"Population" Is Not a Natural Kind of Kinds

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Abstract
Millstein (2009) argues against conceptual pluralism with respect to the definition of "population," and proposes her own definition of the term. I challenge both Millstein's negative arguments against conceptual pluralism and her positive proposal for a singular definition of population. The concept of population, I argue, does not refer to a natural kind; populations are constructs of biologists variably defined by contexts of inquiry.

Keywords
conceptual pluralism, Roberta Millstein, population

July 23, 2010; accepted August 6, 2010
Biological Theory 5(2) 2010, 154–160.

An attractive stance to many concepts is to permit plural definitions of the concept, the specific meanings of which are dependent on and sensitive to the peculiarities of particular contexts; I will call this conceptual pluralism. Conceptual pluralism is an especially attractive stance regarding concepts that do not refer to natural kinds. Gannett (2003: 990) takes such an approach to the definition of "biological population" when she argues that biological populations "are pragmatically and variably constituted in different sorts of investigations of species genome diversity. . . . Population boundaries are not fixed but vary from one context of inquiry to another." A population, on this conceptual pluralist account, is not a mind-independent entity that exists for biologists to discover, but rather is a construct of biologists deployed for the purpose of addressing particular questions. Populations are, of course, classes, or kinds, but nothing more definitive can be said about the concept of population in general, because any particular population is whatever a biologist (or anyone) needs it to be for some particular context or question. The concept of population, then, does not refer to a natural kind.

Such conceptual pluralism with respect to the definition of population reflects the way the term is used in biological practice, because there are many uses of the term "population" in the biological literature, ranging from permissive and context-sensitive definitions—"a group of individuals belonging to the same species" (Keeton and Gould 1986), or "a somewhat arbitrary grouping of individuals of a species that is circumscribed according to the criteria of some specific study" (Orians 1973)—to narrower and mind-independent definitions—"a group of conspecific organisms that occupy a more or less well-defined geographic region and exhibit reproductive continuity from generation to generation" (Futuyma 1986; see also Wells and Richmond 1995). Thus, with respect to the concept of population we observe amongst biologists a spectrum of ontological commitments, long familiar to philosophers, ranging from pragmatic antirealism to mind-independent realism. Permitting conceptual pluralism with respect to the definition of population has several attractions: consistency with biological practice, avoidance of linguistic policing, and austerity of conceptual commitment. Moreover, conceptual pluralism is consistent with other independently attractive philosophical positions, such as contextualism.[1]

Recently, though, Millstein (2009) has proposed a general definition of population that is meant to apply to the contexts of ecology and evolutionary biology. Millstein motivates her positive account of the concept of population by arguing against conceptual pluralism with respect to population.[2] This is a valuable early contribution to the study of a term that has received little previous philosophical attention, despite its widespread use in biology and the medical and human sciences. However, in this article I criticize both Millstein's negative arguments against conceptual pluralism and her positive proposal for a unitary definition of population. Conceptual pluralism with respect to population retains its attraction: I defend the view that the concept of population is not a natural kind of kinds.

Three Worries About Conceptual Pluralism

Millstein raises three distinct arguments against conceptual pluralism with respect to the definition of population, which I call Inconsistent Usage (IU), Factual Indeterminacy (FI), and Burden of Demarcation (BD). I address each in turn, and provide reasons to think that these arguments are not compelling. In the absence of compelling arguments against conceptual pluralism, such a stance remains a viable (and attractive) option with respect to the definition of population.

Inconsistent Usage (IU)

If different scientists use different definitions of population, and the performance and interpretation of their respective studies depends on their differing definitions of population, then this might lead to artifactual discordance amongst the results of their studies. This is best stated as a conditional, which I will call IU:

IU: If we permit conceptual pluralism with respect to population, then there may be "false controversies in which disputants are simply talking past one another."

To illustrate, Millstein describes a dispute regarding contradictory studies of butterflies. Švitra (2008) failed to replicate the findings of Munguira and Martin (1999), and Millstein suggests that the source of disagreement could be because the two groups of researchers might have studied different populations of butterflies. According to Millstein, it is because of situations such as this that "there is a reason to think that attempting to define the concept of population is a worthwhile endeavor." The hope seems to be that if the antecedent of IU is avoided, then at least we avoid one potential source of artifactual disagreement. Švitra might have reached the same findings as Munguira and Martin—goes this reasoning—had Svitra shared Munguira and Martin's definition of the *concept* of population.

However, if it were true that multiple groups of researchers reached contradictory conclusions because they studied different populations, then a satisfactory solution would not necessarily be that the researchers use the same definition of the *concept* of population, but rather a sufficient solution would be that the researchers study the same *population*. Two biologists can study the same population even if the biologists have differing concepts of population, just as two lexicographers can successfully resist the same workplace injustice without sharing the same definition of justice. Two children can enjoy the same game without sharing the same concept of game, and two bacteria can thrive in the same Petri dish without having

any concepts at all. The general point is that two agents can have the same relation to an entity without sharing a concept of that entity.

One might think that sharing the definition of a concept is at least *sufficient* for two biologists to avoid artifactual disagreements based on conclusions that depend on the concept in question. Indeed, one might think that the best way to ensure that two biologists study the same population is for them to share the same concept of population. This would require that the concrete extension of an abstract concept be determined by the details of a particular context, which may or may not be true in particular cases. Below I argue that Millstein's definition of population is insufficient in this regard. In any case, sharing the definition of a concept is by no means necessary for scientists to avoid artifactual disagreements based on conclusions that depend on the concept in question. Biologists who wish to compare findings based on the same population do not need the same *definition* of the concept of population, nor do they need the same concept of population—all they need is to study the same *population*. Of course, multiple biologists who purport to study the same object must have some way of agreeing on what that object of study is, but there is no reason why a shared (and universal) concept of population is required for that.

Factual Indeterminacy (FI)

Millstein's primary criticism of conceptual pluralism with respect to population is that if we permit multiple definitions of population, then, for any proposition about the world that requires the concept of population, there will be no determinate fact of the matter about the world. I will explain this worry further below, but first I will use her example to help motivate the worry.

The land snail *Cepaea nemoralis* often displays three morphs: pink, brown, and yellow. If we allow the concept "population" to mean whatever we want, then we can delimit the set of *C. nemoralis* in any way we want. For instance, the set of all pink morphs of *C. nemoralis* could be a population. As there is no variation with respect to color in this population, there would be no selection or drift with respect to color. Instead, if the population included all pink and brown morphs which were equally fit, then there would be no selection with respect to color, but there would be drift. Finally, if the population included all three morphs, and the pink and brown morphs were equally fit but the yellow morph was fitter than pink and brown ones, then selection would favor yellow morphs, and pink and brown morphs would undergo drift with respect to each other.[3] Millstein's point with this example is that three different ways of delimiting the snail population support three different claims regarding the operation of selection and drift.

Thus she writes, "If any (gerrymandered or otherwise) set of organisms is legitimately called a 'population,' our ascriptions of selection and drift are purely arbitrary." Her primary worry regarding conceptual pluralism with respect to population is best stated as a conditional, which I will call FI:

FI: If we permit conceptual pluralism with respect to population, then "there simply would be no fact of the matter about whether selection is operating or not."

The anxiety provoked by FI depends on what Millstein means by "fact of the matter" (FOTM). By FOTM, one might mean something like (1) an aspect of the world that is independent of our knowledge of it.

Alternatively, by FOTM one might mean something like (2) a proposition about the world, the truth value of which depends on the relation between the proposition (and the concepts employed therein) and the world.[4]

The conditional FI would be interesting and indeed worrying if by FOTM Millstein means (1): It surely would be odd if there was no fact of the matter whether selection is operating or not. As we believe that there *is* a fact of the matter whether selection is operating or not, the antecedent of FI could not be true. If so, Millstein's criticism of conceptual pluralism with respect to population would be vindicated. However, by FOTM Millstein *cannot* mean (1) because FI is false under (1): quite obviously our choice of definitions does not influence aspects of the world independent of our knowledge of them. By FOTM Millstein *must* mean (2). Under (2), FI is true. But under (2), FI is also trivial. If our propositions are based on concepts about which we are conceptual pluralists, then there may be no stable relations between propositions that depend on those concepts and the world. For example, if we permit conceptual pluralism with respect to "game," then there is no fact of the matter about whether chess is a game. My uncle thinks chess is a game (because his concept of game requires a game to demand skill and be challenging); I think chess is not a game, it is a chore (because my concept of a game requires a game to be relaxing and fun); and Bobby Fischer thinks chess is not a game, it is a career (because his concept of game requires a game not to be his profession). To use a biological illustration, Maienschein (2010) has argued that the history of embryology shows changing definitions of what counts as an embryo, which has clear implications for policy and medical ethics, but the plurality of definitions itself has neither led to a chaos of indeterminacy regarding *factual* claims about embryos nor has it hindered embryological research (although quite obviously differing *moral* claims about the embryo have hindered some embryological research).

Millstein claims that this lack of stability between the world and our propositions about the world is an "unacceptable conclusion." It is, however, a perfectly acceptable conclusion. Either conceptual pluralism implies that there is no single fact of the matter about the world *if* by fact of the matter one means propositions about the world, the truth value of which depends on one's definitions (which is a perfectly acceptable

conclusion); or, in contrast, conceptual pluralism does *not* imply that there is no single fact of the matter about the world *if* by fact of the matter one means aspects of the world independent of our knowledge of such facts (which is also a perfectly acceptable conclusion).

Burden of Demarcation (BD)

In the absence of a singular definition of population we have another reason to worry, according to Millstein, which I will also state as a conditional and call it BD.

BD: If we permit conceptual pluralism with respect to population, then "a huge burden will rest on characterizing what constitutes legitimate biologically and theoretically informed research."

It is unclear how the consequent of BD follows from the antecedent. After the unsuccessful attempts by the positivists and Popper to state demarcation criteria for "characterizing what constitutes legitimate [scientific] research," most philosophers now recognize that, at the very least, stating such demarcation is a challenge, if not a huge burden. Many have simply given up on this burden. Regardless, the consequent of BD is a truism; it holds whether or not we are conceptual pluralists with respect to population. Perhaps most importantly, the lack of a shared definition of population, and more generally the lack of scientific demarcation criteria, has not hindered the growth of biological research that depends on a notion of population.

Millstein's Definition of Population

Millstein proposes a definition of population primarily for the contexts of ecology and evolutionary biology. Here is her definition:

> *Populations* (in ecological and evolutionary contexts) consist of at least two conspecific organisms, who, over a species-appropriate time span, are mating or are engaged in a Darwinian struggle for existence, or both. The population is the largest number of organisms who are causally interconnected. Organisms who are located in the same spatial area (including recent migrants) are part of the population if and only if they are engaged in causal interactions with other conspecifics. (2009: 271)

I raise three problems for this definition: It is vague; it does not resolve the issues presented above that Millstein thinks are problems if we permit a conceptual pluralist account of population; and finally, it is overly restrictive (as definitions often are). I describe each problem in turn, though my main criticism is the third: Her definition of population is overly restrictive because, given that populations are not natural kinds but are rather pragmatic constructs for particular contexts of inquiry, any definition would be overly restrictive.

The notions of "Darwinian struggle for existence," "causally interconnected," and "same spatial area" are loose enough to allow nearly any two conspecific organisms to be part of the same population. Take Darwinian struggle for existence. What specific conditions must be met in order to determine whether two organisms are engaged in a Darwinian struggle for existence? Presumably, there are many context-specific answers to this question. However, in the absence of a single general answer, the above definition shifts indeterminate plurality away from the definition of the concept of population itself to an account of when two organisms are engaged in a Darwinian struggle for existence. "Causally interconnected" is similarly vague. Every entity everywhere is causally related to every other entity, as long as we consider remote miniscule gravitational forces or potential nonlinear chains of causes, like the flaps of a butterfly wing. The causes that Millstein thinks are relevant to defining population are causes related to selection: mating and struggle for existence. This is perhaps appropriate given that her definition is meant to apply to contexts of ecology and evolutionary biology. However, as Gannett (2003) argues, boundaries of causal interactions in the contexts relevant to selection are imperfect and dynamically changing. Barriers to gene exchange, for example, are incomplete and fluid (no pun intended). The notions that Millstein's definition relies on are, in one sense, clear enough—"Darwinian struggle for existence" and "causally interconnected" are not conceptually vague. They are, however, epistemically vague. Biologists often lack epistemic access to the causal interactions on which Millstein's definition relies. That is why Mayr wrote that "normally the 'population' is more or less an abstraction because there is a considerable interchange of individuals between neighboring populations, owing to the absence or incompleteness of physical barriers" (1942: 24).

This point of Mayr's is general: The presence or absence of particular causal interactions is dynamic—a set of individual organisms may sometimes display the relevant causal interactions necessary for the set to be called "population" by Millstein's definition, and at other times may not. Millstein recognizes this—she writes that "a species may have one population structure in one place and time and a different population structure in different places or times. In other words, a given population structure isn't a permanent feature of a species" (Millstein 2010). But from such population fluidity it follows that despite the reasons given not to be worried about IU, if one were still worried about IU, Millstein's proposed definition of population could not resolve IU, as some researchers might study a set of organisms that at one time display the requisite causal interactions, and other researchers could study the same set of organisms that at another time do not display the requisite causal interactions, and thus these researchers could reach contradictory conclusions (depending on the question) based on the same set of organisms, even if they both used Millstein's definition of population. It also follows that despite the reasons given above not to be worried about FI, if one were still worried

about FI, Millstein's proposed definition of population could not resolve FI because propositions about the world which rely on the definition of population might be true when a set of organisms display the requisite causal interactions, and might be false when the set of organisms do not display the requisite causal interactions (or vice versa), and thus Millstein's worry that there is no "fact of the matter" about the proposition (or the world?) would remain.

Also, related to the fluidity of populations is the notion of populations as individuals. The Ghiselin–Hull thesis—that species are individuals ("spatiotemporally localized entities that have reasonably sharp beginnings and endings in time" (Hull 1980))—has been influential in the philosophy of biology, and as Millstein notes, philosophers have tried to extend the individuality thesis to other biological entities, like colonies (Hamilton et al. 2009) and ecosystems (Odenbaugh 2008). Millstein argues that the notion of population meets the Ghiselin conditions for an entity to be an individual. This is not the venue for a sustained critique of the Ghiselin conditions for individuality. However, my worry is that any set of entities meets these conditions when stated loosely enough, and so any set of entities has the paradoxical property of being an individual according to these criteria. Consider the conditions of spatiotemporal localization and shared fate of parts. Given the dynamic fluidity of populations, a population only meets these in a trivial sense: A population is spatiotemporally localized to whatever spatiotemporal region it happens to occupy (a small island; a continent; Earth), and all the parts of any population have the same shared fate that at some unspecified time in the future they will cease to exist. The most constraining condition is perhaps the "integrated cohesion" condition. Millstein claims that populations meet this condition because they are causally interconnected, but I have already argued that this notion is too vague to be constraining. Are populations individuals? I am not sure what hangs on this for Millstein because her definition of population does not directly rely on the individuality thesis. Regardless, any attempt to tighten the criteria for individuality could have the effect that populations of interest to biologists no longer meet them.[5]

Beyond the vagueness of the notion of causal interaction on which the above definition of population depends, the causes related to selection—those causes that Millstein has picked out as important for characterizing the notion of causal interaction—hardly exhaust those which are important to many biologists who rely on a notion of population. This leads to my third general criticism of Millstein's proposed definition: that it is overly restrictive. Although Millstein's positive proposal for a definition of population might be a compelling definition for some research questions in ecology and evolutionary biology, it is an overly restrictive definition for the broad array of population-based questions that many ecologists (and geneticists, and epidemiologists, etc.) are interested in. To illustrate this, consider again the example of *C. nemoralis*. It is perfectly reasonable for an ecologist to pose certain questions about the set of brown morphs, for example. Maybe they have special resistance to predation? Maybe they are less heat tolerant? Millstein rightly claims that we cannot study selection or drift with respect to snail color on the set of brown morphs because there is no variation with respect to that trait (but a biologist could study selection or drift with respect to certain sub-types of the brown population, sub-types that vary with respect to another trait, such as body length). In any case, another biologist could study selection and drift with a demarcation of snail population appropriate to such questions.

More generally: If a biologist were interested in a question about a *subset* (or *superset*) of a set of conspecific organisms that are causally interconnected, then the proposed definition would preclude that scientist from calling such a subset a "population" (as it is the full set of conspecific organisms that are causally interconnected). Millstein could, perhaps, let such a biologist use the word "group" or "collection" or some other synonym, reserving the term "population" for the conspecific set. But this biologist would be justified in thinking that such linguistic policing is based on a poorly founded quibble.

One might think that, at the very least, the concept of population must be sub-species, that is, the concept of population must be a grouping within a species—more precisely, any population must at least be a proper subset of a species. But then, why exclude talk of the "population of micro-organisms in my gut," which includes upwards of 1,000 species from the bacterial genera *Bacteroides*, *Bifidobacterium*, *Clostridium*, *Escherichia*, *Eubacterium*, *Fusobacterium*, *Lactobacillus*, *Ruminococcus*, *Peptococcus*, and *Peptostreptococcus*, and the fungal genera *Aspergillus*, *Candida*, *Penicillium*, and *Saccharomyces*. Again, Millstein could respond by offering a different term for such superspecies groupings, like "collection." But again, the biologist interested in my intestinal flora might find such linguistic policing inconsistent with biological practice, since, to quickly name a few, this is precisely how Gorbach et al. (1969), Wolin (1974), Salminen et al. (2005), and Cash et al. (2006) use the term "population." Such linguistic diversity supports my general argument for conceptual pluralism with respect to population because the use of the concept of population by biologists does not refer to a natural kind (of kinds).

Millstein explicitly limits the context to which her proposed definition of population is meant to apply to ecology and evolutionary biology. To expect a definition of population to apply more broadly might be expecting too much. But then, the more one delimits the context in which a definition is meant to apply, the more one mitigates the motivation for a definition in the first place. At least one motivation for standard definitions in science (discussed briefly below) is to

facilitate mutual understanding amongst scientists. However, if a proposed definition is explicitly meant to apply only to a single discipline, then the motive of facilitating understanding among disciplines decreases because the target scope has decreased. Moreover, the delimitation of the domain of application of Millstein's definition of population is a circuitous admission of conceptual pluralism with respect to population, for if different disciplines are entitled to their own definition of population, it follows that one must permit multiple definitions of population. The degree of plurality depends on how finely grained one demarcates disciplines. But how does one determine the grain, and identify the boundaries, for the appropriate demarcation of disciplines? Given that scientific disciplines are such culturally dependent constructs, any such demarcation will seem arbitrary. Is the discipline of ecology a stand-alone discipline that deserves its own definition of population? What about sub-disciplines of ecology, like behavioral ecology, or molecular ecology? What about different ways of construing ecology that might be country-specific? The gerrymandering that Millstein is worried about with respect to demarcating populations reappears, if we accept her proposal, in the demarcation of disciplines.

Millstein admits that it is possible that "different biologically and theoretically informed research questions might yield different and equally cogent definitions of population." Despite that, she claims that she would "like to see if one definition can do the job." In this section I have argued that her definition cannot do the job. No definition can. We should permit conceptual pluralism with respect to the definition of population.

Conclusion

One motivation for singular universal definitions in science is to use them in descriptions of natural regularities regarding entities (either concrete or abstract) that can exist in multiple general relations (such as laws), and to have the terms describing these entities be commensurable, i.e., to mean the same thing in all the contexts in which the term occurs. Newton's three laws, for example, rely on a concept of force; part of the value of Newton's laws is that the same concept of force in each law allows for both conceptual austerity and harmony, and such conceptual harmony allows novel derivations of nomological corollaries by combining the three conceptually commensurable laws in various ways. Biology, though, does not usually attain the degree of conceptual unity that physics does. Why should it? As Dupré (1981) and others have argued, biological knowledge is disconnected and local rather than unified and general. A related motivation for singular universal definitions in science, as mentioned above, is to allow disciplines to achieve broad understanding of shared terms. This, though, does not imply the need for universal definitions, but perhaps for a broader understanding that meaning is context-sensitive. And in any case Millstein delimits her definition of population to only apply to the contexts of ecology and evolutionary biology.

Conceptual pluralism has become popular in philosophy, perhaps due in part to the influence of Wittgenstein's scattered remarks in *Philosophical Investigations* on the sensitivity of the meaning of a term to the context of its use, or to recent modesty amongst philosophers toward the policing of linguistic usage, or to the rise of pluralism in other areas of philosophy. Millstein attempts to buck this trend by criticizing conceptual pluralism with respect to population and by proposing her own positive definition of population. Clearly articulated and shared definitions of technical terms are obviously desirable, especially in science—hence the ongoing efforts of philosophers to explicate notions, such as time and space in physics, and gene, species, and life in biology. Millstein's discussion of the concept of population can be seen as part of this ongoing effort. Even if biology cannot attain the conceptual unity which physics does, having shared definitions of technical terms might be at least a valuable heuristic for biologists. "Population," however, is not a narrow technical term in this sense, and is used in many different ways by biologists in different contexts, for a diverse plurality of particular research questions. Such plurality of uses does not betray conceptual confusion amongst biologists, but merely indicates the medley of biological research traditions. The term "population" is more like the term "game" and less like the term "species."

I have argued both that Millstein's critical arguments against conceptual pluralism with respect to population fail, and that her positive proposal for a definition of population is unsatisfactory. Millstein has only briefly described her position, and so criticism is perhaps premature. Although she suggests that she has "gone a fair way towards establishing" her account of population (Millstein 2010), earlier she claims to "harbor no illusions that [her] short article will have settled the question of what a population is" (2009). However, the concept of population is not a concept for which one can provide a definition in terms of conditions for the determination of what things in the world count as a population. That is because, contrary to what Millstein supposes, the set of things in the world that are rightly considered populations by those scientists who most often use the term is not a natural kind; in other words, there do not exist multiple groupings of entities that all meet principled criteria such that all and only these groupings can be called populations. Rather, entities in the world are grouped according to any number of possible criteria, for whatever pragmatic purpose scientists may have, and the resulting sets of entities can be (and often are) called

populations: populations are pragmatic kinds, but not natural kinds.[6] In the absence of compelling arguments against conceptual pluralism with respect to population, defining the concept of population is not something on which philosophers should expend their special resources. Since Millstein's arguments against conceptual pluralism with respect to population are not compelling, the case that Gannett (2003) made for conceptual pluralism with respect to population maintains its attraction: the concept of population is not a natural kind.

Acknowledgments

I am grateful to Roberta Millstein for discussion and detailed feedback on earlier drafts of this article. Nancy Cartwright, Joyce Havstad, and Alexandre Marcellesi also provided valuable suggestions to improve this article.

Notes

1. Conceptual pluralism is consistent with (indeed, is entailed by) semantic contextualism. There is a rich literature in epistemology on the context-sensitivity of meaning and knowledge; although reviewing this literature could supplement my defense of conceptual pluralism with respect to population, such a review would take this article far afield. See, though, DeRose (2009) for a summary of relevant arguments.

2. The most explicit formulations of these arguments are made in Millstein (2009). Millstein (2010) provides several cases to illustrate the same core position.

3. This is a slight departure from Millstein's description of this hypothetical case: in her description she claims that in the latter scenario selection would favor the pink morphs instead of yellow; I assume she means the case in the way I have described it.

4. This two-fold way of thinking about facts has a long history. In Carnap's *Meaning and Necessity*, for instance, facts are understood as in above-mentioned (2). On the other hand, Wittgenstein's *Tractatus* famously argues that the world is a bunch of facts, or states of affairs, about which we have thoughts (and thoughts are propositions), and so facts are understood as in above-mentioned (1).

5. Millstein claims that "it might be the case that if selection and drift are population-level causal processes," for which she argues in Millstein (2006), "then populations must be individuals." Even if this conditional claim were true, which is not at all clear, there are reasons to think that its antecedent is false; although arguing the point here is impossible, see Walsh et al. (2002) and Matthen and Ariew (2002). This additional consideration is not, then, an independent reason to think that populations must be individuals.

6. Depending on one's views of natural kinds, at least some populations might turn out to be natural kinds; e.g., if a scientist decided to study the population of all members of a given species, and if one thought species are natural kinds, then one would think this population happened to be a natural kind. But this only suggests that some specific populations are natural kinds, not that all populations are natural kinds, or that the concept of population refers to a natural kind.

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