Reviewer(s)' Comments to Author

Reviewer 1

General comments

Hsu and colleagues use stable istotope analyses to examine how the trophic positions of generalist predators vary temporally with crop stage, and across conventional and organic rice production systems. This study’s primary value is that it slightly improves temporal coverage (3 timepoints) of recent efforts to quantify pest consumption by generalist predators in crop systems using more-costly molecular gut content analyses (Krey et al. 2017, Roubinet et al. 2017,2018, Mabin et al. 2020). From a single season of field data, the authors found that predators’ diet composition changes over time by increasing the proportion of rice herbivores consumed and that generalist predators more frequently consumed rice herbivores in the late season than did predators on organic farms. However, the paper lacks any report or analysis of background densities of predators and herbivores in each system, which is key in contextualizing the temporal patterns of prey consumption described. Adding these conspicuously missing data seems key. In fact, the most abundant, key pest taxa are not even noted anywhere in the document (I’m assuming spiders and lady beetles were they key predators, but that should also be noted explicitly). Several important details about methods and analyses are also missing. Finally, I suggest abbreviating some of the less-relevant sections of the introduction (general importance of generalist predators, weaknesses of controlled experiments) and incorporate a stronger synthesis of related work that clarifies the novelty of this study relative to other recent papers on prey consumption by generalist predators in conventional and organic agroecosystems. Just a few key references are pasted below.

> GC’s response:

Thanks for pointing out the significance of our study, which is using stable isotope to quantify the temporal changes in pest consumption by predators in agro-ecosystems.

I agreed that it is important to know the temporal changes in the background densities of prey and predator species in the field, as these might affect the predators’ dietary patterns observed in our study. We did have the data on the numbers of individuals collected in the samples during our field surveys. The temporal changes in the relative abundances of the three prey guild were shown in Appendix S1: Figure S2. I have also made some additional figures the mean abundances of prey and predator guilds in each farm type at each crop stage. See “Major Concerns Line 125-126” for more details.

The review commented: “In fact, the most abundant, key pest taxa are not even noted anywhere in the document.” and “Several important details about methods and analyses are also missing”. I disagree with these views. In fact, we did mention that spiders and lady beetles were the primary predators in our study system (See line 139 - 141). As for the key pest taxa, we have also provided a summary table of families in the three prey guilds as well as the predator guild. Moreover, what kinds of details about the methods and analyses are missing? Could you state them explicitly?

Finally, I do not think that the general importance of generalist predators and the weaknesses of controlled experiments are less relevant to our study. Since we are examining the generalist predators instead of specialist predators (parasitoids), it is of course reasonable to introduce a bit about why these generalist predators are important components in the agro-ecosystems. Additionally, one of the strengths of using stable isotope analysis as oppose to field controlled experiments is that it can better reveal the temporal dynamics of predator-prey trophic interactions in natural settings, and this is indeed the novelty of this study relative to others.

References to consider

Roubinet, E., Birkhofer, K., Malsher, G., Staudacher, K., Ekbom, B., Traugott, M., & Jonsson, M. (2017). Diet of generalist predators reflects effects of cropping period and farming system on extra‐and intraguild prey. Ecological Applications, 27(4), 1167-1177.

> GC’s response: Similar study design (organic vs. conventional; early vs. late crop season) and research questions (effects of alternative prey and predator compositions on predator’s diet); using molecular gut content analysis to determine predators’ diet and intraguild predation. Like stable isotope analysis, DNA‐based molecular gut content analysis (MGCA) can document how communities of generalist predators utilize prey under field conditions. But this approach only provides a snapshot of what predator individual consumes recently rather than the time-integrated dietary information. Furthermore, MGCA gives the detection frequencies of prey items in predators’ gut contents, but it does not quantify the proportion of these prey items in predator’s diet. This could lead to potential bias since high detection frequency does not necessarily imply high consumption in terms of number of individuals or biomass.

Roubinet, E., Jonsson, T., Malsher, G., Staudacher, K., Traugott, M., Ekbom, B., & Jonsson, M. (2018). High redundancy as well as complementary prey choice characterize generalist predator food webs in agroecosystems. Scientific reports, 8(1), 1-10.

> GC’s response: Again, using DNA‐based molecular gut content analysis to investigate prey preferences of generalist predators targeting fifteen inter- and intraguild prey at two crop periods. Did not account for the differences in farming system.

Mabin, M. D., Welty, C., & Gardiner, M. M. (2020). Predator richness predicts pest suppression within organic and conventional summer squash (Cucurbita pepo L. Cucurbitales: Cucurbitaceae). Agriculture, Ecosystems & Environment, 287, 106689.

> GC’s response: Still another study using molecular gut content analysis to identify the key predators of the pest herbivore (striped cucumber beetle) and whether the predator richness was related to pest abundance. The difference between farming system was compared, but the temporal dynamics over crop stage was not examined.

Krey, K. L., Blubaugh, C. K., Chapman, E. G., Lynch, C. A., Snyder, G. B., Jensen, A. S., ... & Snyder, W. E. (2017). Generalist predators consume spider mites despite the presence of alternative prey. Biological Control, 115, 157-164.

> GC’s response: Using molecular gut content analysis to examine whether the density of alternative prey would disrupt the pest consumption by generalist predators in organic and conventional farms. Did not include effects of crop season.

This review seems to advocate the use of molecular gut content analysis to examine predator-prey trophic interactions. However, stable isotope analysis does have some advantages over MGCA, the main being that it can actually quantify predators’ diet composition rather than simply giving the predation frequency. I think we can emphasize this more in our introduction if needed. Overall, these two approaches should be complementing each other to achieve a greater resolution of predator-prey trophic interactions (Also see “Carreon‐Martinez, L., & Heath, D. D. (2010). Revolution in food web analysis and trophic ecology: diet analysis by DNA and stable isotope analysis. Molecular Ecology, 19(1), 25-27.” for a brief review of SI and MGCA.)

Positive Comments

The writing was strong, and the paper had really clear and well-executed transitions in to help the reader follow their logical path, even for a reviewer like me who does not have extensive experience with rice agriculture (esp. line 71-72).

Conducting complementary multivariate analyses of both the differences among centroids and differences in dispersion was a good idea and lent strength to the conclusions the authors drew (line 164-167).

Extremely clear and easy-to-follow explanation of the implications of the statistical results (e.g., line 215-216).

Major Concerns

Line 125-126: It’s never noted how many samples were run per site and per timepoint. Please clarify. Including a table that includes which taxa and how many individuals were analyzed for each site will clarify much. At the very least, make sure to include your N for each farm system and timepoint.

> GC’s response: It is unfair to say that the sample sizes were missing in our study. We actually provided the numbers of replicate farms as well as the number of predator capsules analyzed at each stage in our Appendix S1: Table S3. The reviewer asked us to provide a summary table for the sample sizes of the arthropod taxa per site and per timepoint, yet I do not think it is necessarily to go that deep into the “taxa” level, since we were analyzing trohpic guilds instead of individual taxa. Here is the figure showing the mean numbers of individuals for the prey and predator guilds in our sweep net samples:

Abundance.tiff

Line 138-139: The authors’ argument that substituting trophic guilds for individual species would be appropriate for community analyses needs justification. Predator hunting mode can affect prey suppression and individual predator species can have different implications for the structure and functioning of the rest of the predator community. If this does not hold true for rice agroecosystems, then a citation is needed along with a fuller discussion of why a species-composition approach was forgone.

> GC’s response:

The reasons for using trophic guilds but not individual species (families):

1. For prey, since we only had two biotracers (C and N), it is not appropriate to include more than three sources, and that is why we assigned the prey items into the three trophic guilds.

2. For predators, of course, hunting modes can affect which prey items the predators consume. However, since in this study we are mostly interested in the diet of generalist predators as a whole rather than individual predator species, using trophic guild will be appropriate for our research questions and our stable isotope approach can reveal the broad picture of the predators’ dietary patterns in the farms.

Line 139-141: Were all predators either ladybeetles or spiders? If not, in what guild were other predatory species included? Were any predators actually omnivores and would this affect your results if there were?

> GC’s response: The predator guild contained both ladybeetles and spiders, and the taxonomy of these predators was shown in Appendix S1: Table S1. The spiders are mainly carnivorous, although they might also engage in intra-guild predation. Additionally, the ladybeetles may also feed on pollen. Omnivory could potentially bias the predators’ diet estimates if the additional food sources are not included in the stable isotope mixing model. However, I do not think these predators are “highly omnivorous”. Therefore, although the actual dietary proportions might change if they do feed on other food sources, the overall results should still be qualitatively similar and so it is unlikely that it will greatly affect our main conclusions.

Line 179-180: Was an interaction between farm and crop stage included in these analyses? Many of the claims made by this paper implicitly rely upon such a term (i.e., that the effect of crop stage depends upon farm type) so this term is needed if it is not currently included. An interaction is included in a later suite of analyses (line 194-195) but it is unclear if one is included in the diet composition analysis.

> GC’s response: MixSIAR does not support interactions between fixed factors, and therefore we did not include the interaction term in the predators’ diet estimation (Line 179-180). Because of this problem, we fitted an additional beta regression model (which allows the specification of interaction terms) using the diet estimates from the mixing model to test for the interaction between farm type and crop stage (line 194-195).

Lines 194-196: It’s not clear what the independent variable is in your model. Please clarify for readers unfamiliar with stable isotope analyses what you mean by “herbivore consumption” throughout the paper, how that value was generated, and what the units are.

> GC’s response: Thanks for pointing out this issue. We did forget to mention the response variable, which is the proportion of rice herbivore consumed in predators’ diet. In our study, “herbivore consumption” means the proportion of predators’ total diet (in terms of biomass) that comes from herbivores. In other words, it is the proportional contribution of herbivores to predators’ diet. This proportion is estimated by the stable isotope mixing model and expressed as a fraction.

Lines 202-205: I don’t see the results from this model in the results section.

> GC’s response: The results were not shown in the main text but actually in the Appendix S1: Figure S3. I think we can briefly describe the results of this model at the end of *“Effects of farm type and crop stage on rice herbivore consumption”* section.

Line 223: Which are the key predators in the system? Which are the most abundant herbivores in the system? Please report all these things. It’s not clear which taxa contribute to the effects reported throughout the paper.

> GC’s response: Here is some information about the taxonomic details of the predator and rice herbivore trophic guilds in our organic and conventional farms:

1. Predator: (The numbers represent the total numbers of individuals collected in the sweep net samples pooled across all replicate farms and all four crop stages.)

|  |  |  |
| --- | --- | --- |
| Taxon | Organic | Conventional |
| Araneae | 91 (74.0%) | 105 (76.6%) |
| Coccinellidae | 32 (26.0%) | 32 (23.4%) |

2. Rice herbivore: (The numbers represent the total numbers of individuals collected in the sweep net samples pooled across all replicate farms and all four crop stages. Only the top three abundant taxa are shown. The total numbers of rice herbivore individuals in organic and conventional farms were 853 and 797, respectively.)

|  |  |  |
| --- | --- | --- |
| Taxon | Organic | Conventional |
| Delphacidae / *Nilaparvata* | 536 (62.8%) | 501 (62.9%) |
| Cicadellidae / *Nephotettix* | 261 (30.1%) | 248 (31.1%) |
| Pentatomidae / *Scotinophara* | 34 (4.0%) | 32 (4.0%) |

Again, I would like to reiterate that this study does not focus on individual taxa but instead the trophic guilds, which are what our manuscript is mainly based on.

Lines 267-268: This claim of a strong effect of predators on pests isn’t supported by the data. Such a claim would require some sort of an experimental predator exclusion treatment. Even correlative evidence of this pattern is not offered here, no report of predator or herbivore densities are provided in this study. These claims need to be tempered throughout.

> GC’s response: I do not think that our claim of strong per capita effect of predator on rice herbivores is lack of support by our results. Based on the results of stable isotope mixing model, we showed that predators’ diet consisted of high proportion of rice herbivores in terms of biomass. Here, “strong per capita effect” means that on average each predator individual consumed “high amount (biomass)”, not “high number (abundance)”, of rice herbivores in their diet. These are two different aspects of predator-prey interactions, and when it comes to “biocontrol”, people usually think about predators’ effects on pest density/abundance. So I think it is important to make clear the distinction between them. Otherwise, many readers might get confused with our statement.

Line 299-301: A citation is needed to justify the claim that previous work has suggested that generalist predators “provide more effective biocontrol services in the field over time.”

> GC’s response:

Below are two references supporting our claim that generalist predators are more effective than specialist biocontrol agents:

1. Symondson, W. O. C., Sunderland, K. D., & Greenstone, M. H. (2002). Can generalist predators be effective biocontrol agents?. *Annual review of entomology*, *47*(1), 561-594.

“The work of DeBach (47) and Ehler (59) provide good examples of where generalist predators were more effective than specialists at controlling pests (see also “Experimental Evidence from Manipulative Field Studies”).”

2. Stiling, P., & Cornelissen, T. (2005). What makes a successful biocontrol agent? A meta-analysis of biological control agent performance. *Biological control*, *34*(3), 236-246.

“Although there has been a debate as to the merits of specialists versus generalists in biocontrol efficacy (Symondson et al., 2002) more recent data have started to strengthen the case for generalists (e.g., Chang and Kareiva, 1999, Murdoch et al., 1995). Symondson et al. (2002) reviewed the evidence for generalist predators as efficient biocontrol agents and, based on 181 manipulative studies, they concluded that in approximately 75% of the cases generalist predators significantly decreased pest abundance. Our meta-analysis results also indicated that biocontrol efficacy tended to be higher when agents were generalists.”

Line 318-319: This result is not particularly meaningful to me without information about the densities of both herbivores and predators in each system. If the conventional system had pest outbreaks, then of course the rate of consumption of herbivores in that system would be expected to be higher. I’m not sure that truly highlights the unappreciated role of generalist predators.

> GC’s response: Thanks for pointing this out. Yes, based on our results, we cannot make any statement regarding the effects of predators on pest densities in the field, and it is possible that predators consumed more rice herbivores in their diets simply due to higher pest abundance in conventional farms. The link between per capita pest consumption by predators and pest abundance in the field needs further clarification. Nonetheless, we showed that predators in conventional farms did exert stronger “per capita consumption effect” on rice herbivores, indicating that these predators could play an important ecological role (predator-prey trophic interactions) in this farming system.

Perhaps we can modify the original statement as “highlighting their significant ecological role in predator-prey interactions in conventional farms.”

Figure 2: Given that an interaction term was not included for these analyses, the grouping of points by both farm type and crop stage makes interpreting the graph along the lines presented in the results difficult. This figure should be modified to be two panels, one with only two ellipses to show analyzed differences between the farm types (but lumped across crop stage) and a second with three ellipses to show tested differences among crop stages (but lumped across the two farm types).

> GC’s response: Thanks for this suggestion. Yes, the original figure is a bit clutter and hard to interpret. I have made a new figure splitting farm type and crop stage into two separate panels. I think this does make it cleaner and easier to visualize.

Isospace2.tiff

Figure 2: The colors used for crop stage are not likely to be visible to readers who are red-green colorblind. This colorblindness simulator (https://www.color-blindness.com/coblis-color-blindness-simulator/) accepts files and can be used to test whether your color palette will be visible to people with colorblindness. Alternatively, Colorbrewer (https://colorbrewer2.org/#type=sequential&scheme=BuGn&n=3) has a checkbox in the middle left for “colorblind safe” that can be used to find hexadecimal codes (R accepts these in all plotting packages of which I am aware) for palettes that are created to be colorblind safe.

> GC’s response: The colors for crop stage in the new figure are now color-blind friendly.

Fig. 3 & 4: please provide more information about units on the y axis. Proportion of what? For whom? In the caption, you might provide readers with a bit of detail about how you use stable isotopes to infer the proportion of a predators’ diet composed by different groups of arthropods.

> GC’s response: I have modified the figures and their captions accordingly:

Figure 3. Predators’ diet composition in organic and conventional farms over crop stage. The proportions of different prey sources in predators’ diet were estimated using a Bayesian stable isotope mixing model, and the mean and SE were computed from the Bayesian posterior means of the replicate farms. Due to insufficient sample sizes, there was no diet estimation at the seedling stage.

Proportion_Or.Cv.tiff

Figure 4. Rice herbivore consumption by predators in organic and conventional farms over crop stages. The mean was computed from the Bayesian posterior means of the replicate farms; error bars represent Tukey’s adjusted 95% confidence intervals. Different letters indicate statistical significance (P < 0.05).

Confint.Farm_Stage.tiff

Minor Comments

Line 76-79: In the phrase “…temporal variations in species composition…” it is unclear whether predator or herbivore species are exhibiting this temporal variation.

> GC’s response: “Species composition” simply means the major arthropod taxa in the farms, including predators, herbivores, and detritivores.

Line 87-90: When indicating the lack of clarity on the impact of organic farming on predator efficacy, positive and nonsignificant results are not (in this reviewer’s opinion) sufficient to indicate that this is a gap in knowledge. I think a much simpler claim would be that organic farming sometimes has an effect on predators and thus organic farms need to be included in your study.

> GC’s response: Yes, I agree that the fact that previous studies have shown positive and non-significant results of organic farming on biocontrol efficacy of predators is not sufficiently a knowledge gap on its own. Rather, it means that we have to take this factor (farming practice) into account when evaluating the biocontrol by predators. I suggest replacing “remain unclear” with “are mixed”.

Lines 91-94: Missing reference.

GC’s response: Here are some references regarding the use of manipulative experiments to compare the biocontrol efficacy of predators between organic and conventional farms:

1. Östman, Ö., Ekbom, B., & Bengtsson, J. (2001). Landscape heterogeneity and farming practice influence biological control. *Basic and Applied Ecology*, *2*(4), 365-371.

2. Crowder, D. W., Northfield, T. D., Strand, M. R., & Snyder, W. E. (2010). Organic agriculture promotes evenness and natural pest control. *Nature*, *466*(7302), 109-112.

3. Birkhofer, K., Fließbach, A., Wise, D. H., & Scheu, S. (2008). Generalist predators in organically and conventionally managed grass‐clover fields: implications for conservation biological control. *Annals of applied biology*, *153*(2), 271-280.

Line 94-95: Missing reference.

> GC’s response: See the references below.

1. Grant, J. F., & Shepard, M. (1985). TECHNIQUES FOR EVALUATING PREDATORS FOR CONTROL OF INSECT PESTS 1.2.

“In other words, it may be easier for the predator to locate the prey, thus overestimating actual mortality caused by predation.”

2. Sih, A., Crowley, P., McPeek, M., Petranka, J., & Strohmeier, K. (1985). Predation, competition, and prey communities: a review of field experiments. *Annual Review of Ecology and Systematics*, *16*(1), 269-311.

See page 290-291 (section “*By experiment type*”)

Line 108-109: For the claim that stable isotope analysis is “a common method,” a citation should be provided.

> GC’s response: See the references below.

1. Thompson, D. R., Bury, S. J., Hobson, K. A., Wassenaar, L. I., & Shannon, J. P. (2005). Stable isotopes in ecological studies. *Oecologia*, *144*(4), 517-519.

2. Phillips, D. L. (2012). Converting isotope values to diet composition: the use of mixing models. *Journal of Mammalogy*, *93*(2), 342-352.

3. Boecklen, W. J., Yarnes, C. T., Cook, B. A., & James, A. C. (2011). On the use of stable isotopes in trophic ecology. *Annual review of ecology, evolution, and systematics*, *42*, 411-440.

Line 118: If the quality of the irrigation water has the potential to affect your results, include a table summarizing that information by farm in the supplemental information.

> GC’s response: Since our study mainly focuses on terrestrial rather than freshwater arthropod communities, the effects of irrigation water, if any, should be relatively small.

Line 123-124: Include to which taxonomic level the majority of insects were identified. Given that the paper invokes the importance of species composition at various points, this information seems important.

> GC’s response: This information is actually provided in Appendix S1: Table S1. I think we can add “See Appendix S1: Table S1 for details.” in the end.

Line 126-128: Does pooling multiple individuals into the same capsule for isotope analysis have the potential to change results? What was the average number of individuals per sample? If generally one sample was formed of a single individual that average should approach one and would be good to include.

> GC’s response: Given that there is not much intraspecific variation in individual diet, pooling multiple individuals in a single capsule will not affect their stable isotope signatures and thus the results of stable isotope analysis. Depending on the individual biomass of the species, some capsules contained > 10 individuals (e.g., chironomids), some around 3-5 individuals (e.g., plant hoppers and leaf hoppers), and some only single individual (e.g., stink bugs). The main goal is to meet the minimum sample weight requirements for the stable isotope analysis.

Line 139-141: Include parenthetically the taxonomic name of the groups you consider “ladybugs” and “spiders.” This is more important for spiders as it will give an indication of whether spiders were of a single family or many.

> GC’s response: The taxonomy information of predators is actually provided in the Appendix S1: Table S1. Though, it does not hurt to show the taxonomic name here: spiders (Araneidae, Clubionidae, Oxyopidae, Tetragnathidae, Thomisidae), ladybugs (Coccinellidae).

Line 282-284: Did the abundance of predators change with the increasing abundance of rice herbivores (line 279-281) or just the relative consumption rate of rice herbivores?

> GC’s response: Based on our sweep net samples, the number of predators did not seem to increase with the abundance of rice herbivores. See the abundance figure I have made earlier.

Line 321: A rhetorical question is a weak transition to these mechanisms. Please rephrase this to more directly state that you have identified two mechanisms.

> GC’s response: Maybe we can simply rewrite the sentence as “We propose two possible non-mutually exclusive explanations for higher rice herbivores consumption by predators in conventional farms.”

Line 323-325: Don’t you technically have the data to examine both density and diversity of the arthropods in your systems? Proposing mechanisms you can actually test with your data seems strange. I urge the authors to directly report these results instead of speculating about it here. They are quite important for contextualizing your claims of higher predation rates of rice pests in the conventional system.

> GC’s response: Yes, it is important to our stable isotope analysis results with densities of predators and prey in the field. See the abundance figure I have made earlier. Basically, based on our sweep net samples, there were no obvious differences in the abundances of prey sources as well as predators between organic and conventional farms.

Lines 335-341: This point seems not particularly relevant and I suggest cutting it. Instead, a more serious caveat to consider could be how elevated trophic signatures of fungus and bacteria feeding decomposers might confound your results over time, as the availability of fungus and bacteria fluctuate. (see ref below)

Steffan, S. A., & Dharampal, P. S. (2019). Undead food-webs: integrating microbes into the food-chain. Food Webs, 18, e00111.

> GC’s response: I do not think this is really an issue in our study system. The rice paddies are typically drained later in the crop season, and the abundance of detritivores (which may feed on fungus and bacteria) will largely decrease. As a result, the distinct isotope signatures of these fungus and bacteria may not have affected our analysis.

Line 344: Yes indeed. Please report the density and diversity of predators in your fields.

> GC’s response: See the abundance figure I have made earlier.

Line 552: Give the range of individual predators per sample.

> GC’s response: “Each point represents a capsule sample containing 1-5 predator individuals, depending on their body sizes.”

Figure 4: Why did you switch from ± standard error in Figure 3 to ± confidence intervals in Figure 4? It would be better if these were consistent. Also, include what the error bars are in the y-axis label (as you do in Figure 3).

> GC’s response: In Figure 3, we used SE instead of CI as error bars because we were simply showing the variation of the diet proportions among individual replicate farms. On the other hand, in Figure 4, we were testing the difference in the proportion of rice herbivore consumption between organic and conventional farms, and therefore we used CI as error bars along with the letters above to show the statistical differences. I have modified the y-axis label and added what the error bars represent in Figure 4. See the response to “Major concerns: Fig. 3 & 4”.

Table S1: Add a column indicating to which order families belong.

> GC’s response:

|  |  |  |
| --- | --- | --- |
| **Trophic guild** | **Order** | **Family / Genus** |
| Rice herbivore | Hemiptera | Alydidae / *Leptocorisa* |
|  | Hemiptera | Cicadellidae / *Nephotettix* |
|  | Hemiptera | Delphacidae / *Nilaparvata* |
|  | Lepidoptera | Hesperiidae |
|  | Hemiptera | Lygaeidae / *Pachybrachius* |
|  | Hemiptera | Pentatomidae / *Scotinophara* |
|  | Lepidoptera | Pyralidae |
|  | Orthoptera | Pyrgomorphidae / *Atractomorpha* |
| Tourist herbivore | Orthoptera | Acrididae |
|  | Coleoptera | Chrysomelidae |
| Detritivore | Diptera | Chironomidae |
|  | Diptera | Chloropidae |
|  | Diptera | Ephydridae |
|  | Diptera | Muscidae |
|  | Diptera | Sciomyzidae |
|  | Diptera | Stratiomyidae |
|  | Orthoptera | Tetrigidae |
| Predator | Araneae | Araneidae |
|  | Araneae | Clubionidae |
|  | Coleoptera | Coccinellidae |
|  | Araneae | Oxyopidae |
|  | Araneae | Tetragnathidae |
|  | Araneae | Thomisidae |

Reviewer 2

Comments to the Author

This is an innovative, highly interesting study using stable isotopes to explore pest consumption by generalist predators in rice crops. The focus is on seasonal changes in diet composition, and on differences between organic and conventional farming systems. Many of the central results such as the shift from detritivore to pest dominance both in availability and in consumption are expected, but have not been quantified in any comparable way before and are thus highly novel. The study is well designed and overall well presented. However, I have three main concerns that must be addressed before it can be published:

First, it is essential to provide information on management differences that may explain differences in predator-prey dynamics: fertilizer type and amount and plant protection (insecticides in particular). Differences between conventional and organic farming systems are usually due to these management factors, including indirect effects such as higher weed density and diversity in organic fields due to the absence of herbicides. To interpret the differences in diet composition reported in this study, it is important to know about possible underlying management differences.

Second, there are several conclusions about biocontrol, that cannot be drawn based on diet composition alone. We need information not only on the composition but also on the densities of predators and pests in both management systems across the season. See explanations below.

Third, the biocontrol potential of generalist predators can be limited by intraguild predation. This should at least be discussed. Is it possible to estimate intraguild predation (as a fourth prey category) with the current dataset? Both ladybeetles and (hunting, not web building) spiders are known for high rates of intraguild predation.

> GC’s response: Thanks for the overall comments on our study. Below are my thoughts on the reviewer’s concerns:

For the first concern, it is for sure that the management practices may largely influence the observed dietary patterns of predators in the organic and conventional farms. Basically, the main difference between our organic and conventional farms was the use of organic or synthetic chemicals, and we did mention this in our methods (Line 119). I am not quite sure if the farmers in the conventional farms applied herbicides or not. I think we can check on the available management data provided by the farmers for more details, including the type and amount of the chemicals used.

For the second concern, yes, I agree that predators’ diet composition alone may not be sufficient to draw any conclusion about their biocontrol. It is important to know the densities of pests and predators in the field, and we did mention this as one of our potential caveats. We did have the abundance data of the prey and predators in our sweep net samples, and I have made a new figure showing the mean abundances of these arthropod guilds in organic and conventional farms over crop season.

For the third concern, it is possible that these generalist predators engaged in intra-guild predation, lowering their biocontrol potential. However, if they engaged in intra-guild predation, it should have already been reflected in their stable isotope signatures (higher δ13C and δ15N compared to no intra-guild predation), and higher δ13C and δ15N of predators may reduce the proportion estimates for herbivores (which were lower in δ13C and δ15N). As a result, if these predators did feed on each other, the mixing model may tend to underestimate the actual proportions of herbivores in predators’ diet. On the other hand, it is not suggested (though theoretically possible) to include predators themselves as a food source in the stable isotope mixing model, which is a limitation of this analysis.

I think we can add a brief discussion of intraguild predation in the potential caveats of this study:

“Third, the predators examined in our study may engage in intra-guild predation, which was not accounted for in the stable isotope mixing model. However, if these predators did exhibit intra-guild predation, it should have already been reflected in their stable isotope signatures (i.e., higher δ15N compared to without intra-guild predation), and this may increase the proportion estimates for detritivores (higher δ15N) while decrease the proportion estimates for herbivores (lower δ15N) in the mixing model. In other words, under intra-guild predation, the mixing model would tend to underestimate the actual proportions of herbivores in predators’ diet. Therefore, our results of herbivore consumption by predators should be relatively conservative. We encourage further research to investigate how intra-guild predation might affect the estimation of predators’ diet composition in stable isotope analysis.”

Line 119: “Synthetic”, not “Synthesized”.

> GC’s response: Yes, it should be “Synthetic”, not “Synthesized”. We should correct this error.

Line 150: Was intraguild predation considered in mixing models?

> GC’s response: As mentioned earlier, it is not suggested (though theoretically possible) to include predators themselves as a food source in the stable isotope mixing model, and so we did not consider this in our mixing model.

Line 254-255 (and elsewhere, including in Abstract): It is indeed surprising that predators in conventional farms consumed higher proportions of rice herbivores than in organic farms at tillering, while the relative availability of rice herbivores was higher in organic than in conventional farms during that period. To conclude about biocontrol potential, it is nevertheless essential to report also (a) the level of pest infestation and ideally crop damage in both farming systems. As a minimum, the absolute number or biomass of rice herbivores and other prey groups per sampling effort should be given. (b) Similarly, the density of predators is essential, which is often (but not here?) higher in organic than in conventional crops. If predator density was multiple times higher in organic than in conventional farms, then the higher proportion of rice herbivores consumed in conventional farms may still mean lower instead of higher biocontrol potential. Thus, any conclusion about biocontrol potential is only valid if predator and prey densities are also reported. You already touch on this limitation in the potential caveats section, but you must keep it in mind throughout the manuscript and avoid overconclusion.

> GC’s response: I totally agree with this. To draw any conclusion about the biocontrol efficacy of predators in organic and conventional farms, we also need to know the densities of predators in the farms. I have made a new figure showing the mean abundances of the arthropod guilds in our sweep net samples in organic and conventional farms over crop season. In fact, there was not much difference in predator abundances between the two farming system.

Actually, reviewer 1 also raised the same concern here (the same sentence!). I think we should really modify this statement to avoid over-interpretation and confusion.

Line 268: A high per capita consumption of rice pests is no guarantee for successful biocontrol. There are countless examples of even specialist enemies that consume exclusively (100%) certain pest species but are not effective biocontrol agents. Also the increase of effect during the crop season (Line 271) is only true if total consumption (depending on the predator densities) is increasing faster than prey density.

> GC’s response: I agree. A successful biocontrol depends on not only per capita consumption but also the densities of predators, and the total effect of predators on prey is the product of both components. I think we should modify the statement and try not to infer too much about “biocontrol’. I suggest modifying the sentence as something like “…, highlighting the critical ecological role of generalist predators in predator-prey trophic interactions in rice agro-ecosystems.” As for Line 271, we actually wrote: “…, suggesting an increasing per capita effect of predators on pests over the crop season.” We did not say that the total pest consumption by predators increased over the crop season!

Line 279-281: Don’t mix increases of relative and absolute abundances. An increase in the relative abundance does not automatically reflect an increase in absolute abundance; it may also reflect a decrease of other prey.

> GC’s response: Since there were only three prey guilds and the total proportion summed to 1, an increase in the relative abundance of rice herbivores would of course correspond to a decrease in the relative abundances of the other two guilds. It has nothing to do with the absolute abundance. However, I think the sentence “compared with that of tourist herbivores and detritivores” may be a bit confusing, as readers might mis-interpret it as “the relative abundances of tourist herbivores and detritivores increased over crop season as well, although the degree of increase was lower than that of the rice herbivores”. This is not what we meant to say here. Maybe we can rewrite the sentence like “In our study sites, the relative abundance of rice herbivores increased as the crop developed, whereas that of tourist herbivores and detritivores decreased.”

When speaking of per capita effects (Line 268, Line 292, and Line 341), please be clear if you mean per capita prey or per capita predator. Based on the results shown so far, it can only be per capita predator. However, a high per capita predator consumption of rice pests has no strong implications for rice pest population regulation. Per capita can be misleading because it often refers to prey mortality rate, so please be clear and avoid overconclusion.

> GC’s response: In our study, “per capita effects” means “per capita predator effects on prey”, that is, the average proportions of prey sources consumed by each predator individual. In fact, in Line 268 and Line 341, we did write “strong per capita effect of predators on pests”. In Line 292, we wrote “they still exerted a strong per capita effect on pests”, and it should be sufficient to infer that the effect is per capita predator rather than per capita prey based on the context. Additionally, we have discussed the distinction between per capita pest consumption and pest suppression in our potential caveats.

Line 292 & 341: You are showing diet composition, not effects on of predators on prey. Thus, the word “effects” must be replaced.

> GC’s response: I disagree. Diet composition represents the consumptive “effect” of predators on prey! Still, we can use “consumption” instead of “effects” to avoid confusion.

Line 320: As explained above, you cannot conclude about pest management based on the diet proportion alone.

> GC’s response: We should modify the statement and try not to infer too much about “biocontrol”. Maybe we can rewrite this sentence as “highlighting their significant ecological role in predator-prey interactions in conventional farms.”

I think Figures S1, S2 and S3 are important enough to be moved to the main manuscript. Instead, Figure 1 could be moved to supplemental material. Figure S2 (relative prey availability) is particularly interesting in comparison with Figure 3, so maybe you want to combine all four panels in one figure. Figure 4 is partly redundant with Figure 3 (all means are already displayed there). I think Fig. 4 is illustrative, but not essential and the pairwise differences can also be described in the text. Thus, if space is limiting, this figure could be moved to the supplemental material.

> GC’s response:

1. Figure 1: Since farming system (organic vs. conventional) is a main focus of this study, I think it is important to provide readers some kind of visual information in the main text.

2. Figure S2 and Figure 3: Yes, it would be interesting to combine these two figures to better compare how the predators’ dietary proportions changed with the relative abundances of the prey sources.

3. Figure 4: Yes, some information in this figure has already been present in Figure 3. However, here we focus specifically on rice herbivores and provide some additional information regarding the comparisons of the proportion between organic and conventional farms over crop stage, which is not that intuitive in Figure 3 since the proportions in organic and conventional farms are separate in two panels rather than placed side by side in the same plot. Moreover, even if the test results can simply be described in text, a figure is much more informative and easier for readers to grasp the results (A figure is worth thousands of words!). So I think Figure 4 should be kept in the main text. On the other hand, Figure 4 can be combined with Figure S3, which shows the relationship between the relative abundance of rice herbivores and predators’ dietary proportion in organic and conventional farms.

My overall suggestion would be:

1. Keep Figure 1 and 2 in the main text as is.

2. Combine the original Figure 3 and Figure S2 into new Figure 3.

Figure 3.tiff

3. Combine the original Figure 4 and Figure S3 into new Figure 4. (Note that I have change the linetype in panel (b): organic farms: solid; conventional farms: dashed; all: dot-dashed.)

Figure 4.tiff

4. Keep Figure S1 in the appendix as is.

Line 359: The biocontrol value depends on the densities of predators and rice pests, and (absolute) consumption rates. Diet composition alone does not allow to conclude about biocontrol value.

> GC’s response: Yes, I agree. Maybe we should rewrite this statement as something like “…, suggesting an increasing in per capita pest consumption by generalist predators over time regardless of farm type.”

Line 360: “per capita pest consumption” is misleading, it can be interpreted as pest mortality rate which you have not determined.

> GC’s response: I do not think “per capita pest consumption” is misleading. It simply means the average consumption of pests in the diet of each predator individual. Nonetheless, we can replace “The per capita pest consumption by predators” with “The proportion of rice pests in predators’ diet”.