Oxford: Oxford University Press, Clarendon Press.

Craver CF, Bechtel W (2006) Mechanism. In: Sarkar S, Pfeifer J (eds) *Philosophy of science: an encyclopedia*. Routledge, New York, pp 469–478

Darden, L. (2002) 'Strategies for discovering mechanisms: Schema instantiation, modular subassembly, forward/backward chaining', *Proceedings of the Philosophy of Science Association*, 2002(3), pp.S354–S365.

Darden, L. (2006) *Reasoning in biological discoveries: Essays on mechanisms, interfield relations, and anomaly resolution*. Cambridge: Cambridge University Press.

Darden, L. (2013) 'Mechanisms versus causes in biology and Medicine', in H.-K. Chao, S.-T. Chen and R.L. Millstein (eds.), *Mechanism and causality in biology and economics*. Dordrecht: Springer Netherlands (History, Philosophy and Theory of the Life Sciences), pp. 19–34. Available at: https://doi.org/10.1007/978-94-007-2454-9_2

Dods, R.R. (2004) 'Knowing ways/ways of knowing: Reconciling science and tradition', *World Archaeology*, 36(4), pp.547–557. Available at: https://doi.org/10.1080/0043824042000303719

Drouin-Gagne, M.-E. (2014) 'Western and Indigenous sciences: Colonial heritage, epistemological status, and contribution of a cross-cultural dialogue', *Ideas in Ecology and Evolution*, 7. Available at: https://doi.org/10.4033/iee.2014.7.12.c

El-Hani, C.N., Poliseli, L. and Ludwig, D. (2022) 'Beyond the divide between indigenous and academic knowledge: Causal and mechanistic explanations in a Brazilian fishing community', *Studies in History and Philosophy of Science*, 91, pp.296–306. Available at: https://doi.org/10.1016/j.shpsa.2021.11.001

El-Hani, C.N. and de Ferreira Bandeira, F.P. S. (2008) 'Valuing indigenous knowledge: To call it "science" will not help', *Cultural Studies of Science Education*, 3(3), pp.751–779. Available at: https://doi.org/10.1007/s11422-008-9129-6

Filotas, E. *et al.* (2014) 'Viewing forests through the lens of complex systems science', *Ecosphere*, 5(1), p. art1. Available at: https://doi.org/10.1890/ES13-00182.1

Glennan SS (1996) Mechanisms and the Nature of Causation. *Erkenntnis* 44(1):49–71

Glennan SS (2002) Rethinking Mechanistic Explanation. *PSA* 69(S3):S342–S353

Glennan, S. and Illari, P. (2017) *The Routledge handbook of mechanisms and mechanical philosophy*. London: Routledge.

Gorelick, R. (2014) 'Indigenous sciences are not pseudosciences', *Ideas in Ecology and Evolution*, 7. Available at: https://doi.org/10.4033/iee.2014.7.11.c

Halina, M. (2017) 'Mechanistic explanation and its limits', in S Glennan and P Illari (eds.), *The Routledge handbook of the philosophy of mechanisms*. New York: Routledge, pp. 213–224.

Kosolosky, L. (2012) 'Philosophy-of-science in practice vs. philosophy of science-in-practice', *SPSP Newsletter*, 2(Autumm), pp.9–10.

Leonelli, S. (2009) 'Understanding in biology: The impure nature of biological knowledge', in H. De Regt, S. Leonelli and K. Eigner (eds.), *Scientific understanding: Philosophical perspectives*. Pittsburgh: University of Pittsburgh Press, pp. 189–209.

Ludwig, D. and Poliseli, L. (2018) 'Relating traditional and academic ecological knowledge: Mechanistic and holistic epistemologies across cultures', *Biology & Philosophy*, 33(5–6), p.43. Available at: https://doi.org/10.1007/s10539-018-9655-x

Machamer, P., Darden, L. and Craver, C.F. (2000) 'Thinking about mechanisms', *Philosophy of Science*, 67(1), pp.1–25.

Matthewson, J. and Calcott, B. (2011) 'Mechanistic models of population-level phenomena', *Biology and Philosophy*, 26(5), pp.737–756.

Nadasdy, P. (2003) *Hunters and bureaucrats*. Vancouver: UBC Press.

Pâslaru, V. (2009) 'Ecological explanation between manipulation and mechanism description', *Philosophy of Science*, 76(5), pp.821–837.

Pâslaru, V. (2015) 'Causal and mechanistic explanations, and a lesson from ecology', in I.D. Toader, G. Sandu and I. Pârvu (eds.), *Romanian studies in philosophy of science*. Dordrecht: Springer Verlag.

Poliseli, L. (2018) *When ecology and philosophy meet. Constructing explanations and achieving understanding in scientific practice*. Ph.D. dissertation, Federal University of Bahia.

Poliseli, L. (2020) 'Emergence of scientific understanding in real-time ecological research practice', *History and Philosophy of the Life Sciences*, 42(4), pp.1–25.

Poliseli, L. *et al*. (2022) 'Philosophy of science in practice in ecological model building', *Biology and Philosophy*, 37(4), pp.0–21.

Raerinne, J. (2010) 'Causal and mechanistic explanations in ecology', *Acta Biotheoretica*, 59(3), pp.251–271.

Solé, R. V. and Goodwin, B. (2000) *Signs of life: How complexity pervades biology*. New York, NY: Basic Books.

Tripp, D. (2005) 'Action research: A methodological introduction', *Educ Pesq*, 31(3), pp.443–466.

Whyte, K.P. (2013) 'On the role of traditional ecological knowledge as a collaborative concept: A philosophical study', *Ecological Processes*, 2(1), p.7. Available at: https://doi.org/10.1186/2192-1709-2-7

Wimsatt, W.C. (1994) 'The ontology of complex systems: Levels of organization, perspectives, and causal thickets', *Canadian Journal of Philosophy, Supplementary Volume*, 20, pp.207–274.

Wood, H. (1999) *Displacing natives: The rhetorical production of Hawaii*. Lanham, MD: Rowman & Littlefield.